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Corn Seeds Identification Based on Shape and Colour Features

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Abstract-Corn is one of the agricultural products that are essential as daily food sources or energy sources. Corn selection or sorting is important to produce high-quality seeds before its distribution to areas with varying conditions and agricultural characteristics. Hence, it is necessary to build corn seeds identification. In this paper, we propose a corn seed identification technique that incorporates the advantage of combining shape and color features. The identification process consists of three main stages, namely, ROI selection, feature extraction, and classification using the Artificial Neural Network (ANN) algorithm. The shape feature originates from the eccentricity value or comparison value between a distance of minor ellipse foci and major ellipse foci of an object. Meanwhile, the color features are extracted based on the HSV (Hue-Saturation-Value) channel. The experimental result shows that the proposed system achieves excellent performance for the identification of poor and good corn quality for BIMA-20 and NASA-29 species. The classification result for BIMA-20 Good vs. BIMA-20 Bad gives an accuracy of 89%, while the classification accuracy of BIMA-20 Good vs. NASA-29 Good is 97%.

Keywords: artificial neural network, eccentricity, feature extraction, region of interest

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1. Introduction

In the field of food and agriculture technology, to meet production requirements is very difficult. the difficulty is related to the level of product diversity and its non-homogeneous nature. To assess the quality of products or goods, it is necessary to consider the feature specifications including corn [1].

Corn is one of the agricultural products that can be used either as essential food sources in daily life or energy sources. The selection or sorting process must be carried out to produce quality seeds which will then be distributed to areas with varying conditions and agricultural characteristics. Prakasa et al. have successfully developed a system to automatically detect a region of interest (ROI) using the K-means algorithm. ROI will produce images containing only one corn seed by determining the location

and boundary box of each corn seed in the input image. Based on the test results, the model is proven to be able to detect ROI with an accuracy exceeding 90% [2].

It is very important to check the quality of corn seeds so that they are safe and of a high standard. Traditionally inspecting corn seeds way is very time-consuming and also depends on the skills of employees/humans. it would be very interesting to be able to control human error and also expect the same quality from many staff with various levels of skill [3].

Feature extraction has a fundamental role in classification techniques[4]. The colour value is one of the object features that widely used in classification algorithms. The colour feature is significant in determining the quality of any fruit[5]. Colour characteristics can be represented in a variety of colour representations or commonly referred to as colour space. There are several colour spaces used to

represent colour values. One of the colour space is called HSV (hue, saturation, value). The HSV is a result of the geometrical transformation from The RGB (red, green, blue) colour map[6]. Another feature that can be used to characterize the physical properties is object shape. The shape features can be represented in roundness, convexity, compactness, elongation, eccentricity, and sphericity [7]. Use the shape feature to classify pollen grains [8].

Moallem et al. [4], in their research, have also succeeded in identifying healthy apples and defective apples by applying several segmentation algorithms such as background removal, stem tip detection, calyx detection, primary segmentation defects, and repair of defective areas. By combining statistical, texture, and geometric features, they achieve excellent classification result for healthy apples of 91.75%, and defective apples is an average of 91.5%.

Xiao Ling et al. classifying waxy corn kernels based on a combination of spectral, morphological, and texture features. This feature is extracted from hyperspectral images that look and are almost infrared. Morphological features are used as many as five features, including area, circularity, aspect ratio, roundness, and solidity. Then the texture features used amounted to eight features including energy, contrast, correlation, entropy, and standard deviation. Both features were extracted as the appearance features of each peeled corn. Furthermore, the model was built for the classification of corn seed varieties based on various feature groups, namely Support vector machine (SVM) and partial least squares-discriminant analysis (PLS-DA). The accuracy results achieved using the SVM model are higher than using the PLS-DA model [9].

According to the grain-grading standards, the corn quality is classified based on several conditions, such as moisture, weight, colour, shape, odour, and damage. Among these criteria, the moisture, weight, and odor of corn can still be evaluated using electronic analyzers or other special instruments. Moreover, the damage can still be seen manually. Therefore, the assessment can introduce some errors. A plausible way to classify corn is by using computer vision to classify corn automatically [10].

In this study, we propose the identification of corn seeds using the combination of shape and color features. The data used in the study consisted of three categories, BIMA-20 Good, BIMA-20 Bad, and NASA-29 Good.

2. Method

Figure 1 shows our proposed corn seed identification. According to Figure 1, the corn seed image data will be divided into training and testing data. The corn image data contains many corn seeds in one image. The first step is carried out by preprocessing corn image data and detecting the region of interest (ROI) to produce images containing only one corn seed. The next step will be feature extraction based on shape and colour. Then at the last stage, the classification will be carried out; the corn seed data extracted from the training data will be used to conduct

training with ANN algorithm that produces output in the form of a classification model. The classification model will then be used to test the test data based on the shape and colour features that have been extracted.

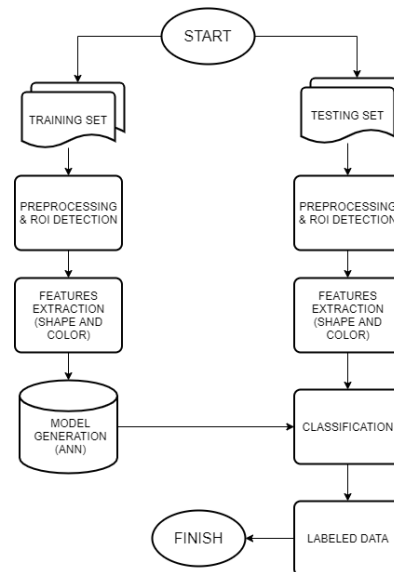


Figure 1: Flowchart System

a. Capturing the corn image data

The capturing process of corn image data is conducted at the Laboratory of Computer Vision Research Group, Research Center for Informatics - Indonesian Institute of Sciences (LIPI) Bandung, with a modified apparatus from the previous research[2]. The corn seed samples are provided by the Assessment Institutes for Agricultural Technology of Gorontalo, Ministry of Agriculture Republic of Indonesia. The method of capturing corn image data using a Canon EOS 70D DSLR camera, with the lighting arranged so that the corn can be seen clearly. The apparatus arrangement is displayed in Figure 2.

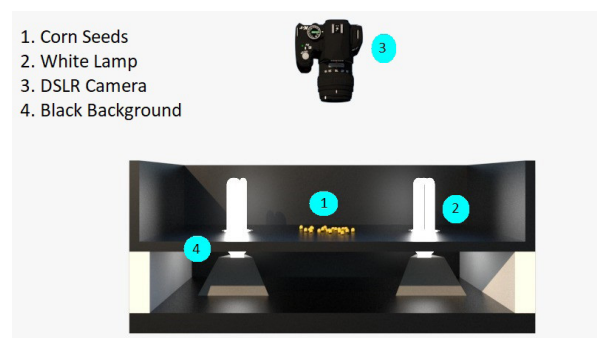


Figure 2: Environment setting corn seed imaging

b. Detection of the region of interest (ROI) and Preprocessing

The purpose of ROI detection is to obtain a single corn seed in each image. Prakasa et al.[2] had successfully developed an algorithm to detect the ROI automatically using the k-means algorithm. The ROI will produce images containing only one corn seed by determining the location

and boundary box of each corn seed in the input image. Figure 3 is an input image in the RGB channel, which is converted into a red channel, as shown in Figure 4. Figure 5 shows the preprocessing median filtering done to eliminate noise in the image. Figure 6 shows the result of segmenting the corn seed from background objects by calculating the threshold value using the Otsu method. The result of the erosion process is depicted in Figure 7.

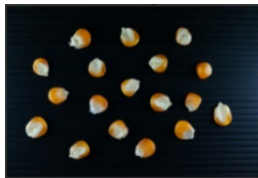


Figure 3: RGB Channel

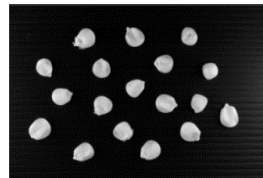


Figure 4: Red Channel

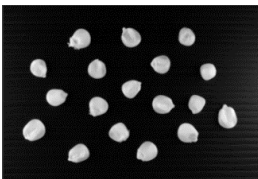


Figure 5: Median Filter

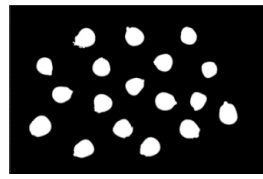


Figure 6: Otsu Thresholding

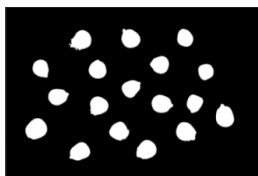


Figure 7: Erode

c. Feature Extraction

The feature used in this study is 2 (two) types, namely, shape and colour feature. We use the eccentricity value to represent the shape feature and HSV value to represent the colour feature.

1) Shape feature: eccentricity

Shape features are physical dimensional measures that characterize the appearance of kernels [11]. Eccentricity is the comparison value between the distance of the minor ellipse foci with the major ellipse foci of an object with the eccentricity value of an elongated object or straight-line shape is close to one. In contrast, a circular object will have an eccentricity value near to zero [12][13].

$$Ecc = \sqrt{1 - (\text{minor axis} / \text{major axis})^2} \quad (1)$$

Figure 8 shows an example of the minor and major axis. The minor axis is the shortest line (line p3 to p4), while the major axis is the longest line (line p1 to p2). The length of the two lines is calculated using Euclidean distance [14].

2) Colour feature: HSV

The colour value is one of the essential indicators to measure the quality of fruit appearance [15][16].

To distinguish an object with a particular colour, we can use the Hue value, which is a representation of visible light (red, orange, yellow, green, blue, purple). Hue can be combined with Saturation and Value, which is the brightness level of colour. The original RGB value is converted to HSV to obtain the values of these three parameters [17][18] using linear support vector machine (SVM).

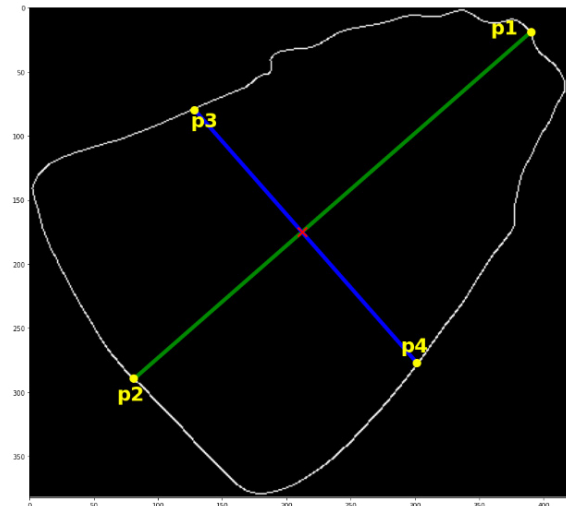


Figure 8: Minor axis & Major axis

d. Artificial Neural Network

Artificial Neural Network (ANN) is a method that models the nervous system of the human brain or commonly referred to as neurons, while the task is to introduce patterns, especially assemblages. This model is based on the ability of the human brain to organize neurons so that they can improve patterns effectively [6]. The ANN characteristics can be seen from the pattern of relationships between neurons, the method of determining the weights of each connection, and its activation function. In general, ANN consists of:

- 1) An input layer, which contains several input neurons that functions to send data
- 2) Hidden layer, which is where the primary process of ANN occurs
- 3) Output layer, which contains several neuron outputs
- 4) Activation function.

The ANN process starts from the input received along with the weight value, after entering the input values that will be added by a propagation function. The results of the addition will be processed by the activation function of each neuron. Then the results will be compared with a certain threshold. If the value exceeds the threshold, the activation of neurons will be canceled. Conversely, if it is still below the threshold value, the neurons will be activated. Once active, the neuron will send the output value to the output layer [7][19][20].

Table 1 The Result of Features Extraction

No	Shape			Colour			Label
	Major axis	Minor axis	Eccentricity	H	S	V	
1	10309	9351	0.421	26167	163251	144307	BIMA20_GOOD
2	9735	9138	0.345	28347	157900	141916	BIMA20_GOOD
3	9785	9726	0.109	29348	161522	149893	BIMA20_GOOD
4	10406	8885	0.521	23477	199624	141244	BIMA20_GOOD
5	10122	9675	0.294	24821	207008	137560	BIMA20_GOOD
6	9748	8719	0.447	26137	167724	132771	BIMA20_GOOD
7	10542	9543	0.425	29248	157730	147806	BIMA20_GOOD
8	10458	8658	0.561	25941	168078	119700	BIMA20_GOOD
9	10301	10283	0.06	25993	186081	140040	BIMA20_GOOD
10	10309	9351	0.421	26167	163251	144307	BIMA20_GOOD

3. Result and Discussion

The following is the amount of corn seed images that we used in the experiment:

- BIMA-20 Good: 632 images
- BIMA-20 Bad: 487 images
- NASA-29 Good: 488 images

Figure 9 shows some examples of corn images used in the experiment. From each image, we extract shape and colour feature, with the result examples can be seen in Table 1. We split the data into training and testing data with 70% and 30% for training and testing data, respectively.

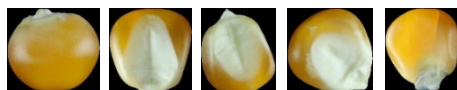


Figure 9: Corn seeds image that have been extracted

The setting of the ANN parameter used in this paper consists of three hidden layers and one output layer. The number of neurons in each layer is as follows: layer 1= 128 neurons, layer 2= 128 neurons, and layer 3= 64 neurons. The setting is selected because it was the most optimal and produced the highest accuracy. We have tried to implement the neurons setting as follows; layer 1 = 32 neurons, layer 2 = 32 neurons, and layer 3 = 16 neurons. However, the accuracy obtained by using this setting was 57% for BIMA-20 Good vs. BIMA-20 Poor and 71% in the classification of BIMA-20 Good vs. NASA-29 Good. We also have used another setting as follows; layer 1 = 256 neurons, layer 2 = 256 neurons, layer 3 = 128. The accuracy of this setting is only 70%.

We investigate two scenarios in our corn seed identification: (1) classification of BIMA-20 Good vs. BIMA-20 Bad, and (2) classification of BIMA-20 Good vs. NASA-29 Good. The results of the classification by the ANN method are summarized in a format called a

confusion matrix. Confusion matrices are commonly used to describe the performance of a classification method whose actual class is known [12]. The data in the confusion matrix shows the number of class predictions that correspond to the actual class. F1 score is used to measure classification performance by applying Equation 2 [21], where TP, TN, FP, and FN are the number of true -positives, true-negatives, false-positives, and false-negatives, respectively [1].

$$F1\ Score = \frac{TP+TN}{TP+TN+FP+FN} \quad (2)$$

a. Classification result of BIMA-20 Good vs. BIMA-20 Bad

In this section, we classify the corn seed of BIMA-20 Good and BIMA-20 Bad classes. The results of classification using the ANN method and summarized in the form of a confusion matrix is shown in Figure 10, Figure 11, and Figure 12. True Positive is the amount of data from the BIMA-20 Good class that was successfully classified correctly into the Good class. True Negative is the amount of data from the BIMA-20 Bad class that was successfully classified correctly into the Bad class. False-positive is the amount of data from the BIMA-20 Bad class that was not successfully classified into the Bad class. False Negative is the amount of data from BIMA-20 Good, which was not successfully classified into the Good class.

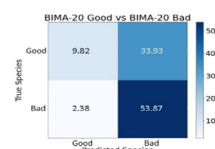


Figure 10: Confusion matrix BIMA-20 Good vs. BIMA-20 Bad using shape feature

The classification result which is shown in Figure 10 only uses the eccentricity properties of the corn seed with the accuracy is 64%. In contrast, the classification result

using colour features is depicted in Figure 11, in which by using H, S, and V we achieve a classification accuracy of 88%. Meanwhile, accuracy results in Figure 12 with feature extraction using shape and colour obtained from BIMA-20 Good and BIMA-20 Bad data that is equal to 89%.

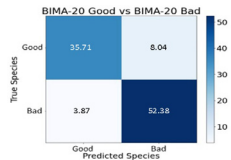


Figure 11: Confusion matrix BIMA-20 Good vs. BIMA-20 Bad using colour feature

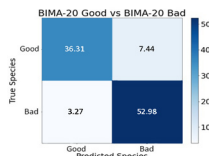


Figure 12: Confusion matrix BIMA-20 Good vs. BIMA-20 Bad using shape and colour feature

b. BIMA-20 Good vs. NASA-29 Good

In this section, we show the classification result of BIMA-20 Good vs. NASA-29 Good. The results of classification using the ANN method and summarized in the form of a confusion matrix, as shown in Figure 13, Figure 14 and Figure 15. True positive is the amount of data from the BIMA-20 Good class that was successfully classified correctly into the Good class. True Negative is the amount of data from the NASA-29 Good class that was successfully classified correctly into the Good class. False-positive is the amount of data from the NASA-29 Good class that was not successfully classified into the Good class. False Negative is the amount of data from BIMA-20 Good that was not successfully classified into the Good class.

In Figure 13, we only use the shape feature extraction, namely eccentricity, with an accuracy of 71%, whereas, in Figure 14 we use colour feature extraction, namely H, S, and V values, with an accuracy of up to 96%. Meanwhile, accuracy results in Figure 15 with feature extraction using shape and colour obtained from the BIMA-20 Good vs. NASA-29 Good data that is equal to 97%.

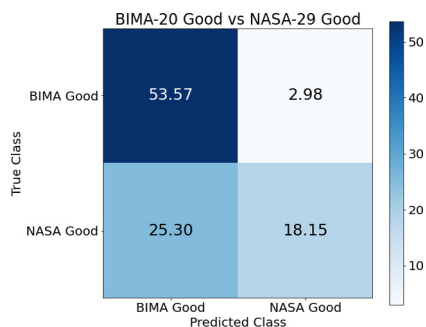


Figure 13: Confusion matrix BIMA-20 Good vs. NASA-29 Good using shape feature

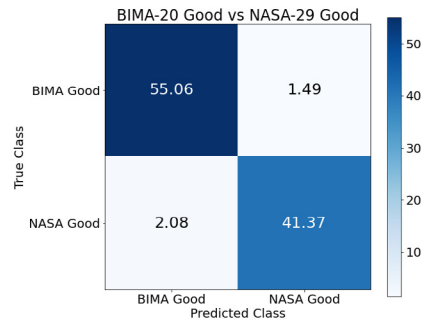


Figure 14: Confusion matrix BIMA-20 Good vs. NASA-29 Good using colour feature

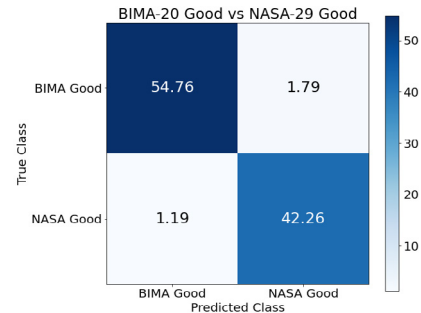


Figure 15: Confusion matrix BIMA-20 Good vs. NASA-29 Good using shape and colour feature

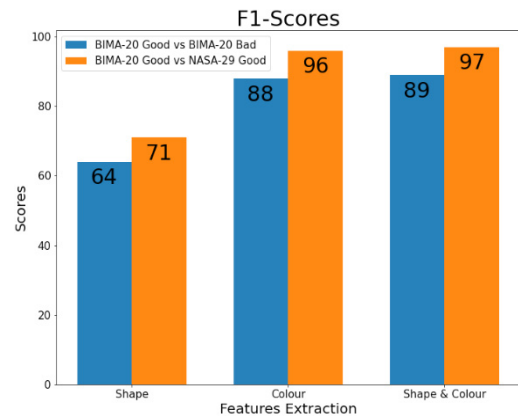


Figure 16: F1-Scores Diagram

The F1 score is shown in Figure 16. Based on Figure 16, the classification results between BIMA-20 Good vs. NASA-29 Good are better, both in terms of shape features, colour features, or shape, and colour features. However, the colour feature classification results are better than the shape feature classification results. Colour features have a strong influence in terms of this classification.

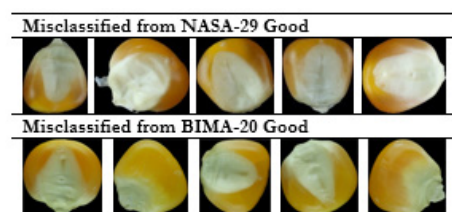


Figure 17: The example of misclassification cases.

Figure 17 is an example of a picture that was misclassified from NASA-29 Good vs. BIMA-20 Good. The misclassification is because the colour of corn seeds from NASA-29 Good has a brighter colour than corn seeds from BIMA-20 Good.

4. Conclusion

In this study, we proposed corn seed identification using color and shape features. We used eccentricity as the shape feature and HSV channel as the color feature. Based on the results obtained in the experiment, we can conclude that the proposed algorithm is performed better in classifying the corn varieties at the same quality than quality grading. In this case, the using of colour feature produce a higher degree of accuracy than the shape feature. This condition is caused due to the shape of corn seed is relatively the same.

Data Availability

The corn images are available in the RIN (Repositori Ilmiah Nasional/National Scientific Repository) of the Indonesian Institute of Sciences. The images are stored as three datasets, BIMA-20 Good, BIMA-20 Bad, and NASA-29 Good. The dataset can be found in the following link: <https://data.lipi.go.id/dataverse/seed-grading>

Author Contributions

All authors are equally contributed in the paper preparation.

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Performance Assessment of University Lecturers: A Data Mining Approach

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Abstract-A lecturer with a good performance has a positive impact on the quality of teaching and learning. The said quality includes the delivery of teaching materials, learning methods, and ultimately the academic results of students. Performance of lecturers contributes significantly to the quality of research and community service which in turn improves the quality of teaching materials. It is desirable, therefore, to have a method to measure the performance of lecturers in carrying out the Tri Dharma (or the three responsibility) activities, which consist of teaching and learning process, research, and community service activities, including publications at both national and international level. This study seeks to measure the performance of lecturers and cluster them into three categories, namely “satisfactory”, “good”, and “poor”. Data were taken from academic works of nursing study program lecturers in conducting academic activities. Clustering process is carried out using two machine learning approaches, which is K-Means and K-Medoids algorithms. Evaluation of the clustering results suggests that K-Medoids algorithm performs better compared to using K-Means. DBI score for clustering techniques using K-Means is -0.417 while the score for K-Medoids is -0.652. The significant difference in the score shows that K-Medoids algorithm works better in determining the performance of lecturers in carrying out Tri Dharma activities.

Keywords: machine learning; data mining; k-medoids; lecturer performance; k-means

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1. Introduction

Performance appraisal is an activity usually carried out by an organization or institution. Performance appraisal is an organized, structured, and periodic process for observing individual performance and institutional productivity in accordance with predetermined organizational criteria and goals [1]. Performance appraisal has similar meaning with evaluation of performance [2].

Performance appraisal is implemented in many organizations and in case of universities, it means to assess the performance of lecturers [3]. Lecturers are important stakeholders for tertiary education institutions and they play the role as both educators and scientists. Lecturers have responsibilities to explore new knowledge and disseminate to ordinary people and students [4]. Performance evaluation of lecturers is important to evaluate the achievements of higher education institutions and to encourage lecturers to be productive. Lecturer activities under evaluation include teaching and learning activities,

research activities as evidenced by the publication papers, and community service [5].

In many cases, lecturers performance is evaluated using a form of questionnaire to students. It assesses the aspect teaching and learning activities. Teaching evaluation alone is certainly not sufficient because lecturer activities are not only teaching but also doing research and community service. However, multicriteria performance appraisal requires a special calculation that involves items being examined. This paper describes the results of research to calculate performance figures using the data mining methods. Assessment aspects are transformed into attributes of data to be processed. We examine two different calculation methods namely K-Means and K-Medoids algorithms.

Data mining is a machine learning approach that seeks to find knowledge from a big set of available data utilizing artificial intelligence techniques, statistics, and mathematics. Data mining is usually operated against large amounts of data stored in databases, warehouses, or

other repositories [6]. Data mining is often referred to as an effort to find knowledge in databases or Knowledge Discovery in Databases (KDD) [7].

Many papers have discussed the application of data mining to data from higher education institutions. The requirements include predicting the length of study of students, assessment of student performance, lecturer performance, determination of college promotion strategies, selection of scholarship grantees, and evaluation of learning outcomes of alumni. The application of data mining has been carried out to gain new knowledge about the behavior of leaders, students, alumni, lecturers, and university staffs which utilized decision support systems and assisted managers in making decisions [8]. Twijri and Noaman revealed that data mining in tertiary institutions is one area of research that is rapidly developing and has quickly become popular because of its benefits for the institutions [9]. Romero et al. stated that there had been an increase in research interest to apply data mining methods in the educational sector, so that a new term had emerged called Education Data Mining. The research was very useful to reveal student behavior, assist instructors, improve teaching quality, assess and improve e-learning systems, and improve curricula [10].

Chalaris et al. revealed that the educational process can be improved through decision making on various processes by utilizing existing knowledge in the organization's database or through collecting data with questionnaires, which are then extracted using data mining [11]. Data mining techniques are very useful in marketing analysis, analysis of student acceptance selection, predicting student performance, planning curriculum, analyzing learning outcomes, and maximizing the efficiency of the educational process [12, 13].

Data mining is a process of exploration and analysis in an automatic or semi-automatic way to find meaningful patterns and rules on large amounts of data [14]. Data mining is one of the most common methods used to investigate information, patterns, and relationships that have not yet been explored [15]. Data mining provides benefits in many fields including e-commerce, bioinformatics and education known as Educational Data Mining (EDM) [16, 17].

The description related to the application of data mining and its application in the world of education inspires the author to observe the application of data mining for assessing lecturer performance. Two data mining methods were tested namely K-Means and K-Medoids. K-means clustering algorithm is a data mining technique that groups data based on the distance closest to the cluster center. While the K-medoids algorithm or also known as PAM (Partitioning Around Medoids) uses the clustering partitioning method to find the k cluster for object n, by first finding the initial object randomly (medoid) as a representation for each cluster. Each remaining object is grouped with the most similar medoid. The k-medoid method uses a representative object as a reference point and not the average object per cluster. The algorithm

takes the input parameter k the number of clusters to be partitioned between a set of objects n.

2. Method

There are two major processes carried out in this research, namely data mining and evaluation or validation. The data mining process has four main stages, namely (a) data collection, (b) data preprocessing, (c) data mining and (d) analysis [18]. Evaluation or validation is done by clustering algorithm (see figure 1).

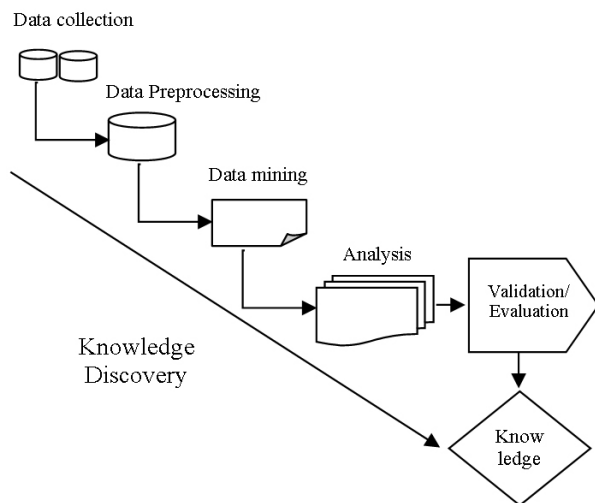


Figure 1. Knowledge Acquisition with data mining

a. Data collection

Data for this study were obtained from the Tri Dharma activities of a Higher Education institution. The data includes aspects of teaching, research, and community service. Data related to the teaching aspect was obtained from the Quality Assurance Unit. Data on research and community service activities was obtained from Research and Community Service Unit, and data on lecture evaluation by students was obtained from the Academic Administration Unit.

b. Data preprocessing

Preprocessing is needed to prepare data before the main data mining process is carried out. Preprocessing has several purposes such as cleaning data from typos, and filling in table columns so they are not empty which can cause failures in computation. Preprocessing is also to reduce the dimensions of the data and adjust the attributes so that calculation may be simplified. Preprocessing in this study includes grouping the raw data into the categories of teaching, research and community service, so that this process produces accumulated values in all of the three aspects.

c. Data mining

Data mining method in this study is basically clustering. Clustering techniques is an unsupervised learning method which partitions objects in a data set

into several groups. There are many algorithms that apply distance equations such as Euclidean Distance [19] to determine the similarity of data, which is the basis for determining whether an object goes into a particular cluster [20]. This study examines two clustering techniques for grouping lecturers based on their performance. The two clustering techniques are K-means and K-medoids.

K-Means clustering is a data grouping technique that breaks a set of objects into k clusters based on the closest distance of an object to a centroid cluster. The steps of the K-means clustering algorithm applied in this study are as follows [21] (see also Figure 2).

- Stage 1 : Determine the number of clusters in the preprocessing dataset
 Stage 2 : Randomly select an object from each cluster to be the center location of the initial cluster or centroid
 Stage 3 : Group objects according to the distance closest to the centroid
 Stage 4 : Recalculate the centroid of each cluster formed to update the centroid location
 Stage 5 : Repeat steps 3 through 5 until no object has moved to another cluster.

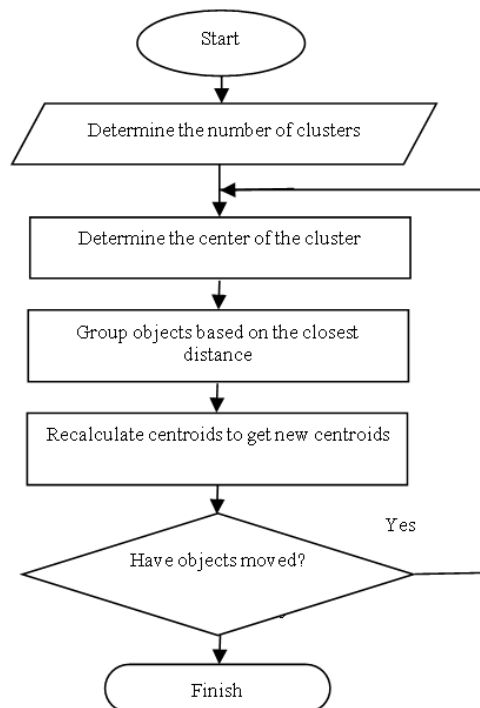


Figure 2. K-means algorithm flowchart

K-medoids are also often referred to as the PAM (Partitioning Around Medoids) algorithm which also breaks the set of objects into k clusters. The stages of clustering with the K-medoids technique are as follows [26] (see also Figure 3).

- Stage 1 : Initialize the cluster center by the number of clusters (k)

- Stage 2 : Each data or object is entered into the closest cluster based on Euclidian Distance
 Stage 3 : Randomly select objects as new medoids candidates in each cluster
 Stage 4 : Each object in each cluster is calculated its distance from the new medoid candidate.
 Stage 5 : Calculate the total deviation (S) by calculating the value of total new distance - total old distance. If $S < 0$ is obtained, exchange the object with the data cluster to create a new set of k objects as medoids
 Stage 6 : Repeat steps 3 through 5 until there is no change in the medoid, so that clusters and cluster members are obtained.

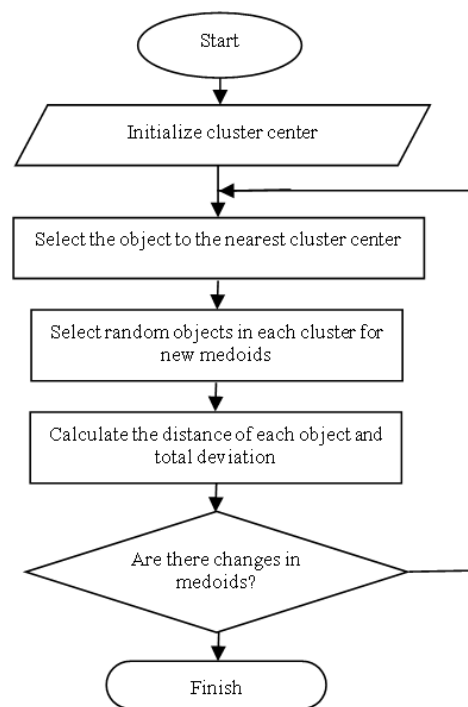


Figure 3. K-medoids algorithm flowchart

d. Analysis

The analysis phase is carried out to get the pattern of lecturer performance grouping. The tool used is Rapid Miner. This tool is widely used in data science, including for data preparation, machine learning, text mining, and predictive analysis [22].

e. Evaluation/validation

The evaluation process is carried out using the Davies-Bouldin Index (DBI) approach. DBI was developed in 1979 by David L. Davies and Donald W. Bouldin using the DBI metric to evaluate the performance of clustering algorithms [23]. This evaluation metric measures the distance between clusters and the level of data grouping within the cluster. If the DBI value is small, the distance between large clusters and the distance of objects in small clusters is a sign that clustering is optimal.

3. Result and Discussion

a. Data Collection

Data mining process using K-Means and K-Medoids begins with collecting data. Samples were taken from lecturer performance data from two study programs in Universitas Muhammadiyah Kalimantan Timur. The attributes specified are teaching performance scores, research performance scores and community service activities.

Teaching performance scores are calculated against Instructional Development Training activities (known as PEKERTI), applied approach (AA), writing

textbooks/references, literary works, developing learning methods and lecturers evaluation by students. Research performance scores were obtained from the attributes of intellectual property rights, international-level keynote/invited speakers, national-level keynote/invited speakers, papers in reputable international journals, papers in accredited national journals, papers in national journals, works of art, sports achievements and awards. Whereas the score for community service is derived from the attributes of technology implementation, environmental management, technology application, community empowerment, and partnership development (see Table 1-3).

Table 1. Data collection on teaching aspects

Number	Respondents	PEKERTI	AA (Applied Approach)	Text Books	Literature work	Development of Learning methods	Lecturer Evaluation by Students (EDOM)
1	Lecturer 1	Yes	Yes	-	-	-	9
2	Lecturer 2	-	Yes	-	-	-	9
3	Lecturer 3	-	Yes	Yes	-	-	9
4	Lecturer 4	Yes	Yes	-	-	-	9
5	Lecturer 5	Yes	-	-	-	-	9
6	Lecturer 6	-	-	-	-	-	9
7	Lecturer 7	Yes	-	-	-	-	9
8	Lecturer 8	Yes	-	-	-	-	9
9	Lecturer 9	Yes	-	-	-	-	9
10	Lecturer 10	-	-	-	-	-	9
11	Lecturer 11	-	-	-	-	-	9
12	Lecturer 12	-	-	-	-	-	9
13	Lecturer 13	Yes	-	-	-	-	9
14	Lecturer 14	Yes	-	-	-	-	9
15	Lecturer 15	Yes	-	-	-	-	9
16	Lecturer 16	Yes	-	-	-	-	9
17	Lecturer 17	Yes	-	-	-	-	9
18	Lecturer 18	-	-	-	-	-	9
19	Lecturer 19	Yes	-	-	-	-	9
20	Lecturer 20	Yes	-	-	-	-	9
21	Lecturer 21	Yes	-	-	-	-	9
22	Lecturer 22	-	-	-	-	-	9
23	Lecturer 23	-	-	-	-	-	9
24	Lecturer 24	Yes	-	-	-	-	9
25	Lecturer 25	-	-	-	-	-	9

Table 2. Data collection of research aspects

Number	Respondent	IPR	Keynote speaker/ International invitation	Keynote speaker/ National invitation	Reputable international journal	Accredited national journal	National Journal	Art works	Sports work	Awards
1	Lecturer 1	Yes	-	Yes	-	Yes	Yes	-	-	-
2	Lecturer 2	Yes	-	-	-	-	Yes	-	-	-
3	Lecturer 3	-	-	Yes	Yes	-	Yes	-	-	-
4	Lecturer 4	-	-	-	-	-	Yes	-	-	-
5	Lecturer 5	-	-	-	-	-	Yes	-	-	-
6	Lecturer 6	-	-	-	-	-	Yes	-	-	-
7	Lecturer 7	-	-	-	-	-	Yes	-	-	-
8	Lecturer 8	-	-	-	-	-	Yes	-	-	-
9	Lecturer 9	Yes	-	-	-	Yes	Yes	-	-	-
10	Lecturer 10	-	-	-	-	-	Yes	-	-	-
11	Lecturer 11	-	-	-	-	-	Yes	-	-	-
12	Lecturer 12	-	-	-	-	-	Yes	-	-	-
13	Lecturer 13	-	-	-	-	-	Yes	-	-	-
14	Lecturer 14	-	-	-	-	Yes	Yes	-	-	-
15	Lecturer 15	-	-	-	-	Yes	Yes	-	-	Yes
16	Lecturer 16	Yes	-	-	-	Yes	Yes	-	-	-
17	Lecturer 17	-	-	-	-	-	Yes	-	-	-
18	Lecturer 18	-	-	-	-	-	-	-	-	-
19	Lecturer 19	-	-	Yes	Yes	Yes	Yes	-	-	-
20	Lecturer 20	-	-	-	-	Yes	Yes	-	-	-
21	Lecturer 21	-	-	-	-	Yes	Yes	-	-	-
22	Lecturer 22	-	-	-	-	-	-	-	-	-
23	Lecturer 23	-	-	-	-	-	-	-	-	-
24	Lecturer 24	-	-	-	-	-	Yes	-	-	-
25	Lecturer 25	-	-	Yes	Yes	-	Yes	-	-	-

Table 3. Data collection of community service aspects

Number	Respondent	Appropriate technology	Environmental management	Application of technology	community development	Partnership Development
1	Lecturer 1	-	-	Yes	Yes	-
2	Lecturer 2	-	-	Yes	Yes	-
3	Lecturer 3	-	-	Yes	Yes	-
4	Lecturer 4	-	-	Yes	Yes	-
5	Lecturer 5	-	-	Yes	Yes	-
6	Lecturer 6	-	-	Yes	Yes	-
7	Lecturer 7	-	-	Yes	Yes	-
8	Lecturer 8	-	-	Yes	Yes	-
9	Lecturer 9	-	-	Yes	Yes	-
10	Lecturer 10	-	-	Yes	Yes	-
11	Lecturer 11	-	-	Yes	Yes	-
12	Lecturer 12	-	-	Yes	Yes	-
13	Lecturer 13	-	-	Yes	Yes	-

Number	Respondent	Appropriate technology	Environmental management	Application of technology	community development	Partnership Development
14	Lecturer 14	-	-	Yes	Yes	-
15	Lecturer 15	-	-	Yes	Yes	-
16	Lecturer 16	-	-	Yes	Yes	-
17	Lecturer 17	-	-	Yes	Yes	-
18	Lecturer 18	-	-	Yes	Yes	-
19	Lecturer 19	-	-	Yes	Yes	-
20	Lecturer 20	-	-	Yes	Yes	-
21	Lecturer 21	-	-	Yes	Yes	-
22	Lecturer 22	-	-	Yes	Yes	-
23	Lecturer 23	-	-	Yes	Yes	-
24	Lecturer 24	-	-	Yes	Yes	-
25	Lecturer 25	-	-	Yes	Yes	-

b. Data pre-processing

The pre-processing phase is carried out to change the dimensions of raw data into data with the attribute scores of teaching performance, research, and community service. Scoring of each attribute is carried out based on Operational Guidelines for Assessing Credit Scores for Academic Promotion / Lecturer Rank, Directorate General of Science and Technology Resources and Higher Education, Ministry of Research, Technology and Higher Education in 2019 [24]. Teaching performance scores are the accumulation of each PEKERTI attribute credit score,

applied approach, textbooks or references, literary works, development of learning methods and EDOM. The research score is an accumulation of each IPR attribute credit score, international and national keynote / invited speakers, reputable international journal publications, accredited national journals, national journals, works of art, sports achievements, awards. Then the community service performance score is an accumulation of each credit score attributes of appropriate technology service, environmental arrangement, technology application, community empowerment and partnership development.

Table 4. Pre-processing results

Number	Respondent	Teaching aspects	Research aspects	The aspect of community service	Total
1	Lecturer 1	39	85	6	130
2	Lecturer 2	24	50	6	80
3	Lecturer 3	44	60	6	110
4	Lecturer 4	39	10	6	55
5	Lecturer 5	24	50	6	80
6	Lecturer 6	9	10	6	25
7	Lecturer 7	24	50	6	80
8	Lecturer 8	24	10	6	40
9	Lecturer 9	24	75	6	105
10	Lecturer 10	9	10	6	25
11	Lecturer 11	9	50	6	65
12	Lecturer 12	9	10	6	25
13	Lecturer 13	39	10	6	55
14	Lecturer 14	24	35	6	64
15	Lecturer 15	39	55	6	100
16	Lecturer 16	24	75	6	105

Number	Respondent	Teaching aspects	Research aspects	The aspect of community service	Total
17	Lecturer 17	39	10	6	55
18	Lecturer 18	24	0	6	30
19	Lecturer 19	39	45	6	90
20	Lecturer 20	24	35	6	65
21	Lecturer 21	24	35	6	65
22	Lecturer 22	9	0	6	15
23	Lecturer 23	9	0	6	15
24	Lecturer 24	24	10	6	40
25	Lecturer 25	9	20	6	35

c. Data mining

Preprocessing data is processed using Rapidminer. The clustering process is carried out into three categories by applying the K-means algorithm and K-medoids techniques.

The process of applying the K-Means algorithm with Rapidminer begins with determining the centroid value. Because it is desirable to cluster into three categories, 3 centroids are generated, namely one for each cluster (see table 5).

Table 5. K-means Centroid

Attribut	Cluster_0	Cluster_1	Cluster_2
Total	66,500	27,778	100,667

Table 6. K-Means clustering result

Cluster category	Amount	Members of the group
Poor	9	Lecturer 6 Lecturer 8 Lecturer 10 Lecturer 12 Lecturer 18 Lecturer 22 Lecturer 23 Lecturer 24 Lecturer 25
Good	10	Lecturer 2 Lecturer 4 Lecturer 5 Lecturer 7 Lecturer 11 Lecturer 13 Lecturer 14 Lecturer 17 Lecturer 20 Lecturer 21
Satisfactory	6	Lecturer 1 Lecturer 3 Lecturer 9 Lecturer 15 Lecturer 16 Lecturer 19

Clustering means the process of grouping data into one cluster by determining the proximity of data points on the centroid. The results of clustering with Rapidminer

produce 10 data items entered into Cluster_0, 9 data items entered into cluster_1 and 6 items entered into cluster_2. Clusters_1 with the smallest centroid value are labeled as cluster Poor, Clusters_0 with medium centroid value are well labeled, and Clusters_2 with high centroid value are labeled as satisfactory. Membership of each cluster can be seen in Table 6.

Table 7. K-medoids Centroid

Attribut	Cluster_0	Cluster_1	Cluster_2
Total	90,00	35,00	65,00

Table 8. K-medoids clustering result

Cluster category	Amount	Members of the group
Poor	9	Lecturer 6 Lecturer 8 Lecturer 10 Lecturer 12 Lecturer 18 Lecturer 22 Lecturer 23 Lecturer 24 Lecturer 25
Good	7	Lecturer 4 Lecturer 11 Lecturer 13 Lecturer 14 Lecturer 17 Lecturer 20 Lecturer 21
Satisfactory	9	Lecturer 1 Lecturer 2 Lecturer 3 Lecturer 5 Lecturer 7 Lecturer 9 Lecturer 15 Lecturer 16 Lecturer 19

The application of the K-Medoids algorithm also begins with the determination of three centroids for the 3 targeted clusters. Centroid values obtained when processing data with Rapidminer are shown in Table 7 with different centroid values from the centroid determination results

for the K-Means method. Clusters with satisfactory labels have centroids at the number 90, while clusters with good and bad labels have centroids of 65 and 35 respectively.

Clustering with the K-Medoids method produces a number of data items that are somewhat different for each cluster. Cluster_0 which has a satisfactory label has 9 members. Cluster_1 with the label is not good getting 9 data items. Whereas Cluster_2 with good label gets 7 data items (see Table 8).

d. Analysis

Table 5-8 shows that clustering with the K-Means and K-Medoids methods gives different results in many ways. The centroid point calculation results give different values for the same cluster label. For example, for the cluster Satisfactory, the K-Means method places the centroid at a value of 100.7 while the K-Medoids method puts the centroid at a value of 90.0. As a result, it certainly can be expected, the number of data items entered into each cluster becomes different.

Table 9. Comparison of clusters between K-means and K-medoids techniques

Cluster category	K-means	K-medoids
Poor	Amount = 9 lecturers Members: Lecturer 6 Lecturer 8 Lecturer 10 Lecturer 12 Lecturer 18 Lecturer 22 Lecturer 23 Lecturer 24 Lecturer 25	Amount = 9 lecturers Members: Lecturer 6 Lecturer 8 Lecturer 10 Lecturer 12 Lecturer 18 Lecturer 22 Lecturer 23 Lecturer 24 Lecturer 25
Good	Amount = 10 lecturers Members: Lecturer 2 Lecturer 4 Lecturer 5 Lecturer 7 Lecturer 11 Lecturer 13 Lecturer 14 Lecturer 17 Lecturer 20 Lecturer 21	Amount = 7 lecturers Members: Lecturer 4 Lecturer 11 Lecturer 13 Lecturer 14 Lecturer 17 Lecturer 20 Lecturer 21
Satisfactory	Amount = 6 lecturers Members: Lecturer 1 Lecturer 3 Lecturer 9 Lecturer 15 Lecturer 16 Lecturer 19	Amount = 9 lecturers Members: Lecturer 1 Lecturer 2 Lecturer 3 Lecturer 5 Lecturer 7 Lecturer 9 Lecturer 15 Lecturer 16 Lecturer 19

Furthermore, it can be seen in Table 9 that shows how the two methods place each data item in a cluster. to group data items into the same and different categories.

Both methods put 9 of the same data items into the cluster Poor. Meanwhile, the K-Means method places 10 data items in a cluster Good and 6 data items in the cluster Satisfactory. The K-Medoids method places 7 data items in either cluster and 9 data items in cluster Satisfactory. Cluster placement discrepancies occur for Lecturer 2, Lecturer 5 and Lecturer 7 data items. All three data items have the same attribute values based on the pre-processing data in Table 4.

e. Evaluation/validation

Clustering with two different methods, namely K-Means and K-Medoids has resulted in a somewhat different data cluster. The next question is which method gives better or more accurate results. To answer this question, a standardized or agreed-upon measuring instrument is needed. One of the measurement tools that can be used to determine which method is more optimal in the clustering process is the Davies-Bouldin Index (DBI). The more optimal clustering results will have a smaller DBI value. Table 10 presents the DBI values for the results of lecturer performance data clustering using the K-Means method (first row) and K-Medoids (second row). DBI results from clustering using the K-Means method are -0.417 while DBI results from clustering using the K-Medoids method are -0.652. The DBI number indicates that the K-Medoids method in this situation results in more optimal clustering than the K-Means method.

Table 10. Comparative evaluation results between K-means and K-medoids

Numb	Clustering Technique	DBI evaluation value
1	K-Means	-0.417
2	K-medoids	-0.652

4. Conclusion

In this research, we have conducted a clustering process on lecturer performance data in carrying out teaching activities, research and publications, as well as community service. Data obtained from records of lecturer activities in two study programs, i.e. Nurse and Pharmacy. We examine 6 attributes of teaching activities, 9 attributes of research and publication activities, and 5 attributes of community service activities. In pre-processing, a score is put for each activity based on the Credit Score Assessment Guidelines for Academic Promotion of Lecturers, then reducing the dimensions by accumulating scores for each activity.

We examine two clustering methods, namely K-Means and K-Medoids. Both methods provide three clusters with three different centroid points. Placement of data items into each cluster is somewhat different. Both clustering methods place 9 of the same data items into cluster Poor. The K-Means method places 10 data items in cluster Good and 6 data items in the cluster Satisfactory. Whereas the K-Medoids method places 7 data items in cluster Good and 9 data items in cluster Satisfactory.

Evaluation of the clustering results with DBI (Davies Bouldin Index) gives a value of -0.417 for the K-Means method and a value of -0.652 for the K-Medoids method. The last fact suggests that the K-Medoids method shows better clustering results than K-Means.

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Design and Implementation of a Smart Home Security System Using Voice Command and Internet of Things

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Abstract- A smart home security system consists of various sensors and recorders to automatically provide data on the conditions of a house. Home electronic equipment may be controlled from distant places using the internet of things technology and speech recognition. This research aims to develop a smart home security system by monitoring fire hazards and theft. It helps also control electronic equipment using voice commands that is useful especially for the disabled. The system design consists of hardware, software, and application design. Hardware design uses ESP8266, Arduino Mega 2560, MicroSD Card module, VC0706 serial camera, DHT22, magnetic door switch, PIR HC SR501, and Google Assistant device. Software design uses Arduino IDE for programming Arduino Mega and ESP8266. Applications used in the design are Adafruit.io, Thingspeak, and IFTTT (If This Then That). Voice commands control home electronic devices (lights), while fire and theft are monitored through the use of sensors and cameras. The system test shows that voice command can control lights on and off at an accuracy of 88%. Temperature and humidity sensors acquire data and send them to Thingspeak application for online fire monitoring. Sensors to detect intruders in the form of door switch and PIR work well and automatically activate cameras that capture objects to store in a MicroSD card.

Keywords: internet of things, smart home, home security, speech recognition, control

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1. Introduction

Smart home security systems that are widely implemented today have replaced the more traditional home security system. A security system has changed from wired to wireless to control all existing apparatus. Such a system provides benefits in the form of cost and energy saving and can increase the value of a home security system. Control and monitoring of smart home security can be done remotely using an Android device without even touching the apparatus. It certainly provides its benefits, especially for those with disabilities [1].

Smart home security systems are built by installing sensors and recording devices to monitor the condition of the house's security both in the event of fire and theft. Electronic gadgets and electrical equipment that is in the smart home can also be controlled remotely automatically, one of them with voice commands that allow users no need to touch the button again.

The smart home security system that has been developed is done with a face recognition system to open

and lock the door of the house. Of course, this system will be useful to maintain the security of the house from the side of avoiding someone who is not entitled to access the house through an existing door, thus avoiding theft. A face recognition system is done by installing a webcam camera to capture images of someone's face that will be compared following the given template [2].

The system for opening and locking smart home doors can also be done with fingerprint recognition for anyone who will open the door. Although the use of fingerprint recognition for security systems is not limited to home security, this system is an alternative security system by recognizing someone's fingerprint-based on its compatibility with the existing template. This system is built with a fingerprint scanner that will allow someone to lock or open the door automatically which replaces the conventional door locking system [3].

The security of smart homes can also be monitored using surveillance cameras that watch the movements of an unwanted body. Motion sensors are installed to detect the movements of a person that will activate a camera to record

objects that appear [4] [5]. The recorded data will provide information about the existence of an object. The camera performance will only be active if there is a movement of an object being staked, in other words, if no object is detected then the camera will not do the object recording.

Smart home security in the form of detection of fire is done by installing sensors and cameras that will detect the presence of fire while sending data information to its users. The sensor that is installed will detect the presence of fire and the camera will record the object that occurred and at the same time send a message about the fire. This system will also activate the alarm and the motor when there is a fire [6].

Smart home automation systems will also allow users to be able to control existing electrical and electronic equipment. Control of this smart home is done by utilizing several technologies such as voice recognition, gesture control, eye retinal motion, and others [7]. The voice commands given will be used to turn on and turn off the equipment automatically. Voice command recognition is built using a special hardware module that is integrated with the Arduino microcontroller device to process commands and controls.

A home security system for smart homes that supports parents and people with disabilities was built with the introduction of voice commands to control electronic equipment and improve the home security system. This system was built to be able to recognize users through voice commands to control electronic equipment remotely using an android application to read voice commands. This system is also equipped with an ultrasonic sensor that will detect the presence of a moving object and send messages to its users [8].

This study aims to develop a smart home security system in the form of monitoring the occurrence of fires and theft as well as controlling electronic devices using voice commands that will benefit parents and people with disabilities. Voice command recognition uses a special Google Assistant device found on the Android smartphone application to replace and turn on the lights. Another system that is built is the detection of object movements using sensors that are installed to activate the camera that records the detected objects whose results are stored on a MicroSD card. The existence of fire is detected using a temperature and humidity sensor whose results are displayed on the LCD and sent to an IoT application in the form of Thingseak so that it can be monitored for an increase in temperature and humidity.

2. Literature Review

The basic idea of the system developed in this study is a smart home security that will be able to monitor the condition of home security from fire and theft, and can control the electronic devices in the smart home by using IoT-based remote voice commands. Previous research has been done to develop systems related to smart home and security, including research conducted by Saumya who

conducted research on the Internet of Things for surveillance and fire alarms [9]. This research resulted in an integrated fire monitoring and alarm system with IoT which was implemented for industry and home. Temperature and gas sensors will detect the presence of fire and send the results using a GSM network. The smart security system built in this study is still limited to fires. Other research has been carried out to develop a forest fire detection and monitoring system using Zigbee and GPRS [10]. Sensors used to detect fires are temperature and humidity sensors. The network is built in the form of long distance communication via Zigbee and long distance communication via the GPRS network. The network used on this system is GPRS and has not used IoT.

Utilization of speech recognition technology is also used to support the development of smart home systems by exercising control of home appliances using voice commands. Chan Zen has conducted research to create a smart home system that is controlled by voice commands [11]. The system is built by utilizing the Telegram application, the Alexa Voice Service, and the Amazon Developer Console which is integrated with equipment control and home security. Home security referred to in this system is the existence of voice control can ensure to lock and open the door automatically. Control of household appliances can also be done by voice commands with iOS [12]. The voice command given will be matched with the voice template given, and if appropriate the voice command will be used to control the electronic device.

Sradha has conducted research for home security monitoring systems and home appliance automation using IoT [13]. Home security is done by monitoring using PIR sensors, gas sensors, temperature and humidity sensors. Added a camera to record the captured object. The system will give a signal if something is not desired and also with an alarm that sounds. Equipment automation is done remotely with the buttons provided on the Android application device. The developed system is not yet possible to automate devices with voice commands.

3. Method

This research focuses on developing smart home automation and security systems. The smart home security system is focused on monitoring fire and theft by installing sensors and cameras connected to the Arduino microcontroller, data storage unit, LCD viewer and IoT ESP8266 device. The sensors used in include DHT22 temperature and humidity sensors, magnetic door switch sensors, HC SR501 PIR motion sensors. The camera used to capture images is the VC0706 serial camera that is connected to the MicroSD card storage module. Data processing in the form of Arduino Mega 2560 microcontroller module which is connected to the input and output system.

Smart home automation in this study focuses on the use of voice recognition technology by giving voice commands. The difference between voice recognition

and speech recognition lies in the subject that it analyzes. Speech recognition emphasizes the analysis of spoken text, while speech recognition requires analysis of the voice of the speaker and the spoken text becomes the second analysis to be used together [7]. Voice commands are recognized by using an Android smartphone device that is installed by Google Assistant which is then integrated with the IFTTT application, Adafruit.io and the IoT NodeMCU + ESP8266 device.

The system is designed and implemented into three parts namely the hardware part, the software part, and the application part. The hardware part consists of the DHT22 temperature and humidity sensor module, the HC SR501 PIR sensor module, the magnetic door switch, the Arduino Mega 2560 module, the ESP8266 module, the NodeMCU

+ ESP8266 module, the 16x2 + I2C LCD module, the VC0706 serial camera module, the relay module, the SD module card, mini buzzer, and power supply module. For software in the form of Arduino Integrated Development Environment (Arduino IDE). The application part consists of the IFTTT application, the Adafruit.io application, and the Thingspeak application.

a. Hardware section

The hardware part of the system consists of modules and components used for the design and implementation of a smart home security system with remote control based on voice commands and the internet of things. The overall system hardware design is shown in the block diagram in Figure 1.

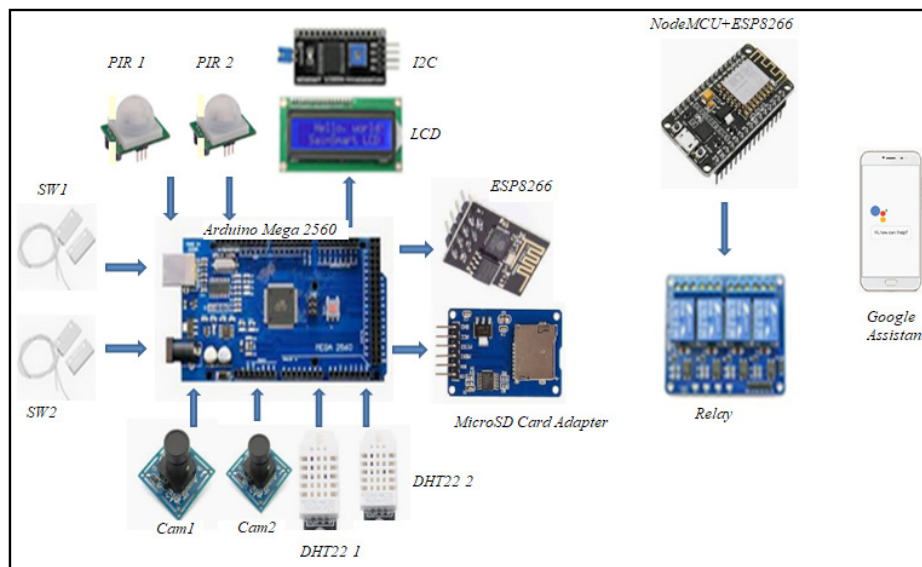


Figure 1. Overall Design of the System Hardware Section

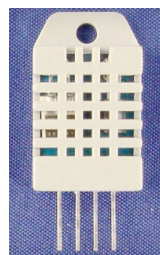


Figure 2. DHT22 sensor [14]

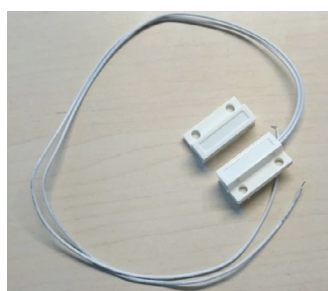


Figure 3. Magnetic Door Switch [15]

The system hardware part generally consists of three parts, namely the input part, the process part, and the output part. The input part consists of sensors mounted on the system, the process part is an Arduino microcontroller and the IoT module unit, and the output part is a viewer and relay.

The hardware input part of the smart home security system

Smart home security systems have hardware that acts as a temperature and humidity sensor, motion sensor, and image capture sensor. DHT22 is a module used for temperature and humidity sensors of smart home security systems. Two DHT22 are used which have the same function but are only placed in different locations. Based on the specifications, DHT22 uses a 5VDC voltage, has a digital output signal, can measure temperatures from -40 to 80-oC and humidity from 0 to 100% RH [14]. Both DHT22 one and two are directly connected to the Arduino 2560 data processor. The physical form of the DHT22 sensor is shown in Figure 2.

The motion sensors used in this system are magnetic door switches and PIR motion sensors. The magnetic door switch functions to connect and open the electricity when the door is closed and opened. This switch consists of two magnets that can be passed by voltages up to 100V at 500mA. The switch will close if the two magnets are attached and the switch will open if the two magnets are separated [15]. Physically the shape of the magnetic door switch looks like in Figure 3.

PIR motion sensor is used to detect the motion of an object by measuring the level of infrared radiation produced [16]. Humans who have body temperature will emit radiation in the form of infrared waves that cannot be captured by the eye, but can be captured by electronic devices namely PIR sensors. This principle used in smart home systems is to detect the presence of strangers who enter the house. One of the most widely used PIR sensors is the HC-SR501 PIR [17]. Physically the shape of the HC-SR501 PIR looks like in Figure 4.

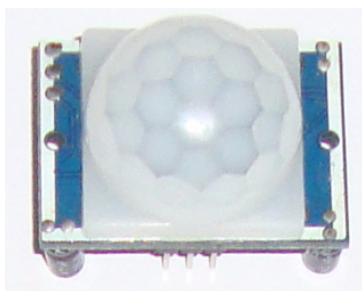


Figure 4. HC-SR501 PIR sensor

A serial camera is installed to capture the object after it has been detected by the sensor and then the results will be saved in Micro SD. The serial camera used is VC0706 which has the ability to image acquisition and processing applications. Communication interface for photos and

data is done with UART on the serial port. This camera is specifically designed for surveillance so that the resolution is not high only to a maximum of 640x480 pixels and sensitive to infrared light [18]. The VC0706 camera is seen in Figure 5.

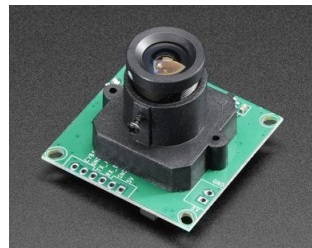


Figure 5. VC0706 Serial Camera [18]

The hardware process part of the smart home security system

The processing part of this system uses two modules, Arduino Mega 2560 microcontroller and NodeMCU + ESP8266. Arduino Mega 2560 is used to process data from sensors and the results will be displayed on the LCD, Micro SD Card, and ESP8266 for communication with IoT. NodeMCU + ESP8266 is used to connect IoT in the form of data from voice commands to the relay module to turn lights on and off.

Arduino Mega 2560 is a microcontroller module based on ATmega 2560 which has 54 digital I / O pins, of which 15 pins can be used as PWM outputs, 16 pins can be used as analog inputs, and has 4 UART for serial communication. This Arduino is also supported by the presence of a 16 MHz crystal oscillator, USB connection, power supply jack, ICSP header, and reset button [19]. The arrangement of pins on the Arduino Mega 2560 is shown in Figure 6.

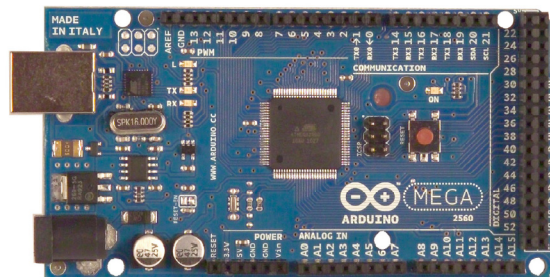


Figure 6. Arrangement of pins on Arduino Mega 2560 [19]

The connections of each pin on the Arduino Mega 2560 with other hardware parts in this system are in accordance with Table 1.

NodeMCU + ESP8266 is a microcontroller that is equipped with a WiFi module ESP8266 so that it can communicate with the internet. NodeMCU has several features including GPIO, I2C, UART, ADC, PWM, and WiFi. NodeMCU also has a memory capacity of 4 MB and although it is small, it is sufficient for a small system implementation [20]. The arrangement of pins on NodeMCU + ESP8266 is shown in Figure 7.

Table 1. Arduino Mega 2560 connection with Hardware Input / Output System

Numb.	Pin Arduino Mega 2560	Pin Hardware Input/Output
1.	D21 (SCL)	SCL (I2C LCD)
2.	D22 (SDA)	SDA (I2C LCD)
3.	D19 (RX1)	TX (ESP8266)
4.	D18 (TX1)	RX (ESP8266)
5.	D50 (Miso)	Miso (MicroSD Card)
6.	D51 (Mosi)	Mosi (MicroSD Card)
7.	D52 (SCK)	SCK (MicroSD Card)
8.	D53	CS (MicroSD Card)
9.	D17 (RX2)	TX (Cam 1)
10.	D16 (TX2)	RX (Cam 1)
11.	D15 (RX3)	TX (Cam 2)
12.	D14 (TX3)	RX (Cam 2)
13.	D2	Dout (PIR 1)
14.	D3	Dout (PIR 2)
15.	D4	Dout (Door switch 1)
16.	D5	Dout (Door switch 2)
17.	D6	Dout (DHT22 1)
grl	D7	Dout (DHT22 2)

**Figure 7. Composition of pins on NodeMCU + ESP8266 [20]****Table 2. NodeMCU + ESP8266 Pin Connection with Relay**

Numb.	Pin NodeMCU+ESP8266	Pin Relay 2 Channel
1.	D3	IN1 (Relay 1)
2.	D2	IN2 (Relay 1)
3.	D1	IN1 (Relay 2)

The connection of each pin on NodeMCU + ESP8266 with other hardware parts on this system is in accordance with Table 2.

The hardware output section of the smart home security system

The hardware output part of this system is used to display and store data from sensors installed on the system. The hardware used as the output of the system is I2C 16x2 LCD, SD Card Module, and Relay.

LCD as a data viewer that is widely used in microcontroller programming has many character sizes provided as needed. Generally LCDs have data pins, power supply controls and display contrast regulators [21].

One LCD that has a size of 16x2 (16 columns and 2 rows) is the M1632 LCD. This LCD hardware has 16 input pins, so it will require a lot of I / O pins when connected to the Arduino or NodeMCU data processing module. I2C is a solution to minimize the use of I / O pins on the LCD M1632 when it interfaces with the data processing module. One type of I2C is I2C LCM1602 which has 4 input pins and 16 output pins. If I2C is connected to a data processor it only requires 2 pins, namely SCL and SDA, while VCC and GND only need to be connected to the + 5V voltage source. I2C output just need to be connected with the LCD in accordance with the names of the pins listed. Figure 8 and Figure 9 are the 16x2 and I2C LCD displays.



Figure 8. 16x2 LCD [21]

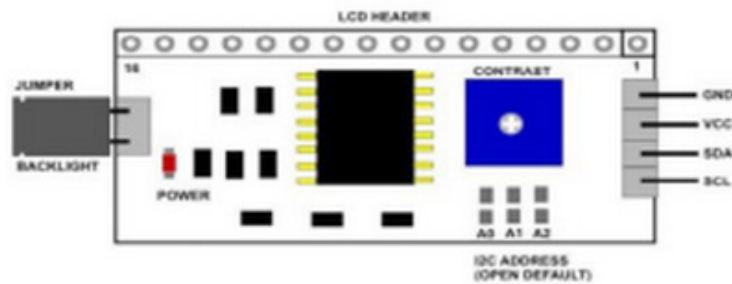


Figure 9. I2C Module [21]

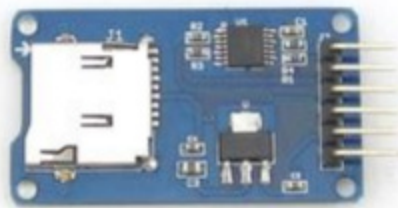


Figure 10. MicroSD Card Adapter Module [22]



Figure 11. 2 channel relay module [23]

MicroSD card adapter module or more easily called a microSD card module is a Micro SD card reader module, through the file system and SPI interface driver, MCU to complete the file system for reading and writing MicroSD cards [22]. This module is suitable for various applications that require data storage media, such as attendance systems, queuing systems, and other data logging application systems. Micro SD cards are memory cards that are generally sized 11 x 15mm, with various sizes of capacity used for data storage and reading data that is already in it. The physical form of the micro SD module is shown in Figure 10.

The relay functions as a switch that is controlled by electricity in this system to turn off and turn on the lights

based on voice commands. The system uses a 2 channel relay module with currents up to 10A at a voltage of 250VAC or 30VDC [23]. Because the lights controlled in this system are only three, there is one relay that is not used. The control pin for this relay is from the NoeMCU + ESP8266 module. The 2 channel relay module used looks like in Figure 11.

b. Software section

The software used in making the C ++ program is the Arduino IDE which is a freeware that can be downloaded for free through the official Arduino website. This software is used to write programs on Arduino Mega 2560 hardware and NodeMCU + ESP8266.

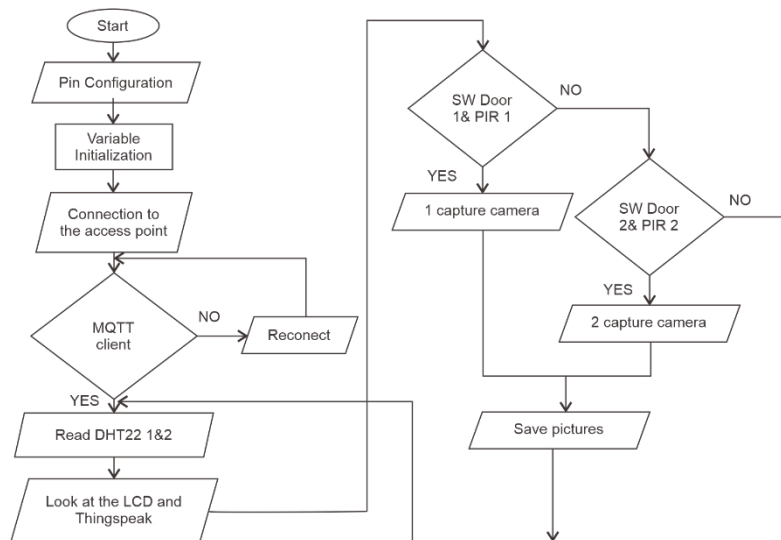


Figure 12. System flow chart for Arduino Mega 2560

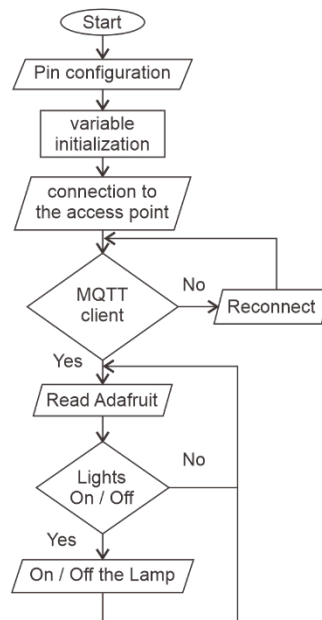


Figure 13. System flow diagram for NodeMCU + ESP8266

The flow chart for designing software on smart home security using voice commands and internet of things is divided into two parts, namely the flow chart on Arduino Mega 2560 and the flow diagram on NodeMCU + ESP8266. As for each system performance flow chart looks like in Figure 12 and Figure 13.

Software design begins by designing a program for Arduino Mega 2560 devices that is used to process data coming from door switch sensors, PIR, DHT22. Data from the DHT22 sensor will be displayed on the LCD and Thingspeak server via IoT ESP8266 which is also installed on the Arduino Mega 2560. The program is designed when there are objects that are simultaneously detected by the PIR sensor and the magnetic door switch will instruct the camera to capture images and store them on the MicroSD module card.

The next software design is the design of the program on the NODEMCU + ESP8266 device which is an IoT device that will function to switch ON / OFF the three lights using voice commands received through the Google Assistant device. MQTT connections on NodeMCU + ESP8266 will be connected to the Adafruit io application.

c. Application section

There are three applications used in this system, namely IFTTT, Adafruit.io, and Thingspeak. IFTTT (If This Than That) is an applet that can be filled with certain inputs with the desired output. Input here is a voice command connected to the Adafruit io device to turn on and turn off the lights. The voice command design written on IFTTT to turn on and turn off the lights is shown in Figure 14. While all the voice commands used in this

system to turn on the three lights are in accordance with Table 3.

The second application is Adafruit Io which is used for communication with IoT hardware which contains commands to turn off and turn on lights in the hardware

design. In this application, three switches are designed that can be controlled using voice commands connected to IFTTT. The design of the Adafruit.io application for controlling three relays is shown in Figure 15. Note that Relay 1 is not used in the system.

Figure 14. One of the Input and Output designs on IFTTT

Table 3. Design All Voice Commands on the IFTTT Application

Numb.	Voice Commands (Input)	Function (Output)
1.	<i>On Lamp One</i>	Light 1 - Turns on
2.	<i>Turn On Lamp One</i>	Light 1 - Turns on
3.	<i>Lamp One On</i>	Light 1 - Turns on
4.	<i>Off Lamp One</i>	Light 1 - Off
5.	<i>Turn Off Lamp One</i>	Light 1 - Off
6.	<i>Lamp One Off</i>	Light 1 - Off
7.	<i>On Lamp Two</i>	Light 2 - Turns on
8.	<i>Turn On Lamp Two</i>	Light 2 - Turns on
9.	<i>Lamp Two On</i>	Light 2 - Turns on
10.	<i>Off Lamp Two</i>	Light 2 - Off
11.	<i>Turn Off Lamp Two</i>	Light 2 - Off
12.	<i>Lamp Two Off</i>	Light 2 - Off
13.	<i>On Lamp Three</i>	Light 3 - Turns on
14.	<i>Turn On Lamp Three</i>	Light 3 - Turns on
15.	<i>Lamp Three On</i>	Light 3 - Turns on
16.	<i>Off Lamp Three</i>	Light 3 - Off
17.	<i>Turn Off Lamp Three</i>	Light 3 - Off
18.	<i>Lamp Three Off</i>	Light 3 - Off

The third application is Thingspeak in the form of a webserver that functions to display temperature and humidity data from two DHT22 sensors connected to

Arduino Mega 2560 and ESP8266. The design of the temperature and humidity display system in the system is shown in Figure 16.

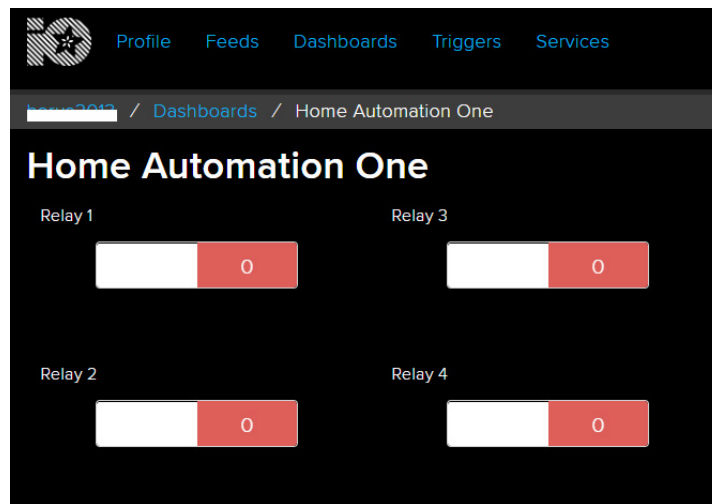


Figure 15. Design of Relay Control on the Adafruit.io Application

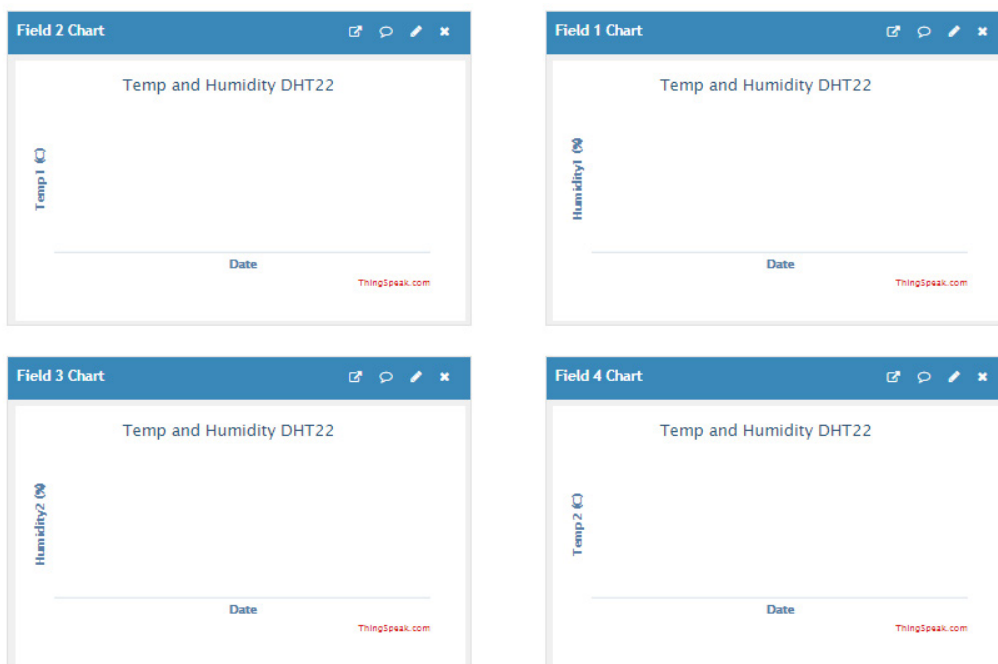


Figure 16. DHT22 Temperature and Humidity Viewer on Thingspeak

4. Result and Discussion

The results of the study were based on an evaluation of the performance of the system implemented in the form of a prototype miniature smart home security system and control of the automation of smart home devices using voice commands. Various experiments were carried out to test the system both from sensor performance, the object captured by the camera stored on a MicroSD card, the sensor display on the LCD and the IoT Thingspeak application and the connection of the IoT ESP8266 module to the server. The implementation of the whole system is shown in Figure 17.

Voice command experiments are carried out by giving different speaker voices (male and female) with different voice commands based on variations of the

speaker's mouth distance with a microphone that has an Android smartphone (Samsung J2 Prime) installed by Google Assistant. The experimental results are analyzed based on the responses generated by the resulting system performance. The voice command on Google Assistant starts with the initial command "Hi, Google" and after that is followed by the next voice command, for example the command to turn on light one, lamp two or lamp three.

The test is carried out to determine the system's functionality to be able to turn on and turn off each lamp based on the voice commands given by varying the distance between the speaker and the microphone on the smartphone. The voice commands tested follow the voice commands in Table 3. with two speaker voices (male and female) with a maximum microphone spacing of 50 cm with different volume. The test results will

be known whether the voice commands with different speaker voices and different distances make the system continue to work well to turn on and turn off the lights. Table 4 is an example of the test results for the "On Lamp One" voice command on lamp 1.

Table 4. shows that the voice commands given from both speaker 1 and speaker 2 with a maximum distance of 50 cm get a 90% success rate. This means

that the system is able to respond well to the voice commands given from each speaker with a maximum distance of 50 cm from the speaker with a microphone.

The same test is carried out for other voice commands in accordance with Table 3 and the results are obtained based on the level of success of the system to respond to the voice commands given by each speaker with a maximum distance of 50 cm as in Table 5.

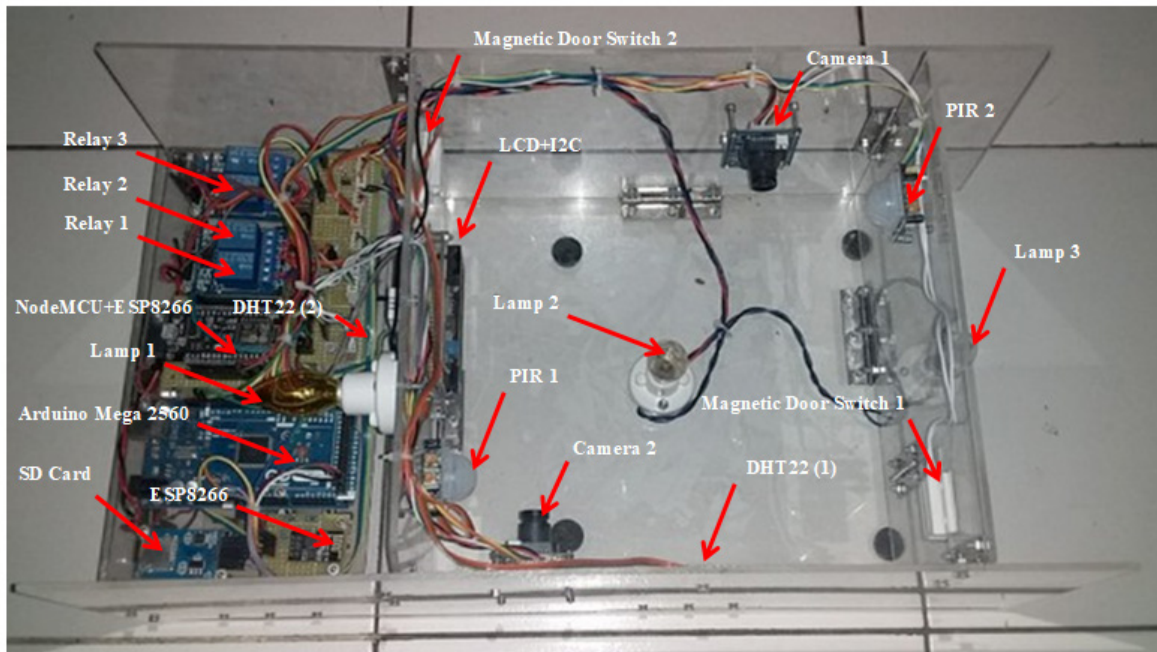


Figure 17. Prototype of a Miniature Smart Home Security System

Table 4. Test Results for Voice Commands for Turning on Lights 1

Voice Commands	Distance with Mic (cm)	Performance Results on Lamp 1	
		Speaker 1 (Male)	Speaker 2 (Female)
<i>"Hi Google, On Lamp One"</i>	10	On	On
	20	On	On
	30	On	On
	40	On	On
	50	On	Off (Not responding)

Table 5. Percentage of success of giving voice commands to the system

Voice Commands	% Success		Average %
	Speaker 1	Speaker 2	
<i>On Lamp One</i>	100	80	90
<i>Turn On Lamp One</i>	100	100	100
<i>Lamp One On</i>	80	80	80
<i>Off Lamp One</i>	100	80	90
<i>Turn Off Lamp One</i>	100	100	100
<i>Lamp One Off</i>	80	100	90
<i>On Lamp Two</i>	80	80	80
<i>Turn On Lamp Two</i>	100	100	100

<i>Lamp Two On</i>	80	80	80
<i>Off Lamp Two</i>	100	80	90
<i>Turn Off Lamp Two</i>	100	100	100
<i>Lamp Two Off</i>	80	60	70
<i>On Lamp Three</i>	100	80	90
<i>Turn On Lamp Three</i>	100	100	100
<i>Lamp Three On</i>	80	60	70
<i>Off Lamp Three</i>	100	80	90
<i>Turn Off Lamp Three</i>	100	80	90
<i>Lamp Three Off</i>	80	80	80
<i>Average % of Speakers</i>	92	84	88

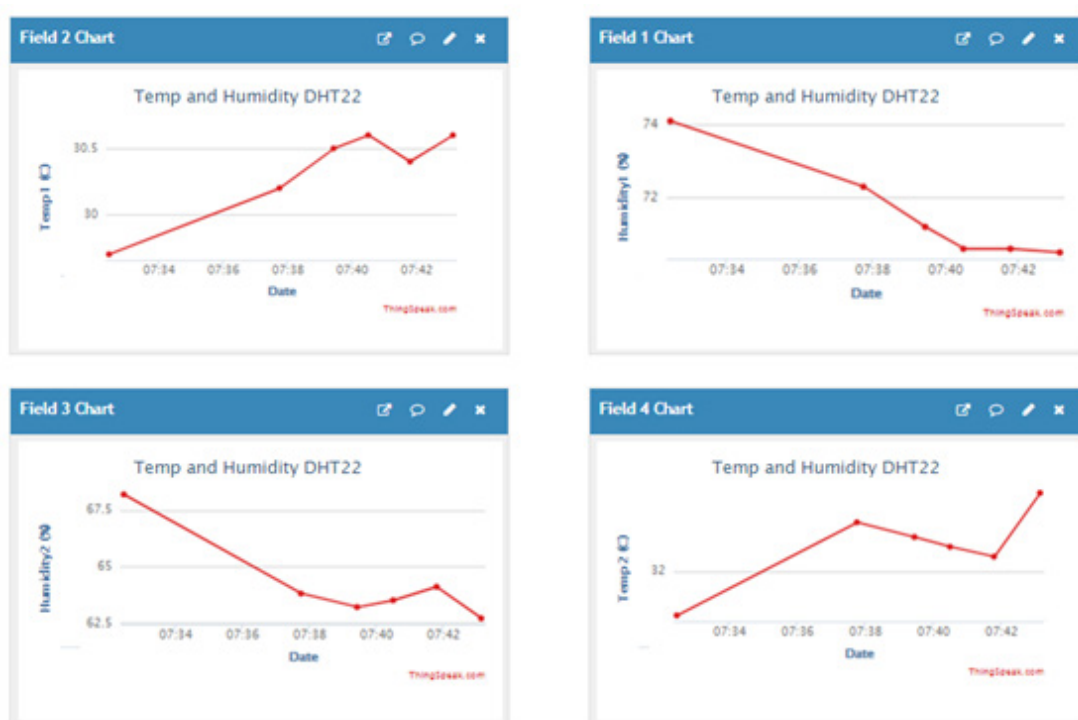


Figure 18. Temperature and Humidity Reading Results of Both DHT22 Sensors on Thingspeak

Based on Table 5, shows that the success rate of the system from speaker 1 is 92% and speaker 2 is 84% of the 18 voice commands spoken at a maximum distance of 50cm. The overall overall success of the system from testing voice commands is 88%, so the voice recognition system using Google Assistant which is implemented to turn off and turn on three lights can run very well.

The test results on the DHT22 sensor to measure the amount of temperature and humidity are done by observing the results of the temperature and humidity display in the Thingspeak application and also the results of the display directly on the LCD. The results of observations of temperature and humidity measurements displayed by Thingspeak from the two DHT22 sensors are shown in Figure 18.

In this study, the use of Thingspeak is only to observe the performance of the sensor to read the magnitude of the temperature and humidity, and does not give an indication of a fire. The temperature and humidity readings from the DHT22 sensor that appear on Thingspeak have shown that the system has worked to read data and display it online on the Thingspeak application.

The performance testing of the catches of the two VC0706 serial cameras is done by giving a trigger to the PIR sensor pair and the door switch. The camera will capture images if the door switch and PIR are active. The results of this object shooting will then be saved on the MicroSD card module. If one of the two sensors is inactive then the camera will not take an image and do not save the image. Table 6, shows the results of the test shots on camera 1 and camera 2.

Table 6. Test results for shooting images on the VC0706 serial camera



Numb.	SW1	PIR 1	SW2	PIR 2	Gambar Picture	
					Camera 1	Camera 2
1.	ON	ON	OFF	OFF		No picture
2.	ON	OFF	ON	ON	No picture	
3.	OFF	ON	ON	OFF	No picture	No picture
4.	OFF	OFF	OFF	ON	No picture	No picture

Table 6. shows that from the system testing for capturing images of objects carried out by the VC0706 serial camera will only run if both the magnetic door switch sensor and the PIR are active. if one of the two sensors is inactive then the camera will not shoot the image. The test results show that the system has worked following the desired workflow.

5. Conclusion

We have implemented the system design to carry out monitoring and control of smart home security using voice commands and IoT. System implementation consists of hardware, software, and applications that work side by side to measure temperature and humidity. Measurement results are monitored online through Thingspeak. The system can also control lights on and off using online voice commands and Google Assistant. Finally, the system can take pictures of moving objects and store them into a MicroSD card. Accuracy testing using voice command shows a success rate of 88%, which means that the system is very suitable for controlling devices in a smart home security system.

Further works are needed to enhance the performance of the system because it has not been able to transmit camera shots online or give a warning in the case of temperature rise that may indicate a fire. Such improvement may be created by adding a device to send alarm data in an image or text format through e-mail or short messages.

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Pesma Apps as Android-based Integrated Applications for Mahasantri Pesma KH Mas Mansur UMS

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Abstract-Pesantren Mahasiswa Internasional KH Mas Mansur (Pesma) has a shuttle facility for everyone who lives there. However, the use of the shuttle is not optimal because the ordering procedure still uses manual techniques. It contrasts with the rapid development of industry 4.0 and the mission of Pesma to get digitalization. This paper describes the effort to improve Pesma shuttle bookings by developing an application. The application is built upon the Android Studio 3.5.1 platform and uses Firebase real-time database. The development method implements the System Development Life Cycle (SDLC), Waterfall. The research results in an application called “Pesma Apps” that can be used by staff and mahasantri. Testing the Pesma apps, we obtained sufficiently good results where the black box testing proves that all functions work well. A usability testing using SUS with 30 respondents produces a good result at the level of 72.6, which suggests that the application is accepted.

Keywords: android studio, android, pesma apps, shuttle

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1. Introduction

The rapid changing of globalization nowadays makes the development of Information Technology growing very fast. It makes the use of mobile device increases, especially smartphones, which greatly encourages the effectiveness of an activity. Many people and institutions utilize the development of Information Technology, especially the use of smartphones in the form of android-based applications to facilitate work and daily activities[1]

The demands for the rapid development of information technology requires people to follow these developments. Especially in the education, commerce, transportation and health sectors. In fact, people nowadays want the ease of accessing things through smartphones that most people currently have. [2].

Pesantren Mahasiswa Internasional KH Mas Mansur (Pesma) Universitas Muhammadiyah Surakarta (UMS) is an institution owned by UMS and under supervision of Lembaga Pengembangan Pondok Al-Islam dan Kemuhammadiyah (LPPIK) UMS. An active student of UMS who live in Pesma is called Mahasantri. Mahasantri receives some facilities related to education (Language, Religion, and soft skill), sports, and transportation (Shuttle). Shuttle is an operational car that is owned by

Pesma. It can be utilized by directors, staff, employees, and students or Mahasantri. However, the use of shuttle is not optimal yet, because of the ordering procedure that still applies traditional methods. To begin with, mahasantri who wants to book/order the Shuttle is required to confirm to the driver that the unit is ready to use. The authors consider that the process is overcomplicated and is not relevant in the fast-paced era of today. Besides improving the quality of human resources, Pesma also has another mission, namely digitalization. This digitalization is a response of rapid development of industry 4.0 that the purpose is to achieve improvements regarding automation and operational efficiency, as well as effectiveness [3]. However, it can take place in Pesma via smartphones in which there are android-based applications. Therefore, the authors would like to conduct research on existing case studies at Pesma, especially related to Pesma Shuttle bookings.

The output of this research is named “Pesma Apps”. Pesma Apps is an integrated application for Mahasantri. However, the authors will examine a smaller scope which focuses on ordering Shuttle. The application is based on Android. The authors create this application using Android Studio and Java Programming. Android mobile OS provides a flexible environment for Android Mobile

Application Development as the developers can not only make use of Android Java Libraries, but it is also possible to employ normal Java IDEs[4] . However, android can enhance reliability, usability and other features of existing products[5]as we all know that the development of hardware for mobile device is getting better and the performance index is veryhigh than the actual requirements ofthe software configuration. Phone’s features are now more dependent on software or application. This paper describes development of Android mobile platform application. Development environment of Windows Mobile and Apple’s iPhone are very simplified for mobile applications. Mobile applications give users a quick and reliable user experience. Primary focus of this paper is on the Android architecture based on Linux version 2.6. It is Linux based an open-source mobile phone operating system. Basically Java programming language is used to develop android application. Android SDK provides set of application programming interfaces (APIs).

2. Method

The method that used in this research refers to the System Development Life Cycle (SDLC). System Development Life Cycle (SDLC) is a general methodology used to develop information systems. SDLC consists of several phases starting from the planning, analysis, design, implementation and maintenance phases of the system. This SDLC concept underlies various types of software development models to form a framework for planning and controlling information systems. SDLC models that are often used include Waterfall [6]. The authors, in compiling research, were using the SDLC Waterfall model[7]. The Waterfall model has a systematic approach starting from the sequence based on the system’s needs and then going to the stages of analysis, design, development, testing or verification and maintenance stages that were implemented in this research.

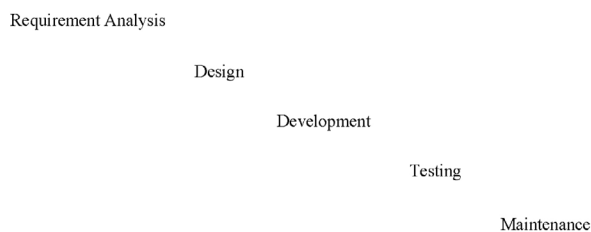


Figure 1. Scheme of Waterfall method

a. Requirement Analysis

The analysis of the equipment required to design the Pesma Apps application include:

- 1) Tools and Materials:
Tools and materials used for design according to the Table 1. Macbook Pro used for make programming code and Android smartphone with 5.0 minimum version used for build the application

Table 1. Hardware and Software Needs

Hardware	Software
Macbook Pro (Retina, 13-inch, Early 2013), Processor 2,6 GHz Intel Core i5, Memory 8 GB 1600 MHz DDR3 Graphics Intel HD Graphics 4000 1536 MB	Android Studio 3.5.1
Smartphone Android OS	Adobe XD
USB Cable	Java Programming

b. Design

Design is the initial stage to analyze the shape and design of the application to be created. This design includes a use case diagram that will illustrate the form of a series of interactions between users and activities that are performed in the system.

1) Use Case Diagram

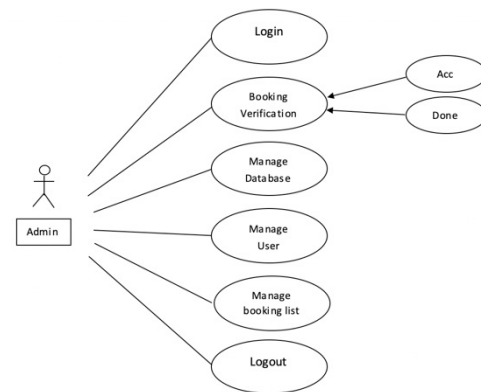


Figure 2. Use Case Admin

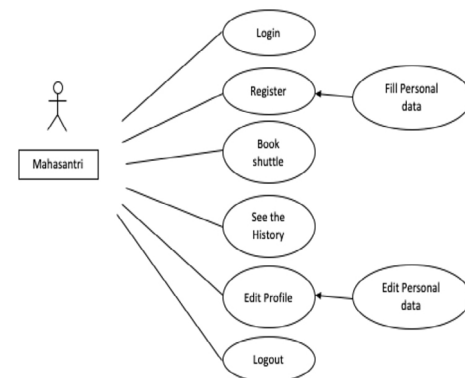


Figure 3. Use Case Mahasantri or User

Use case diagram is applied to model the behavior of information systems that will be created. Use case will describe an activity carried out by the actor. Actors are components involved in using the application. It provides the simplest representation to visualize how actors interact with the admin[8]. Figure 2 describes a use case in which admin can manage the database as

well as view the user that has been registered, booking list and booking verification. Based on Figure 3, it is observed that user can carry out registration, book shuttle, view the history, and edit user profile.

2) Activity Diagram

The UML Activity Diagram (AD) is an important diagram for modeling the dynamic aspects of a system[9]. Figure 4 describes admin's activity to control the application and to book shuttle.

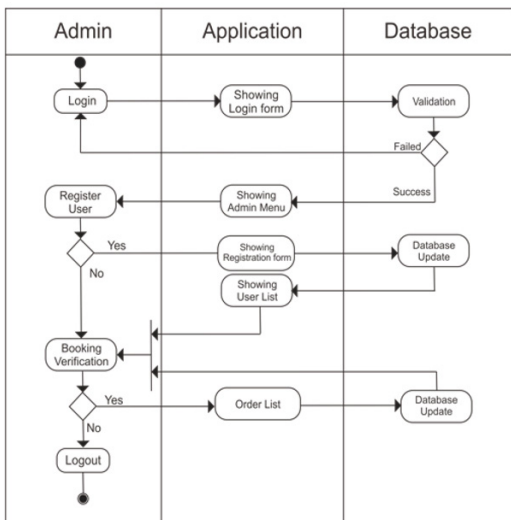


Figure 4. Admin Activity

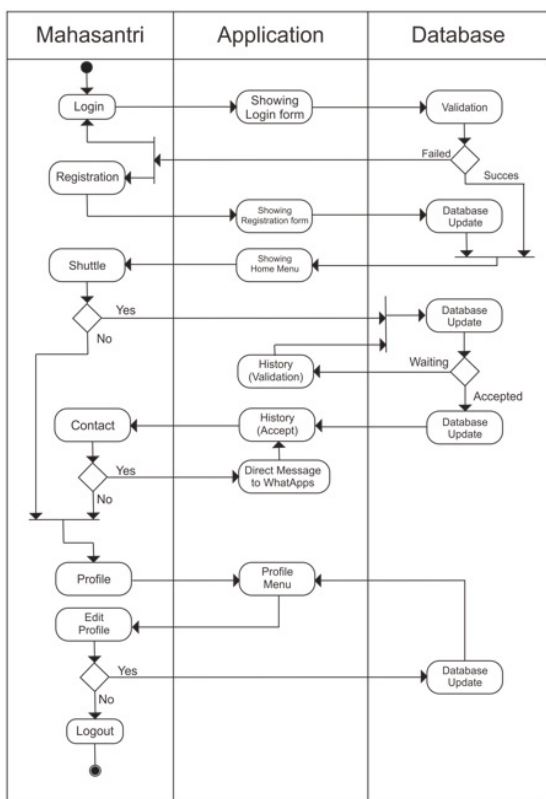


Figure 5. Mahasantri or User Activity

Figure 5 describes the activity that mahasantri can perform several activities such as Registration, Booking shuttle, and the several other commands.

c. Development/Implementation

The authors started to create applications using Java Programming language to translate the logic expected by the authors with Android Studio Application 3.5.1.

d. Testing

Testing is an important stage to test the feasibility of an application that has been made and make sure that the application is made in accordance with the initial planning in terms of interface and function. The authors used 2 methods to test applications that are made using the Blackbox testing and System Usability Scale (SUS) because of its versatility, ease of administration, and comparative value[10] data were collected on the usability of applications used on two kinds of mobile platforms—phones and tablets—across two general classes of operating systems, iOS and Android. Over 4 experiments, 3,575 users rated the usability of 10 applications that had been selected based on their popularity, as well as 5 additional applications that users had identified as using frequently. The average SUS rating for the top 10 apps across all platforms was 77.7, with a nearly 20-point spread (67.7–87.4).

Black Box testing is an application testing in terms of specific functional without testing the design and program code. The point of black box method only tests the functional application and also, it can evaluate valid and invalid entries from users(Putri, 2019). System Usability Scale (SUS), the authors used a questionnaire with a 5-point liker scale, consisting of SD (Strongly Disagree), D (Disagree), N (Neutral), A(Agree), SA (Strongly Agree).

e. Maintenance

The last phase is the stage of making an application in accordance with the design that has been made. The authors implemented the design using the help of the Android Studio 3.5.1 application using Java programming language and Firebase database because it combines many products with Google's infrastructure and developer-friendly environment[12]. Android Firebase API needed to gain the access to database[13]. The minimum SDK is Android 5.0 version.

3. Result and Discussion

a. Application Display Results

1) Introduction to The Initial Menu

The initial menu of the application is the user sign-in display, the option to the admin page, and the button for registration – displayed in Figure 6.

User Sign-in menu Figure 6, appears after splash screen, when the application opened. Users are required to enter the Student Number (NIM) or

Student Number that has been registered. If the student is not registered yet, the student is required to choose the option register, as shown in figure 7.

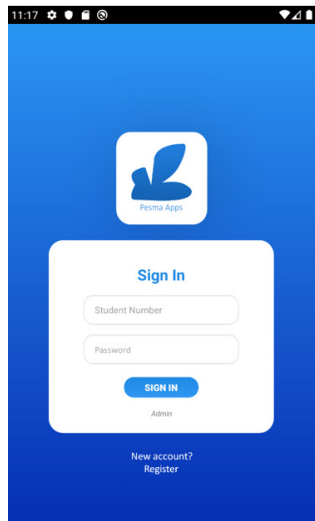


Figure 6. Sign in User

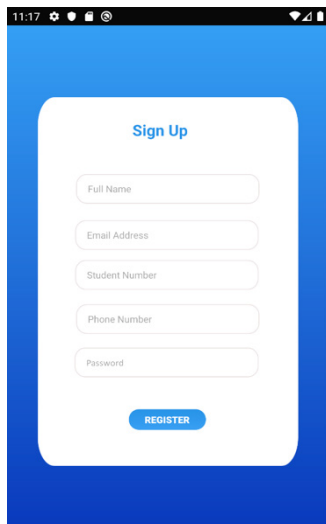


Figure 7. Register User

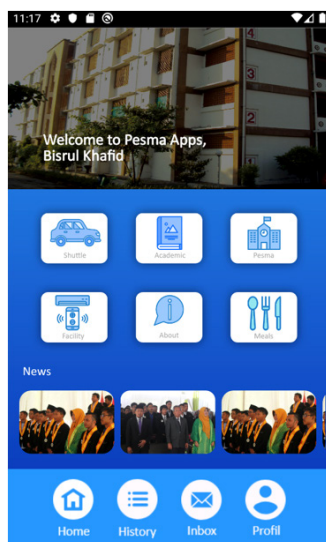


Figure 8. Home

After the registration is conducted successfully. The home page will be displayed, as shown in Figure 8.

The home menu shown in Figure 8, displays the main menus that can be accessed by the user including Shuttle, Academic, Pesma, Facility, About, and Meals. This research focuses on Shuttle menu that displayed in Figure 9.

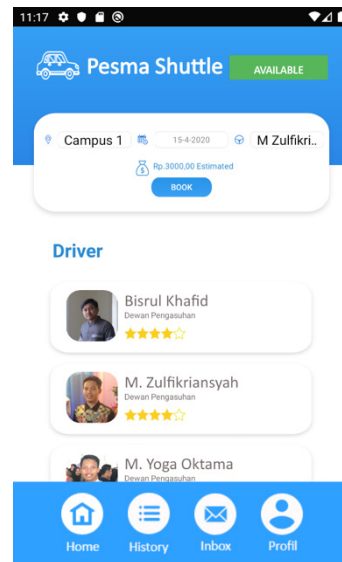


Figure 9. Shuttle Menu

The application provides a function for booking a shuttle. Users are required to choose the desired destination according to the destination list that is available in the application. After selecting a destination, the user chooses the day of the shuttle booking and also picked the available driver. The user presses the book button for the ordering process after deciding the destination selection process, time, and driver. The history menu displays the history of the user transaction – shown in figure 10

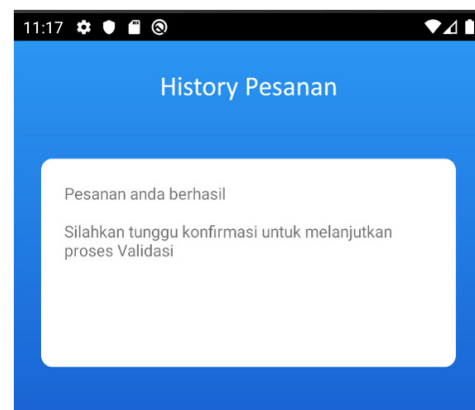


Figure 10. History

- 2) Admin Menu
Admin menu will be displayed after the admin successfully signs in process. The display of the admin menu is shown in Figure 11.

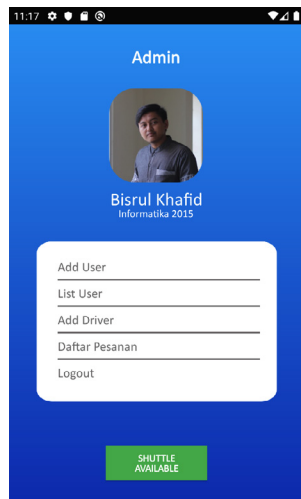


Figure 11. Admin Menu

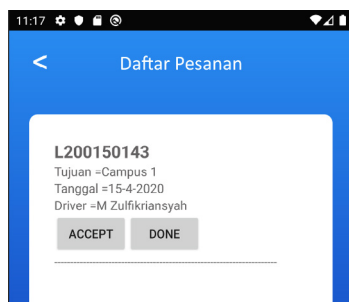


Figure 12. Order List

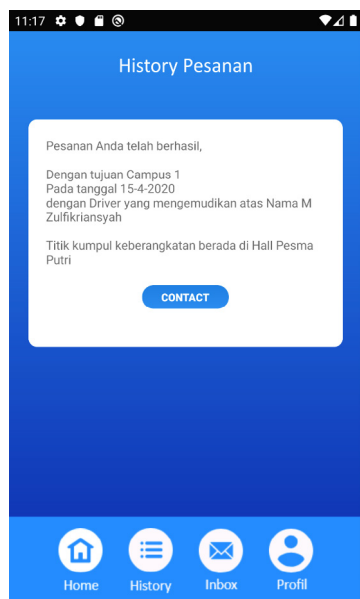


Figure 13. History after Approval

There are several features that can be accessed by the admin, such as add user, user list, order list, logout – which can be seen in Figure 11.

The main feature that connects to shuttle booking is shown in Figure 12. It displays a list of incoming orders for being processed by the admin. Also, accept function, which is the approval process for incoming

orders. Hence, the user can view the transaction in the history menu after the approval process from the admin.

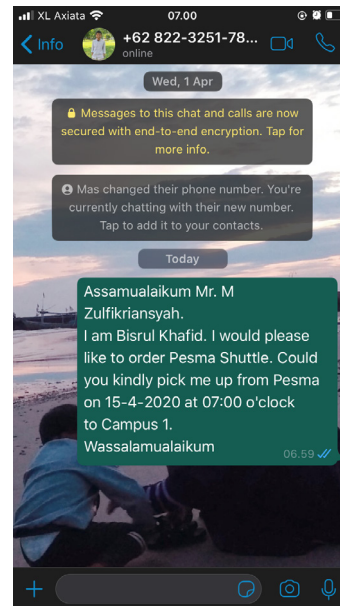


Figure 14. WhatsApp Message

After approval process from the admin, the user is able to view the history after approval, as displayed in Figure 13.

The user can carry out further transactions to the driver by clicking contact button. Then, the display will be directed to WhatsApp or the driver number. It is displayed in Figure 14. The default message from the user to the driver to order the Shuttle.

b. Black Box Test

The authors employed black box testing to test the application functionally. The purpose of this black box testing method is to find the malfunctions in the program[14]

c. Usability Test

The usability test used in this study uses the System Usability Scale (SUS) method with 30 respondents from Pesma K.H. Mas Mansur to evaluate usability of Pesma Apps.

The System Usability Scale (SUS) is conducted using a questionnaire that can be used to measure computer system usability according to the user's subjective perspective[15] menunjukkan perlu dilakukannya pengujian usability. Pengujian usability dijalankan untuk mengukur aspek-aspek usability yaitu: efektivitas, efisiensi, dan kepuasan pengguna. Penelitian ini menggunakan kuesioner System Usability Scale (SUS). The question provided, along with the scale, is informed in Table 3. The result of SUS calculation is shown in Table 4. The result is then converted into statistics – informed in Figure 15.

Table 2. Black Box Testing

No.	Component Tested	Testing	Input	Output	Result
1	Sign In Menu	Form of user sign in and admin sign in	Student Number / username and Password input	Successfully sign in with NIM / username and password that already registered in the database	Valid
2	Sign Up Menu	Form of user sign up	Personal data input	Successfully register using student number as Mahasantri Pesma	Valid
3	Shuttle Menu	Destination drop down	Choosing a destination	Successfully choose the destination and show the estimated cost	Valid
		Date drop down	Choosing a booking date	Successfully choose the booking date	Valid
		Driver drop down	Choosing a driver	Successfully determine the driver	Valid
4	History Menu	Book button	Clicking the button for booking	Booking process successful	Valid
		Contact button	Clicking the button for contacting the driver	Successfully open WhatsApp and directly contact to the driver's number	Valid
5	Edit Profile	Form of profile edit	Changing the personal data	Successfully change the personal data	Valid
6	Admin Menu	User list	Clicking User List menu	Showing the registered user	Valid
		Order list	Controlling the booking list	Showing the history menu	Valid

Table 3. Table of Information Code and Scale

Information Code			
P1	I think that I would like to use this system frequently	1	Strongly Disagree
P2	I found the system unnecessary complex	2	Disagree
P3	I thought the system easy to use	3	Neutral
P4	I think that I would need the support of a technical person to be able to use this system	4	Agree
P5	I found the various functions in this system were well integrated	5	Strongly Agree
P6	I thought there was too much inconsistency in this system		
P7	I would imagine that most people would learn to use this system very quickly		
P8	I found the system very cumbersome to use		
P9	I felt very confident using this system		
P10	I needed to learn a lot of things before I could get going with this system		

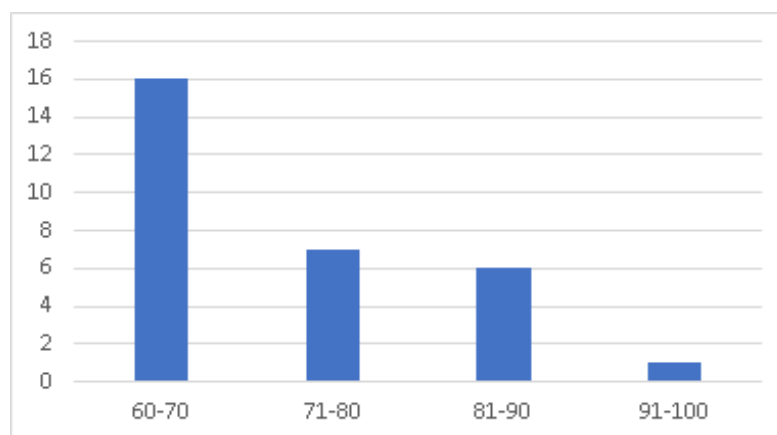


Figure 15. Graphic of SUS Score

Figure 15 describes the graphic score of SUS Usability test. There are 30 respondents giving scores in 60-70 range, 6 respondents giving scores in 71-80 range, 4 respondents giving scores in 81-90 range, and 1 respondent giving scores in 91-100 range. The complete result of SUS score is informed in Table 4.

Table 4. Result of SUS Usability Testing

No Respondent	Calculating										Result	SUS Score (Result x 2,5)
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10		
1	3	4	4	3	3	4	4	4	4	2	35	87,5
2	3	3	3	3	3	3	3	3	3	3	30	75
3	3	3	3	1	3	3	3	3	2	2	26	65
4	2	3	3	4	3	2	4	3	4	3	31	77,5
5	3	2	3	1	3	3	3	3	3	3	27	67,5
6	3	2	2	3	2	2	3	3	3	2	25	62,5
7	2	3	3	3	1	3	3	3	3	3	27	67,5
8	3	3	3	2	3	3	3	3	3	2	28	70
9	3	3	3	3	4	3	4	4	4	4	35	87,5
10	3	3	3	3	2	3	3	2	3	2	27	67,5
11	4	3	3	3	4	4	3	4	4	3	35	87,5
12	2	3	2	3	2	3	2	3	3	3	26	65
13	1	2	2	4	1	2	3	3	3	3	24	60
14	3	3	4	4	3	4	4	3	3	3	34	85
15	3	3	3	3	1	3	3	1	3	3	26	65
16	2	2	3	3	1	2	3	2	3	3	24	60
17	3	3	3	2	3	3	3	3	3	2	28	70
18	4	2	4	3	2	3	3	3	3	3	30	75
19	3	2	3	2	2	2	3	2	3	2	24	60
20	2	3	3	3	2	3	3	3	2	3	27	67,5
21	2	2	3	3	2	3	3	3	3	3	27	67,5
22	4	3	3	1	3	3	4	3	3	3	30	75
23	3	3	3	3	2	2	2	3	2	1	24	60
24	4	0	4	0	4	3	4	4	4	0	27	67,5
25	3	4	4	4	4	4	4	4	4	4	39	97,5
26	4	3	3	3	4	3	4	3	4	3	34	85
27	3	3	3	3	3	3	3	3	3	3	30	75
28	3	3	3	3	1	3	3	3	4	3	29	72,5
29	4	3	3	3	3	3	4	3	4	3	33	82,5
30	3	3	3	3	1	3	3	3	4	3	29	72,5
SUS Result												2177,5

The results of the SUS usability test calculation shown in Table 4, produce a total SUS score of 2535. The average value of the total SUS score earned from Equation (1).

$$\text{Average Score} = \frac{\sum_{i=1}^n \bar{x}_i}{N}$$

\bar{x}_i = Total score SUS

N = Total respondent

$$\text{The Average Score of SUS} = \frac{2177,5}{30} = 72,5833333 \quad (2)$$

The Average score of SUS is 72,583333 - earned from equation (1), thus concluded that Pesma Apps shows Good results and Acceptable, based on SUS score ranking taken from [16] with research about SUS Usability testing that can be observed in Figure 10.

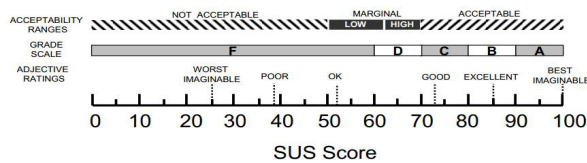


Figure 16. SUS Score Ranking

4. Conclusion

Based on the experiment, it is concluded that the application created from this research is ready to use. The name of the application is "Pesma Apps". Pesma Apps is made to facilitate students in ordering Pesma shuttle. This application provides the information regarding shuttle that can be ordered. It can also show the available routes that can be ordered by mahasantri – along with the estimated costs that must be paid by mahasantri.

The black box evaluation the Pesma Apps produces good results. The functions of the application results in valid results meaning the whole process of the application works well. The usability testing using SUS results in a good score of 72.6. Therefore, it can be stated that the application is acceptable and it can be declared that this application is well-conducted and this research can be further developed to make it better, for example about database management and academic learning system.

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Customer Satisfaction Analysis Based On SERVQUAL Method to Determine Service Level of Academic Information Systems on Higher Education

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Abstract-Higher education institutions such as universities or institutes that create graduate students with high qualifications must be able to provide the best services to their stakeholders. One kind of higher education service is academic information system services. The service quality level of the academic information system in a university can be decided by measuring the level of users' perception and the level of users' expectations that can be fulfilled. As an organization that offers academic information system services, the university must be able to measure the level of academic information system services as an approach to ensure the quality of services. This study aims to determine the level of customer satisfaction index in terms of service of higher education academic information systems using the service quality method. The service quality method is used to identify academic information system services that are analyzed based on the service quality dimensions. The results show that the value of the customer satisfaction index is 77.37% which refers to the satisfied category.

Keywords: customer satisfaction index; service quality; weighted gap score; academic information system; quality improvement

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1. Introduction

Higher education is an organization or institution that educates students and produces graduates with high ability and competence. As an institution that produces graduates with high qualifications, higher education such as the university should be able to properly manage the services available so that the available services can be delivered maximally to its stakeholders.

The users of university service are students, lecturers, and university employees. The biggest portion of service users is students. Therefore, a significant amount of effort is needed to improve the value of education services continuously by focusing on the interests of increasing service user satisfaction. Various types of higher education services include academic information system services, library services, English services, sports facilities services, health services, and others need an evaluation to ensure the quality of such services. A university which is an organization that offers various services should be evaluated in terms of service level. As mentioned before, students become the biggest users in experiencing a higher education service. Student satisfaction is often used to

assess the quality of education in a university. Therefore, the quality of education can be determined by meeting the needs and expectations of students.

To understand the quality of services, institutions require ways or methods to measure the provided service so that it can be identified whether the service level is good or not. Various concepts and models have been developed to measure user satisfaction. According to [1], Servqual is a superior method in analyzing a service perceived by users toward the difference of their perception and their expectation of what they feel about a product or a service. Servqual tests five dimensions of service quality namely tangible, responsiveness, assurance, empathy, and reliability. Each dimension is a measure of service quality for both perceptions and expectations. It is further stated in [2], [3] that the use of Servqual can be applied to understand the level of the gap that exists between perceptions and expectations among users in the banking service quality content. In the hospitality sector, [4] and [5] state that Servqual can be used to measure the quality of hotel management on the perceptions and expectations of customers. Obtaining the gaps information is beneficial for quality improvements of the hotel management.

Moreover, Servqual can also be used in transportation services [6], fitness services [7], online service [8], [9], and health services [10]. Even though the Servqual method has been used in various fields, the use of the in Higher Education such as universities to evaluate provided services is still low. Authors in [11], [12] used Servqual to find out how to calculate the quality of class services by viewing students as customers and having broad implications for stakeholders in the delivery of higher education. Authors in [13] stated that the use of Servqual can analyze the perception gap between students and staff on the quality of educational services.

This research focuses on the Academic Information System (SIKADU) service that is available at the State University of Surabaya. The research problem is how to measure the level of satisfaction of the users of academic information system service at a State University in Surabaya. Wherein these levels of user satisfaction of academic information system services have not been yet measured properly. Service improvements are only based on suggestions and complaints boxes from users so that service improvements have not been well planned.

This study used Servqual to determine the Customer Satisfaction Index (CSI) by analyzing each dimension of service quality in the academic information system. This study also developed a questionnaire instrument in accessing the five dimensions of Servqual. The questionnaire instrument is developed using 7 Likert scales in its measurement. The purpose of this study is to determine the level of CSI in the academic information system service of a State University of Surabaya using the Servqual method. The CSI results can then be used as a basis for implementing the quality improvement of the academic information system at the State University of Surabaya.

2. Literature Review

a. Service Quality

Authors in [14] defined service quality as follows: service is as perceived by the user toward service or product, while perceived quality is a comparison between user perception and expectation on a service or a product. User expectations are the services expected, arising from a need. Whereas, perception is how customers view and assess the provided services whether it is appropriate or not. Therefore, the interpretation of customer needs is very crucial for a service provider organization. This is if the performance of an organization excels in service, it can strengthen competitiveness and establish relationships with customers, consolidate brands, and communicate with markets. Servqual is a method or way to evaluate service quality in an organization and can be used to measure the level of user satisfaction with the Servqual dimensions.

Servqual has been widely applied to improve the quality of an organization. Authors in [15], [16] applied Servqual dimension in the food business to measure the

satisfaction of customers. In the health sector, [10] use Servqual to evaluate patient fulfillment with the quality of hospital health services. The results of his research can show which Servqual attributes have a high level of user satisfaction and which Servqual attributes have a low level of user satisfaction. In the banking sector, [17] conducted a study of the relationship between Servqual and user satisfaction at banks. The results of his research disclosed that the multidimensional Servqual scale correlates positively and significantly with the unidimensional customer satisfaction scale. In the field of aviation, research conducted by [18] identified Servqual using the framework of Servqual with several modifications. Furthermore, Servqual is used as an antecedent to measure customer satisfaction, a condition that can generate loyalty towards an airline brand. From the development of Servqual attributes, an inquiry of the relationship between Servqual and user satisfaction on airlines can be investigated.

b. Customer Satisfaction Index (CSI)

Referring to [19] the CSI is a way to calculate the level of overall user satisfaction by looking at the level of importance of each product and/or service attribute. The CSI is an applied index to calculate the level of overall user satisfaction by considering the level of importance of each attribute through measurement [20]. In this research, the computation of CSI can be calculated through the following steps [21]:

Step 1: Calculate the Mean Importance Score (MIS) of each attribute

$$MIS = \frac{\sum_{i=1}^n Y_i}{n} \quad (1)$$

Where :

n = total respondents

Y_i = the expectation value of i-th attribute

Step 2: Calculate Weight Factors (WF) per attribute. Furthermore, this WF is a MIS percentage value each attribute to the total MIS of all attributes.

Step 3: Calculate the Mean Satisfaction Score (MSS) of each attribute using equation (2).

$$MSS = \frac{\sum_{i=1}^n X_i}{n} \quad (2)$$

Where:

n = total respondents

X_i = the expectation value of i-th attribute

Step 4: Calculate the Weight Score (WS_i) in equation (3) for each attribute. WS_i is a multiplication between WF_i and MSS_i, so that

$$WS_i = WF_i \times MSS_i \quad (3)$$

Where: i = the i-th attribute

Step 5: Calculate the Customer Satisfaction Index using equation (4).

$$CSI = \frac{\sum_{i=1}^p WS_i}{K} \times 100\% \quad (4)$$

Figure 1. The display of Academic Information Systems

3. Method

The questionnaire instrument was developed based on the Servqual method conducted by [22] which refers to the dimensions of Servqual. In filling out the questionnaire, Likert scale with a scale of 7 is used. The aim of using the scale is to promote respondents to provide an assessment more precise to their preferences. Table 1 shows the results of the developed questionnaire.

Table 1. The Questionnaire Instrument

Dimension	No	Indicator
Tangible	1	The SIAKADU display has features that are easy to understand
	2	The SIAKADU system can be accessed anywhere and anytime
	3	The SIAKADU system has the same features on the mobile and web versions
Reliability	4	The SIAKADU system has no bugs (errors) when accessed
	5	The SIAKADU has a real-time information system
	6	The SIAKADU provides valid information
Responsiveness	7	The SIAKADU features works according to their functionality
	8	The SIAKADU error handling and repairing on systems is done quickly
	9	The SIAKADU system is easily accessed using various devices such as PCs, smartphones, tablets
Assurance	10	The SIAKADU system has a security system that is guaranteed against user data
	11	The SIAKADU system has a user guide that can be accessed by users
	12	The SIAKADU guarantees the privacy of each user
Empathy	13	The SIAKADU uses grammar that is easy to understand
	14	The SIAKADU has a procedure that is easily understood by users

Prior to collect respondent's data, a validity and reliability test are applied to the questionnaire. The questionnaire is compiled and developed based on the 5 dimensions of Servqual having indicators of 14 question items. The questionnaire is tested on 30 respondents to get the value of validity and reliability. Table 2 shows the validity of all indicators. The validity test results show that the calculated correlation value from the 1st indicator to the 14th indicator is greater than the table correlation value which is 0.361 for N = 30. Therefore, it can be said that all 14 question items are valid.

Table 2. Validity and reliability questionnaire test results

Variable	Cronbach's Alpha	No indicator	r_{xy}
Tangible	0.6453	1	0.701
		2	0.481
		3	0.705
Reliability	0.8259	4	0.833
		5	0.651
		6	0.861
Responsiveness	0.7600	7	0.781
		8	0.670
		9	0.715
Assurance	0.7961	10	0.670
		11	0.871
		12	0.727
Empathy	0.9268	13	0.728
		14	0.842

Then the reliability test from the questionnaire was conducted. A questionnaire is said to be reliable if the calculated value is greater than the table value. By using SPSS, a calculation is performed to calculate the reliability value with an alpha value of 5%. Table 2 also shows the results of the reliability test for each variable. The calculation results show that the calculated value is greater than the table value of 0.361 with N = 30. So it can be stated that all variables are reliable.

The population of respondents was all students at the State University of Surabaya. The questionnaire is sent to selected respondents via a simple random sampling method. The questionnaire data collection was carried out online and offline. The questionnaire is compiled on the Google form for those who fill in online, and the implementation of offline data collection is done face to face to fill out the questionnaire. Notification of filling out the questionnaire was sent via e-mail and WhatsApp to 260 respondents. A total of 225 respondents filled the entire indicator in the questionnaire from various faculties and levels while the rest (35 respondents) did not fill at all or only partially filled in so that their involvement in filling the questionnaire could be ignored. The population of respondents was all students at a State University of Surabaya.

4. Result

The composition of respondents is as follows: the number of male respondents with a percentage of 74.2% and female respondents with a percentage of 25.8%. With the largest number of respondents in the engineering faculty at 41.3% and the smallest was the sports science faculty at 0.4%. Table 3 shows the distribution of data from the respondents.

Then the calculation of the mean value of each Servqual dimension is calculated. For example, it can be seen in table 4 on the tangible dimensions with indicator number 1 that the mean value of expectation is 5.91 and

the mean value of perception is 5.59. Then the Gap value can be obtained with a value of -0.31. Likewise, for the calculation of other Servqual dimensions in this research.

Next, by using steps (1) and (2), the Mean Importance Score (MIS) can be obtained as shown in column 2 of Table 4 and Weight Factors (WF) can be obtained as shown in column 5 of Table 4. Then the Mean calculation is performed Satisfaction Score (MSS) in step (3), the MSS value can be obtained as seen in column 3 of Table 4. Then step 4 is used to calculate Weight Score (WS) which is the multiplication of WF with MSS. WS calculation results are shown in column 6 of Table 4. The last step is step 5 used to calculate the CSI obtained with a value of 77.37%.

Table 3. Data distribution from respondents

Characteristics	Number of Respondents	Percentage (%)
Age (years)		
18-25 year	225	100
Total	225	100
Gender		
Male	167	74,2
Female	58	25,8
Total	225	100
Faculty		
Faculty of Science Education	32	14,2
Faculty of Language and Art	33	14,7
Faculty of Engineering	93	41,3
Faculty of Social and Law	19	8,4
Faculty of Mathematics and Natural Sciences	29	12,9
Faculty of Economics	17	7,6
Faculty of Sports Sciences	2	0,9
Total	225	100

Table 4. Servqual calculation results

No	MIS Scale 7	MSS Scale 7	GAP Score	WF Score	WS Score
1	5.91	5.59	-0.32	6.78	37.90
2	6.07	5.63	-0.44	6.96	39.20
3	6	4.81	-1.19	6.88	33.11
4	6.12	4.68	-1.44	7.02	32.86
5	6.12	5.25	-0.87	7.02	36.86
6	6.47	5.78	-0.69	7.42	42.90
7	6.33	5.6	-0.73	7.26	40.67
8	6.48	5.69	-0.79	7.43	42.30
9	6.44	5.37	-1.07	7.39	39.67
10	5.82	5.02	-0.8	6.68	33.52
11	6.05	5.21	-0.84	6.94	36.16
12	6.49	5.58	-0.91	7.45	41.54
13	6.44	5.91	-0.53	7.39	43.66
14	6.43	5.59	-0.84	7.38	41.23
Total	87.17	-	-	-	541.58
Customer Satisfaction Index (CSI)					77.37

Table 4 shows the process of calculating the CSI in analyzing 14 indicators from the Servqual dimension. Table 4 also shows the Gap scores of the 14 indicators on Servqual. Overall, the gap scores of the 14 indicators show negative values. This shows that the users' expectations are not fulfilled toward the users' perception of academic information system services. The highest negative value gap score is indicator number 4 which is The SIAKADU system has no bugs (errors) when it is accessed, and the lowest negative value Gap is an indicator for number 1 which is the SIAKADU display has features that are easy to understand. By knowing the highest negative gap score of the indicator, then this indicator to be the priority in improving the indicator followed by other indicators sequentially according to the gap score.

Table 5. The category of customer satisfaction index

No	Index Value	Category
1	81%-100%	Very Satisfied
2	66%-80.99%	Satisfied
3	51%-65.99%	Quite Satisfied
4	35%-50.99%	Slightly Satisfied
5	0%-34.99%	Not Satisfied

Meanwhile, to find out the overall level of satisfaction of users, the CSI is used. Table 5 is a category of CSI that consists of 5 categories that refer to the study of [23]. The categories can be described as Very Satisfied category with the index value at 81% -100%, the Satisfied category with the index value at 66% -80.99%, the Quite Satisfied category with the index value of 51% -65.99%, the Slightly Satisfied category with the index value at 35% -50.99% and Not Satisfied category with the index value at 0% -34.99%. The CSI calculation results in table 4 show a value of 77.37%. By referring to table 5, this CSI value is included in the category with the Satisfied category.

5. Conclusion

The results showed that the use of Servqual can be applied to determine the level of user satisfaction to academic information system services at the State University of Surabaya. The Servqual method in this study can help to determine the level of user satisfaction through the use of the CSI formula. In addition, the use of the CSI formula produces a value of 77.37%, so it can be concluded that the satisfaction of users of academic information systems is in the satisfied category. Furthermore, decision-makers can improve the Servqual dimension, where the gap value is large to be corrected. By doing Quality Improvement, it is expected that the service level can increase to a Very Satisfied category.

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Combining Usability Testing with In-Depth Interview for Online Credit Hour Website Evaluation

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Abstract- The Online Credits Hour (KRS) application is one of the existing systems at the University of Muhammadiyah Magelang where the academic community, including lecturers, students, and education staff, produces a large amount of student academic data. Evaluation is necessary to find out whether the system runs well. This study is an effort to evaluate the system employing a usability test consisting of five indicators, namely learning ability, memory, efficiency, errors, and satisfaction. The five indicators materialized in the form of questionnaires to online KRS users. The survey involved 118 respondents. The method of study includes validity and reliability tests. The validity test employs a correlation test. The reliability test uses a simple linear regression analysis test and the comparison uses the significance value Alpha equals 0.05. The validity test for all five indicators results in value above 0.05. The reliability test of all the answers in the questionnaire has a Cronbach's Alpha value of 0.93, which suggests that the whole has correspondence. The evaluation results show that the KRS Online application has the highest value in the memorability indicator at 3.97, indicating that the KRS Online application is easily accessible with easy procedures to obtain data. The lowest value is on the error indicator at a level of 3, which means that the KRS Online website shows many errors, such as a broken link or poor navigation.

Keywords: usability, usability testing, usability evaluation

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1. Introduction

Nowadays, the development of the internet and information technology made many opportunities from various sectors and provided many benefits [1], [2]. Not only providing opportunities in the goods and services sector, but the internet and information technology provide many benefits to the education sector [3]. One of the uses of information and communication technology that is already widely used in the education sector is especially for universities and government [4], [5].

One of the uses of information and communication technology in tertiary institutions is the existence of an online credit hour form (KRS) website that makes it easy for students and lecturers to track academic activities that take place at tertiary institutions. Based on the benefits gained by the existence of this KRS Online Website, it is appropriate for universities to develop and maintain the existing KRS Online Website optimally. However, in reality, it is still rare for universities to spend more effort to evaluate information technology [6], applications, and websites owned [7], [8] as the KRS Online Website

alone. It is essential to conduct this evaluation, considering the online KRS website as one of the sites that are often used by the academia (be it students, lecturers, education staff) to record the academic footprint of students with an insignificant amount of data [8].

This evaluation will be useful to find out how effective and efficient it is [5]–[9] from the KRS Online Website for users. This evaluation will also be beneficial, as one of the bases for developing a website, if you add a few features in the future. Evaluations that have been done separately to find out how far the utilization of a technology or application is one of them is using usability analysis [3]. Usability is part of the science of Human-Computer Interaction, which focuses on studying interface design and interactions between humans and computers [10], [11], [12]. This usability study will discuss user experience in learning and using certain technologies, applications, or websites [9]. Existing indicators on usability are also used to measure how satisfied the user is in using the technology, application, or product to achieve goals. In this case, the measure of success can be seen from how well an application or technology is in providing quality service

to users [13], [14]. Not only can that, but also how far the application of technology reduces the possibility of errors that occur so that the learning process in using forms is easily obtained [16].

There are five indicators [14], [15] used in this research. Those indicators used to determine the quality of a website is interacting with its users. Learnability is one indicator of usability that is used to find out how easy it is for users to learn websites that are used in fulfilling existing tasks. The second indicator is memorability. Memorability is an indicator that is used to determine the extent of user convenience considering how to use a website if, after all this time, is not using it.

Furthermore, efficiency is an indicator that is used to find out how efficiently the users are doing some of the tasks available in the application. Errors are indicators that are used to find out how many mistakes are made by users when using a website and are related to the user's way of correcting errors. Satisfaction is an indicator that explains the level of user satisfaction in utilizing a site [16].

Some research that tries to evaluate websites using usability shows that usability can describe in more detail related to user experience in using specific applications or systems. Indeed, some things that benefit from knowing the conditions of experience and user satisfaction in using an app or system include able to increase the efficiency of the system itself [15]-[17]. Even from the appearance side, if the appearance design of the application is more user friendly and easy to use, the user does not need to spend much time just to understand and repeatedly ascertain the purpose of the appearance of the application or system.

When software does not meet usability criteria, users will spend too much time understanding the interface, thus making them less efficient at work and it can increase productivity. The excellent interface allows users to concentrate more on their work than on the device they are using less training. Therefore, time and costs can be reduced. A usable product will also reduce problems experienced by users, and because of that, support for the product can also be reduced. Increased acceptance, when users like the system because of its proper nature, they will be more comfortable in using it. Reducing development costs making changes from the start in the design life cycle is much cheaper than making it at the end of increased sales. The usefulness of a system can be superior competitiveness when compared to other products. For this reason, the focus of this research is to evaluate the existing KRS Online Website at universities with usability testing and in-depth interviews to find out the extent of the use of the system. The purpose of this study was to determine the level of usability on the KRS website.

2. Method

In this study, what will be the object is the online KRS site owned by the University of Muhammadiyah Magelang

(krsol.ummg.ac.id). The research to be carried out, in this case, is a combination of qualitative and quantitative analysis using five indicators that exist in usability testing. There are four stages carried out to implement this method, namely the exploration of concepts and identification of problems, data collection, data analysis, and finally, the results and discussion.

a. *Exploration of Concepts and Identification of Problems*
In the initial stages of the study, the exploration begins of concepts and identification of problems. It was carried out with a literature study related to the ideas that will be used in this research. The literature studies sought as a reinforcement of the concept include usability, usability evaluation, usability testing, website user experience, and matters relating to human-computer interaction. The results of this literature study will be used to strengthen the basic concepts that will be used as a reference for the data analysis process and identify existing problems.

b. *Data Collection*

At the data collection stage, the first thing to do is to make a research instrument. In this study, the research instrument is made in the form of a questionnaire by lowering statement items from the five indicators that exist in usability testing. The five indicators used are learnability, memorability, efficiency, errors, and satisfaction. The five indicators will be derived into several statement items for each indicator that represents the user experience in using the KRS Online Website. This questionnaire will be distributed with a purposive sampling approach to the academic community of the University of Muhammadiyah Magelang using the KRS Online Website.

Table 1 explains the coding and statement items derived from the five usability testing indicators. In its assessment, this instrument uses a Likert Scale, with five response choices, namely strongly disagree (SD), disagree (D), neutral (N), agree (A), strongly agree (SA), with the range of scores on positive items being 1-5. Apart from the questionnaire, additional data will also be collected through a series of interviews with several IT experts to strengthen the evaluation results from the KRS Online Website obtained through the questionnaire. For gaining more perspective about the experience of the user. We choose seven users to conduct an in-depth interview. This interview process aims to explore further the aspects of users regarding the use of the application. The ten people chosen to be interviewed the following qualifications, the first is that the user must be a student from the University of Muhammadiyah Magelang. The user must include inactive users of the application, which means they use the app for at least three years in a row. The questions raised in this depth-interview process is about the user's experience while using the application, what obstacles are often experienced, and the user's assessment of the application. The interview was carried out for approximately fifteen minutes per person.

Table 1. Coding and Item Questionnaire Statement

Indicator	Code	Statement of the Questionnaire
<i>Learnability</i> (A)	(A1)	The KRS Online website can be learned easily
	(A2)	I easily and quickly receive detailed and specific information on KRS online
	(A3)	I can quickly understand the contents and information content presented on the KRS Website online
	(A4)	I was able to quickly understand and understand the flow of navigation available on the online KRS Website
	(A5)	Without written instructions or a manual book, I was able to study the use of the KRS Website online
<i>Memorability</i> (B)	(B1)	I can easily remember the use of the KRS Online Website
	(B2)	I can easily find out and remember navigation directions and features on the online KRS Website
	(B3)	I find it easy whenever using the KRS website online
<i>Efficiency</i> (C)	(C1)	I was able to access the menu on the KRS Website online quickly
	(C2)	I easily obtained information about the KRS Online Website
	(C3)	I was able to immediately find the information I wanted to find from the start opening on the KRS Online Website Errors
<i>Errors</i> (D)	(D1)	I found no errors when using the KRS Online Website
	(D2)	I did not find an error menu or not following its function
	(D3)	I can find the features and menus that I am looking for on the KRS Online Website
<i>Satisfaction</i> (E)	(E1)	I am happy with the interface design that exists on the KRS Website online as a whole
	(E2)	I feel comfortable using the KRS Website online
	(E3)	The combination of colors and content layout is pleasant to look at
	(E4)	The KRS Online website is in line with my expectations when I see the title on the system page

c. *Data Analysis*

Analysis of the data to be used in this study uses a mixed-method approach or a combination of quantitative and qualitative data analysis. For quantitative analysis, it was using descriptive statistical analysis, which aims to find out the average evaluation results of the five indicators that exist in usability testing on the KRS Online Website. For qualitative analysis, it is carried out by transcribing the results of in-depth interviews with several KRS Online Website users and processing them with NVIVO Tools.

Which means, researchers first determine the conditions related to the intended respondent. The requirements applied in this study are, users of KRS Online, in this case, University of Muhammadiyah Magelang students. Before the questionnaire was distributed, two tests were first carried out. Reliability testing was conducted by selecting ten prospective respondents randomly to see to what extent potential respondents can understand the statements contained in the questionnaire. Furthermore, the Reliability Test is carried out whether or not the draft questionnaire will be distributed reliably. In conducting Reliability Tests, use SPSS tools.

3. Result and discussion

a. *Search Related Studies and Identification of Problems*

The first step we do is selecting some studies related to the concepts that will be used in this research. We try to search and retrieve from several journal articles and conference papers from the database, i.e., IEEE Xplorer, ACM Digital Library, AIS Electronic Library, Emerald Insight, ProQuest, and ScienceDirect/Scopus. It aims to gain more understanding about usability testing and in-depth interview concept. From the searching result, we found almost eleven papers that show the idea of usability testing and thorough interview and how we must do to solve the problems.

b. *Analysis, Reliability and Validation Test*

In distributing questionnaires, this research uses a purposive sampling method [18] to get respondents.

Table 2. Questionnaire Instrument Reliability Test Results

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.934	0.936	18

Table 2 shows the results of the reliability test conducted. The analysis found that Cronbach's alpha was 0.934, which means that the statement was received. After the questionnaire is confirmed valid and reliable, then the survey is distributed using the Google form electronic page within three weeks to get responses from respondents who have been determined. The period used to get respondents is for two weeks, from the results of the distribution of questionnaires obtained 118 respondents who have filled

and assessed the University of Muhammadiyah Magelang KRS Online Website. Table 3 shows the delivery of the sample of respondents who entered and assessed the KRS Online Website.

Table 3. Number of Respondent Samples

	Gender	Distribution
Valid	Male	84
	Female	34
	Total	118

A validity test is done again after all the data from the respondents are collected. Those action becomes necessary to know and test the strength of conclusions and inferences from the test results to approach the truth [23]. This test is done by identifying the r count of the value of existing items. If the value of r count > value of r table, then the group question can be considered "Valid" [24]. The amount of r Table in this study is 0.325 obtained from the table r significance for two way testing with a value of 0.05, and with degrees of freedom $n-2$, it can be said to be valid. After the validity test is done, then the detailed statistical calculations are performed to see the results of the usability testing conducted.

- c. *Conducting Usability Testing and In-depth Interview*
The first process carried out in usability testing is to calculate the data that entered from the questionnaire using descriptive statistics. In this descriptive statistical calculation, the average results of usability testing conducted on the KRS Online Website are then divided into five categories and assessment ranges. If the average value of usability testing is in the field of $0 < 1$ then it can be stated that the Website belongs to a very bad category. The range of values of $1 < 2$ website is said to have a pretty lousy rating, for a variety of benefits of $2 < 3$, the Website is considered quite good, range $3 < 4$ websites are said to be good enough, and the Website is declared very good if the rating is in the range $4 = < 5$.

Table 4. Website Rating Categories and Range

Interval	Categories
$0 < 1$	Very Bad
$1 < 2$	Bad Enough
$2 < 3$	Good
$3 < 4$	Pretty Good
$4 = < 5$	Very Good

We can see from the result of grouping usability testing result that has been carried out, supported

by qualitative data processing from the effects of in-depth interviews to several users of the KRS Online Website. It is found that the indicator of memorability is the aspect that has the highest rating, with a value of 3.97, which means it is quite good. This can be said that users can easily remember and know the usage of the KRS Online Website. Followed on the second rank is the learnability indicator of 3.86, which means good enough, and it can be interpreted that KRS Online Website users find the Website easy to learn, both in terms of the flow and navigation provided by the Website. Not only that, without manual books or instructions for use, but users can also still run the KRS Online website as it functions. Efficiency becomes the third indicator with an assessment of 3.51, which means that it even exists in a reasonably good range. Users find that they can quickly get the information they want to see just by looking at the start page on the Website. Not only that, but users also feel able to do many activities (access) with a fast time. Next is the satisfaction indicator of 3.46 which is also included in the quite good category. Table 5 displays the average total results of each indicator from the usability assessment conducted.

Overall the use of the KRS Online Website, users feel that in terms of the design and interface provided by the Website makes users feel comfortable. Besides, user expectations are met when using the KRS Online Website. The latter is an error indicator with a value of 3.30, still in the good enough category. In dealing with existing errors, the KRS Online Website is rated by the user to be able to provide certain notifications in the event of an error. However, in some cases, users often encounter errors without notification. This causes the user experience in terms of dealing with existing errors.

After doing the calculation process using descriptive statistical analysis, the next thing to do is to make additional confirmation using the in-depth interview approach to find out more about the experience of KRS Online Website users. Seven students were confirmed with an in-depth interview approach to telling their experiences using the application. Of the seven students, was agreed that if the existing KRS Online Website felt it was easy enough to remember and know the usage of the application without the manual. From the interviews process, almost seven users agreed that the KRS Online Website was easy to learn, including the content and information provided was also easy to understand. The barriers that often occur in the user in using the application is, there is no notification when an error occurs in the use of the application. this makes some users confused about operating it. From two approaches that have been done, usability testing and interview can be drawn to a common thread, that overall this application is good enough to meet user needs.

Table 5. Average of each Usability Indicators

Code	Statement	Average	Average/ Indicator
Learnability (A)			
(A1)	The KRS Online website can be learned easily	4.02	3.86
(A2)	I easily and quickly receive detailed and specific information on KRS online	3.71	
(A3)	I can quickly understand the contents and information content presented on the KRS Website online	3.91	
(A4)	I was able to quickly understand and understand the flow of navigation available on the online KRS Website	3.84	
(A5)	Without written instructions or a manual book, I was able to study the use of the KRS Website online	3.85	
Memorability (B)			
(B1)	I can easily remember the use of the KRS Online Website	4.19	3.97
(B2)	I can easily find out and remember navigation directions and features on the online KRS Website	3.89	
(B3)	I find it easy whenever using the KRS website online	3.82	
Efficiency (C)			
(C1)	I was able to access the menu on the KRS Website online quickly	3.47	3.51
(C2)	I easily obtained information about the KRS Online Website	3.56	
(C3)	I was able to immediately find the information I wanted to find from the start opening on the KRS Online Website Errors	3.50	
Errors (D)			
(D1)	I found no errors when using the KRS Online Website	2.90	3.30
(D2)	I did not find an error menu or not following its function	3.42	
(D3)	I can find the features and menus that I am looking for on the KRS Online Website	3.59	
Satisfaction (E)			
(E1)	I am happy with the interface design that exists on the KRS Website online as a whole	3.27	3.46
(E2)	I feel comfortable using the KRS Website online	3.61	
(E3)	The combination of colors and content layout is pleasant to look at	3.47	
(E4)	The KRS Online website is in line with my expectations when I see the title on the system page	3.50	

4. Conclusion

The aims and focus of this research are to evaluate the existing KRS Online Websites at universities with usability testing and in-depth interviews to find out the extent of the usefulness of the system. There are five indicators used to evaluate or evaluate the Website. Namely learnability, memorability, efficiency, errors, and satisfaction. The total sample of respondents in this study was 118 people. The test method used in this study includes a validity test consisting of a reliability test and a correlation test. While the significance of the Alpha value used in this study was 0.05. From the results of the data validity test conducted, all indicators have values above 0.05.

From the reliability test results, all statements contained in the questionnaire also have a Cronbach's Alpha value of 0.93, which means that all comments are in accordance. The evaluation results show that of the five existing indicators, the KRS Online Website has the highest value on the memorability indicator of 3.97. This means that the KRS Online Website is easy to remember navigation and its layout to get information. For the lowest value of the five indicators is the error indicator with a value of 3, this means that the KRS Online Website is still found many errors or errors either on the broken link or on the existing navigation. For further research so that it can be combined again with various kinds of indicators, then the correlation between current indicators can be known so that they can see the important indicators.

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Application of Context-Aware and Collaborative Mobile Learning System Design Model in Interactive E-Book Reader Using Design Thinking Methods

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Abstract-E-books as a learning medium have been widely used and utilized to support learning processes. The presence of e-books as digital books can be accepted by users because of the interactive content and display. However, the current format of e-book has not provided a mechanism/platform that accommodates contemporary learning styles on a two-way networked learning basis. E-books are more static in the sense that it has minimal interaction context. E-books have not been able to integrate learners with their learning environment in an interaction construct to support a learning activity. To address this problem, this study recommends a new approach called context-aware and collaborative mobile learning system design model. The method used in implementing the design model is design thinking. Usability testing using the guerrilla usability testing method is carried out to determine the quality of the e-books produced. The results obtained at the stages of empathize and define produced list and learning problems experienced by students when using e-books. The ideate and prototype stages produced e-book prototypes developed based on context-aware and collaborative mobile learning system design model. In the test stage, usability testing of 30 students showed good results. It is said to be good because there are no assignments with a score of one in the rubric usability testing table. So it can be concluded that the design model applied to the prototype e-book is feasible and can be understood by users.

Keywords: context-aware; e-book; design thinking

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1. Introduction

Mobile learning has become a very important learning style in modern life. In the concept of learning, mobile learning brings the benefits of the availability of teaching materials that can be accessed at any time by visualizing interesting material anytime and anywhere. Mobile learning is defined as a learning process through mobile devices that provides on-demand access to learning content and services (without the constraints of time, location, environment, and devices) [1]. In a mobile learning system, students can continue their education out of the classroom, move during the learning process and change places using mobile devices. This mobility causes changes in the learning context. In a learning process there are interactions between learners, by way of conveying thoughts to one another and taking appropriate action in an interactive session. When learners interact, they can understand and use information that is situational or information in the form of context that can improve the quality of interaction [2].

The term “context” first appeared in research conducted by Schilit and Theimer [3]. They define context as location, identities of people closest to, objects, and changes in the objects. Since then, many researchers have made efforts to propose an accurate definition of context on mobile computing devices. The most common definition is: “All information that can be used to describe the situation of an entity that participates in interactions between users and systems” [4]. In m-learning, context can be associated with information about the user (name, address, etc.), devices (Smartphone, PDA, Tablet, etc.), localization (at work, on the train, public places, etc.), time (time of the day, weekdays/holidays, etc.), activities (interaction activities, etc.), collaboration (tools, modes, collaboration activities, etc.) and, physical environment (brightness level, noise level, etc.) where all these elements can change the way users interact with whatever device is being used. In this context, information is useful for adjusting the interaction and application behavior with the student’s circumstances.

The use of e-books is an example of mobile learning. E-books are one of the learning media that are widely used and used to support learning processes. The presence of e-books as digital books can be accepted by users because of the interactive content and display that can be accessed anywhere and anytime [5]. However, the current format of e-book has not provided a mechanism/platform that accommodates contemporary learning styles on a two-way networked learning basis. E-books developed are more static in the sense that it has minimal interactive content [6]. It is static because e-books' current feature only allows learners to interact only with the e-books. Meanwhile, in the context of reading or learning, a learner may interact with other learners or even with his teacher / lecturer (in a discussion forum for example) related to the topic in the book he is reading.

The static features of this e-book have not been able to integrate learners with their learning environment in an interactive construct to support a learning activity. In an effort to improve the access context of learners with the learning environment, this study recommends a context aware and collaborative mobile learning system design model which is an ability that refers to a system in using contextual information to provide better services to users in a flexible and easy to manage fashion. To plan a design and model system in accordance with the needs of the user's situational context, a new model appears to answer these problems, namely the design thinking model. Design thinking is a new model in the design process and user-focused problem solving methods [7]. Design thinking itself was popularized by David Kelley and Tim Brown, founder of IDEO and design consultants with an innovative product-based design background.

Based on the above background this research focuses on the question: How to implement a context-aware and collaborative mobile learning system design on an interactive e-book reader using design thinking methods? It is hoped that through this research, we (1) find out the learning problems experienced by students when using e-books, (2) recommend a design model for a learning media in the form of context-aware and collaborative mobile learning system, and (3) determine the level of eligibility of the e-book after applying the context aware and collaborative mobile learning system design model.

2. Method

a. Research design

This study recommends a design model that is context aware design and collaborative mobile learning system applied to an interactive e-book reader. The design model was developed based on the design process and the user-focused problem solving method, namely design thinking. Figure 1 is the design of this study.

In this study we divided users into 2 groups. The first group acted as respondents who were asked to fill out a questionnaire about the needs and problems encountered when using e-books as a means of learning (Empathize

stage). Needs and problems obtained from questionnaires are grouped, sorted and compiled into a list of user needs (Define stage). Based on this list of user needs, a design model in the form of context-aware and collaborative mobile learning system was developed (Ideate stage). Then a prototype is made in the form of an e-book with the design of the model (Prototype stage). The second group acts as a tester or test model. The second group did not know about all the processes that were done before, so at this stage it was the first experience for the second group in prototype testing.

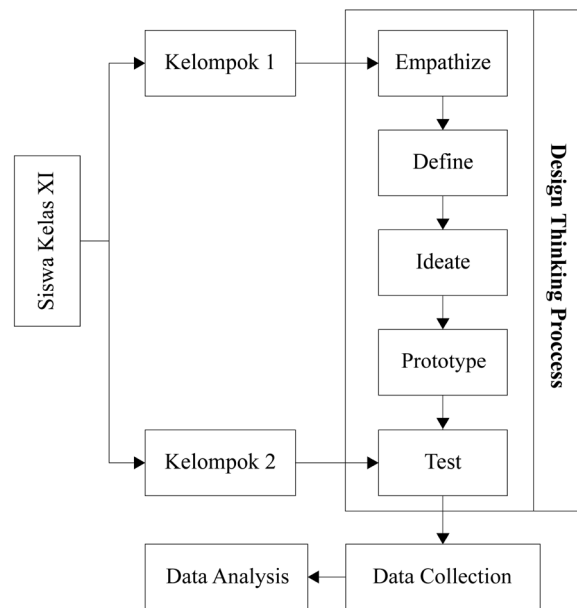


Figure 1. Research Design

Tests conducted are usability testing. Usability comes from the word usable which generally means it can be used well. Something can be said to be usable if the failure in its use can be eliminated or minimized and it provides benefits and satisfaction to users [8]. One method of usability testing is Guerrilla Usability Testing. The main point of this method is trying to capture first-time user experience [9]. This method is also the simplest method for testing a design by going to public places and asking people about the design. In addition, Guerrilla Usability Testing can be done when a design needs to be validated and tested quickly but with a low budget. Prototype testing at this test stage uses the Guerrilla Usability Testing method. At this stage the researchers collected data on the results of usability testing. These results are used to determine the feasibility of an interactive e-book reader prototype in which context-aware and collaborative mobile learning system designs are applied.

b. Research subject

This study included 60 students of class X majoring in TKJ (Computer Network Engineering) SMK Yapema, Gading Rejo, Pringsewu, Lampung. It consists of 2 classes where each class consists of 30 students. The first group consisted of 30 students as questionnaire filler

respondents. The questionnaire contains the needs and problems encountered when using e-books as a basis for developing applications. The second group consisted of 30 students acting as a tester to test the prototype that had been developed.

c. Application of design thinking

Design thinking is a very complex model because it is multi-disciplinary which involves various mindsets [10]. The stages in design thinking are as follows:

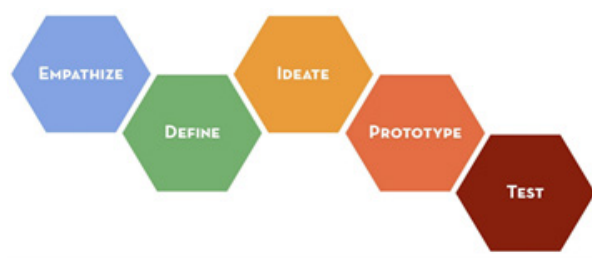


Figure 2. Design Thinking [10]

The first stage in design thinking is empathize, at this stage an observation is carried out in the form of giving questionnaires to research subjects, namely group 1 about the needs or problems encountered in using e-books as a learning tool. The second stage is define, at this stage the needs and problems obtained from the questionnaire are grouped, sorted and arranged into a list of user needs. The third stage is ideate, at this stage a list of user needs is processed. Based on this list of user needs, a design model in the form of context aware and collaborative mobile learning system was developed. The fourth stage is prototype, context aware design and collaborative mobile learning systems that have been developed based on user needs implemented into the prototype, which is an interactive e-book reader. The fifth stage is the test, at this stage the usability testing is done on the prototype with the Guerrilla Usability Testing method.

d. Research Instruments

The instruments used in this study were questionnaire and usability testing rubric. Questionnaire is used in the empathize stage. Then the usability testing rubric is used at the test stage to collect prototype feasibility test results.

e. Analysis and data collection

The data collection process starts at the time the design thinking process begins. The process of gathering problems and user needs is done at the empathize stage. In the define stage, grouping of problems or user needs is done, and then arranged into a list of solutions or ideas. At the ideate stage, the context aware and the collaborative mobile learning system design begin to be designed based on a list of solutions or ideas obtained from the define stage. After the model is arranged, it is implemented on an interactive e-book reader prototype. Then the feasibility test was conducted by group 2 using the guerrilla usability testing method to measure the usability level of the interactive prototype e-book reader.

3. Result

The research process begins when the design thinking process begins. There are 5 stages, as follows:

a. Empathize

The purpose of this stage is to collect user problems and needs. In group 1, 30 students were given a questionnaire containing questions about the needs and problems encountered when using e-books as a learning tool. The answers from filling out the questionnaire are collected, selected and sorted by the number that appears the most.



Figure 3. Filling out the questionnaire at the empathize stage

b. Define

The purpose of this stage is to analyze the results obtained from the empathize stage, namely finding urgent problems to be addressed. The steps at this stage are (a) grouping the various problems obtained from the empathize stage, (b) after the group is formed, rank from the largest to the smallest group, and (c) the group with the largest number is the most urgent problem that must be addressed. Based on the results of data retrieval from the questionnaire and through several stages above, researchers only took 4 needs or problems with the largest number. The 4 list of user requirements are as follows:

1. Book recommendation according to the user's circumstances
2. Chapter recommendation according to user's circumstances
3. Messaging feature as a means of discussion with fellow students.
4. Interactive quiz with recommendations for the right answer chapter

c. Ideate

The purpose of this stage is to gather ideas that can solve the problems obtained from the define stage. Problems and needs obtained are then developed into a design model. It is at this stage that a context aware and collaborative mobile learning system design model is developed. Based on previous research on context aware conducted by several researchers, context-aware applied is about a system designed to support students in learning specific courses, which has specific learning objectives and pre-planned learning process [11]. By synthesizing the

system architecture from the relevant works, context aware design architecture in this study consists of three layers: context sensing layer, contextual adaptation layer, and application layer.

The context sensing layer contains various logic sensors to sense the learning context state. The second layer manages aspects of the direct context sensed from the context sensing layer and concludes the indirect context aspects. It also provides a set of learning adaptation and learning strategies that are appropriate depending on the learning context. The third layer, the application layer, is tasked with interacting with the users, such as gathering information and their requirements, displaying adaptive learning objects and providing the right communication approach. At this ideate stage the researcher recommends a model that is context-aware and collaborative mobile learning system design based on the problems collected at the define stage, as follows:

1. Book recommendation feature according to the user's situation

The context awareness applied is book recommendations based on user profiles. When the user first accesses the book's menu recommendations, the system recommends books according to the user's profile even without the need to fill in a search keyword. This book's recommendations are based on the user's profile, namely the level of education, interests, and work that is filled in by the user at the time the user processes the registration. The context aware design applied is as follows:

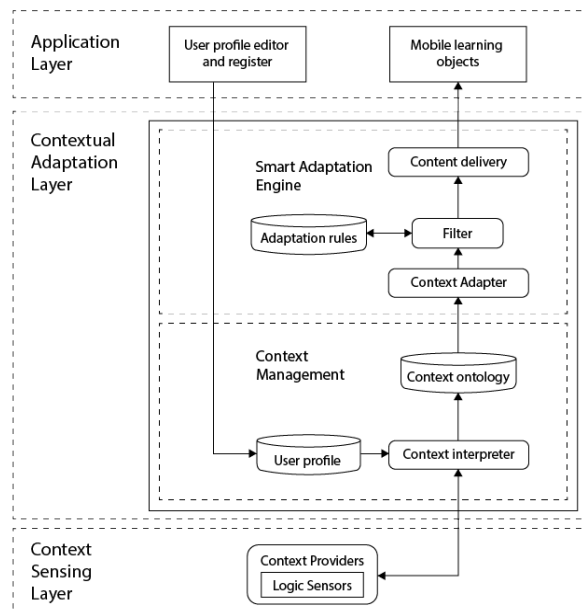


Figure 4. Architectural design context aware book recommendations

There are three layers in the context aware design, namely the application layer, the contextual adaptation layer and the context sensing layer. At the application layer the user registers by entering the level of education,

interests, and work, then stored in the user profile database. The data is then translated into a data context by a context interpreter. At the same time the system responds through the context provider in the form of a logic sensor at the context sensing layer. The translated data is entered into the ontology context database in the form of metadata. Data is forwarded by the context adapter to be filtered and adjusted to the appropriate adaptation rule. At the filter stage, the method used is the content base filtering method contained in the database adaptation rules. Content-based filtering is the provision of recommendations given by exploring the contents of user profiles, product descriptions or matters relating to the formation of user choices for an item [12].

Content-based filtering method forms the profile of its users based on the forming attributes of an item. The content-based filtering method algorithm is explained in the following stages: (a) A book item is broken down based on a component vector forming it, (b) the user will provide a value in the form of education, interest and work during the registration process which will be stored in the user's personal data profile, (c) then the system will form a user profile based on the weight of the component vector forming an item, namely by making a query of all the book's components and then calculating the weight using the TF-IDF algorithm. TF-IDF (Term Frequency-Inverse Document Frequency) algorithm is an algorithm that can be used to analyze the relationship between a phrase / sentence and a collection of documents [13]. In calculating the weight of TF-IDF the following formula is used:

$$W = TF * ((D/DF) + 1) \tag{1}$$

From the results of calculations with formula (1) above, it can be seen that the book recommendations are in accordance with the user's situation based on the highest value to the lowest. The results are sent to the user at the context of delivery stage so that they can be received in the form of mobile learning objects namely recommended books.

2. Chapter recommendation according to user circumstances

According to Nguyen (2010), the context in the m-learning model is information that has an influence on students in learning activities. Nguyen (2010) argues that there are several context factors that influence the adjustment of learning material for each student, namely: (a) Location, allowing information and services to be localized. Location allows the system of adaptation to places that are located where learners participate. (b) Time, refers to the time of day. Specifically, the interval at which students interact with the system is important for a number of subject matter that requires students to learn. (c) The level of concentration, as a context factor used for adaptation. This shows students' attitudes such as the level

of concentration when they are taking part in learning [14]. The context aware design applied is as follows:

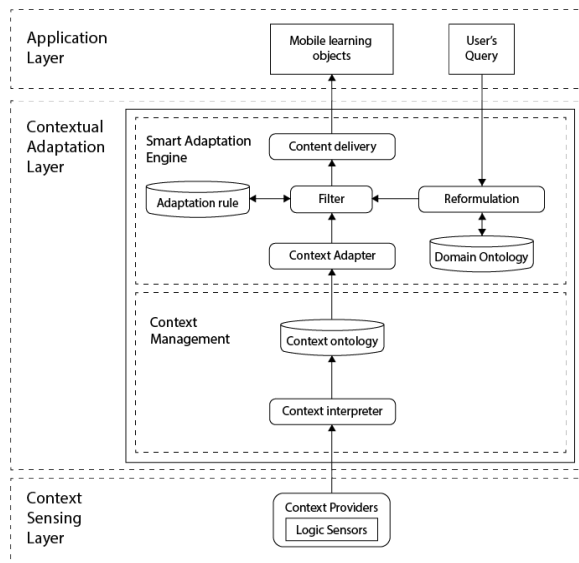


Figure 5. Architectural design context aware chapter recommendations

The context aware that is applied in this interactive e-book reader is the recommendation of book chapters that suits the user's situation. Each chapter is assigned difficulty level based on a scale of 1-3 namely easy = 1, medium = 2 and, difficult = 3 by the book uploader. When students open a book in their e-book, they are faced with a menu: their location, the amount of time they have, and the level of concentration. At the same time the system responds through context providers in the form of logic sensors at the context sensing layer. The translated data is entered into the ontology context database in the form of metadata. Data is forwarded by the context adapter to be filtered and adjusted to the appropriate adaptation rule. Then the system queries the user input at the application layer. Each input in the form of location, time and concentration level is converted into interval values 1-5, 1-5, and 1-3. The input query is then formulated and adjusted to the collaboration data contained in the ontology domain.

The ontology domain contains collaboration values from the three variables that are added together. Then the value collaborations are grouped in the following way: (a) Subtract the largest value with the smallest value to determine the range, (b) Determine the mean with a single non-frequency data,

$$X = \sum_{i=1}^n X_i \quad (2)$$

(c) Determine the standard deviation using the formula:

$$s = \sqrt{\frac{\sum_{i=1}^n (x_i - x)^2}{n-1}} \quad (3)$$

(d) Classifying grades into easy, medium and difficult categories.

Table 1. Grouping criteria

Numb.	Level	Value	Criteria for grouping
1	Easy	1	Value < mean - SD
2	Medium	2	Mean - SD ≤ Value < mean + SD
3	Hard	3	Value ≥ mean + SD

After that, the grouping criteria scale values are obtained and then the matching results of the collaboration scores are performed with the difficulty level of each chapter. For example, the value of collaboration 7 is at the Medium level. Then the recommended chapter with a moderate level of difficulty that will appear to be recommended. The results are sent to the user at the context of delivery stage so that they can be received in the form of mobile learning objects, namely chapter recommendations that are appropriate to the user's situation.

3. Messaging feature as a means of discussion with fellow students

Collaborative mobile learning system is a learning strategy using mobile devices in which a collaborative learning learning strategy is embedded [15]. In this study using the message / message feature as a group learning media. Each student or user in studying a book in an e-book can create a study group with the theme of a particular chapter in a book. Friends studying in study groups are called learning partners. The minimum learning partner is 1 teacher / writer / uploader of the book. The context aware design applied is as follows:

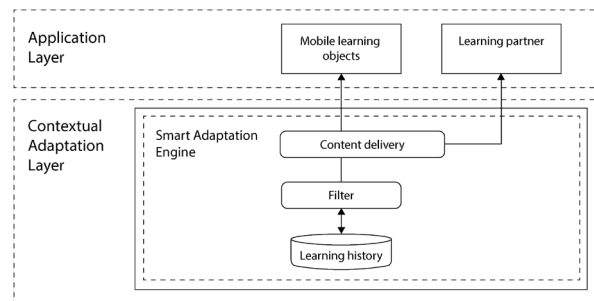


Figure 7. Architectural design context aware book recommendations

When a user accesses a mobile learning object in the form of a chapter, the user can create a discussion group with a learning partner. Every message with the chapter theme is sent by the user via content delivery to the filtered learning partner and then stored in the learning history database. So that the discussion in the form of a message is stored and can be accessed at any time.

4. Interactive quiz with recommendations for the right answer chapter.

The context aware applied is a chapter recommendation based on the results of a quiz in a book. Each book in this interactive e-book reader has

several quizzes. The quiz was created by the book's author / book uploader as a practice material for students / readers. Each question represents several chapters of the book. For example, quiz no. 3 is a question taken from chapter 4 material from the book. After students work on the quiz the system will count the number of true and false values in the learning evaluation. At the consolidator stage, the system collects grades with incorrect answers. Based on these values the system recommends appropriate learning materials or chapters so that it directs students to be able to answer the quiz correctly. The context aware design applied is in figure 8.

c. Prototype

This stage aims to design the application prototype in accordance with the design obtained at the ideate stage. The prototype developed is an interactive e-book reader running on the Android operating system. The first step is to create a user interface in the form of a low

fidelity design (Figure 9).

d. Test

The purpose of this stage is to determine the feasibility of the application prototype by knowing which steps are difficult for users to understand and skip. The test carried out is usability testing with the guerrilla usability testing method. Equipment needed in this stage is the usability testing rubric and prototype. The test takers were thirty students from the second group. The testing phase carried out is as follows: (a) give prototypes to students, (b) explain the scenario, (c) let students try prototypes based on scenarios, (d) record all student activities during the test, and (e) end the test we give students appreciation. We created 5 assignments that students must complete. The five tasks are as follows: (a) register as a user and open book recommendations, (b) open one of the books and fill in the state of self (location, time and concentration), (c) work on the quiz and receive chapter recommendations according to the correct answer, (d) exchange messages with learning partners, and (e) bookmark a book

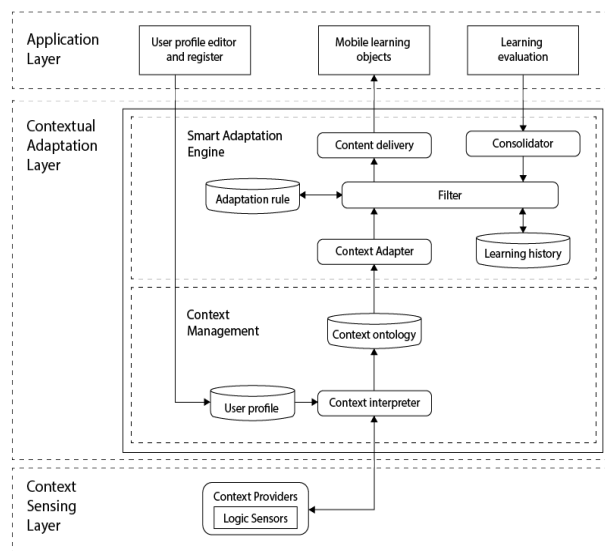


Figure 8. Architecture aware context design recommendations appropriate chapter answers.

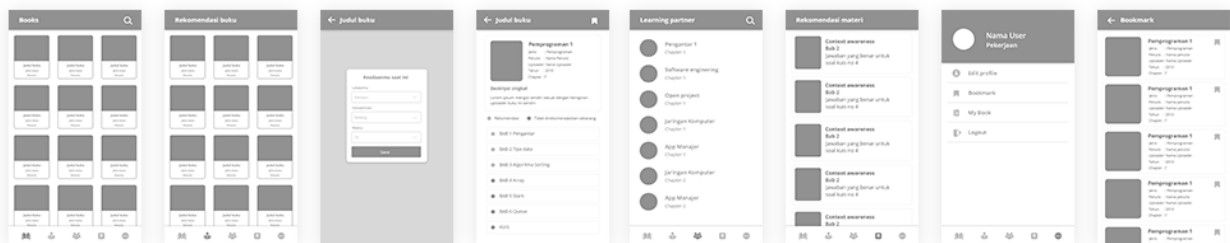


Figure 9. Interactive e-book reader user interface



Figure 10. Prototype interactive e-book reader



Figure 11. Prototype of interactive e-book reader

4. Discussion

After the whole design thinking process is done the next step is data collection and analysis. Data collected from the results of the prototype testing was then analyzed in accordance with what was expected in the preliminary study.

1. Knowing the learning problems experienced by students when using e-books.

From the empathize stage we gathered various problems experienced by students when using e-books as a learning tool namely: (a) Location, time and concentration affect the quality of learning using e-books, (b) book recommendations are needed according to user needs, (c) chapter recommendations are needed according to the user's situation when using e-books, (d) study partners, (e) messages, (f) too much material, (g) quizzes for practice, (h) interactive quizzes, (i) recommendations for suitable material, and, (j) too much and monotonous material. After the determination stage, the four problems with the highest rank are: (a) Required book recommendation feature is appropriate to the user's situation, (b)

required chapter / chapter recommendation feature according to the user's condition, (c) Message feature as a means of discussion with peers, and (d) interactive quizzes with recommended chapter recommendations.

2. Recommend a design model of a learning media in the form of context aware and collaborative mobile learning system.

Based on problems and user-needs gathering at the empathize stage, the researcher recommends a context aware design model and a collaborative mobile learning system. The context aware and the collaborative mobile learning system architecture design consists of three layers: the context sensing layer, the contextual adaptation layer and the application layer. This model is an amalgamation of 4 architectural designs of problems / user-needs compiled into a unified model unit.

3. Knowing the feasibility of the e-book after applying the context aware and collaborative mobile learning system design model.

The test results using the guerrilla method, obtained the following results:

Table 2. Usability test results using the guerrilla method

Task	Score 1	Score 2	Score 3
Task 1 Book registration & recommendations	0	3 (10%)	27 (90%)
Task 2 Books & Recommendations chapter	0	4 (13,33%)	26 (86,67%)
Task 3 Quizzes & Material recommendations	0	7 (23,33%)	23 (76,67%)
Task 4 Study Friends	0	2 (6,67%)	28 (93,35%)
Task 5 Bookmark	0	0	30 (100%)
		10,67%	88,33%

Score 1: The user cannot perform the task
 Score 2: The user can do the task but with a few problems
 Score 3: Users can carry out tasks without problems

From the results of the usability test in table 2, we can see that the easiest assignment is assignment 5 with thirty students able to carry out assignments without problems. The reason why assignment 5 becomes the easiest task to do is that it only presses the bookmark button, so students don't need much effort to complete the assignment.

Task 3 becomes the most challenging task to do even most students can do it without problems. However, compared to other assignments, this task has the highest number of students who cannot perform assignments without problems (seven students). The reason why this task is the most challenging task to do is because it requires two processes. Assignment 3 requires students to work on the quiz until it has been completed until they have obtained true and false grades. The wrong value is used by the system to provide recommendations for the correct answer in the form of appropriate material to students. So students can receive material on the quiz recommendation feature. Because there is no assignment with a score of one, so it can be concluded that this prototype design is feasible to use and understand by users.

5. Conclusion

The application of context aware and collaborative mobile learning system design with this design thinking method is expected to help students in their learning processes, especially in the use of e-books as a learning tool. The use of design thinking methods in developing context aware and collaborative mobile learning systems design model is expected to be able to bridge between the needs of users with the results of products that match their needs. The application of the five stages in design thinking consisting of empathize, define, ideate, prototype, and test can identify learning problems experienced by students so that learning media are developed in accordance with the problems faced. The application of context aware and collaborative mobile learning system design in this study is an example that learning media developed with design thinking methods (from learning problems experienced by students) will also be easy to use by students when learning. Therefore, this becomes an interesting discussion about whether implementing a context aware and collaborative mobile learning system design using design thinking methods for other learning media research will produce the same results.

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Virtual Reality Visualization of Tongkonan Traditional House as Promotional Media for Cultural Tourism using ADDIE Model

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Abstract-Indonesia is a country that is rich in culture and customs. Indonesia also has great potential in the field of tourism, especially cultural tourism. The key to attracting tourist visitors lies in the information media provided. In this paper, a desktop-based application is developed with 3D virtual reality graphics model technology with Tongkonan traditional house from the Toraja tribe and their environment as the object. This 3D virtual reality visualization aims to be an interactive promotional media for the millennial generation in introducing cultural tourism, especially the Tongkonan traditional house of Toraja. In this application, the user can explore the traditional house objects as a whole – with the help of navigation control in the form of keyboard and mouse. The ADDIE model method was used in designing this desktop application. The user response test was used to measure respondents' attitudes toward the application using the Likert scale and succeeded in getting the very good category in 17 questionnaire statements and the good category in three questionnaire statements. Therefore, it can be concluded that the VR visualization of Tongkonan Traditional House can act as an interactive promotional media to the millennial generation.

Keywords: 3D virtual reality, traditional house, tongkonan, ADDIE model

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1. Introduction

Indonesia is a country that has a long history in terms of culture and customs. Some regions in Indonesia have collections of culture, art, and knowledge that become attractions for tourists. Data from the Central Statistics Agency (BPS) cited through the Indonesia Millennial Report in January 2019 described that dominating the demographic structure in Indonesia will be controlled by millennials with an age range of 18-30 years old. At present, the population in Indonesia is around 179.1 million people, (67.6%) are of the productive age group, and 24% are of the millennial generation. The huge size of the target market of the millennial generation is the target market for the tourism industry. The millennial generation is known as an adventurous generation. From traveling, they get pleasure and experience. Not infrequently, millennial also makes traveling as a lifestyle choice.[1]

A preliminary survey conducted on the interest of attractive tourist destinations with millennial generation as the target respondent is shown in Figure 1 below.

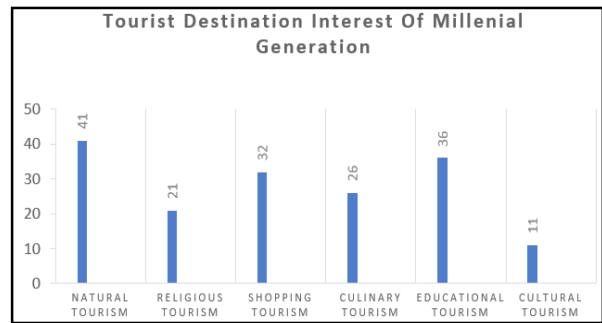


Figure 1. Tourist Destination Interest of Millennial Generation

From the preliminary survey results, it is concluded that the interest of millennial generation towards cultural tourism is currently the lowest at 11% compared to natural tourism by 41%, religious tourism 21%, shopping tourism 32%, culinary tourism 26% and educational tourism as much as 36%.

Cultural tourism puts forward the types of tourism activities that use culture as an object. One of the cultural elements contained in cultural tourism is the form and

architecture where in this case is the architecture of a house or a traditional house. According to Faisal, R.M, (2014) in his research, he explained that traditional house is a house that characterizes a certain region that symbolizes the culture of the local community. Until now, many tribes in Indonesia still maintain their traditional houses as an effort to preserve the values of their culture.

Tongkonan traditional house is a traditional house from the Toraja region located in South Sulawesi Province, Indonesia. Various potentials—ranging from beautiful tourist attractions, preserved local wisdom, and the form of traditional house—that are considered unique, makes Toraja a regency that is quite prominent in tourism surveyed according to the official tourism website.

The diversity of Indonesian culture has not been utilized by the government as cultural tourism attractions. According to an article reported by Arthur in his interview with Yohan Tangkesalu as the Tourism Promotion Agency for the 2018-2021 period, he was stated that the number of tourist attractions was still lacking, so that efforts are needed to advance tourism in the Toraja region in terms of promotion, especially the Tongkonan traditional house. To make the tourism sector of an area develops, it must be supported by good and attractive tourism promotion. Also, according to Apriani & Pahrul Irfan, tourism promotion can be done digitally or conventionally.[2] According to Martin Lister et al. The delivery of information through conventional media such as brochures, flyers, banners, and other print media is currently inadequate to attract. This is because objects such as parks, environments, and buildings are 3-dimensional objects. The project is not yet completed if the objects are only shown in 2-dimensional. The preliminary survey stated that the current millennial generation is more interested in getting information from digital/online media (about 57%) compared to getting information from friends/relations (about 22%) and from print/conventional media (about 21%).

Therefore, an approach needs to be conducted by making prospective tourists be able to observe or learn visually regarding the shape of the tourist attraction design before actually visiting it directly. According to Novrisa W. Wulandari in her writing, it states that, in average, a human is only able to remember 20% of the information heard, while 30% remember the information seen, and almost 90% of people can remember information based on what is experienced.[3] The design of promotional media for Tongkonan traditional house that will be offered used 3D Virtual Reality or 3-dimensional virtual reality that is used to observe things in a whole in the virtual world – simulated by a computer. Therefore, when people watch the virtual world, this is as if people experience first hand the incident. Ikpe Justice and Murali Shanker concluded that the visualization of the 3D/VR model is more effective compared to the visualization of the 2-D model.[4]

Virtual Reality (VR) is a technology that enables users to interact with certain environments that are imitated, including the shape and appearance of the environments simulated by a computer, which is known as computer-

simulated environment. By implementing VR, users can interact with virtual environments using standard input such as keyboard and mouse. At present, visual experiences are in the form of virtual reality. The visual experiences are generally displayed on a computer screen and sometimes displayed through stereoscopic VR. Some visualizations also contain information from sensing result including sound through the speaker[5][6].

According to Lacrama, the concept of VR refers to the system principles, techniques and, methods used in designing software products. The concept of VR is then used with the assistance of multimedia computer systems with specific device systems[7][8].

Judging from its ability, VR technology has the potential as a medium for cultural tourism promotion[9]. Users can directly interact with artificial objects and their environment. Users can also get a sensation from their sense of hearing. The advantages of VR include the ability in offering experiences resembling the real world. Hence in this paper, a Desktop-Based 3D Virtual Reality Visualization of Tongkonan Traditional House was developed. This application becomes an interactive promotional media to introduce Indonesian cultural tourism, especially traditional house tourism to the millennials. This promotional media product can be distributed to an event held by Tourism Promotion Board i.e. in exhibitions of traditional houses targeting the millennial generation.

2. Methods

a. Data Collection

Data sources are divided into two types, namely primary data and secondary data. Primary data is data obtained directly through the results of questionnaires that have been distributed randomly. The results were in the form of (1) data frequency report containing diagrams for the distribution of the first questionnaire, and (2) data frequency report containing percentages for the distribution of the second questionnaire. Secondary data was obtained indirectly through the collection of journals, thesis guidelines, books, and several articles on the internet.

The data collection instrument used in this study was questionnaires. This instrument is used to assess the effectiveness of the making of a research application. Data obtained from this questionnaire was quantitative data. The questionnaire is an efficient data collection technique (Sugiono 2013). The results of this questionnaire were quantified and analyzed to draw conclusions. Questionnaires were distributed twice, namely:

b. First Questionnaire Instrument

The making of the first questionnaire instrument was aimed at millennials from the age range of 18-30 years old. The first questionnaire was created using the google form questionnaire in order to obtain preliminary data – which is used to support the research problem. The questionnaire consisted of 8 questions reviewed in 3 aspects namely age, tourist destination, and promotional media.

Table 1. First Questionnaire Instrument

No	Assessment Aspects	Indicators	Number of Items	Question Number
1	Age	18-30 years old	1	1
2	Tourist Destination	Interest to tourist destination	2	2,4
		Frequency of visits	1	3
3	Promotional Media	Interest to promotional media	2	5,8
		Influence of promotional media	2	6,7

Table 2. Summary of User Response Instrument

No	Assessment Aspects	Indicators	Number of Items	Question Number
1	Display	3D Graphic	6	1,2,3,4,5,6
		Musical Instrument	2	7,8
2	Information	Information contents and language usage	7	9,10,11,12,13,14,15
3	Usability	Clarity of use	3	16,17, 18
4	Reliability	Navigation Performance	2	19,20

c. Second Questionnaire Instrument

The making of the user response instrument was addressed to millennials with an age range of 18-30 years old. The data was obtained randomly through questionnaire distribution. The results of this questionnaire were used as a measurement tool for testing the feasibility of the application for the millennial generation. Table 2 is the summary of the user response instrument.

Based on table 2, the evaluation aspects are the core questions of the questionnaire which consists of 4 aspects: display, information, usability, and reliability. Indicators are the subset of the core questions. This user response questionnaire consists of 20 questions to find out the percentage of the feasibility of the application developed.

d. Research Steps

The steps of research in developing Tongkonan Traditional House VR are explained as follows:

Data Collection : Data collection used to develop virtualization of Tongkonan Traditional House 3D VR.

Requirement Analysis : Formulation of the problem and recommendations given to solve the problem by using information technology.

Initial 3D Model Development : Designing the shape of the traditional house as a whole using the blender 2.79b software as well as the objects contained, in the form of 3-dimensional graphics.

Scientific Development : Creating a model design using the unity 3D 5.6.7f software by converting the 3-dimensional graphical models that have been created into 3D virtual reality form that can be accessed through the control application. Furthermore, adding information on each object contained in

the traditional house and other displays by embedding navigation controls using keyboard and mouse inputs.

Testing : Testing was done to assess the feasibility of the application being developed. The user response test was then analyzed and concluded from each question whether the user's response is in line with the desired results or not.

Final Model : The final model was generated after testing the user's response to the application developed.

e. ADDIE Model

The development of learning model used in this study is the ADDIE (Analysis-Design-Develop-Implement-Evaluate) Learning Design Model. This model is combined according to the research and development steps recommended by Borg and Gall based on several considerations such as suitable for developing instructional model product/targeted; effective and dynamic learning; and very helpful in the development of learning for teachers. The ADDIE instructional design model developed by Reiser and Mollenda (1990s) is a generic learning/training design model that guides the establishment of training tools and infrastructure – that are effective, dynamic and support training performance itself. Thus helping training instructors in managing training and learning [10][11].

Research and development methods are used to produce a particular product and to test the product itself. The test benefits to measure the effectiveness of a product. ADDIE model consists of five stages, including analysis, design, development, implementation, and evaluation [12].

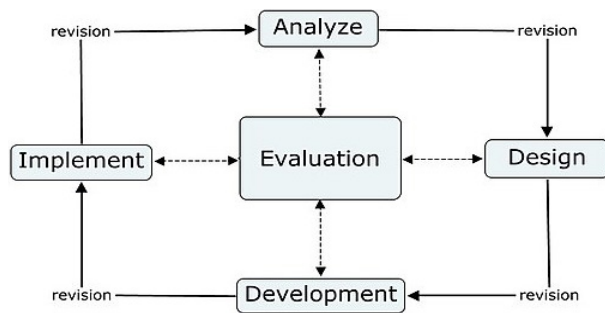


Figure 2. ADDIE Model

Source: Forest, E. (2014)

Figure 2 illustrates the five components of the ADDIE Model that are interrelated in a structured and systematic way, in which the first stage to the last stage in its distribution must be systematic and cannot be randomized in order.

Stage 1 : Analysis. The analysis phase is a process of requirements assessment (requirements analysis), identifying problems, and conducting task analysis. The outputs generated were the characteristics or profile of prospective students, the identification of requirements and detailed task analysis based on the requirements.

Stage 2 : Design. This stage is known as blueprint making. Like constructing a building, before being built, there must be a design on paper.

Stage 3 : Development. It is the process of realizing the blueprint or the design into reality. This means that at this stage, everything that is needed or that will support the learning process must all be prepared.

Stage 4 : Implementation. This step is a concrete step to implement the learning system that has been made. That means, in this stage, every element that has been developed is installed or set in such a way according to its role or function so that it can be implemented. After the product is ready, it is tested to a large group. Then it is evaluated and revised. After that, trials can be carried out on large groups and then re-evaluated and revised to produce a final product that is ready to be deployed.

Stage 5 : Evaluation. Evaluation is the process of observing whether the learning system being built is successful according to initial expectations or not. The evaluation phase was carried out at each of the four stages above. This evaluation method is called formative evaluations. The reason for choosing this method is for the purpose is for the revision needs. For example, at the design stage, we need expert review to provide input to the design we are making.

3. Results

a. 3D Blueprint of Tongkonan Traditional House

At the design stage, also known as blueprint making, before the construction starts, there must be a design on paper. The following figures are the blueprint designs for some of the tongkonan traditional house display designs. [13][14]

1) Design of the Front View of the Traditional House

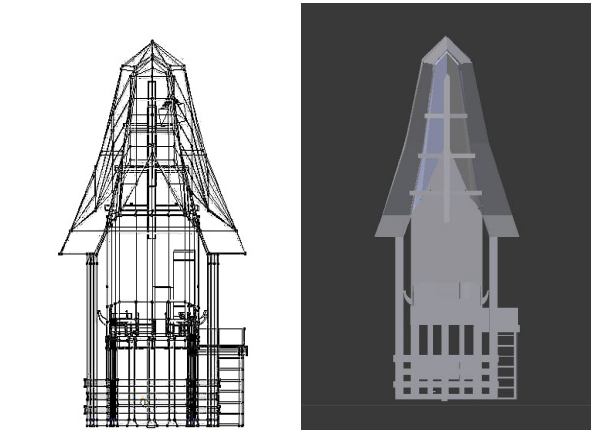


Figure 3. Blueprint of the Front View of the Traditional House

Figure 3 is the design of the front view of the Tongkonan traditional house. The left subfigure is the shape of the house in Blueprint view while the right subfigure is the shape of the house in solid form.

2) Design of the Right Side View of the Traditional House

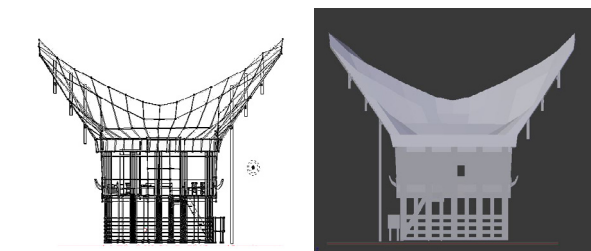


Figure 4. Blueprint of the Right Side of the Traditional House

Figure 4 is the view from the right side of the Tongkonan. The left subfigure is the shape of the house in Blueprint view while the right subfigure is the picture is the shape of the house in solid form.

3) Design of Interior Layout Display of the Traditional House

Figure 5 is the design of interior layout display of Tongkonan traditional house when being viewed from the Z-axis (top view). The left subfigure is the shape of the house in Blueprint view while the right subfigure is the shape of the house in solid

form. These layouts are the layout of the middle part of the traditional house (Kale Banua) where there are three rooms in it. The first room on the right is called Tangdo, the second room in the middle is called Sali, and the third room on the left is called Sumbung.



Figure 5. Blueprint of the Right Side of the Traditional House

b. Development of Tongkonan Traditional House

This step was carried out after the design making. The following are the results of the development step that have been made [2][8][15][16].

1) Front and Rear Views of the Traditional House

Figure 6 depicts the views from the front and rear sides of the Tongkonan traditional house that have been made:

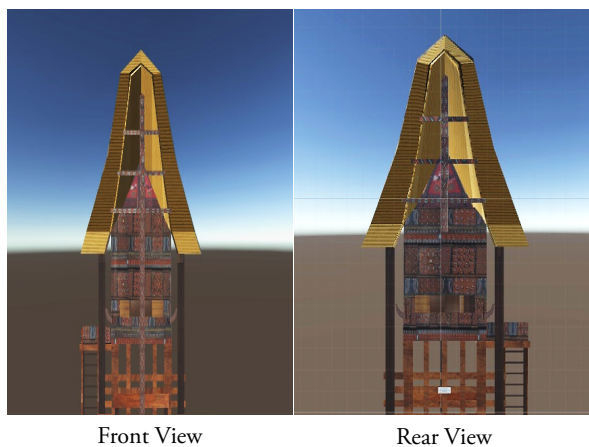


Figure 6. Front and Rear Views of the Traditional House

Figure 6 is the result of the previous design, in which there are additional materials such as wood, bamboo and boards, as well as textures on each layer of the traditional house in the form of wood textures and Toraja batik carving models.

2) The Display of the Left and Right Sides of the Traditional House

The following are the displays of the left and right sides of Tongkonan traditional house that have been made:

Figure 7 is the result of the previous design, in which there are additional materials such as wood, bamboo and boards, as well as textures on each layer of the traditional house in the form of wood textures and Toraja batik carving models.

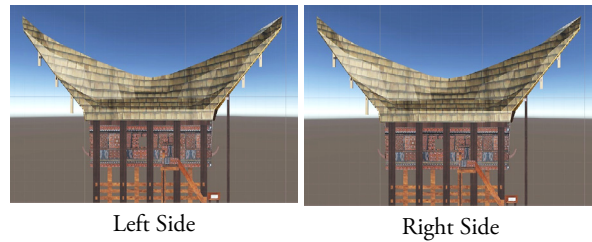


Figure 7. Left and Right Side Views of the Traditional House

3) The Display of the Rooms in the Traditional House

The following figures are the displays of the rooms in the Tongkonan traditional house that have been made:

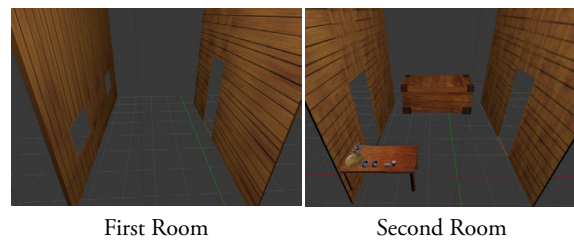


Figure 8. The Display of First and Second Rooms of the Traditional House

Figure 8 is the result of the previous design, in which there are additional materials such as wooden walls, wallboard, and wood texture on each layer of the room for the first room. The second room is the result of the previous design, in which there are additional materials such as a wooden coffin, wooden board, glass cups, plates and tables and wood textures, plates and cups at each layer of the room.



Figure 9. The Display of The Third Room (Sumbung)

Figure 9 is the result of the previous design, in which there are additional materials such as wooden walls, chairs, tables, mattresses, cabinets, as well as fabric textures for mattresses, wooden cabinet, wooden table, and chairs on each layer of the room.

c. Implementation of Tongkonan Traditional House 3D VR

This stage is the stage after the development of the traditional house, namely the design and development.

This phase is presented in the form of a desktop application.

1) Main Menu

The following is the display of the main menu when the application is opened:

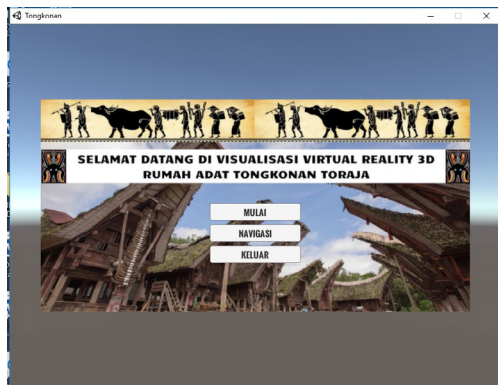


Figure 10. The Display of Main Menu

Figure 10 is the initial appearance when the application is opened. There are greetings and three menus that can be selected by the user, e.g. start menu, navigation menu, and exit menu.

2. Navigation Control

The following figure is the display of navigation control contained in the navigation menu on the main menu:

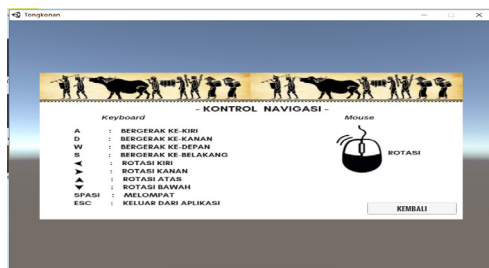


Figure 11. The Display of Navigation Control

Figure 11 is the display of the navigation menu on the main menu. It serves a user guide run the application. There are guidelines for using the keyboard and mouse.

3. The Display of The Information

The following figures are the displays when the user arrives at several objects.

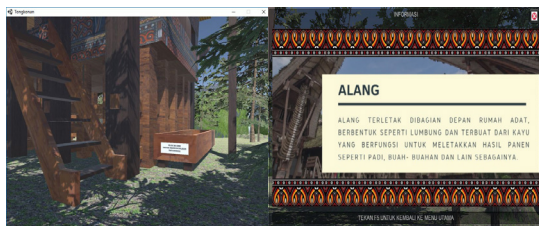


Figure 12. The Display of Alang Object

Figure 12 is a display of Alang located in front of the traditional house. There is an information to be clicked the Alang object on the side. There is the title of the object then followed by a brief description of the object.

The following figures are the display when the user arrives at the Sulluk section:

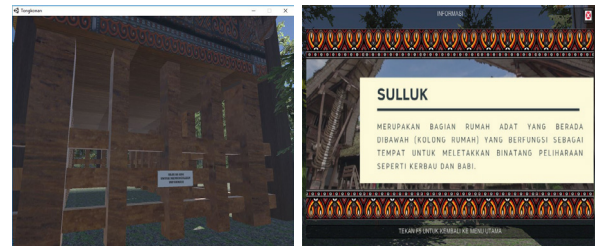


Figure 13. The Display of Sulluk Section

Figure 13 is a display of Sulluk section which is located behind the traditional house. There is an information to be clicked on the Sulluk section which is situated on the Sulluk pole.

The following is the display when the user arrives at the Inan Pa Bulan object:

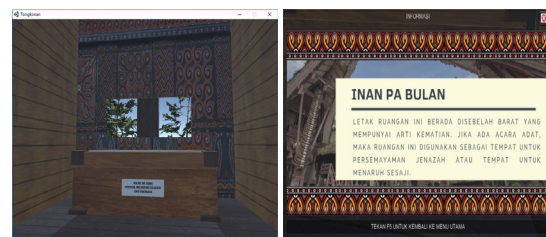


Figure 14. The Display of Inan Pa Bulan Object

Figure 14 is a display of Inan Pa Bulan object found in the second room of the traditional house. There is an information to be clicked on the front side of the chest. There is the title of the object then followed by a brief description of the object.

The following is the display when the user arrives at the Pa Dukkuan Api object:

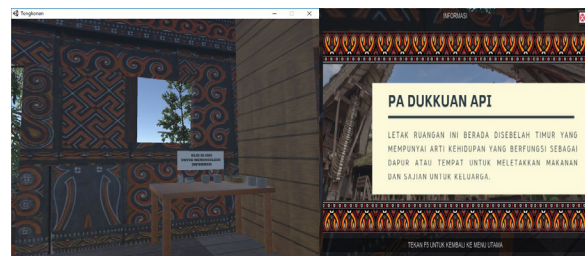


Figure 15 The Display of Pa Dukkuan Api Object

Figure 15 is a display of Pa Dukkuan Api object in the second room of the traditional house. There is an information to be clicked on the top of Pa dukkuan Api object.

The following figures are the display when the user arrives at the Tangdo section:

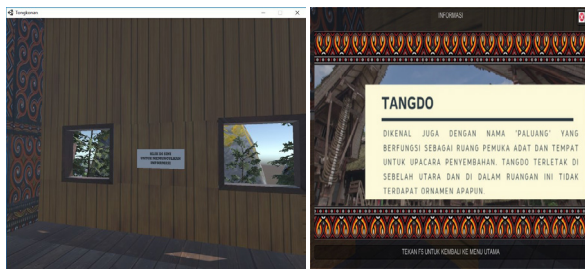


Figure 16 The Display of Tangdo Section

Figure 16 is a display of the Tangdo section in the first room of the traditional house. There is information to be clicked on the wall of the room.

The following figures are the display when the user arrives at the Sumbung section:

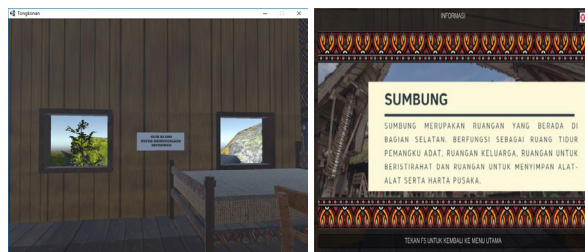


Figure 17 The Display of Sumbung Section

Figure 17 is a display of the Sumbung section in the third room of the traditional house. There is information to be clicked on the wall of the room.

d. User Response Evaluation

The evaluation of this study is in the form of a user response test, conducted by distributing questionnaires to 50 respondents who knew about the Tongkonan traditional house or the culture of the Toraja tribe. Questionnaires were given to be answered by respondents by giving 20 statements about the application which were equipped with information. The statements were measured with a range from very good (VG) to very poor (VP). Then to calculate the results of the quantity, Likert scale calculation was used.

Table 3 is the result of calculating the number of scale values and frequency of each statement. The is information in the form of a scale category at each frequency statement as well as the percentage of answers for each statement.

Table 3. Final Results of User Response Test

Question Number	Scale					Frequency	Category	Percentage
	VG (5)	G (4)	CB (3)	P (2)	VP (1)			
1	100	76	33	0	0	209	SB	84%
2	75	100	27	2	0	204	SB	82%
3	85	108	18	0	0	211	SB	84%
4	85	80	18	14	0	197	B	99%
5	115	92	12	0	0	219	SB	88%
6	130	80	12	0	0	222	SB	89%

Question Number	Scale					Frequency	Category	Percentage
	VG (5)	G (4)	CB (3)	P (2)	VP (1)			
7	185	44	3	0	0	232	SB	93%
8	175	60	0	0	0	235	SB	94%
9	95	108	12	0	0	215	SB	86%
10	125	68	15	0	0	208	SB	86%
11	125	68	9	0	0	202	SB	85%
12	40	100	48	0	0	188	B	95%
13	90	108	15	0	0	213	SB	85%
14	95	104	15	0	0	214	SB	86%
15	115	92	12	0	0	219	SB	88%
16	95	108	12	0	0	215	SB	86%
17	130	96	0	0	0	226	SB	90%
18	80	104	24	0	0	208	SB	83%
19	95	112	9	0	0	216	SB	86%
20	60	80	39	10	0	189	B	95%

4. Conclusion

Based on the results of the analysis and discussion that have been carried out, as well as testing of some user responses, the following conclusions are obtained:

1. The results of this application development allow users to explore the entire area of the Tongkonan Traditional House which is controlled by the user using keyboard and mouse inputs. The feature contained in the application is user interaction with objects that can display information of the object selected by the user. This application is also equipped with a musical instrument to support the atmosphere.
2. The results of the user response test to 50 respondents concerning to the 3D virtual reality visualization of desktop-based Tongkonan traditional house are 17 statements with 4 indicators. The given applications were answered 'Very Good' by 50 respondents as many as three statements were answered 'Good' by 50 respondents. Therefore, it can be concluded that this visualization can act as an interactive promotional media to the millennial generation.

For the research development, the concept of Virtual Reality can be developed in the form of Virtual Reality Simulation by creating an interesting and effective learning experience. Also, the Virtual Reality can be developed with interactive technology from real-world objects where objects from the virtual world seem to appear from real objects in 3D. Hence, users can get a more interactive user experience like the real world.

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Combination of K-Means and Simple Additive Weighting in Deciding Locations and Strategies of University Marketing

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Abstract—Every year UNIMUDA Sorong welcomes new students and keeps promoting to attract more. The process generates a growing number of student data. On the other hand, the promotional strategy to attract new students faces obstacles such as generalization among locations, ineffective time, limited personnel to carry out promotions, and cost inefficiency. This study examines the new student data and university marketing strategies to optimize time, effort, and cost. It uses the K-Means method for data grouping and the Simple Additive Weighting (SAW) for ranking the results of data grouping. The result of this research suggests that location of promotion may be determined from the clustering process using the K-Means method. The silhouette coefficient test invalidates the data clustering, and the SAW method helps the ranking process to obtain a sequence of promotion locations. The ranking results reflect the predetermined decision table that directs promotion location selection according to the promotion strategy. The combination of the two methods helps to decide the location and marketing strategy to optimize time, effort, and cost. The results of this study may be used as a comparative reference for the management to decide the right promotion strategy based on the locations and student background.

Keywords: k-means, simple additive weighting, promotion, new students

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1. Introduction

Competition to attract new student is very tight. Both public and private universities spend much money on promotion by advertising advantages such as low tuition fees and the ease of getting a job after graduation [1]. To survive, education institutions need to arrange the right promotion. Determining the right strategies may reduce costs and achieve promotional goals [2]. The community customers of educational services are very critical in questioning and selecting quality educational institutions. Parents are worried that their children may not be able to compete in the job market. [3].

Universitas Pendidikan Muhammadiyah (UNIMUDA) Sorong has an annual agenda of promotion to attracts new students within and outside the province of West Papua. Determining the location of the promotional activity refers to habitual practices and intuition every year, so it is necessary to investigate whether the location determination is right on target. Determining location quickly and accurately is not an easy task. Many things need to be considered, such as time, effort, and cost [1].

So far, the promotion strategy does not consider the target location. Using the same promotion strategy for all places may result in time-inefficiency, arduous effort, and high costs. Promotional activities have not used student data as a reference in selecting the methods and promotion strategies in attracting new students.

The student data can be analyzed using data mining techniques [4]. Such techniques process student admission data from past years to find patterns or information [5]. Patterns or information may be useful as a reference for making marketing policies [6]. Policies made based on student data are very important in streamlining limited time, energy, and costs.

The use of student data to make decisions regarding new student promotions has been widely observed. Rusli et al. have examined the decision support system for determining the location of promotion using the Analytical Hierarchy Process (AHP) and Technique Order Preference by Similarity to Ideal Solution (TOPSIS). This effort was made to improve the method of determining random promotional locations so that it becomes targeted, namely determining school locations that have the potential to

become promotional sites. The data criteria observed were districts and schools. The AHP and TOPSIS methods are combined in the first and second stage selection processes. The decision support system that was built was evaluated with a User Acceptance Test for further implementation [7].

Other observations were made using the AHP fuzzy method to determine potential areas as higher education promotion targets. Determining the location using last year's registrant data is the problem raised and solved using the AHP fuzzy method with the Triangular Fuzzy Number approach. The data criteria were distance, number of schools, number of students and last year's registrants [8]. Research on campus promotion strategy policies has been carried out using the Weighted Aggregated Sum Product Assessment (WASPAS) method. The problem raised was the random selection of promotion locations so that it was unknown which school had the most potential [9].

Zanakis et al. seeks to compare many decision-making methods such as Elimination Et Choix Traduisant la Realite (ELECTRE), TOPSIS, Multiplicative Exponential Weighting, and Simple Additive Weighting (SAW) Methods. Their observations showed that the best performance was produced by the SAW and MEW methods, followed by TOPSIS, AHP and ELECTRE [10]. Meanwhile, research conducted by Sunarti, namely Comparison of TOPSIS and SAW Methods For Home Selection, concluded that the calculation of the SAW method is more recommended than the TOPSIS method [11]. The comparison between the AHP and SAW methods conducted by Wicaksono shows that the SAW method has the highest accuracy compared to the AHP method [12]. Meanwhile, the comparison between the AHP and SAW fuzzy methods conducted by Erdiansyah et al obtained the results that SAW is more recommended than fuzzy AHP [13].

Studies that are described in the above paragraphs and related to the problems faced have led this study to use the SAW method in determining the location and strategy of university marketing to attract new students. However, Korsemov and Borrisova stated that the SAW method would be better and work more optimally with the help of other methods [14]. Therefore, this study combines SAW with the K-means. The reason is that the K-means method uses non-abstract and clear physical data, which is suitable for the data used in this study. Besides, the K-means method can classify a large number of data with relatively fast and efficient computation time [15].

Jain et al. Described the use of K-means as a clustering method which has been quite reliable for a long time [16]. The development of K-means has undergone several modifications with the emergence of variations such as Fuzzy C-means. However, Velmurugan revealed that the K-means algorithm performs better than the Fuzzy C-means algorithm [17]. In addition, in a survey published by Springer "Top 10 Algorithms in Data Mining", the K-means algorithm is placed in position 2 (two) as the most widely used algorithm in data mining and in the first position for clustering algorithms [18].

The contribution of this paper is to describe the research that combines the K-means method with the SAW method in determining the target location for promotion related to promotional strategies applied. The K-means method is used to divide student data into several clusters where each cluster has a different priority level in determining the location and strategy. The data for each cluster is further processed by the SAW method to obtain the final result in the form of a ranking. The results of this ranking become recommendations for decision makers in determining marketing strategies to attract new students.

2. Method

Combining the two methods can be done if one method functions as a data divider into several clusters and the other method acts as an alternative ranking. In this case, the K-means method is used to determine the best cluster. The best clusters are locations that match the predetermined data criteria. Meanwhile, the SAW method is used for the alternative data ranking process. The results of this ranking are used as a reference for recommendations in promoting new students at the selected location.

a. Data collection

The research data were obtained directly from the source (primary data), namely from the UNIMUDA Sorong admissions office. Determination of the weight value of each data criterion used is based on the decision of the college itself.

b. Research Stage

The research stage began with determining the problem and selecting the data criteria. Furthermore, the analysis was carried out using the k-means clustering method and ranking using the SAW method. The final stage is a recommendation and conclusion (figure 1).

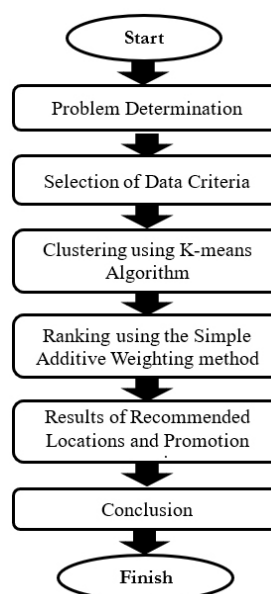


Figure 1. Research Stage

c. Problem Determination and Selection Criteria

The targets to be achieved in this research are to get the location and promotional strategy. The data criteria used in student data are sub-district data, parent's occupation, and the chosen study program.

There are arguments behind the selection of data criteria. The kecamatan data represent the distance between student residences and tertiary institutions. Residence distance is an important factor to streamline existing resources in visiting promotional locations. Parents' job data represent the economic conditions of students to examine the suitability of the strategy of promotion. Study program data was chosen because it is the place where students study. Higher education institutions focus on promotion in eastern Indonesia in accordance with government directives to advance education in the region [19].

To facilitate the data mining process, data criteria were initialized. Data initialization for each criterion can be seen in Table 1.

Table 1. Data criteria

Criteria	Sub Criteria	Value
Sub-District (V1)	1-100 km	8
	101-200 km	7
	201-300 km	6
	301-400 km	5
	401-500 km	4
Parents' job (V2)	>500	3
	Farmers / Fishermen	8
	General employees	7
	Government officer (either civil or military)	6
	Labor	5
	Entrepreneur	4
	Others	3
	Agribusiness	2
	Aquaculture	2
	Indonesian Language Education	1
	English language education	1
	Biology Education	1
	Pharmacy	2
Law	2	
Study program (V3)	Science education	2
	Mathematics education	1
	Primary teacher Education	1
	Physical education, health and recreation	1
	Civic education	1
	Information Technology Education	2
	Chemical Engineering	2
Civil Engineering	2	

The determination of the value of each sub-criterion is a decision of the college admissions team. The value of the sub-district data initialization uses the unit distance of kilometers (km) with a data range every 100 km. Selection of ranges is linked to the geography and demographics of West Papua. Travel to distances over 100 km takes a few days so it is not appropriate to lump them together in groups with distances under 100 km.

Initialization of parent job data uses a value of 1 to 8 according to the number of parents of students who are involved in the job. A score of 8 is given for the jobs most parents are involved in. Lower marks are assigned to jobs that are less engaged.

Study program data were initialized with a value of 1 and 2. A score of 1 was given to study programs that had been around for a long time, namely those that had been established in the range 2004 to 2014. While study programs that were established after 2015 were given a score of 2.

The promotion strategies used are presented in table 2, as has been carried out so far by universities.

Table 2. Promotion strategies

Code	Promotion
P1	Social media
P2	TV, Radio, Newspaper Ads - Mass media
P3	Brochure Spread
P4	Installation of banners, flyers, banners
P5	Education Exhibition
P6	Outreach to schools
P7	Scholarship
P8	Invitation Line Promotion
P9	Broadcast SMS

Recommendations on the decision tree can be seen in table 3. The decision tree is extracted from the results of interviews from the PMB committee, which are then compiled in the form of new student promotion provisions. The decision tree has determined the value to be achieved, for example if the criteria V1, V2, and V3 get values 7-8, 8, and 1, then the promotion strategies recommended is P3, P4, P5, P6.

The distance factor greatly influences the promotion strategy carried out, because of the geography of the West Papua region which consists of islands [20]. So that transportation from universities to the target location for promotion must use the sea route. Parents' work also influences the promotion strategy. Most of the jobs of parents fall into the lower middle income category, for example jobs in the agriculture, plantation, forestry, hunting, fishery and labor sectors [21]. So the promotion strategies carried out have been adjusted to the economic conditions of the students.

Table 3. Decision Tree

sub-District		Parents' job	Study program	Promotion Code
Min	Max			
7	8	8	1	P3,P4,P5,P6
5	6	8	1	P1,P2,P3,P5,P8
3	4	8	1	P1,P2,P9,P8
7	8	8	2	P3,P4,P5,P6,P7
5	6	8	2	P1,P2,P3,P5,P8,P7
3	4	8	2	P1,P2,P9,P8,P7
7	8	7	1	P3,P4,P5,P6
5	6	7	1	P1,P2,P3,P5,P8
3	4	7	1	P1,P2,P9,P8
7	8	7	2	P3,P4,P5,P6,P7
5	6	7	2	P1,P2,P3,P5,P8,P7
3	4	7	2	P1,P2,P9,P8,P7
7	8	6	1	P3,P4,P5,P6
5	6	6	1	P1,P2,P3,P5,P8
3	4	6	1	P1,P2,P9,P8
7	8	6	2	P3,P4,P5,P6,P7
5	6	6	2	P1,P2,P3,P5,P8,P7
3	4	6	2	P1,P2,P9,P8,P7
7	8	5	1	P3,P4,P5,P6
5	6	5	1	P1,P2,P3,P5,P8
3	4	5	1	P1,P2,P9,P8
7	8	5	2	P3,P4,P5,P6,P7
5	6	5	2	P1,P2,P3,P5,P8,P7
3	4	5	2	P1,P2,P9,P8,P7
7	8	4	1	P3,P4,P5,P6
5	6	4	1	P1,P2,P3,P5,P8
3	4	4	1	P1,P2,P9,P8
7	8	4	2	P3,P4,P5,P6,P7
5	6	4	2	P1,P2,P3,P5,P8,P7
3	4	4	2	P1,P2,P9,P8,P7
7	8	3	1	P3,P4,P5,P6
5	6	3	1	P1,P2,P3,P5,P8
3	4	3	1	P1,P2,P9,P8
7	8	3	2	P3,P4,P5,P6,P7
5	6	3	2	P1,P2,P3,P5,P8,P7
3	4	3	2	P1,P2,P9,P8,P7

d. K-means Clustering

K-means clustering is a non-hierarchical data grouping method that classifies data in the form of one or more clusters. Data that have the same characteristics are grouped into one group and data that have different characteristics are separated into other groups. Data within one group has a small degree of variation [22]. The stages of the clustering process using the K-means method are as follows [23].

- 1) Determine the number of clusters.
- 2) Select the initial centroid randomly according to the number of clusters.

- 3) Calculate the data distance to the centroid with the euclidean distance formula.

$$d_{xy} = \sqrt{\sum_{i=1}^n (x_i - y_i)^2} \quad (1)$$

- 4) Update the centroid by calculating the average value of the values in each cluster
- 5) Return to stage 3 if there is still data that has moved clusters or changes in the centroid value.

The determination of the K value uses the silhouette coefficient (SC) method. SC is used to see the quality and strength of the cluster, whether the objects placed in the cluster are called good. This method is used for cluster validation by combining the values of cohesion and separation. The SC value is in the range 1 to -1 with a value close to 1 which means minimizing the distance between objects in a cluster as well as maximizing the distance between the clusters. The SC value of an object i is calculated using equation (2) [24].

$$s(i) = \frac{b(i) - a(i)}{\max\{a, b\}} \quad (2)$$

where :

$a(i)$ is the average distance between object i and all objects in the same cluster.

$b(i)$ is the average distance between object i and all objects in the closest cluster.

The criteria for SC value according to Kaufman and Rousseeuw [25] are:

- a) $0.7 < SI \leq 1$ strong structure
- b) $0.5 < SI \leq 0.7$ medium structure
- c) $0.25 < SI \leq 0.5$ weak structure
- d) $SI \leq 0.25$ no structure

e. Simple Additive Weighting

Simple Additive Weighting is one of the Multi Attribute Decision Making (MADM) methods [26]. This method is often known as weighted summation method [27]. The total score for an alternative is obtained by summarizing the multiplication result between the rank and the weight of each attribute [28]. The SAW method requires a decision matrix normalization process (X) to be proportional to all existing alternative ratings.

The stages of the SAW method are as follows:

- 1) The normalization of the matrix is adjusted according to the type of attribute so that a normalized matrix is obtained [29]. The matrix normalization calculation is shown in Equation (3).

$$r_{ij} = \frac{x_{ij}}{\begin{matrix} \max_i x_{ij} & (\text{benefit}) \\ \min_i x_{ij} & (\text{cost}) \end{matrix}} \quad (3)$$

where :

r_{ij} : The performance rating value is normalized

- x_{ij} : The attribute value that each criterion has
 - $x_{ij}/\max_i x_{ij}$: The greatest value of each criterion
 - $x_{ij}/\min_i x_{ij}$: The smallest value for each criterion
- 2) The calculation of the last alternative value is done using equation (4) [30].

$$V_i = \sum_j^n = 1 w_j r_{ij} \tag{4}$$

Information :

- v_i : The final value of the alternatives
 - w_j : The weight value of each criterion
 - r_{ij} : The performance ranking value is normalized
 - n : Number of criteria
- 3) Perform ranking based on the preference value of each alternative that is the best result of the assessment.

Table 4. Weight of the Assessment Criteria

	V1	V2	V3
Attribute	Benefit	Benefit	Cost

The value of benefit and cost in equation (4) can be seen in Table 4. Determining v1 and v2 as benefit attributes because they are the main factors that affect distance and student economic conditions which in turn affect the location and promotion strategy. Meanwhile, v3 is a cost attribute as a supporting factor in sorting the distribution of students for each study program.

3. Result

This study uses student data from 2015 to 2019 with a total of 2576 people.

a. Preprocessing Data

Data preprocessing is carried out so that there is no data duplication, no missing values so that the data can be processed and does not damage the research results. The data preprocessing stages are:

1. Perform data selection.
This is the selection of the data criteria used in the study. The results of data selection are sub-district, parent's occupation, and study program.
2. Perform data cleaning.
The purpose of cleaning data is to remove noise, clean data that does not match the specified value, and clean empty data. So that the results of data cleaning obtained data of 2,396 students. The reduction in this data is due to the fact that some sub-district data and parents' occupations are empty, the sub-district data does not match the city / regency and province, the double occupation data for parents.
3. Transformation
Changes in the form or initialization of research data in order to facilitate the data mining process. The provisions for the initialization value can be seen in table 1, while the results of the initialization of student data can be seen in table 5.

Table 5. Student Data

Student	V1	V2	V3
Student 1	8	8	2
Student 2	8	4	2
Student 3	8	5	2
Student 4	8	7	2
Student 5	8	6	2
Student 6	8	8	2
Student 7	8	4	2
Student 8	8	6	2
Student 9	8	8	2
...
Student 2396	8	7	1

Source: primary data

b. K-means calculations

The calculation is done is to determine the centroid initial randomly selected from all attribute data. Selection of the initial centroid, namely the value of k = 6. This provision is based on the initial target of promotion carried out by the admission team, namely 6 locations. This is done by considering the limited resources available to carry out promotions at the 6 locations. The initial centroid can be seen in table 6.

Table 6. Initial Centroid

Centroid	Student	V1	V2	V3
C1	Student 43	3	8	2
C2	Student 254	8	3	2
C3	Student 872	6	6	2
C4	Student 1229	5	8	2
C5	Student 1467	7	8	1
C6	Student 2193	4	6	1

Calculation of the distance of each data to each centroid is done by equation (1).

$$\begin{aligned}
 C1 &= \sqrt{(v1 - C1v1)^2 + (v2 - C1v2)^2 + (v3 - C1v3)^2} \\
 C1 &= \sqrt{(8 - 3)^2 + (8 - 8)^2 + (2 - 2)^2} = 5 \\
 C2 &= \sqrt{(v1 - C2v1)^2 + (v2 - C2v2)^2 + (v3 - C2v3)^2} \\
 C2 &= \sqrt{(8 - 8)^2 + (8 - 3)^2 + (2 - 2)^2} = 5 \\
 C3 &= \sqrt{(v1 - C3v1)^2 + (v2 - C3v2)^2 + (v3 - C3v3)^2} \\
 C3 &= \sqrt{(8 - 6)^2 + (8 - 6)^2 + (2 - 6)^2} = 2,8284 \\
 C4 &= \sqrt{(v1 - C4v1)^2 + (v2 - C4v2)^2 + (v3 - C4v3)^2} \\
 C4 &= \sqrt{(8 - 5)^2 + (8 - 8)^2 + (2 - 1)^2} = 3 \\
 C5 &= \sqrt{(v1 - C5v1)^2 + (v2 - C5v2)^2 + (v3 - C5v3)^2} \\
 C5 &= \sqrt{(8 - 7)^2 + (8 - 8)^2 + (2 - 1)^2} = 1,414 \\
 C6 &= \sqrt{(v1 - C6v1)^2 + (v2 - C6v2)^2 + (v3 - C6v3)^2} \\
 C6 &= \sqrt{(8 - 4)^2 + (8 - 6)^2 + (2 - 1)^2} = 4,5826
 \end{aligned}$$

The calculation continues until the nth data is 2396th data. In order to obtain the distance matrix, namely c1, c2, c3, c4, c5 and c6. Comparison and selection of the closest distance between the data and the cluster center were

conducted. This distance indicates that the data is in one group with the closest cluster. The results of calculating the distance of each data to each centroid in iteration 1 can be seen in table 7.

Then the result of the average value of each cluster is used as the new centroid in the next iteration. The average value can be seen in table 8.

After getting the new centroid value, the next iteration is carried out until the centroid value for each cluster does not change. In this study, the calculation process stopped at the 5th iteration. With the value of the centroid of the

4th iteration and the 5th iteration does not change. The results of iteration 5 calculations can be seen in table 9 below.

Table 9 is the final stage of the iteration, the centroid is in accordance with each cluster. Cluster 1 has 72 members, cluster 2 has 456 members, cluster 3 has 74 members, cluster 4 has 463 members, cluster 5 has 87 members and cluster 6 has 1,244 members. The closest distance and cluster members are also listed in the table. From the results of the last iteration, cluster members are formed with the average value as shown in table 10.

Table 7. Iteration Calculation Results 1

Student	C1	C2	C3	C4	C5	C6	Closest distance
Student 1	5	5	2.8284	3	1.4142	4.5826	1.4142
Student 2	6.4031	1	2.8284	5	4.2426	4.5826	1
Student 3	5.8310	2	2.2361	4.2426	3.3166	4.2426	2
Student 4	5.0990	4	2.2361	3.1623	1.7321	4.2426	1.7321
Student 5	5.3852	3	2	3.6056	2.4495	4.1231	2
Student 6	5.0000	5.0000	2.8284	3.0000	1.4142	4.5826	1.4142
Student 7	6.4031	1	2.8284	5	4.2426	4.5826	1
Student 8	5.3852	3	2	3.6056	2.4495	4.1231	2
Student 9	5	5	2.8284	3	1.4142	4.5826	1.4142
...
Student 2396	5.1962	4.1231	2.4495	3.3166	1.4142	4.1231	1.4142

Table 8. Iteration Average Value 1

Cluster	V1	V2	V3
C1	3	7.555556	1.833333
C2	7.984018265	4.648402	1.883562
C3	7.738609113	5.997602	1.992806
C4	5.588235294	7.882353	1.882353
C5	7.972383721	7.656977	1.859012
C6	6.053097345	6.283186	1.460177

Table 9. Iteration Calculation Results 5

Student	C1	C2	C3	C4	C5	C6	Closest distance	Cluster
Student	4.6140	3.3521	2.0034	2.2957	0.3805	4.0453	0.3805	C5
Student 2	5.4966	0.6606	2.0034	4.1888	3.6506	2.8555	0.6606	C2
Student 3	4.9982	0.3693	1.0068	3.3878	2.6517	2.6845	0.3693	C2
Student 4	4.5299	2.3529	1.0068	2.3107	0.6636	3.3633	0.6636	C5
Student 5	4.6638	1.3551	0.1169	2.7218	1.6541	2.8738	0.1169	C3
Student 6	4.6140	3.3521	2.0034	2.2957	0.3805	4.0453	0.3805	C5
Student 7	5.4966	0.6606	2.0034	4.1888	3.6506	2.8555	0.6606	C2
Student 8	4.6638	1.3551	0.1169	2.7218	1.6541	2.8738	0.1169	C3
Student 9	4.6140	3.3521	2.0034	2.2957	0.3805	4.0453	0.3805	C5
...
Student 2396	4.5764	2.5109	1.3384	2.4483	1.0786	3.5013	1.0786	C5

Table 10. The average value of the formed clusters

	V1	V2	V3
Cluster 1	5.315789	4.973684	1.973684
Cluster 2	5.758621	7.534483	1.827586
Cluster 3	3.480769	7.115385	1.711538
Cluster 4	7.963768	6.000000	1.888889
Cluster 5	7.979545	4.650000	1.884091
Cluster 6	7.960545	7.647776	1.861549

Table 10 shows that the average value of cluster 1 is the value of the sub-district, namely 5.315789, the value of parents' work is 4.973684, the value of the study program is 1, 973684 and so on until cluster 6 as shown in table 10..

From the clustering results obtained, the average distance of each jth object is calculated with all objects in the same cluster. Then find the minimum value of the average distance of each object to j-j with all objects in different clusters. Next, look for the SC value of each jth data, so that the coefficient value is the same as the number of datasets. The results of the SC calculation are added up and then divided by the amount of data used. The results of calculating the SC value can be seen in Table 11.

Table 11. SC Calculation Results

Cluster	S(i)
Cluster 1	-0.65814
Cluster 2	0.783079
Cluster 3	-0.67237
Cluster 4	0.799798
Cluster 5	-0.93773
Cluster 6	0.824969

Testing of the number of clusters using 2396 test data, where to find out the best cluster based on the results of the SC value. The cluster values to be tested are k values 1 to 6. In the results of the testing process, the best cluster quality is obtained in cluster 2 with a value of 0.783079, cluster 4 with a value of 0.799798, and cluster 6 with a value of 0.824969 which means that it is included in strong structure category. Cluster 1, cluster 3, and cluster 5 get Si value <= 0.25 which means no structure.

c. Simple Additive Weighting

After obtaining the final centroid of K-means calculation, the next step is calculated using the SAW method to determine the ranking of each cluster member. There are 6 clusters formed from the K-means calculation. The first step is to normalize the data, the value of all members in each attribute is calculated by equation (3). The value included in the benefit attribute is calculated as the max value, and includes the cost attribute which is calculated as the min value. In calculating the member value for each attribute using equation (4).

$$\begin{bmatrix} 5.3 & 5 & 2 \\ 5.8 & 7.5 & 1.8 \\ 3.5 & 7.1 & 1.7 \\ 8 & 6 & 1.9 \\ 8 & 4.7 & 1.9 \\ 8 & 7.6 & 1.9 \end{bmatrix} \tag{4}$$

In solving the value of the attribute, namely by using the SAW method. The first step is to normalize the X matrix.

Normalization V1 :

$$\begin{aligned} r_{12} &= \frac{8}{\max(5.2, 5.8, 3.5, 8, 8, 8)} = \frac{8}{8} = 1 \\ r_{12} &= \frac{8}{\max(5.2, 5.8, 3.5, 8, 8, 8)} = \frac{8}{8} = 1 \\ r_{12} &= \frac{8}{\max(5.2, 5.8, 3.5, 8, 8, 8)} = \frac{8}{8} = 1 \\ r_{12} &= \frac{8}{\max(5.2, 5.8, 3.5, 8, 8, 8)} = \frac{8}{8} = 1 \\ r_{12} &= \frac{8}{\max(5.2, 5.8, 3.5, 8, 8, 8)} = \frac{8}{8} = 1 \\ r_{12} &= \frac{8}{\max(5.2, 5.8, 3.5, 8, 8, 8)} = \frac{8}{8} = 1 \end{aligned}$$

Normalization V2 :

$$\begin{aligned} r_{14} &= \frac{7.5}{\max(5, 7.5, 7.1, 6, 4.7, 7.6)} = \frac{7.5}{7.6} = 0.9852861 \\ r_{14} &= \frac{7.5}{\max(5, 7.5, 7.1, 6, 4.7, 7.6)} = \frac{7.5}{7.6} = 0.9852861 \\ r_{18} &= \frac{7.6}{\max(5, 7.5, 7.1, 6, 4.7, 7.6)} = \frac{7.6}{7.6} = 1 \\ r_{18} &= \frac{7.6}{\max(5, 7.5, 7.1, 6, 4.7, 7.6)} = \frac{7.6}{7.6} = 1 \\ r_{18} &= \frac{7.6}{\max(5, 7.5, 7.1, 6, 4.7, 7.6)} = \frac{7.6}{7.6} = 1 \\ r_{18} &= \frac{7.6}{\max(5, 7.5, 7.1, 6, 4.7, 7.6)} = \frac{7.6}{7.6} = 1 \end{aligned}$$

Normalization V3 :

$$\begin{aligned} r_{20} &= \frac{1.8}{\min(2, 1.8, 1.7, 1.9, 1.9, 1.9)} = \frac{1.8}{1.7} = 0.936502 \\ r_{20} &= \frac{1.8}{\min(2, 1.8, 1.7, 1.9, 1.9, 1.9)} = \frac{1.8}{1.7} = 0.936502 \\ r_{24} &= \frac{1.9}{\min(2, 1.8, 1.7, 1.9, 1.9, 1.9)} = \frac{1.9}{1.7} = 0.919416 \\ r_{24} &= \frac{1.9}{\min(2, 1.8, 1.7, 1.9, 1.9, 1.9)} = \frac{1.9}{1.7} = 0.919416 \\ r_{24} &= \frac{1.9}{\min(2, 1.8, 1.7, 1.9, 1.9, 1.9)} = \frac{1.9}{1.7} = 0.919416 \\ r_{24} &= \frac{1.9}{\min(2, 1.8, 1.7, 1.9, 1.9, 1.9)} = \frac{1.9}{1.7} = 0.919416 \end{aligned}$$

From the results of normalization, the matrix is obtained as shown in table 12.

Table 12. Normalization Results

	V1	V2	V3
cluster 1	0.666177	0.6503439	0.867179
cluster 2	0.721673	0.9851861	0.936502
cluster 3	0.436211	0.9303861	1
cluster 4	0.998023	0.7845418	0.906109
cluster 5	1.000000	0.6080199	0.908416
cluster 6	0.997619	1	0.919416

The next step is the ranking process using the criteria weights that have been given by the decision maker using equation (3). The ranking calculations for alternatives in criteria 1 to criteria 6 are as follows:

$$\begin{aligned} \text{Cluster 1} &= (0.45 * 0.666177) + (0.35 * 0.650344) + \\ &\quad (0.20 * 0.867179) \\ &= 0.700836 \\ \text{Cluster 2} &= (0.45 * 0.721673) + (0.35 * 0.985186) + \\ &\quad (0.20 * 0.936502) \\ &= 0.856868 \\ \text{Cluster 3} &= (0.45 * 0.436211) + (0.35 * 0.930386) + \\ &\quad (0.20 * 1) \\ &= 0.721930 \\ \text{Cluster 4} &= (0.45 * 0.998023) + (0.35 * 0.784542) + \\ &\quad (0.20 * 0.906109) \\ &= 0.904922 \\ \text{Cluster 5} &= (0.45 * 1) + (0.35 * 0.608020) + (0.20 * \\ &\quad 0.908416) \\ &= 0.844490 \\ \text{Cluster 6} &= (0.45 * 0.997619) + (0.35 * 1) + (0.20 * \\ &\quad 0.919416) \\ &= 0.982812 \end{aligned}$$

The results of the alternative ranking calculations that have been sorted can be seen in table 13.

Table 13. Alternative Ranking Calculation Results

No	Cluster	Nilai
1	Cluster 6	0.982812
2	Cluster 4	0.904922
3	Cluster 2	0.856868
4	Cluster 5	0.844490
5	Cluster 3	0.721930
6	Cluster 1	0.700836

The results of the ranking in table 13 show that the highest value is in cluster 6 with a value of 0.982812, then cluster 4 with a value of 0.904922, cluster 2 gets a value of 0.856868, cluster 5 gets a value of 0.844490, cluster 3 gets a value of 0.721930, and cluster 1 gets a final value of 0.700836.

d. Decision Recommendation

Referring to the decision tree that has been determined in table 3, the results of the ranking using the SAW method are used as a recommendation for decision making. The decision tree recommendations is presented in table 14.

Table 14 shows that the first rank is cluster 6 with a value of v1 which is 5.3, the value of v2 is 5, and the value of v3 is 2. The promotion recommended for this cluster is the promotion strategy P1: Social Media, P2: TV-Radio-Newspaper Advertising, Mass media, P3: Brochure distribution, P5: Education Exhibition, P7: Scholarships, and P8: Promotion through invitation. The recommended location for promoting new students in this cluster is the location provided that the distance from the tertiary

institution is between 301 and 400 km. Besides that, the average job condition of the parents of students at this location is as laborers.

Table 14. Recommended Decisions

Cluster	V1	V2	V3	Promotion strategy
Cluster 6	5.3	5	2	P1,P2,P3,P5,P8,P7
Cluster 4	5.8	7.5	1.8	P1,P2,P3,P5,P8,P7
Cluster 2	3.5	7.1	1.7	P1,P2,P9,P8,P7
Cluster 5	8	6	1.9	P3,P4,P5,P6,P7
Cluster 3	8	4.7	1.9	P3,P4,P5,P6,P7
Cluster 1	8	7.6	1.9	P3,P4,P5,P6,P7

In cluster 4, it is ranked second with a v1 value of 5.8, a v2 value of 7.5, and a v3 value of 1.8. Promotions recommended for this cluster are P1: Social Media, P2: TV-Radio-Newspaper-Mass Media Ads, P3: Brochure Distribution, P5: Education Exhibition, P7: Scholarships, and P8: Invitation Promotion. The recommended location for promoting new students in this cluster is the location provided that the distance from the university is between 201 km to 300 km. And the average condition of the parents' work at this location is as private employees.

In cluster 2, it is ranked third with a v1 value of 3.5, a v2 value of 7.1, and a v3 value of 1.7. Promotions recommended for this cluster are P1: Social Media, P2: TV-Radio-Newspaper-Mass Media Ads, P7: Scholarships, and P8: Invitation Promotion, and P9: Broadcast SMS. The recommended location for promoting new students in this cluster is the location provided that the distance from the college is above 500 km. And the average condition of the parents' work at this location is as private employees.

In cluster 5, it is ranked third with a v1 value of 8, a v2 value of 6, and a v3 value of 1.9. Promotions recommended for this cluster are P3: Distribution of Brochures, P4: Posting Banners, Pamphlets, Banners, P5: Education Exhibition, P6: Socialization to schools, and P7: Scholarships. The recommended location for promoting new students in this cluster is the location provided that the distance from the college is between 1 km to 101 km. And the average conditions of work for parents of students at this location are PNS / TNI / POLRI (government servicepeople and the military).

Cluster 3 gets the third rank with a v1 value of 8, a v2 value of 4.7, and a v3 value of 1.9. Promotions recommended for this cluster are P3: Distribution of Brochures, P4: Posting Banners, Pamphlets, Banners, P5: Education Exhibition, P6: Socialization to schools, and P7: Scholarships. The recommended location for promoting new students in this cluster is the location provided that the distance from the college is between 1 km to 101 km. And the condition of the average work of the parents of students at this location is as laborers.

In cluster 1, it is ranked third with a v1 value of 8, a v2 value of 7.6, and a v3 value of 1.9. Promotions recommended for this cluster are P3: Distribution of Brochures, P4: Posting Banners, Pamphlets, Banners, P5:

Education Exhibition, P6: Socialization to schools, and P7: Scholarships. The recommended location for promoting new students in this cluster is the location provided that the distance from the college is between 1 km to 101 km. And the average job conditions of parents of students at this location are farmers and fishermen.

Recommendations are presented in the form of patterns that are useful as the output of this study. The output answers the problems formulated from the start. The decision formulation is obtained by presenting the formed clusters and the promotion strategies listed for each cluster.

This study shows that the combination of the k-means method with SAW can be applied to new student admissions data for the purposes of determining how to promote, both in determining the location or strategy of promotion. Data criteria can be varied to suit the needs and presentation of information.

4. Conclusion

The discussion in the Results section shows that the K-means method has produced 6 clusters. The Silhouette coefficient calculation suggests that cluster 2, cluster 4, and cluster 6 belong to a strong structure. Meanwhile, cluster 1, cluster 3, and cluster 5 go into the no structure category. Cluster ranking using the SAW method produces the following sequence: (1) cluster 6, (2) cluster 4, (3) cluster 2, (4) cluster 5, (5) cluster 3, and (6) cluster 1. The ranking provides six recommendations as to potential locations for conducting new student promotions. The decision for location selection agrees with the promotional strategies as described in the decision tree table.

The combination of the K-means and SAW methods produces a recommendation for promotion locations and the strategy that matches the criteria for the particular promotion locations. The management will hopefully use the generated recommendations to make decisions regarding promotion.

The combination of the two methods yet has drawbacks. There is a similarity in the value of the data criteria between one sub variable and another. It has an effect on the results of grouping using the K-means method resulting in the similarity of the calculated data on the sub-variables.

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Analysis of Communication Network Patterns of Home Industries (A Case Study in Tambaksari, Rowosari, Kendal)

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Abstract-Tambaksari is a village in Kendal Regency that has home industries (*Industri Rumahan*, IR). The local government classifies these industrial activities of BUMDes (Village-Owned Enterprises) into three groups, namely IR-1, IR-2, and IR-3. Each group or class has its specific criteria. The significant local potentials in Tambaksari include fish farming and processing. The advantage of the local potential in Tambaksari is inseparable from the synergy between the local government and the people of Tambaksari. This study observed the patterns of actor interactions in 64 IRs in Tambak Sari. Data were collected from questionnaires and analyzed using the Social Network Analysis (SNA) method. The results showed that Tambaksari IRs have a network density of 5.5%, which suggests that the relationship was weak. Network analysis using UCINET illustrates the separation of the IR group, which further reinforces the existence of competition in the network. The study reveals the dominant actor in the network interaction based on the measure of degree centrality, closeness centrality, and betweenness centrality. He is the actor with id # 29 who is the Chairman of IR-2, 54 years old, who has a Pindang Fish Processing.

Keywords: BUMDes, home industry, social network analysis

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1. Introduction

Tambaksari Village, Rowosari District, Kendal Regency is a village that has great potential in terms of fish processing. Local government groups these industrial activities into a group of BUMDes (Village-Owned Enterprises) under the leadership and responsibility of Mr. Bagus Setiawan as the director. Based on the results of interviews with the Tambaksari BUMDes, it was stated that home industries (*industry rumahan*, IR) in Tambaksari village was divided into 3 IRs, namely IR-1, which means that the business involves 1 or 2 actors, IR-2 consists of 3 to 4 actors, and IR-3 which is industrial scale involving more than 4 actors. The IRs under the BUMDes include fish farming and processing by people who are grouped into Home Industries. In order to support the home industries, the village government holds a meeting every 2 months, providing assistance, training, and provide capital so that the community are encouraged to work together with the village government to increase the potential of

Tambaksari Village. Strong synergy between actors from both the village government and the community has made the Home Industry in Tambaksari as a pilot project of Home Industry at the Kendal Regency Level.

The management of BUMDes of Tambaksari is carried out in an effective, efficient and structured manner [1]. Configuration of the communication network is carried out to determine the roles of actors [3] [4] from government to actors in the Home Industry and data flow that helps the development of BUMDes Tambaksari. A review of the communication network between the BUMDes actors needs to be conducted, so that it can useful for other villages to develop the potential of their villages, which focuses on how to create network configurations that increase accessibility to data sources, as well as to regulate the access right (Brass, 1984) in [2].

This paper reports the analisis of communication network of Tambaksari Home Industry using Social Network Analysis (SNA). SNA was used to model or map the communication network in BUMDes Tambaksari,

Rowosari District. UCINET was used as a tool in Network Analysis.

The results of the mapping shows the relationship between home industry actors. It can be referred to find out what factors that influence the home industry relationship in Tambaksari

2. Method

a. Research Flowchart

The study used a questionnaire survey method covering all home industries industry rumahan, IR) in Tambaksari, Rowosari District. The IR actots in Tambaksari already knew each other.. The research stages are described in the flowchart, Figure 1.

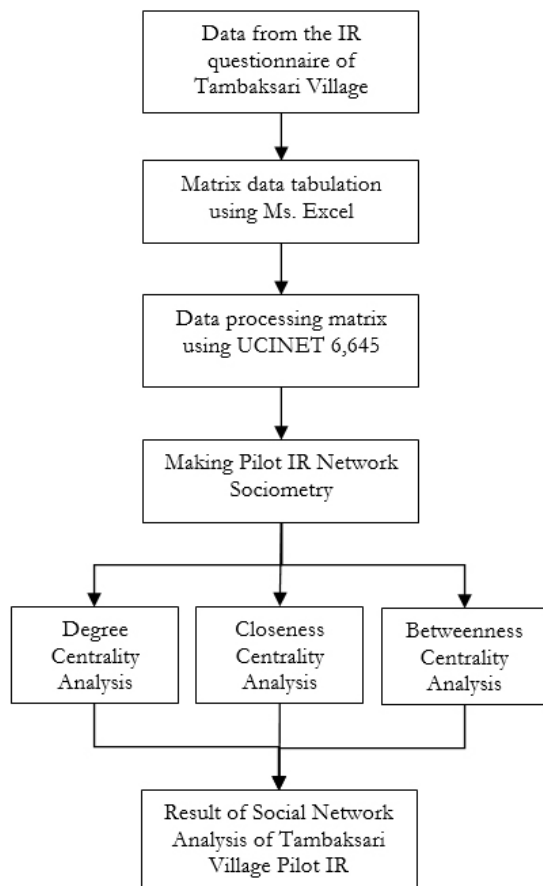


Figure 1. Research Stage Flowchart

b. Data analysis technique

The research data were obtained through a questionnaire distributed to 64 IRs in Tambaksari, Rowosari District. The researcher used a saturated sample, which means that data collection came from all IR actors involved in the research. From the research data collected has 5 attributes, namely ID, part, type of preparation, group and age. The collected questionnaire data are then tabulated into matrix data and grouped based on the names of actors, attributes and relationships between actors, then input data on the UCINET application and make sociometric images using NetDraw [5], followed by

making the results of the IR network data analysis. The following are several stages of the Social Network Analysis (SNA) used in the data analysis of the home industry network:

c. Social Network Analysis (SNA)

The use of Social Network Analysis (SNA) has long been used to map and describe a social network in society before the era of social media such as Twitter, Facebook, and other social networking sites [6]. The interactions in the communication network pattern of the Home Industry will form a picture or map [7]. This will produce a communication network that can be seen and used as a reference for the development process for Villages that have not been able to make good use of their regional potential. SNA can be used to identify actors who play an important role in complex networks [8], [9] so that they can map the structure of relationships between individuals or entities [10] which are interrelated and interdependent on behavior and attitudes in social relationships described by nodes [11]. The actors in the network and ties or edges means a line connecting one node to another node [12]. The choice of the SNA method is based on the fact that by using this method, we can visualize how the relationship between entities that can be visualized to the smallest relationship in the network between individuals [13].

d. Stages of Social Network Analysis (SNA)

- a) Degree Centrality calculates the number of interactions a node has. By calculating the degree centrality of node n_i , using formula (1):

$$C_D(n_i) = d(n_i) \quad C_D(n_i) = d(n_i) \quad (1)$$

where $d(n_i)$ = the number of interactions this node has with other nodes on the network.

- b) Closeness Centrality calculates the distance between a node and all other nodes in the network to measure the closeness or shortest distance of a node. To calculate closeness centrality, you can use formula (2).

$$C_B(n_i) = \sum g_{jk}(n_i) / g_{jk} \quad (2)$$

where $g_{jk}(n_i)$ = the number of shortest paths from node j to node k passing through node i , and g_{jk} = the number of shortest paths between 2 nodes in the network

- c) Betweenness Centrality is a calculation of how often a node is passed or mediated by other nodes to go to a particular node in the network. This value serves to determine the role of actors who bridge interactions in the network. The more often these actors become intermediaries for other actors, the more important these actors are.

Calculation of the betweenness centrality of a node using formula (3).

$$C_c(n_i) = [N - 1 / \sum d(n_i, n_j)] \tag{3}$$

where N = the number of nodes in the network and $d(n_i, n_j)$ = the number of shortest paths connecting nodes n_i and n_j

3. Result

Based on the data that has been processed using the NetDraw tool, the circle symbol is the IR-1 group and the square is the IR-2 group. The processing types are distinguished by magenta color with color ID-1 as the processing home industry of Pindang Fish, light blue color with color ID-2 as smoked fish processing home industry, dark brown color with color ID-3 as Wet Fish processed home industry, white color with color ID-4 as Salted Fish processing home industry, green color with color ID-5 as

Food Processing home industry, light brown color with The color ID-6 is the Home industry Processing and other Business, and the dark blue color with the color ID-7 is the IR Companion. The results of the group sociogram and types of processing are presented in Figure 2.

The Home Industry in Tambaksari Village, Rowosari District, which can be seen in Figure 2, has 2 IR groups and 6 types of processed products. Tambaksari Village Home Industry under the auspices of BUMDes, in each IR group has a companion, with actor # 1 as a companion to IR-1 group and actor # 2 as a companion to IR-2 group which can be seen in Table 1. The dominant type of processing in Tambaksari Village IR can be seen In table 2, namely Pindang Fish with ID 1 and Processed snacks from fish with ID 5. The Pindang Fish is the superior product of Tambaksari Village because the number of businesses is more than other types of processing as seen in Table 2.

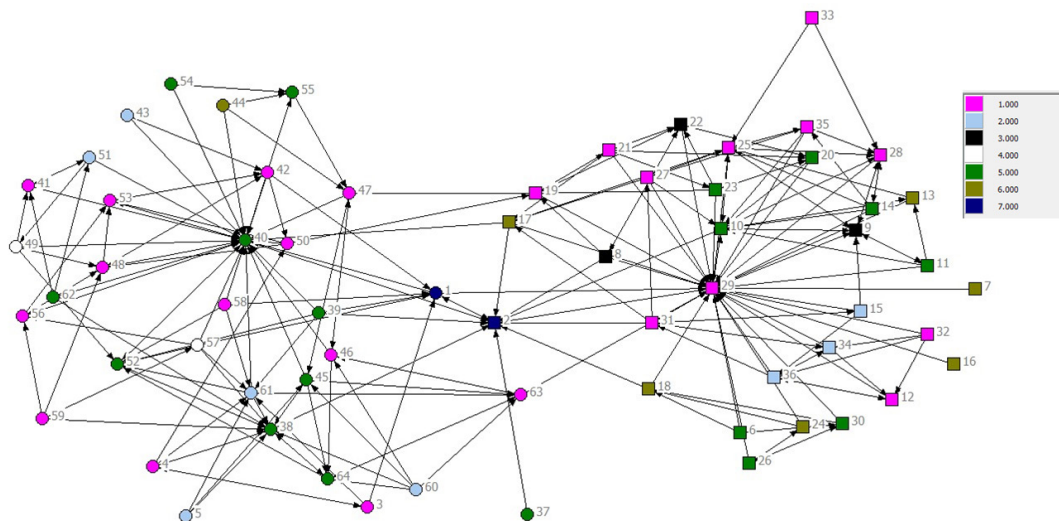


Figure 2. Sociogram Group and Type of Process

Table 1. IR Group Description

Symbol	Information
Circle	Group IR 1
Square	Group IR 2

Table 2. Description of the Type of Process

ID	Information	Number of Enterprises
1	Pindang Fish	24
2	Smoked Fish	8
3	Fresh fish	3
4	Salted fish	2
5	Snacks	18
6	Processed and other businesses	7
7	IR companion	2

a. Density

Figure 3 shows the sociogram of all Tambaksari Village IR data based on age and information on the part of the actors, until the bonding data is obtained which shows the relationship that occurs between the actors.

The results of descriptive statistical calculations using UCINET 6,645. The number of coefficients indicates that there are 221 ties (network) that occur in the network. The average density in the network is 5.5% which means that the density is less than 50%. A very significant difference in network ties can be concluded that the relationship between actors in the network is weak. The interaction patterns between actors are presented in Figure 3 and Table 5.

The bond data shows the weak relationship between actors. The closeness between IR actors is very weak, communication and relationships are less intensive, from the two IR groups in Figure 3 it can be seen that the communication that exists between IR actors and

the IR chairman is closer, than the closeness between other IR members. In addition, the weak relationship between actors is also due to the fact that most of the actors are IR actors who are more concerned with how their business can rotate properly every day so as to reduce social interaction between IR actors in daily life, but in fact these IR actors are neighbors and already know each other. This is reinforced by the existence of a statement from the IR actor stating that the IR relationship lacks communication between other actors. The communication that is established is more of an important matter related to his business. Communication with other IR actors is less established if nothing is needed because the distance from their house is too far away. The IRs focus more on their respective businesses and less communicate with other IR actors who have a far distance from their home. The IR perpetrators said that IR actors could meet and communicate with almost all IR actors during the Tambaksari IR meeting.

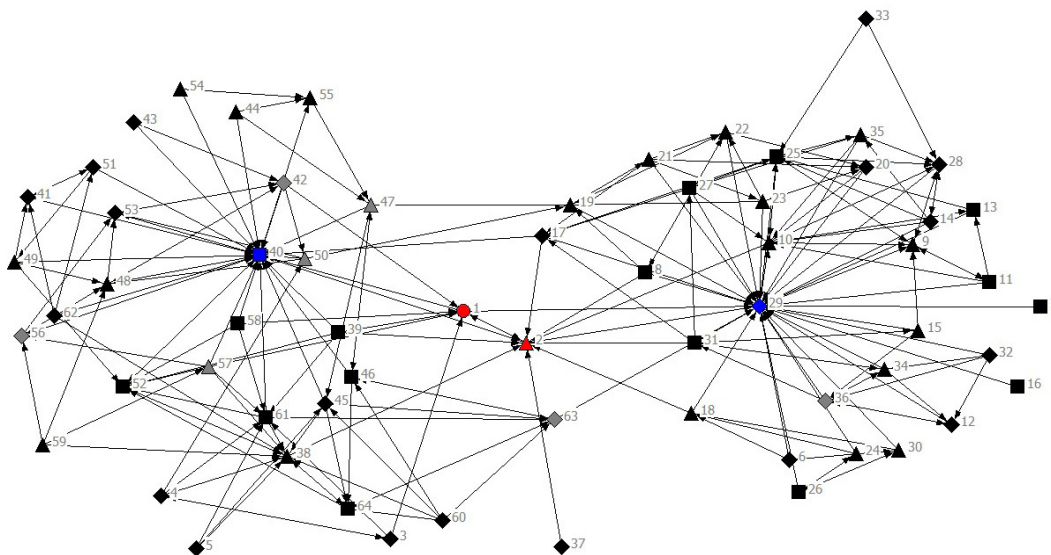


Figure 3. Sociogram All Data

Table 3. Age Description

Symbol	Information
Circle	○ 21-30 years old
Square	□ 31-40 years old
Triangle	△ 41-50 years old
Diamond	◇ more than 51 years old

Table 4. Part Description

Color	Information
Red	■ IR companion
Blue	■ Chairman of the IR
Black	■ Level 2 IR member
Dark Grey	■ Level 3 IR member

Table 5. Density

Density/ Average Matrix Value		
1. Density	2. No of ties	3. Avg Degree
0.055	221	3.453

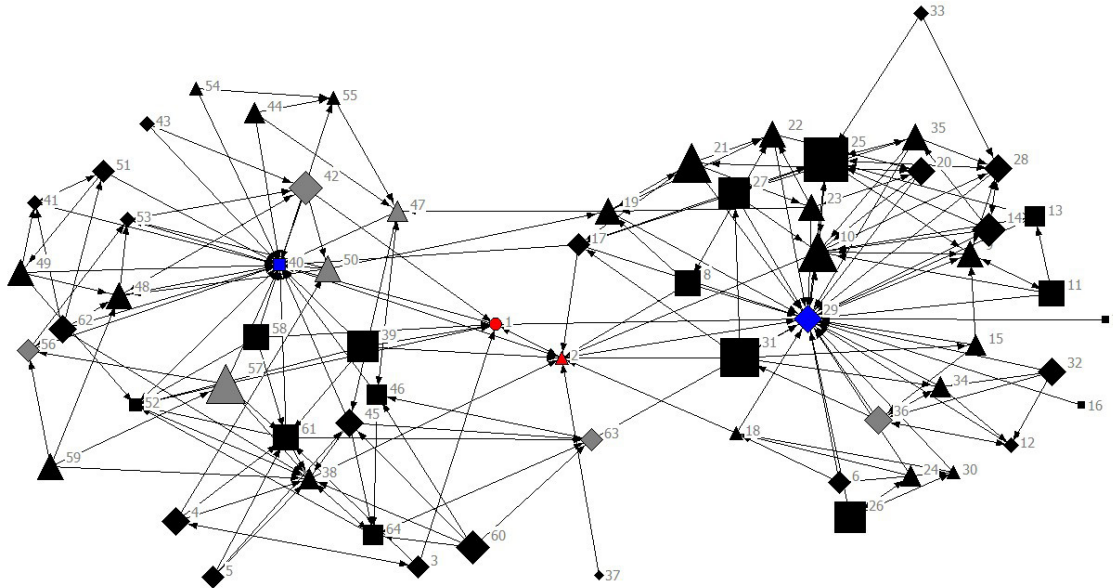


Figure 4. Sociogram Degree Centrality

Table 6. Degree Centrality

Freeman's Degree Centrality Measures				
ID	OutDegree	InDegree	NrmOutDeg	NrmInDeg
25	7.000	7.000	11.111	11.111
10	6.000	9.000	9.524	14.286
31	6.000	1.000	9.524	1.587
21	6.000	2.000	9.524	3.175
29	4.000	31.000	6.349	49.206

In Figure 3, it can be seen that the 2 IR groups were split into 2 parts, it can be concluded that the two groups did not have a comprehensive interaction, but the interactions were only in the scope of each IR. Interactions that are split into 2 indicate that the network has weak interactions. The weak interaction and splitting of the two groups, which can be seen in Figure 3, are prone to competition, seeing that the two groups have almost the same business, namely fish processing. Weak networks should be overcome by holding regular meetings as well as more intense communication between actors in the IR group. The intensity of meetings and communications that are often carried out between actors in the IR group can establish good relationships between IR actors so that the IR actors can collaborate on innovative ideas for the advancement of the Tambaksari Village Pilot IR.

b. Degree Centrality

Data level (degree) shows the interaction or relationship between actors who contact or are contacted by each actor. The number of levels (degree) in the network is 126, with the number of actors who contacted as many as 63 and 63 who were contacted. The value of 7 contacted (OutDegree) and 7 contacted (InDegree) from the data obtained means that actor # 25 sent information to 7 people in the network and received information from 7 people in the network. This shows that actor # 25 is an actor who often maintains contact with other actors in the network and is very influential in conveying and receiving information from other actors. Some IR actors said that actor # 25 is an actor who has a pindang fish business, actor # 25 also supplies pindang fish to other snack-processed actors so that this actor is an actor who

has high relationship interactions with other actors in the network..

Sociogram Degree Centrality based on data processed using the NetDraw tools obtained the following results:

Like actor # 10 which has the highest centrality number 2 as seen in table 6, with OutDegree 6 and InDegree 9. The two actors also have a relationship with actor # 29 as seen in Figure 4. Actor # 25 has an ID 1 Fish business. Pindang and # 10 have ID 5 Food Processed businesses which can be seen in Figure 2, both of them have a good relationship intensity as well as the intensity of contacting or being contacted by actor # 29 as the Chair of IR. However, the intensity of the relationship between actor # 25 and # 10 to contact or be contacted by other actors was higher than actor # 29. This can be seen in Figure 4, that the greatest Degree Centrality or intensity of contacting or being contacted by other actors is found in actor # 25.

Actor # 25 in IR is an actor who also has interactions with IR actors without other actors as intermediaries, many of the IR actors contact actor # 25 because the actor may be a source of information for other IR actors. Actor # 25 as a senior involved in the IR environment became the center of information about IR for several IR actors with whom he had close ties. In contrast to actor # 29, several factors that support actor # 25 have closeness to other IR actors, namely the similarity in production, supply of raw materials, having better experience than other IR actors who have similar production. Another thing that caused the IR actor to contact actor # 25 was the closeness of actor # 25 with actor # 29 who was the Head of the RT who was also the Chair of the IR who owned the Pindang Fish business as seen in Figure 4. Thus, actor # 25 was an intermediary. for some other IR actors who are close to him to find out information about IR obtained from the Chair of the IR.

The level of relationship between IR actors that occurs shows that the level of relationship is still valid for several

actors who have positions and production similarities in IR only. The level of relationship between actors should be better with all IR actors so that IR actors can forge better collaboration by collaborating between businesses, it will allow IR actors to obtain raw materials more easily at lower prices.

c. Closeness Centrality

Sociogram Closeness Centrality based on data processed using NetDraw tools is presented in Figure 5. Closeness Centrality shows the distance or closeness needed by an actor to contact other actors. InCloseness shows how close an actor is to someone in the network and OutCloseness shows how close someone is to an actor in the network. From the calculation results in Table 7, the highest level of closeness (Closeness) is shown in actor # 29 having InCloseness 54.310, which means that the actor has a closeness value to contact other actors by 54 times and OutCloseness is 2.292, which means that other actors have closeness to contact the actor. equal to 2 times. The position of closeness with other actors makes the actor able to interact quickly with other actors.

Actor # 29 has a better relationship closeness than other IR actors, this affects how the relationship between actor # 29 and other IR actors, actor # 29 is better at conveying information to other IR actors, compared to actor # 2 as a companion IRs who convey directly to IR actors, because the relationship that occurs between actor # 29 and IR members is proven to be closer and more intensive, this closeness can be seen in Figure 5.

The closeness of the relationship with the IR of Tambaksari should involve all parties. Not only the Head of IR, IR assistants should also have better closeness to each IR actor in their respective businesses so that they can embrace IR actors to be more active in asking questions and not feel awkward when expressing complaints or ideas. All actors in IR should have a good synergy to generate new ideas of product innovations.

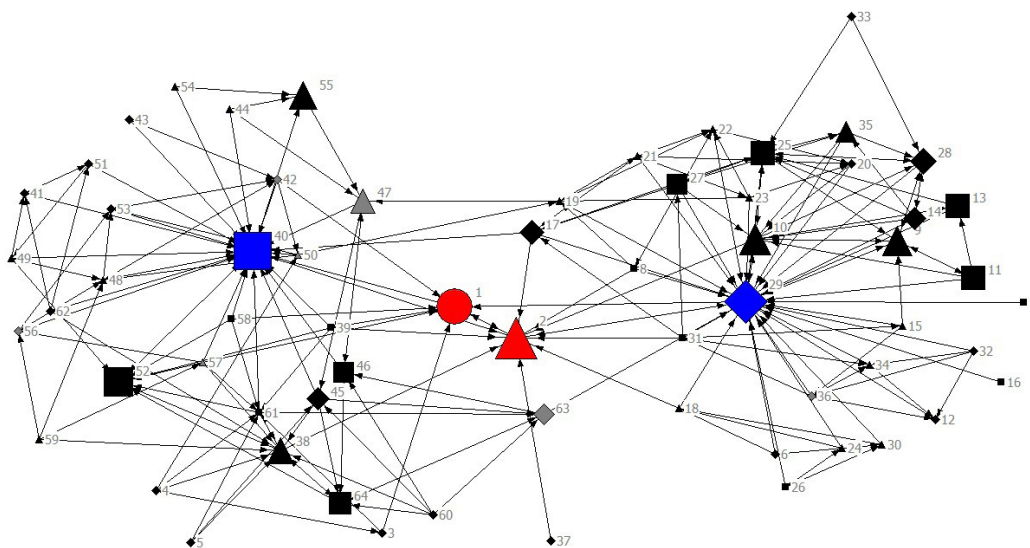


Figure 5. Sociogram Closeness Centrality

Table 7. Closeness Centrality

Closeness Centrality		
ID	inCloseness	outCloseness
29	54.310	2.292
2	54.310	2.283
40	49.219	2.288
1	45.985	2.282
10	37.278	2.289

d. Betweenness Centrality

Figure 6 shows Sociogram Betweenness Centrality, based on data processed using NetDraw tools. Betweenness Centrality in Table 8 shows the intermediation or relationship of actors. The data from the calculation of betweenness centrality shows that actor # 29 occupies the highest position with a Betweenness value of 664,983 and nBetweenness 17,025 and actor # 40 is in second place with a Betweenness value of 502,000 and nBetweenness of 12,825. The figure shows that actor # 29 has the most favorite position in the network and actor # 40 has the next favorite position after actor # 29 in the network because many actors rely on actors # 29 and # 40 to connect with other actors in the network. In addition, the two actors are the Chairmen of the IRs of the Both IR Groups. As seen in Figure 1 and Table 1, actor # 29 is the Chairperson of IR in Group IR 2 who owns a pindang fish business and actor # 40 is Chair of IR in Group IR 1 which has a snack processing business.

Actors with the highest betweenness centrality have the shortest distance to contact other actors in conveying and receiving information. This happens because the actor (node) occupies a position as an intermediary for other actors to connect with other actors in the network.

Actor # 29 is the Chair of the IR 2 group which has a pindang fish business and is 54 years old who is classified as a senior in Tambaksari village IR, this actor has an important position in the network because he is an intermediary for IR actors who want to convey complaints, problems, information to IR actors. It is also based on the activeness of these actors in the IR of Tambaksari village. Actor # 29 also acts as a mediator in the event of problems that occur from an IR member to another IR member, as well as an IR Assistant. Apart from actor # 29, actor # 40, who is the head of the IR 1 group who has a snack processing business and is 32 years old, is in second place in the mediation. Several IR actors said that actors # 29 and # 40 were active actors in the development of IR in Tambaksari village. These actors were said to be able to motivate other IR actors to be innovative in businesses managed by other IR actors. This intermediation can be seen in Figure 6.

Intermediation in IRs appears to be highly dependent on actors # 29 and # 40 as Chair of IRs. This also applies to updating information and problem solving within IRs who depend on the IR Chair. It is said that the IR member will know all the information obtained through the IR Chair as well as the IR assistant who will receive information from the IR member through the IR chairman.

Discussion

Network analysis using Social Network Analysis (SNA) can find out how the interaction between IR actors.. Through the processing of questionnaire data and interviews of the IR actors interaction using UCINET 6,645 shows that there is a gap between the two IR groups in Tambaksari which can be seen in Figure 3. The interaction in Figure 3 shows that the 2 IR groups are split into 2 parts. It can be concluded that in the two Group, there is no complete interaction, but the interaction is only in the scope of each IR. Interaction that is split into 2 indicates that the network has weak interactions and is prone to competition, since that the two groups have the similar business, which is fish processing. The two groups compete each other in the marketing of products and types of processed products. In addition, communication barriers at the Tambaksari Home Industry often occur with weak Density levels. In fact, the Tambaksari IR Committee has tried for all Tambaksari IR groups to build a close kinship in order to increase competitiveness with other Village IRs [14], however, communication within the IR of Tambaksari itself sometimes goes beyond the expectations of IR actors. who is in the IR Pilot of Tambaksari so that communication problems often occur. Poor communication eventually triggers the desire to compete [15]. Communication between home industries groups should be improved to avoid the bad impact of competition. The groups can establish good cooperation with collaboration between the two groups. Collaboration can make the two groups mutually beneficial to each other, such as in getting raw materials and complementing each other in meeting market demand. So that they can realize the common desire to maintain the Tambaksari Village Home Industries to be more advanced.

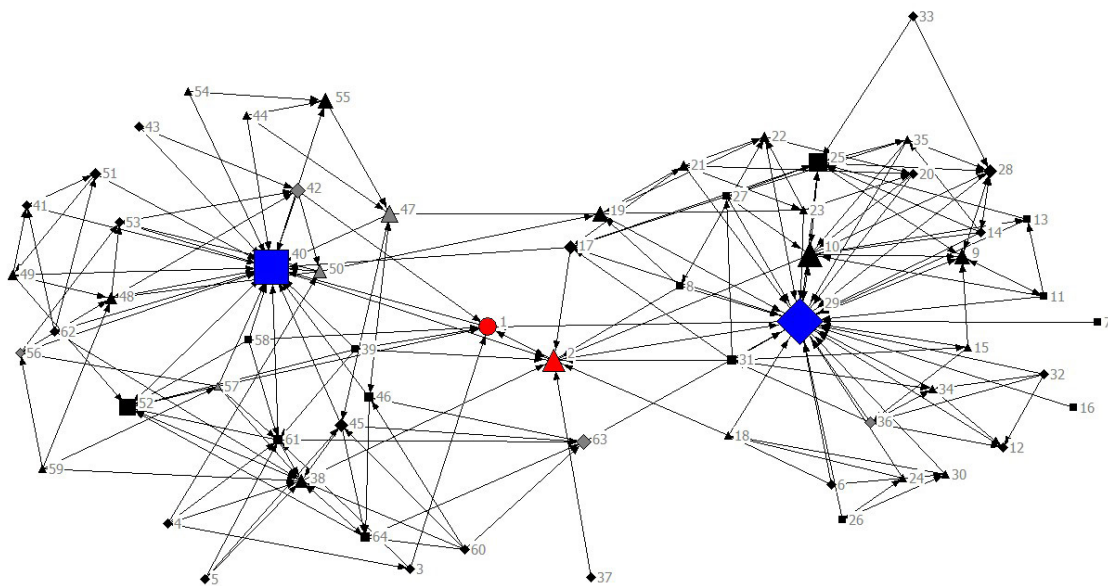


Figure 6. Sociogram Betweenness Centrality

Table 8. Betweenness Centrality

Freeman Betweenness Centrality		
ID	Betweenness	nBetweenness
29	664.983	17.025
40	502.000	12.852
10	310.783	7.957
2	275.000	7.040
1	197.833	5.065

4. Conclusion

In this study, the relationship between Tambaksari Home Industries actors is quite weak. It can be seen in the density level which indicates that there is less intensive relationship between home industries members. In this weak relationship there is actor # 29 who is the chairman of the IR-2 group, 54 years old, who is known to be friendly, and actor # 40 who is the Chair of the IR-1 group, 32 years old, and has a snack business. The two IR group leaders can be a strong link in the network. The current relationship is still centered on the IR Chair. Although actor # 29 becomes a strong liaison, actor # 25 who is in Group IR-2 has the best Degree Centrality, this shows that the actor has the highest centrality that allows other actors to be able to connect with him without the intermediary of other actors. Actors # 29 and # 40 have high Closeness Centrality and Betweenness Centrality compared to other actors. This shows that actors # 29 and # 40 have good closeness and liaison between IRs and other IRs who are members of IR, especially when compared to actor # 2 as IR's companion. Intensive communication greatly affects the actor's closeness to home industries members..

The interaction in the home industries of Tambaksari depends only on a few actors, as the Chair of the IR dominates the interactions. To improve the interactions

between IR groups and IR administrators, it needs intensive regular meetings. The regular meetings can also intensify the interaction between IR actors.

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Integration of Double Exponential Smoothing Damped Trend with Metaheuristic Methods to Optimize Forecasting Rupiah Exchange Rate against USD during COVID-19 Pandemic

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Abstract-COVID-19 pandemic has brought great changes to the stability of the Indonesian state. The disease not only has an impact on public health but also has the effect of weakening the economic sector. One indicator is the weakening of the rupiah exchange rate against the USD. When the pandemic emerged, the rupiah exchange rate started to weaken, which may encourage investors to reduce investment in Indonesia. Therefore, it is necessary to predict the rupiah exchange rate during the COVID-19 pandemic for the coming period. This study applies the Double Exponential Smoothing forecasting method by adding a damped trend factor. The calculation of the parameters of the method becomes the research optimization problem. This optimization problem is then solved using metaheuristic methods, namely Genetic Algorithm (GA) and Particle Swarm Optimization (PSO). The performance of the forecasting model is measured based on the magnitude of the forecast error. This study shows that the PSO algorithm is better at obtaining the optimal parameters for predicting the rupiah exchange rate in the coming period compared to GA. The integration error rate of Double Exponential Smoothing damped trend with PSO is 0.70%, while the error rate for the same method with GA is 0.72%. Thus, the integrated performance of double exponential smoothing with metaheuristic optimization is a more excellent method in predicting the rupiah exchange rate against the USD during the period of the Coronavirus outbreak. Furthermore, the addition of a trend dampening factor to the DES method also significantly increases the forecast accuracy.

Keywords: double_exponential smoothing; genetic_algorithm; metaheuristic; particle_swarm_optimization; covid-19

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1. Introduction

The Indonesian economy is affected by the emergence of the COVID-19 that began to plague in early 2020. The exchange rate of the rupiah against the USD is a major indicator of the economy in Indonesia. In January 2020 the rupiah strengthened to the level of Rp. 13,612, -. This month, Indonesia has not had the impact of the COVID-19 outbreak. However, the rupiah exchange rate against the USD began to weaken in February 2020 until March reached a value of Rp. 16,000, -. Along with the weakening of the rupiah exchange rate against the USD, the Government announced the COVID-19 pandemic in Indonesia. The ferocity of the COVID-19 greatly affects the level of investment decisions of some investors so that it has a very significant impact on the capital market [1]. All sectors of the economy experienced weakness. Looking

at the data on the rupiah exchange rate against the USD on the official website of Bank Indonesia, transactions experienced a quite high jump. With this condition, stakeholders must be able to understand the trend pattern of the rupiah exchange rate that occurred during the Pandemic. From the uncertainty of the rupiah exchange rate against the USD during the COVID-19 pandemic, it is necessary to predict the rupiah exchange rate for the coming period. The prediction only takes into account the pattern of the rupiah exchange rate against the USD in January to April 2020.

The forecasting method that can be applied to problems that contain trends is double exponential smoothing (DES). The DES method has two parameters that affect the accuracy of forecasting, namely the data smoothing parameter and the trend smoothing parameter. The values of these two Holt parameters must

be optimized so that the combination of the two can minimize forecasting errors [2]. There are no specific rules for getting the two optimal DES parameters. Generally, parameters are selected based on predictor intuition or by way of “trials” [3]. Zuhaimy Ismail, et al applied the Genetic Algorithm (GA) to estimate parameters from DES. The results of his research show that DES with parameter optimization using GA can improve forecasting accuracy on the Kuala Lumpur Composite Index and the daily Ringgit exchange rate against USD. In Nazim’s research, the best value of the two smoothing parameters was searched using the “solver” in Microsoft Excel [4]. Meanwhile, Ortiz optimized the DES parameters with the Particle Swarm Optimization (PSO) algorithm for forecasting the Philippine Peso exchange rate against other countries’ currencies [5]. The results showed that PSO was able to improve forecasting precision. On the other hand, Eusebio took a metaheuristic approach including GA, PSO and Simulated Annealing to optimize the parameters of the Holt-Winters method in predicting short term load forecasts [6]. His research concluded that the calculation of parameter optimization using an evolutionary approach is a fast and simple method of considering a large number of possible combinations for parameter values.

Based on some of the studies above, this study aims to predict the middle rupiah exchange rate against USD at the time of the COVID-19 outbreak using the DES forecasting method. and optimize its parameters using metaheuristic methods. The metaheuristic methods used are population-based, namely GA and PSO. However, another problem is the DES forecasting formula for the next period in the form of linear trend where the movement cannot be stopped. Therefore, the DES method in this study added a trend reduction factor (DES_{DT}). The trend damping factor is the same as the 2 parameters in DES which must be chosen so as to increase the accuracy of the forecast. So that GA and PSO performance will be measured in obtaining 3 parameters, namely the data smoothing parameter, the trend smoothing parameter and the damping factor. Next, the comparative GA and PSO performance is measured based on the magnitude of the forecast error obtained. The results of this study are expected to be a recommendation for a method to build a forecasting system for the rupiah exchange rate against the USD.

2. Theory

a. Double Exponential Smoothing Damped Trend

The results of forecasting the Holt’s Linear method or in this study are called double exponential smoothing, showing an indefinite constant trend into the future. This method tends to make excessive predictions especially for forecasting with long horizons [7]. DES forecast forecasting with a damping factor is calculated using the following recursive scheme [8], equation (1).

$$\begin{aligned} \hat{y}_{t+h|t} &= \ell_t + \sum_{j=1}^h \hat{\alpha}^j b_t \\ \ell_t &= \hat{\alpha} y_t + (1 - \hat{\alpha})(\ell_{t-1} + \hat{\alpha} b_{t-1}) \\ \ell_t &= \hat{\alpha}(\ell_t - \ell_{t-1}) + (1 - \hat{\alpha})\hat{\alpha} b_{t-1} \end{aligned} \quad (1)$$

Where, $\hat{y}_{t+h|t}$ forecast value h the next period of t and y_t the actual value of the data. Estimated level for the period t , ℓ_t , greatly influenced by smoothing parameters α . Meanwhile, the trend estimates for the period t , b_t , greatly influenced by smoothing parameters β . The $\hat{\alpha}$ parameters is a trend dampening factor that indicates how quickly the local trend is damped. The α , β and $\hat{\alpha}$ parameters values range from 0 to 1. Apart from being influenced by the selection of the three parameters, the initial value for ℓ_t and b_t should also be considered [9]. This study adopted research [10] where the initial value was given ℓ_0 and b_0 , the *intercept* and *slope* values of the regression equation for the first one month of the dataset.

Metaheuristic Optimization

Metaheuristic optimization method is an optimization method that is able to handle complex and large-sized problems and produce satisfactory solutions in a reasonable time [11]. Metaheuristic methods explore the search space to find solutions that are close to optimal solutions. Metaheuristic algorithms incorporate mechanisms so as not to get trapped in the local search space [12]. There are 2 ways to solve optimization problems using metaheuristic methods, namely single solution-based metaheuristics and population-based metaheuristics. Single solution-based metaheuristics work iteratively through the search path, moving from the newest solution to the nearest neighbor in the search space. Meanwhile, population-based metaheuristics work iteratively in a population of solutions. First, the solution population is initialized, then a new solution population is sought. Then a selection procedure is applied to determine the most recent solution population. The iteration process stops until the criteria stop being met. This study uses a metaheuristic optimization method based on population.

b. Genetic Algorithm

Genetic Algorithm (GA) is a search technique adopted from the process of natural evolution. The computation process that occurs in this algorithm is analogous to the process of selecting living things in a population. Therefore, the search process in genetic algorithms is carried out at once for a number of possible solutions to problems [13]. The basic structure of GA is:

1. population initialization
2. population evaluation
3. population selection that will be subject to genetic operators
4. the process of crossing certain chromosome pairs
5. certain chromosome mutation processes

6. evaluation of the new population
7. Repeat from Step 3 until the stop conditions are met

Genetic Algorithm has characteristics in finding optimal solutions. GA tends to converge relatively long but is able to find solutions in a wide solution space [14].

c. Particle Swarm Optimization

Particle swarm optimization (PSO) is a population-based metaheuristic method that mimics the social behavior of living things such as flocks of birds, fish to find places that have enough food. The basic principle of the PSO algorithm, a swarm consisting of N flying particles represented by the vector xi in the decision space. Every particle has a position and a velocity. Optimization takes advantage of cooperation between particles. The success of some particles will affect the behavior of other particles. Each particle adjusts its position towards the global (optimum) solution according to the following 2 factors: pbest (the best solution so far achieved by several particles) and gbest (the best solution achieved by all particles) [11]. The iteration process is carried out to update the position and velocity of the particles. Equation (2) is a mathematical equation used for the PSO iteration algorithm:

$$\begin{aligned} V[t,d] &= U(-1,1) * c_1 (pbest[d] - X[t-1,d]) + U(-1,1) * c_2 (gbest[d] - X[t-1,d]) \\ X[t,d] &= X[t-1] + V[t,d] \end{aligned} \quad (2)$$

In Equation (2), U (-1,1) is a number generated randomly from -1 to 1 that is uniformly distributed. The coefficients c1 and c2 are the parameters defined by the researcher that push the particles towards pbest and gbest [5]. The PSO algorithm converges very quickly but it is still likely to be trapped in the local optimal solution because it cannot find a new solution space [14].

d. Evaluation of Forecasting Models

Evaluation of the performance of the DESDT forecasting model is carried out to determine the level of forecasting errors. The measurement of forecast error uses the following mean absolute percentage error (MAPE) formula, equation (3).

$$MAPE = \frac{1}{n} \sum \frac{|y_t - \hat{y}_t|}{y_t} \times 100 \quad (3)$$

The smaller the MAPE value, the better the forecasting accuracy and vice versa. Forecasting accuracy is very good if the MAPE value is below 10, whereas if the value is in the interval [10 - 20] then the forecasting is said to be good [15].

For algorithm comparisons, forecast error is also measured in the error formula, equation (4) [16].

$$\begin{aligned} \text{Mean Absolute Deviation} & : MAD = \frac{1}{n} \sum_{t=1}^n |y_t - \hat{y}_t| \\ \text{Mean Square Error} & : MSE = \frac{1}{n} \sum_{t=1}^n (y_t - \hat{y}_t)^2 \\ \text{Sum Square Error} & : SSE = \sum_{t=1}^n (y_t - \hat{y}_t)^2 \end{aligned} \quad (4)$$

with, \hat{y}_t is the forecast value for period t while y_t is the actual value of data for period t.

3. Method

The following are the stages of integration of DESDT with the metaheuristic method:

Stage 1. Data Preparation. The data used are daily data on the mean value of the rupiah exchange rate against USD for the period January 2 - April 30, 2020. This data is secondary data downloaded from the official website bi.go.id.

Stage 2. Divide the dataset. The dataset used in this study will be divided into 2 segments, namely training data and testing data. The best parameters from DESDT are obtained from the training process, while the testing process aims to measure the performance of PSO and GA in getting the best parameters.

Stage 3. Compile the parameter optimization model formulation. The parameter selection of the DESDT method is an optimization problem. So in this step it is important to determine the objective functions and constraints in accordance with the objectives of this study.

Stage 4. The training stage is to solve the parameter optimization problem using population-based metaheuristic methods. This solution will produce the best parameters for DESDT.

Stage 5. Testing phase. This stage is the forecasting stage for the next (daily) period. The best parameters obtained at the training stage are input at this testing stage.

Stage 6. DESDT integration performance measurement with metaheuristics. DESDT integration performance with metaheuristics is measured based on equation (3) - (4). From these performance measurements, GA and PSO can also be compared in finding optimal solutions.

a. Research data

The research data used in this study is secondary data downloaded from the official website of Bank Indonesia from January to May 2020. The features available in the data are the selling rate and the buying rate. In this research, the observed rupiah exchange rate is the middle rupiah exchange rate against the USD. The middle rate is the rate between the sell rate and the buy rate. The middle rate is calculated based on the number of selling and buying rates divided by two [17]. The rupiah middle rate is presented in Figure 1.

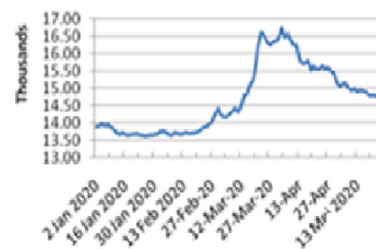


Figure 1. Graph of the rupiah exchange rate against USD January - May 2020

The rupiah transaction against the USD was seen to have strengthened in January and was relatively stable until February 2020. A hike in the trend in the exchange rate began to appear in March. In March Indonesia experienced the COVID-19 pandemic condition. The rupiah continued to weaken until early April. After two weeks, the rupiah exchange rate seems to have begun to strengthen again until early June 2020. In accordance with the research objectives, to test the DESDT integration with metaheuristic optimization, the rupiah middle exchange rate dataset is divided into two parts given in Table 1 below.

Table 1. Distribution of the dataset

Data Set	Period	Lots of Data
Training data	January 2 - April 30, 2020	84 days
Testing data	May 4 - May 29, 2020	16 days

The training data sample was taken until April 30 because during that period the rupiah exchange rate graph began to strengthen again. Here the integration performance of DESDT with metaheuristics is tested whether it can produce forecasts with small errors. Linear trends in training data are presented in Figure 2 below.

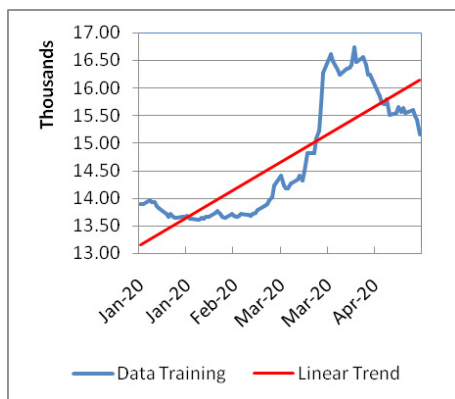


Figure 2. Linear trends in training data

The training data is processed using Equation (1) to obtain optimal DESDT parameters using GA and PSO. This stage is called the training stage. The output from the next training stage is used to predict the next period. This forecasting process is a testing phase. The results of forecasting the DESDT method with GA and PSO will be compared with testing data. The magnitude of forecasting errors is the difference between forecasting results with testing data. This forecasting error is measured based on Equation (3) - (4)

b. Parameter Optimization Model Formulation

The training phase begins with compiling a parameter optimization model. The parameter optimization problem

here is to get the best value from the DESDT parameter so that the forecast results are close to the actual value. So that the functional cost in this study is the magnitude of the training data forecasting error. While the limitation of this optimization problem is the forecasting formula of the DESDT method. The following is the formulation of the parameter optimization model:

$$\begin{aligned}
 & \text{Minimization Equation (3)} \\
 & \text{Subject to} \tag{5} \\
 & - \text{Equation (1)} \\
 & - 0 \leq \alpha, \beta, \check{\sigma} \leq 1
 \end{aligned}$$

The parameter optimization problem (5) will be solved using the GA and PSO metaheuristic methods which are implemented in the MATLAB program.

2. Results and Discussion

The results of this study describe the performance of the GA and PSO methods at the training and testing stages

a. Results of the Training Stage

The result of the training stage is the solution to Equation (5), namely the smoothing parameter values α , and the damping factor $\check{\sigma}$ that minimizes forecast errors. Because the metaheuristic method is a stochastic method, the optimal value of the three parameters is carried out up to 10 times running the program. The test results are summarized in Table 2.

Table 2. Training Results

Cost Function	MAPE (%)	α	β	$\check{\sigma}$	
GA	Worst MAPE	0.619163	0.992003	0.875853	0.431585
	Best MAPE	0.612822	0.907839	0.910162	0.481209
	Mean MAPE	0.615051			
PSO	Worst MAPE	0.625930	0.997737	0.219646	0.493563
	Best MAPE	0.612380	0.867514	0.993331	0.503997
	Mean MAPE	0.615291			

The DESDT parameter optimization has been carried out by GA and PSO. The comparison of the results of the GA and PSO training methods to find the best DESDT parameters is shown in Table 2. In the 10 times running the program, overall GA is better than PSO shown by Mean MAPE with a very small difference of 0.0002%. MAPE PSO is smaller than Best MAPE GA. DESDT parameters taken at the training stage here are a combination of parameters with Best MAPE. The matching of the forecasting result curve at the training stage with the actual data on the rupiah exchange rate against the USD for Worst MAPE and Best MAPE is presented in Figures 3 and 4 below.

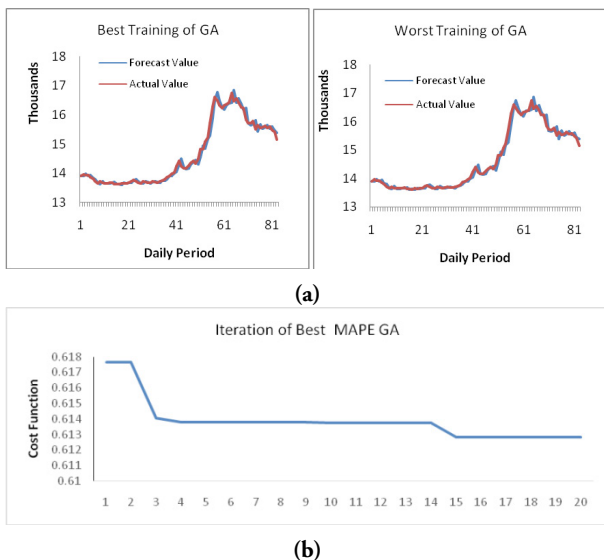


Figure 3. Graphic matching curve for the training stage and GA iteration on Best MAPE

Matching the curve of Figure 3a shows that the parameters produced by GA for both Best MAPE and Worst MAPE are very good with an average error of 0.61%. Figure 3c. is an iteration of GA to get optimal parameters for Best MAPE. It can be seen in iteration 15, GA begins to converge on the best solution. Meanwhile, a graph comparing the results of DESDT and PSO forecasting with actual data is presented below:

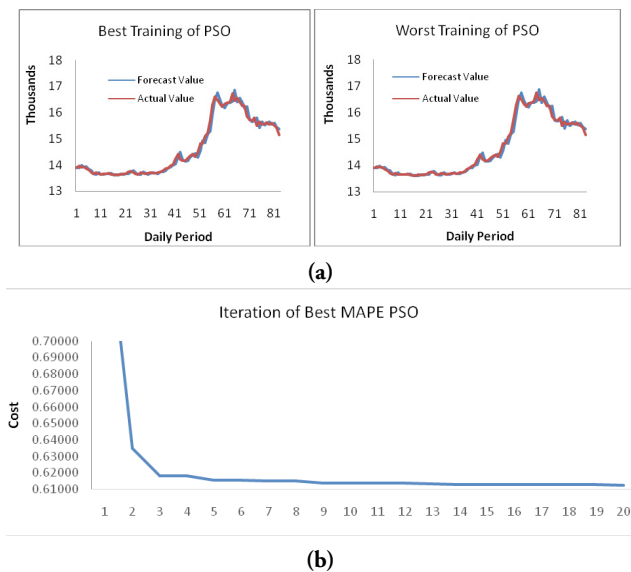


Figure 4. Graph of PSO training and iteration stage matching curve at Best MAPE

Figure 4a. shows that the training results from the PSO algorithm provide forecasting results that match the actual data well. Meanwhile, Figure 4b is the PSO iteration

to get the optimal solution with Best MAPE. The PSO algorithm begins to converge to the optimal solution at the 14th iteration. The search for optimal solutions for the GA and PSO methods is limited to 20 iterations.

The optimal parameters with Best MAPE obtained by each GA and PSO method then become input in the forecasting process for May 2020

b. Testing Phase Results

The integration of the DESDT method with GA (DESDTGA) and DESDT with PSO (DESDT PSO) is measured for its performance based on the forecast error for May 2020. Forecasting errors in the testing phase are the difference between the forecasting results of the DESDTGA and DESDT PSO methods with testing data. The matching of the forecasting result curve for DES integration with Metaheuristics is given in Figure (5).

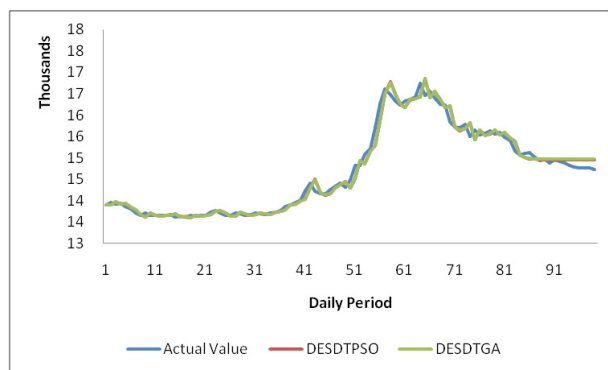


Figure 5. Matching curve forecasting result of DES integration with metaheuristics to actual data

The forecast period starts at the 85th period of the data set. The DESDT PSO forecast curve is closer to the actual data. As a comparison of the two methods, the measurement of forecast error is not only based on MAPE but is also measured based on Equation (4). Measurement errors for the DESDTGA and DESDT PSO methods and their competing methods are summarized in Table 3.

DESDT PSO method performs better than DESDTGA in all forecast error measurements. For DESDT PSO, the average forecast error against the actual data is IDR 105,119 which is shown in the MAD measurement. MAPE measurement shows the average forecast error ratio to actual data in each period of 0.7%. The integration of the DESDT method with the metaheuristic method both provides better forecasting than the Solver program. Whereas in the 4th method, the DES method is given to determine the effect of the damping factor on the forecasting results. It turns out that all types of forecast error measurements show that the damping factor can improve the DES forecasting results.

Table 3. Results of Measurement Error Forecasting Methods

Methods	α^*	β^*	δ^*	MAPE	MAD	MSE	SSE
DESDTGA	0.907839	0.910162	0.481209	0.723373	108.3304915	17729.467	283671.47
DESDTPSO	0.867514	0.993331	0.503997	0.706112	105.1197506	16635.617	282805.491
DESDT + Solver	0.972602	0.729724	0.449050	0.876080	129.956134	24579.494	393271.91
DES + Solver	0.947969	0.311962	-	4.546026	674.582524	607932.83	9726925.415

3. Conclusion

Calculation of optimal parameters from the DESDT method is important to improve forecast accuracy. Through the metaheuristic approach, the optimal parameters of the DESDT forecasting method are obtained quickly and simply because the combinations of the three parameters are very abundant. Based on the results of the testing phase, the optimal solution of the PSO method provides a forecast error of 0.017% smaller than the GA method. The DESDTPSO method's forecasting error is 0.706% with optimal parameters for DESDT are $\alpha^*=0.867514$, $\beta^*=0.993331$ and $\delta^* = 0.503997$.

It is necessary to understand the trend pattern of the rupiah exchange rate against the USD at the time of the Corona outbreak. Thus, future investment planning can be designed properly. The DES forecasting method was chosen as a consideration for the trend pattern in the rupiah exchange rate against the USD by adding a dampening factor. The measurement of forecast errors using the DES method with DESDT shows that the addition of trend dampening factors can significantly improve the forecast results of the rupiah exchange rate against the USD. Therefore, the integration of the DESDT method with metaheuristics can be recommended for the construction of a forecasting system for the rupiah exchange rate against the USD.

Forecasting the rupiah exchange rate in this study only considering historical data patterns during the Corona pandemic without considering the influence of the Indonesian Government's efforts to reduce the adverse effects of Corona. Related research should add the factors that influence the fluctuation of the rupiah exchange rate so that it becomes a better prediction.

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Application of the Certainty Factor and Forward Chaining Methods to a Goat Disease Expert System

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Abstract-Goats are livestock that is financially very attractive to rural Indonesian. Efforts to solve problems related to goat farming are necessary. One of them is maintaining the health of the cattle by knowing how to cope with disease-stricken goats. Goat productivity will decrease if the treatment of the disease is sub-optimal. Goat diseases are very diverse, ranging from mild to severe. Breeders themselves can traditionally treat several diseases without the involvement of veterinarians or experts. However, a larger number of diseases need treatment with the help of experts. Expert systems are a potential solution to help farmers. It will automatically suggest decisions or conclusions in solving a problem. This study observes an expert system built using the Certainty Factor combined with Forward-Chaining. By combining the two methods, the information generated may discover the type of disease and suggest its management effectively with a high degree of certainty. The system can expectedly become a reference for goat breeders to consult about their goat livestock diseases. The knowledge base of the system uses 21 types of symptoms, eight types of diseases, and their solutions. The user does not need to input the belief value and the disbelief value that is usually input in the expert system. By involving the admin as a knowledge base processor, the correctness of the conveyed information maintains.

Keywords: expert system, certainty factor, forward chaining, goats

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1. Introduction

Goats are livestock that are in great demand in Indonesia. One of the problems often faced by breeders is goat disease. The productivity of the goats has decreased if the handling of the disease is not optimal. There are many types of goat disease, ranging from mild to severe [1]. The disease can be treated in the traditional way by the farmer himself without having to involve a doctor or expert. If the treatment and handling of livestock is not optimal, it can result in cattle death and loss. If their livestock is sick or even dies, the breeders usually slaughter the goat before the goat dies. This makes the selling price of sick goats cheaper than healthy goats. Thus the breeders often lose money because the gain from selling the meat cannot cover the initial capital to purchase new young fresh goat.

Seeing this condition, efforts to solve the goat livestock problem are important. One of them is maintaining the health of livestock by knowing how to cope with and deal with disease-stricken goats [2]. The application of this system

apart from providing information about goats also makes it easier for a breeder to carry out consultations without having to enter the value of believe (MB) and the value of disbelief (MD).

From reference [13], there are 8 common types of goat disease, namely:

1. Worms
2. Diarrhea
3. Scabies or Ringworm
4. Tympany or Bloat
5. Pink Eye
6. Poisoning
7. Tetanus
8. Anthrax

The knowledge and experience of veterinarians or experts can be implemented into a system called an expert system. The application of doctor-like analysis skills is modeled using software on a computer. The modeling can provide problem solving suggestions as well as an expert

or a doctor [3]. Expert system is a system that combines knowledge to solve problems as is done by an expert or expert [4]. The information system can reach higher precision in narrower domain problems [5].

This expert system can be a potential solution. The system automatically provides decisions or conclusions in solving a problem [6] [14]. There are several parts to an expert system, namely the consulting and development environment. In the development section, the task of system builders is to introduce and build components into the knowledge base [7]. An expert system architecture (Arhami, M. 2005) can be seen in Figure 1.

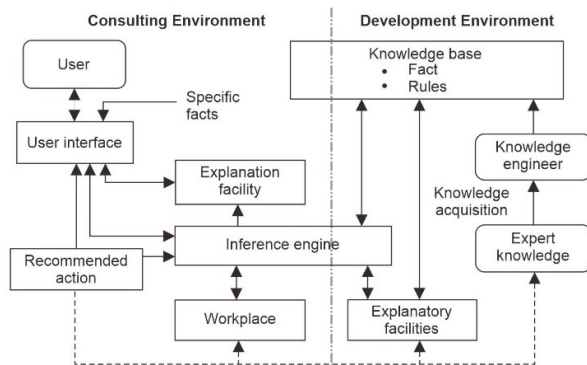


Figure 1. Expert System Architecture.

The method used in this expert system is *Certainty Factor*. The Certainty Factor method is used when facing a problem whose answer is uncertain. This uncertainty can be a probability. By presenting the degree of confidence and uncertainty, this method is similar to the fuzzy logic method [4]. There are several differences between the two methods, namely if the fuzzy logic conditions are more than one, the believe value only sees the lowest value in the AND operator, so that the OR value is higher for each condition. The measure of certainty in this method is in accordance with the rules and facts entered in the system [8].

$$CF[h,e] = MB[h,e] - MD[h,e] \tag{1}$$

Information:

CF[h,e] = Certainty Factor.

MB[h,e] = Measure of belief on the hypothesis with a range of values or weights 0-1.

MD[h,e] = Measure of disbelief, the hypothesis with a range of values or weights 0-1.

h = The conclusion or hypothesis is generated (between 0 - 1).

e = Facts or events (Evidence).

There are several combinations of CF against certain premises:

- CF with one condition:
 $CF[h,e] = CF[e] \times CF[rule] = CF[user] \times CF[expert]$ (2)

- CF with more than one premise:
 $CF[A \text{ and } B] = \text{Min}(CF[a], CF[b]) \times CF[rule]$ (3)

$$CF[A \text{ or } B] = \text{Max}(CF[a], CF[b]) \times CF[rule] \tag{4}$$

- CF with a similar conclusion:
 $CF_{combined}[CF1, CF2] = CF1 + CF2 \times (1 - CF1)$ (5)

This method is very suitable to be applied to expert systems that have advantages in performing calculations. By using a measure of the degree of certainty or confidence, this method can compute with one calculation. Furthermore, the data is processed to produce accurate decisions. One example is the object of this research, namely the detection of goat disease and its solution.

The Forward Chaining method (Arhami, M. 2005) is often called bottom-up reasoning, because reasoning from facts at the lower level to conclusions at the upper level is based on facts. This method starts working by using available data and certain inference rules to get the other data to a conclusion. An inference engine that uses Forward Chaining looks for inference rules until it finds one of the correct IF - THEN hypotheses or clauses. Reasoning starts from the facts first to test whether the hypothesis is true or not. The facts in the system are stored in working memory for later continuous update [9]. The following is an example of inference using the FC method [10]. See Figure 2.

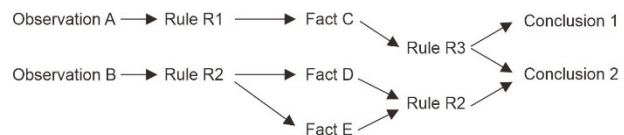


Figure 2. Forward Chaining Process

IF [antecedent] THEN [consequent]
 IF [premise] THEN [conclusion]
 IF [condition] THEN [action]

2. Method

a. Research methodology

The research flow diagram can be seen in Figure 3.

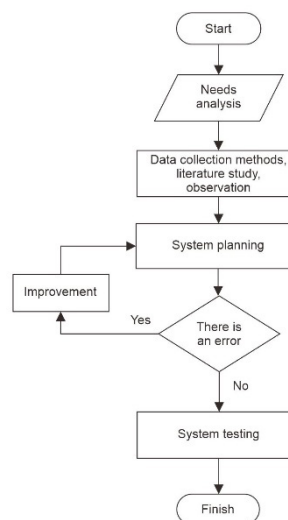


Figure 3. Research Flowchart

- The research stage, among others:
1. Requirement analysis. Among them is the study of literature, namely understanding the theory used. This includes the type of disease, its symptoms, and its solutions [13]. Next is to determine the value of confidence (MB) and value of uncertainty (MD). Other supporting data are articles related to the object of this study, namely knowledge of goat disease.
 2. Observation. This is done by directly interviewing several goat breeders to see the existing problems and taking accurate data about the goat diseases there.
 3. The next process is system design, starting from determining the user interface to entering the knowledge base and rules of existing diseases and symptoms. If there is an error either in calculation or the results of the system analysis, then it will be corrected and reviewed.
 4. The final step is a thorough system test. There are two access rights in this system, namely the user in conducting consultations, and the admin to manage this expert system.

b. Knowledge Base

This system uses a knowledge base as a data base regarding disease facts, symptoms facts, and solutions. Symptoms of disease that are processed in the expert system for diagnosing goat disease are 8 types of disease and 21 kinds of symptoms. These facts can be seen in Table 1 and Table 2.

Table 1. Types of diseases

Disease Code	Name of Disease
P001	Worms
P002	Diarrhea
P003	Scabies or Ringworm
P004	Tympany or Bloat
P005	Pink Eye
P006	Poisoning
P007	Tetanus
P008	Anthrax

Table 2. Symptom

Symptom Code	Symptom name
G001	The cattle looks lethargic, weak, pale
G002	Decreased appetite
G003	Goat diarrhea, enlarged stomach and hair standing up and dull
G004	Goat manure is light green, shiny, or reddish, or blackish in color.
G005	The skin appears red spots that form boils so that it experiences stiffness, thickening, and scaling.
G006	Skinny cattle

Symptom Code	Symptom name
G007	Cattle rubbed their skins against the barn because it was itching and looked like they were losing their hair
G008	Livestock have difficulty breathing
G009	The left side of the stomach looks big, if it is tapped it will sound like a drum
G010	Livestock seems restless
G011	Cattle fall and find it difficult to get up again
G012	The eyes ooze and flicker
G013	The eyes are red and swollen
G014	Ulcers appear on the clear membrane until you experience blindness
G015	Livestock convulsions
G016	The mouth is frothy, the mucous membranes of the eyes are bluish,
G017	Stool mixed with blood
G018	Cattle have high fever
G019	Part of his body became stiff
G020	Swollen pectoral glands, chest full of ulcers
G021	Removes blood from the ears, mouth and anus

c. Results of Certainty Factor Data

The application of the CF method requires several variables, namely the weighted value of the MB (measure of believe) and MD (measure of disbelieve). Each symptom will be given a weight or confidence value according to its confidence level, between 0 and 1. The rule of symptoms against the type of disease that is present will be used as the knowledge base in the system.

The data is taken from reference book [13]. The data is entered into the expert system's knowledge base and adjusted for the weight or confidence value of each symptom. This value or weight is between 0-1, by looking at the symptoms that appear in goats. There were 8 types of diseases included in the knowledge base, which were accompanied by their solutions and treatments.

Following are the symptoms of the disease along with the MB and MD values that were entered into the expert system. Including the type of disease and the rule of symptoms for each type of disease. See Table 3.

Table 3. Disease and symptom data with weighted scores

Disease code	Symptom code	Symptom name	MB	MD
P01	G001	The cattle look lethargic, weak, pale	0,9	0,1
	G002	Decreased appetite	0,9	0,1
	G003	Goat diarrhea, enlarged stomach and hair standing up and dull	1	0,1

Disease code	Symptom code	Symptom name	MB	MD
P02	G001	The cattle looks lethargic, weak, pale	0,8	0,2
	G004	Goat manure is light green, shiny, or reddish, or blackish in color.	1	0
P03	G005	The skin appears red spots that form boils so that it experiences stiffness, thickening, and scaling.	0,9	0,1
	G006	Skinny cattle	0,8	0,2
	G007	Cattle rubbed their skins against the barn because it was itching and looked like they were losing their hair	0,9	0,1
P04	G008	Livestock have difficulty breathing	0,8	0,2
	G009	The left side of the stomach looks big, if it is tapped it will sound like a drum	0,9	0,1
	G010	Livestock seems restless	0,8	0,2
	G011	Cattle fall and find it difficult to get up again	0,8	0,2
P05	G012	The eyes ooze and flicker	0,9	0,1
	G013	The eyes are red and swollen	0,8	0,2
	G014	Ulcers appear on the clear membrane until you experience blindness	0,8	0,2
P06	G015	Livestock convulsions	0,8	0,2
	G016	The mouth is frothy, the mucous membranes of the eyes are bluish,	1	0
	G017	Stool mixed with blood	0,9	0,1
P07	G015	Livestock convulsions	0,8	0,2
	G018	Cattle have high fever	0,9	0,1
	G019	Part of his body became stiff	1	0
P08	G020	Swollen pectoral glands, chest full of ulcers	0,8	0,2
	G021	Removes blood from the ears, mouth and anus	0,9	0,1

d. Forward Chaining Data Results

The FC method is a search technique that starts with known facts, then matches those facts with the IF part of the IF – THEN rules. If there are facts that match the IF part, the rule is executed. When a rule is executed, a new fact (THEN section) is added to the database. The following is a rule of symptoms for each type of disease. See Table 4.

Table 4. Rule of Disease and Symptoms

Disease code	Rule
P01	If G01 And G02 And G03 Then P01
P02	If G01 And G04 Then P02
P03	If G05 And G06 And G07 Then P03
P04	If G08 And G09 And G010 And G11 Then P04
P05	If G12 And G13 And G014 Then P05
P06	If G15 And G16 And G017 Then P06
P07	If G15 And G18 And G019 Then P007
P08	If G20 And G21 Then P08

3. Result and Discussion

Further analysis is needed to determine the comparison between manual testing and real testing on the system so that the effectiveness of this application can be determined. The question is how accurate the *Certainty Factor* and *Forward Chaining* methods are in detecting goat disease.

a. Analysis Stages

The following are the requirements for these two types of system users:

1. Requirements of users or breeders.

User access rights are to view the main page of the system, which is information about the health of goats and register for further disease consultation.

2. Admin Requirements.

Admin access rights include entering knowledge data including types of diseases, symptoms, and solutions. Furthermore, managing the knowledge base, namely entering the rules of disease and symptoms. Then the admin enters the MB and MD values to be part of the knowledge base.

b. Sample case

Farmer X makes a diagnosis through an expert system, by entering the symptoms that arise, as shown in Table 5.

Table 5. Examples of symptom cases entered by X

Numb	Symptom Name	Answer
1	The cattle looks lethargic, weak, pale	√
2	Decreased appetite	√
3	Goat got diarrhea, enlarged stomach and hair standing up and dull	√
4	Goat manure is light green, shiny, or reddish, or blackish in color.	
5	The skin appears red spots that form boils so that it experiences stiffness, thickening, and scaling.	
6	Skinny cattle	√
7	Cattle rubbed their skin against the barn because it was itchy and their hair appeared to fall out	

Numb	Symptom Name	Answer
8	Livestock have difficulty breathing	
9	The left side of the stomach looks big, if it is tapped it will sound like a drum	
10	Livestock feel restless	
11	Cattle fall and find it difficult to get up again	
12	The eyes ooze and flicker	
13	The eyes are red and swollen	
14	Ulcers appear on the clear membrane until you experience blindness	
15	Livestock convulsions	
16	The mouth is frothy, the mucous membranes of the eyes are bluish	
17	Stool mixed with blood	
18	Cattle have high fever	
19	Part of his body became stiff	
20	Swollen pectoral glands, chest full of ulcers	
21	Removes blood from the ears, mouth and anus	

Problem solving:

Possibilities 1. Having **worms** due to the symptoms that exist in the knowledge base is that the livestock looks lethargic, weak, pale, decreased appetite, goat diarrhea, enlarged stomach and hair stands up and dull. There are 3 symptoms that appear, so equation (5) is used to determine the value of Certainty Factor because in this calculation the user does not enter the user's weight. The weight used is in accordance with the expert's weight that has been entered into the system.

$$CF[h,e]g1 = MB[h,e]g1 - [MD[h,e]g1] \\ = 0,9 - 0,1 \\ = 0,8$$

$$CF[h,e]g2 = MB[h,e]g2 - [MD[h,e]g2] \\ = 0,9 - 0,1 \\ = 0,8$$

$$CF[h,e]g3 = MB[h,e]g3 - [MD[h,e]g3] \\ = 1 - 0 \\ = 0,9$$

$$CF_{combined1} [CF1, CF2] = CF1 + CF2 * (1 - CF1) \\ = 0,8 + 0,8 * (1 - 0,8) \\ = 1,6 * 0,2 \\ = 0,32$$

$$CF_{combined2} [CF_{fold1}, CF3] = CF_{fold1} + CF3 * (1 - CF_{fold1}) \\ = 0,32 + 0,9 * (1 - 0,32) \\ = 1,22 * 0,68 \\ = 0,83$$

Note: CFcombined1 or CFfold1 is the calculation of the similarity of symptoms of G01 and G02. CFcombined2 or CFfold2 is the result of the calculation of Case 1 by Mr. Wawan is 0.83. Furthermore, the calculation of the percentage of confidence in disease is:

$$\text{Percentage} = CF_{disease} * 100 \\ = 0,83 * 100 \\ = 83\%$$

Possibility 2. Affecting **Scabies** or **Ringworm**: because the symptoms that exist in the knowledge base are lean cattle.

The number of symptoms that appear is 1, then equation (1) is used to determine the value of Certainty Factor because in this calculation the symptoms that appear are only 1 for P03 disease. The weights used by MB and MD are in accordance with expert weights and uncertainty weights that have previously been entered into the system.

$$CF[h,e] = MB[h,e] - [MD[h,e]] \\ = 0,8 - 0,2 \\ = 0,6$$

Note: CF [h, e] is the certainty factor obtained from the calculation of MB [h, e] - MD [h, e], namely the weight of certainty minus the weight of uncertainty. Furthermore, the calculation of the percentage of confidence in disease is:

$$\text{Percentage} = CF_{disease} * 100 \\ = 0,6 * 100 \\ = 60\%$$

c. System Test Results

The system test stage is the calculation process in the case sample will be compared with the system test results. The results of the system testing will later be used as a reference as a tool for detecting goat disease. There are several menus in this expert system:

1. Expert Main Menu.

This menu is used by the admin to enter the knowledge base, including types of diseases, symptoms and expert weight, and rules. The main menu of the expert system can be seen in Figure 4.



Figure 4. Expert System Main Menu.

This menu is the main view of the expert system. Access rights from this menu are the user as the

breeder who will carry out the consultation, and the admin as the knowledge base processor.

2. Admin Menu.

This menu is used by the admin to enter the knowledge base (such as types of disease, symptoms with weight, solutions, and rules for Forward Chaining), as well as to manage admin login. Expert system admin menu can be seen in Figure 5.



Figure 5. Admin menu.

Admin as the main maintainer of the system can enter the knowledge base, including types of diseases, types of symptoms, solutions, rules of disease and symptoms and the value of MB and MD.

3. User Registration Menu.

This menu is used for user registration by entering some data, including patient code, name, age, gender, address, username, and password. The expert system user registration menu can be seen in Figure 6.



Figure 6. User Registration Menu.

This menu is used by users to register personal data before consulting.

4. User Consultation Menu.

This menu is used by users (who are already registered) to carry out health consultations. The consultation menu can be seen in Figure 7.

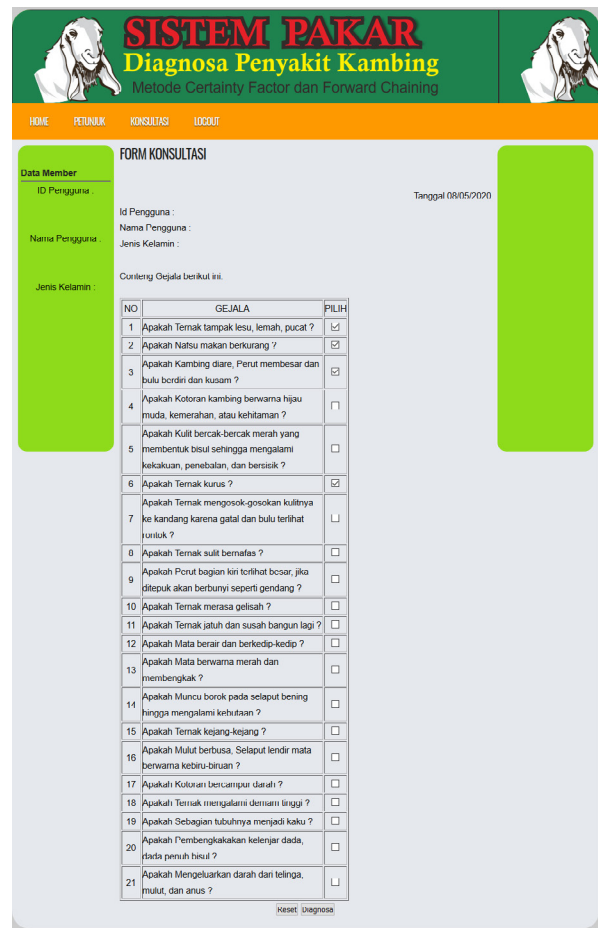


Figure 7. User Consultation Menu.

This menu displays the symptom data that appears and then the user makes a checklist according to the complaints experienced by the livestock.

5. Consultation Result Menu.

This menu displays the results of diagnoses that have been carried out by the user so as to produce data on the results of diseases and their prevention or control. The results of the calculation manually gave a diagnosis result in the form of worms with a percentage of 83%. The results of diagnosis using this system can be seen in Figure 8.

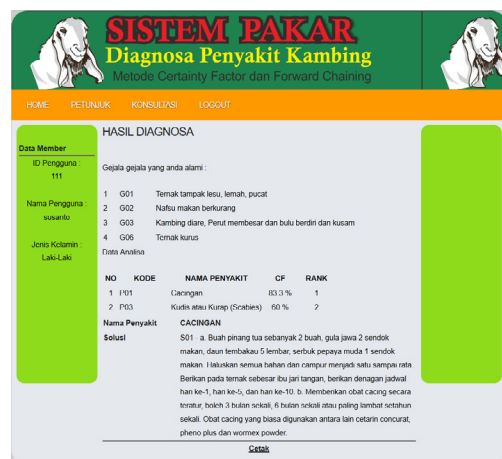


Figure 8. Consultation Result Menu.

This menu displays the results of the consultation in the form of types of diseases that may be infected and their solutions.

c. Discussion

Scenario testing is done by analyzing the results of possible diseases that arise. With manual calculations the results obtained are 83% for worms and 60% for scabies or ringworm. Manual testing is only to show that the rules or relations of disease and symptoms are in accordance with the knowledge base created using the Forward Chaining method. While the Certainty Factor is used to display the percentage value to show the level of confidence that exists in the system that has been entered.

Previous research [11] has several drawbacks, among others, the types of symptoms that appear in the system are not fully visible. The only symptom displayed is one symptom then the user selects Yes or No. While research [12] involved disease data, symptom data and training data, however, rule data were not included. So that the error rate in analyzing the results can still be high.

The combination of the Certainty Factor and Forward Chaining methods is expected to display a user interface that is simpler and easier to run. The result of the percentage of system analysis shows the level of accuracy which will also be displayed on the system. In this case an accuracy rate of 83% was obtained. The percentage only represents the calculation of the example cases above.

4. Conclusion

Based on the explanation above, it can be concluded that the application of the Certainty Factor and Forward Chaining methods is able to analyze the query results to the user during consultation, without the user needing to enter the MB and MD values.

The processing of the rule base and knowledge base can only be done by an admin or an expert. Restrictions on access rights for knowledge bases and rule bases are the full rights of administrators or experts so that the correctness of knowledge data information is maintained.

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Performance Analysis of Isolation Forest Algorithm in Fraud Detection of Credit Card Transactions

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Abstract-Losses incurred due to fraud on e-commerce transactions, especially those based on credit cards, continue to increase, resulting in large losses each year. One mechanism to minimize the risk of fraudulent credit card transactions is to utilize a detection technique for ongoing transactions. Credit card transaction data in its original state does not have a label, and the amount of fraud data on the training data is very small so that it belongs to a very unbalanced category, and the pattern of fraud continues to change. Isolation forest is an unsupervised algorithm that is efficient in detecting anomalies. Several techniques can be applied to improve the performance of the Isolation forest model. Previous studies used the ROC-AUC metric in analyzing the performance of Isolation Forests, which could provide incorrect information. This study made two contributions; the first is to present a performance analysis with both the ROC-AUC and AUCPR. Thus, it can be seen that the high ROC-AUC value does not guarantee the model has the reliability in detecting fraud. In comparison, the information provided through AUCPR is more appropriate to describe the ability of the model to capture data fraud. The second contribution is to propose several techniques that can be applied to improve the performance of the Isolation forest model, namely to optimize the determination of the amount of training data, feature selection, the amount of fraud contamination, and setting hyper-parameters in the modeling stage (training). Experiments were carried out using a real-life dataset from ULB. The best results are obtained when the validation data split ratio is 60:40, using the five most important features, using only 60% of fraud data, and setting hyper-parameters with the number of trees 100, 128 sample maximum, and 0.001 contamination. The validation performance of this model is precision 0.809917, recall 0.710145, f1-score 0.756757, ROC-AUC 0.969728, and AUCPR 0.637993, while for Testing results obtained precision 0.807143, recall 0.763514, f1-score 0.784722, ROC-AUC 0.97371, and AUCPR 0.759228.

Keywords: credit card, fraud, Isolation forest, unsupervised, precision, recall, ROC-AUC, AUCPR

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1. Introduction

The definition of fraud refers to the Black's Law Dictionary is "an act with attempts at fraud or violation by one or more individuals who are generally for financial gain" [1]. According to a report from the Association of Certified Fraud Examiners (ACFE) in 2018, there were losses of more than US \$ 7 billion [2]. One category of fraud is credit card fraud. Fraud trends in transactions continue to increase, resulting in large money losses every year. It is estimated that losses increase each year at double-digit rates by 2020 [3]. This is because physical cards are not needed in an online transaction environment, and information from the card is enough to complete the payments. This makes it easier to commit fraud than before.

One mechanism to minimize the risk of credit card fraud is to use a detection technique for ongoing transactions to identify potential fraud. Several machine learning and data mining techniques have been used in research into credit card fraud detection. The research included supervised learning based on neural networks [4], [5], rule base [4], logistic regression [6], [7], SVM [5] - [7], Random Forest [6] - [9], based on semi-supervised learning using Graph [8], and balanced Random Forest [10], and based on unsupervised-learning using auto-encoder [11], clustering [12], self organizing map [13], local outlier factor [14].

With the size of the current transaction data that is very large then to do a credit card fraud analysis must pay attention to aspects of the study of big data [15]. Some assumptions need to be considered in the condition of

a very large transaction data flow (big data), including that the data obtained are generally without labels (fraud or normal) and the number of incidents of fraud is very small compared to normal (skew). This assumption is of concern in several anomalous detection studies with one of the conclusions that the unsupervised learning algorithm excels at handling predictive tasks for large amounts of unbalanced data [16], [17]. The three unsupervised algorithms most commonly used are local outlier factor (LOF), one-class SVM (OCSVM), and Isolation forest (iForest) [16], [18], [19]. Of the three, iForest is the most efficient in detecting anomalies because it has good scalability capabilities for big data and reasonable memory usage for large sample sizes, so it is very suitable for the production environment [20].

Credit card transaction data in its original state does not have a label, other than that the amount of fraud data on the training data is very small so that it includes a very unbalanced category (highly imbalanced data) as well as a new pattern of fraud that is very open. In this study, a dataset from Kaggle originating from a credit card company in Europe was used. Some previous studies using this data set [21] - [23].

The study of Ounacer et al. [21] showed that Isolation forest is superior compared to an unsupervised algorithm by comparing performance using f1-score metrics, accuracy, and ROC-AUC (Receiver Operator Characteristic - Area Under Curve). Niu et al. [22] compared six supervised models with four unsupervised models. However, the supervised model is balancing using the normal data undersampling technique from 284,807 to 492 (0.17%) so that the resulting model is very vulnerable to bias and overfitting. The criticism for the ROC-AUC metric used by Ounacer et al. [21] and Niu et al. [22] is that the use of ROC-AUC for highly unbalanced data types can provide inappropriate information as a more appropriate alternative is the AUCPR metric (Area Under Curve - Precision-Recall) [24], [25].

The first contribution made in this study is to present a performance analysis with both the ROC-AUC and AUCPR to prove the best metrics for providing appropriate information. Second, building the Isolation forest model in detecting credit card transaction fraud through performance analysis by performing some optimization on the determination of the amount of training data, feature selection, the amount of fraud contamination, and setting hyper-parameters in the modeling stage so that the highest performing model can be obtained both validation data and Testing data shown through metric precision, recall, f1-score, ROCAUC, and AUCPR.

2. Method

This section discusses the theory of the Isolation forest algorithm and continues with the stages of the research scenario starting from understanding data, feature selection, modeling, and evaluation.

a. Isolation forest

Isolation forest is an unsupervised learning method formed from a collection of isolation trees or iTrees from a given data set, where the data will be called an anomaly when it has the shortest average path length on the iTrees.

Anomaly detection with iForest is done in two stages. The first is the training phase (training) to build an isolation tree using subsamples from the training data set. The second stage (testing) provides the test instance to the isolation tree to get an anomaly value for each instance.

1. Training Stage

At this stage, iTrees are created by recursively partitioning the training data set until all instances are isolated or when the maximum height of the tree is reached, which results in a partial model. The height limit of tree l is automatically set by the size of the sub-sample ψ : $l = \text{ceiling}(\log_2 \psi)$, which estimates the average height of the tree. The training stage algorithm can be seen in algorithms 1 and 2.

Algorithm 1 : $iForest(X, t, \psi)$

Inputs: X - input data, t - number of trees, ψ - sub-sampling size

Outputs: a set of t iTrees

```

1: Initialize Forest
2: set height limit  $l = \text{ceiling}(\log_2 \psi)$ 
3: for  $i = 1$  to  $t$  do
4:  $X' \leftarrow \text{sample}(X, \psi)$ 
5:  $\text{Forest} \leftarrow \text{Forest} \cup iTree(X', 0, l)$ 
6: end for
7: return Forest

```

Algorithm 2 : $iForest(X, t, \psi)$

Inputs: X - input data, e - current tree height, l - height limit

Outputs: an iTrees

```

1: if  $e \geq l$  or  $|X| \leq 1$  then
2: return  $exNode\{Size \leftarrow |X|\}$ 
3: else
4: let  $Q$  be a list attributes in  $X$ 
5: randomly select an attribute  $q \in Q$ 
6: randomly select a split point  $p$  from max and min values of attribute  $q$  in  $X$ 
7:  $X_l \leftarrow \text{filter}(X, q < p)$ 
8:  $X_r \leftarrow \text{filter}(X, q \geq p)$ 
9: return  $inNode\{Left \leftarrow iTree(X_l, e + 1, l),$ 
10:  $Right \leftarrow iTree(X_r, e + 1, l),$ 
11:  $SplitAtt \leftarrow q,$ 
12:  $SplitValue \leftarrow p\}$ 
13: end if

```

2. Evaluation Stage

At the evaluation stage, the anomaly value s is obtained from the expected length of the $E(h(x))$ path of each test instant. $E(h(x))$ is obtained by passing instances through each iTrees in iForest. By using the PathLength function, the length of the single path $h(x)$ is obtained by counting the number of ends e from the root node to the termination node that is passed by the x instance in iTrees. When x is terminated on an external node, with $Size > 1$, the value of e and setting $c(Size)$ is obtained. When all $h(x)$ has been obtained, the anomaly value can be calculated with formula 2. Detailed PathLength function can be seen in algorithm 3

Algorithm 3: *PathLength* (x, T, e)

Inputs: x – an instance, T – an *iTree*, e – current path length; to be initialized to zero when first called

Outputs: path length of x

```

1: if  $T$  is an external node then
2: return  $e + c(T.size)$ 
3: end if
4:  $a \leftarrow T.splitAtt$ 
5: if  $x_a < T.splitValue$  then
6: return  $PathLength(x, T.left, e + 1)$ 
7: else  $\{x \geq T.splitValue\}$ 
8: return  $PathLength(x, T.right, e + 1)$ 
9: end if

```

Because *iTree* has a structure equivalent to a Binary Search Tree, the estimated $h(x)$ for terminating an external node is the same as the unsuccessful search on BST. By borrowing analysis from BST to estimate the average length of the *iTree* track. So with n instance data sets, the average length of the unsuccessful search path in BST can be obtained:

$$c(n) = 2H(n-1) - (2(n-1)/n)$$

where $H(i)$ is a harmonic number and can be estimated with $\ln(i) + 0.5772156649$ (Euler constant). Because $c(n)$ is the average of $h(x)$ for n , it can be used for normalization of $h(x)$. The anomaly value s of instant x can be defined as:

$$s(x, n) = 2^{-E(h(x))/c(n)}$$

where $E(h(x))$ is the average value of $h(x)$ of a group of isolation trees. In formula 2:

- When $E(h(x)) \rightarrow c(n), s \rightarrow 0.5$;
- When $E(h(x)) \rightarrow 0, s \rightarrow 1$;
- and When $E(h(x)) \rightarrow n-1, s \rightarrow 0$.

s monotonic of $h(x)$. The relation between $E(h(x))$ and s satisfies the condition when $0 < s \leq 1$ to $0 < h(x) \leq n-1$. By using the anomaly value s , it can be determined:

- if the result of the instance s is very close to 1, then it is confirmed as an anomaly
- if the instant has s very small compared to 0.5, then it is very safe to be categorized as a normal instant, and
- if all instants produce $s \approx 0.5$ then all samples do not have anomalies.

b. Use of Data Sets

The data used in this study is a dataset obtained from Kaggle ULB. The dataset used is a data set containing credit card transactions conducted in September 2013 by European credit card companies for two days. This ULB dataset presents 284,807 credit card transactions, and 492 of them are fraudulent transactions. The number of fraudulent transactions, which is only 0.172% of the number of existing transactions, makes this ULB dataset very unbalanced. The ULB dataset contains

numeric data with 30 feature columns and 1 label/class column. Original feature information from 28 features cannot be displayed and explained in detail because of confidentiality issues (V1, V2, ... V28). The main components of the 28 features are obtained by PCA. Two other features that have not been transformed by PCA are 'Time' and 'Amount'. The 'Time' feature contains the time that passes for each transaction in seconds. The 'Amount' feature contains the transaction fee amount. And the 'Class' column is the response variable and a value of 1 if fraud occurs and 0 if normal.

c. Feature Selection

In this study, feature selection uses a random forest algorithm and filter method. The random forest algorithm is used to calculate the importance score of each feature. Features with a small importance score will be filtered and not used. The feature set that will be used is the 10 best features based on the highest importance score. Figure 1. shows the feature selection process carried out.

d. Distribution of Data Sets

Modeling is done by dividing the dataset into two namely training data (70%) and Testing data (30%). Training data is used to create a model through several variations of the experimental scenario. The schema of the experiments carried out can be presented in Figure 2.

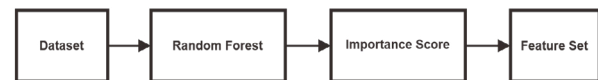


Figure 1. Feature selection process

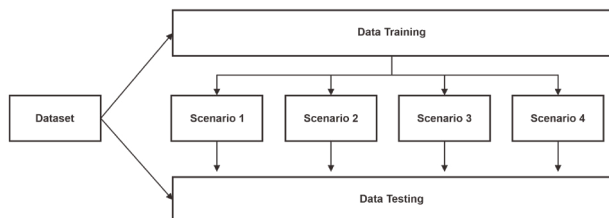


Figure 2. Experimental scenario

Broadly speaking, the experiment was conducted with four scenarios. Scenario 1 focuses on the split ratio used, scenario 2 focuses on the number of best features used, scenario 3 focuses on the ratio of fraud classes used in training, and scenario 4 focuses on the hyper-parameter settings used to create the model. for more details will be explained in detail in each scenario as follows :

- In scenario 1, the training data is split into two parts, namely training model data and validation data with a variety of ratios. Model training data is used to create a classification model, and validation data is used to test the model created. The split ratios used are 90:10, 80:20, 70:30, and 60:40. The split ratio that produces the best model will be used in the next scenario. Scenario 1 can be seen in Figure 3.

2. In scenario 2 a feature selection is performed on the training data and split the data into two with the best ratio of the results of scenario 1. Feature selection is done that is using several variations of the best number of features. The variation in the number of features used is 1 to 10 of the best features. The number of features used that produce the best model will be used in the next scenario. Schema experiment scenario 2 can be seen in Figure 4.
3. In scenario 3 a feature selection is performed with the best number of features from scenario 2 and divides training data into two with the best split ratio of scenario 1. After that, the training model data is separated between data labeled a fraud and normal. The classification model will be made by regulating the ratio of data labeled a fraud. The ratio used is 100%, 90%, 80%, ..., 20%, 10%, 5% of the total amount of data labeled fraud in the training data model. Schema scenario 4 can be seen in Figure 5.
4. In scenario 4, hyper-parameter settings are performed on the best model produced in scenario 3. The parameters of the Isolation forest algorithm are regulated, namely the number of trees, maximum sample, and contamination. The parameters of the number of trees used are 10, 25, 50, 100, 150, and 200. The maximum parameters used are 64, 128, 256, 512, and 1024. Contamination parameters used are 0.0004, 0.0008, 0.001, 0.0015, 0.002. Schema scenario 4 can be seen in Figure 6.

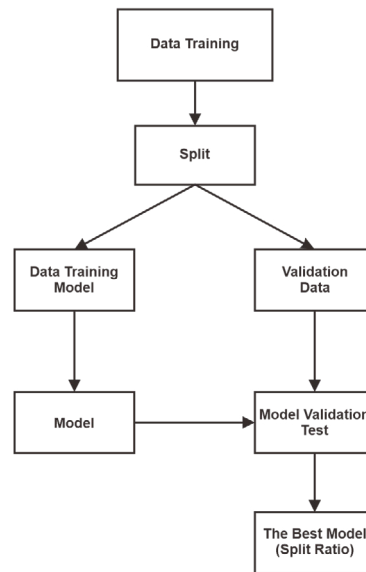


Figure 3. Schema scenario 1

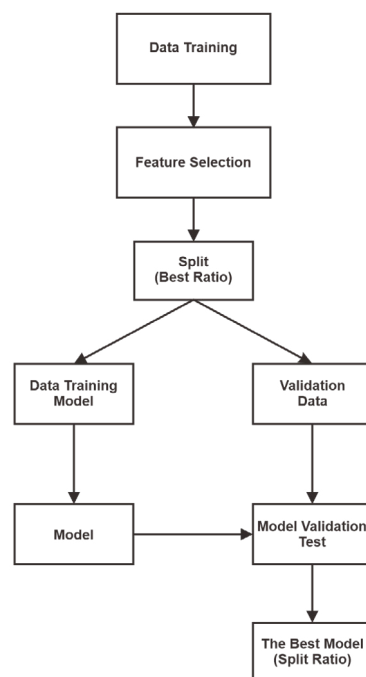


Figure 4. Schematic of scenario 2

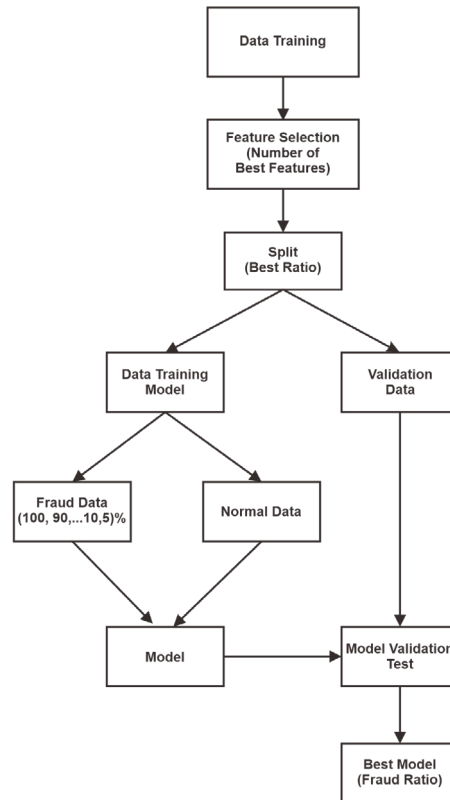


Figure 5. Scenario 3

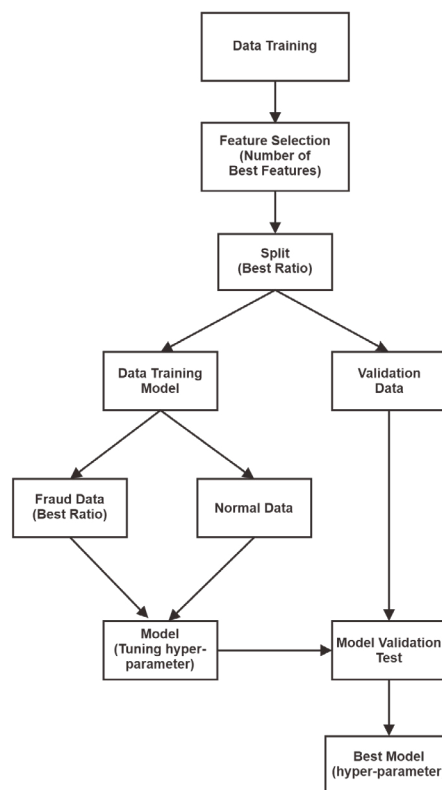


Figure 6. Schematic of scenario 4

e. Evaluation

Evaluation is carried out on training data for each experimental scenario (modeling) using Testing data. Classification model performance was calculated using precision, recall, f1-score, roc auc curve, and precision-recall curve.

3. Result

The experiment was documented in the Github repository (<https://github.com/BagusDAriAwan/fraud>). At the data understanding stage, no missing or blank data was found. While the results for the next stage, which are the results of feature selection and the results of each experimental scenario, are described in the following sub-chapters.

a. Results of Feature Selection Techniques

The results of feature selection using the random forest algorithm can be seen in Table 1. The information in Table 1. describes the attribute with a higher importance score, which has a stronger influence in classifying the data.

b. Experiment Scenario Results 1

Based on the evaluation results on the validation data, the best model with the training data ratio is 60%, and the validation data ratio is 40%. Detailed evaluation results on the validation data for each variation of the split data ratio can be seen in Table 2. The results of the evaluation of the best model using Testing data can be seen in Table 4. Figure 7 shows the best ROC curve and precision Recall model of the validation data, and in Figure 8 is the curve of the best model for Testing Data.

Table 1. Results of the random forest algorithm

Feature	Score	Feature	Score	Feature	Score
V14	0.191396	V19	0.012698	V23	0.006476
V4	0.156735	V8	0.011657	V22	0.006006
V17	0.154208	V6	0.010132	V1	0.005765
V12	0.153089	V27	0.009422	V24	0.005645
V11	0.075608	V3	0.007821	V28	0.005104
V2	0.051632	V26	0.007501	V18	0.004795
V10	0.038917	V9	0.007076	V16	0.004732
V7	0.015483	Amount	0.007075	V25	0.004156
V20	0.014762	V13	0.006597	V5	0.003216
V21	0.013873	V15	0.006509	Time	0.001916

Table 2. Scenario Validation Results 1

Split Ratio	Precision	Recall (TPR)	FPR	F1 Score	ROC AUC	AUCPR
90:10	0.1379	0.1176	0.0013	0.1270	0.9569	0.0828
80:20	0.2286	0.2319	0.0014	0.2302	0.9637	0.1480
70:30	0.2222	0.1942	0.0012	0.2073	0.9554	0.1160
60:40	0.2727	0.2391	0.0011	0.2548	0.9503	0.1576

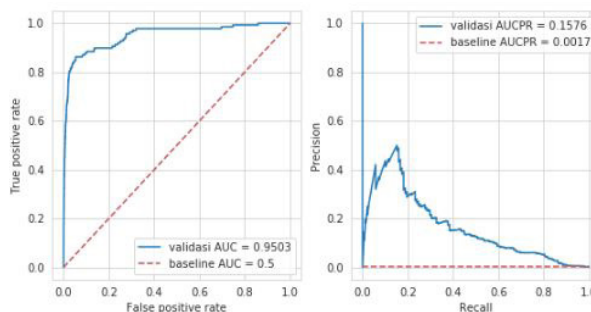


Figure 7. ROC curve and Precision-Recall data Validation scenario 1

Table 3. Best Scenario 1 Validation Confusion Matrix

Split ratio	TN	FP	FN	TP
60:40	79520	88	105	33

Table 4. Scenario Testing Results 1

Split ratio	Precision	Recall (TPR)	FPR	F1 Score	ROC AUC	AUCPR
60:40	0.3382	0.3108	0.0011	0.3239	0.9601	0.2138

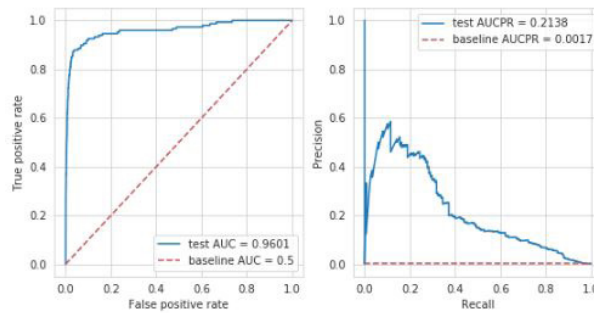


Figure 8. ROC curve and Precision-Recall data Testing scenario 1

Table 5. Best Confusion Matrix Testing Scenario 1

Split ratio	TN	FP	FN	TP
60:40	85295	0	148	0

Table 6. Scenario Validation Results 2

Number of Features	Precision	Recall (TPR)	FPR	F1 Score	ROC AUC	AUCPR
1	0.6160	0.5580	0.0006	0.5856	0.9422	0.5463
2	0.5887	0.5290	0.0006	0.5573	0.9650	0.5061
3	0.6165	0.5942	0.0006	0.6052	0.9684	0.5298
4	0.7231	0.6812	0.0005	0.7015	0.9674	0.6290
5	0.7254	0.7464	0.0005	0.7357	0.9704	0.6379
6	0.6667	0.6522	0.0006	0.6593	0.9731	0.5510
7	0.5500	0.5580	0.0008	0.5540	0.9667	0.4620
8	0.5845	0.6014	0.0007	0.5929	0.9713	0.5277
9	0.4310	0.3623	0.0008	0.3937	0.9714	0.3027
10	0.3798	0.3551	0.0010	0.3670	0.9732	0.2959

To better understand the characteristics between ROCAUC and AUCPR, a confusion matrix for the best model of validation data is presented in Table 3, and a confusion matrix for testing data in Table 4. It appears that a very large TN value compared to TP causes the ROCAUC value tending always to be high. Whereas AUCPR better describes the performance characteristics of the resulting model.

c. Experiment Scenario Results 2

Details of the evaluation results on the validation data with the number of features used can be seen in Table 6. Based on the evaluation results on the validation data, the best model with the number of features used are the 5 best features. The results of evaluating the best model using Testing data can be seen in Table 7. In Figure 9 the best ROC curves and precision Recall models are presented in the validation data and Figure 10 for Testing data.

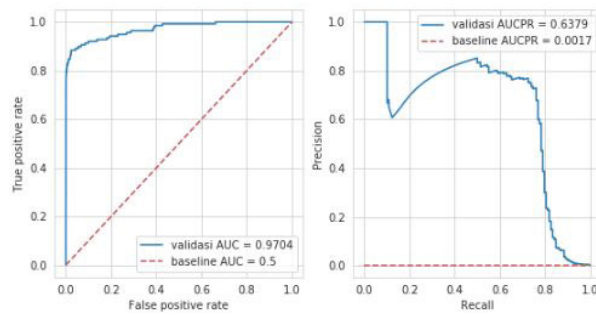


Figure 9. ROC curve and Precision-Recall data Validation scenario 2

Table 7. Scenario Testing Results 2

Number of Features	Precision	Recall (TPR)	FPR	F1 Score	ROC AUC	AUCPR
5	0.7222	0.7905	0.0005	0.7548	0.9732	0.7503

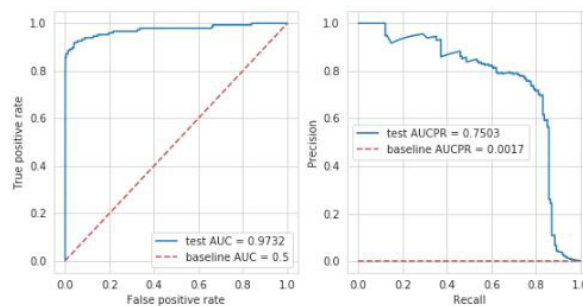


Figure 10. ROC Curve and Precision-Recall Data Testing Scenario 2

Table 8. Scenario Validation Results 3

Fraud Ratio (%)	Precision	Recall (TPR)	FPR	F1 Score	ROC AUC	AUCPR
100	0.7254	0.7464	0.0005	0.7357	0.9704	0.6379
90	0.7368	0.7101	0.0004	0.7232	0.9704	0.6094
80	0.7481	0.7101	0.0004	0.7286	0.9706	0.6294
70	0.7795	0.7174	0.0004	0.7472	0.9704	0.6363
60	0.8000	0.6957	0.0003	0.7442	0.9692	0.6429
50	0.7807	0.6449	0.0003	0.7063	0.9704	0.6049
40	0.7767	0.5797	0.0003	0.6639	0.9706	0.6033
30	0.8026	0.4420	0.0002	0.5701	0.9695	0.6071
20	0.8415	0.5000	0.0002	0.6273	0.9715	0.6463
10	0.7736	0.2971	0.0002	0.4293	0.9719	0.6316
5	0.7209	0.2246	0.0002	0.3425	0.9713	0.6227

d. Experiment Scenario Results 3

Based on the evaluation results on the validation data, the best model with a fraud ratio in the training data is 60%. Details of the evaluation results in the validation data for each variation of the fraud ratio in the training

data can be seen in Table 8. The results of the evaluation of the best model using Testing data can be seen in Table 9. Figure 11 shows the best ROC curve and precision Recall model in the validation data and Figure 12 for Testing data.

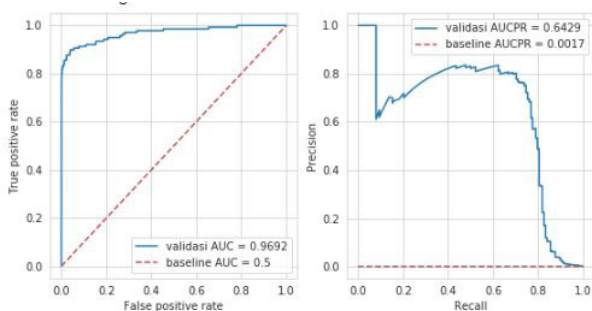


Figure 11. ROC curve and Precision-Recall data Validation scenario 3

Table 9. Scenario Testing Results 3

Fraud Ratio	Precision	Recall (TPR)	FPR	F1 Score	ROC AUC	AUCPR
60	0.7970	0.7162	0.0003	0.7544	0.9751	0.7524

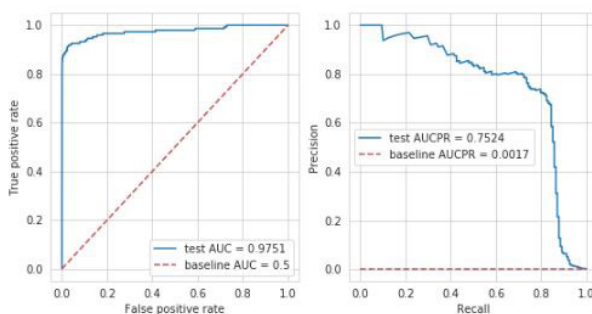


Figure 12. ROC curve and Precision-Recall Data Testing scenario 3

Table 10. Best Model Validation Results for Scenario 4

Precision	Recall (TPR)	FPR	F1 Score	ROC AUC	AUCPR
0.8099	0.7101	0.0003	0.7568	0.9697	0.6380

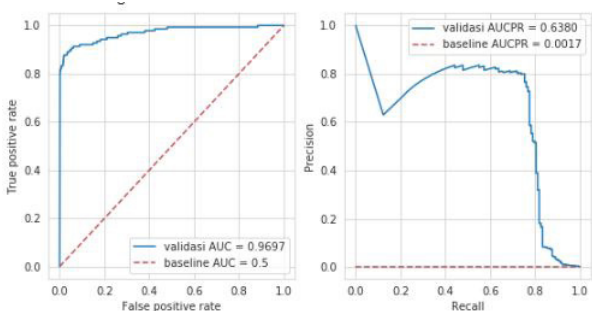


Figure 13. ROC curve and Precision-Recall data Validation scenario 4

Table 11. Scenario Testing Results 4

Precision	Recall (TPR)	FPR	F1 Score	ROC AUC	AUCPR
0.8071	0.7635	0.0003	0.7847	0.9737	0.7592

e. Experiment Scenario Results 4

Through a series of scenario 4 experiments on validation data, it was found that the best hyper-parameter model setting was to use the number of trees 100, maximum sample 128, and contamination 0.001. Evaluation results

on the validation data can be seen in Table 10 with Figure 13 for the ROC curve and its precision-recall. Evaluation results on the Testing data for the best model can be seen in Table 11 and Figure 14 presents the ROC curve and precision Recall.

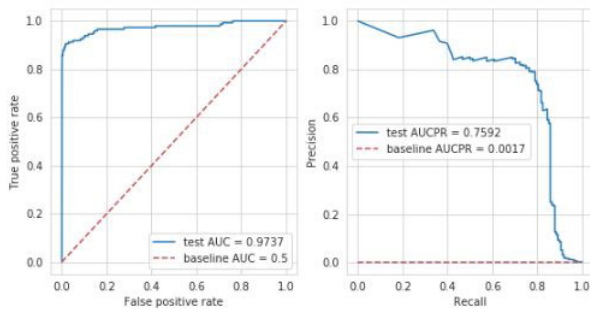


Figure 14. ROC curve and Precision-Recall data Testing scenario 4

4. Discussion

From a series of stages of experiments carried out, it appears that setting the amount of training data affects the quality of the model. This is indicated by obtaining a ratio of 60:40 in the validation data as the best value. Next, the selection of the most important features succeeded in providing a very significant performance improvement from f1-score 0.254826 to f1-score 0.735714. Setting the amount of fraud data in training has also been proven to improve validation performance. The last is setting some hyper-parameters to increase the f1-score validation performance to 0.756757. Overall performance testing data shows good results, even higher than validation data it shows that the resulting model is not overfitting.

In the case of fraud detection in credit card transactions, the value of precision takes precedence over recall considering that companies or organizations generally try to minimize normal customers who have detected fraud (False Positive) because it gives inconvenience so that it can cause loss of the customer. Therefore the final model obtained is prioritized to be able to increase the value of precision with a little compensation in its recall so that the highest precision is obtained by 0.809917, recall 0.710145 with the highest f1-score value is 0.756757.

Table 12. Resume of four experimental scenarios

Scenario	Precision	Recall (TPR)	FPR	F1 Score	ROC AUC	AUCPR
1	0.2727	0.2391	0.0011	0.2548	0.9503	0.1576
2	0.7254	0.7464	0.0005	0.7357	0.9704	0.6379
3	0.8000	0.6957	0.0003	0.7442	0.9692	0.6429
4	0.8099	0.7101	0.0003	0.7568	0.9697	0.6380

To compare between ROC and AUCPR, a resume of the four scenarios experiment results can be seen in table 12. It appears that all ROCAUC values are greater than 0.95, although this gives a good impression, it does not reflect the ability of the model to detect actual fraud, i.e., refer to the value precision, recall, and f1-score. In comparison, the AUCPR values from the four scenarios show better compatibility with the values of precision, recall, and f1-score. Thus it is proven that AUCPR is better

used as a performance metric for fraud detection on credit card transactions.

5. Conclusion

In this study, we analyze several factors that influence the performance of the Isolation forest model to detect fraud on credit card transactions. There are four experimental scenarios, namely the analysis of the effect of split ratio on data validation, the effect of feature selection, the effect of the amount of fraud data on training data, and the setting of hyper-parameter values. The experimental results show the best results obtained when the data validation split ratio is 60:40, using the five most important features, using 60% of fraud data in training, and setting hyper-parameters with the number of trees 100, maximum sample 128, and contamination 0.001. The best validation results of this model are precision 0.809917, recall 0.710145, f1-score 0.756757, ROC-AUC 0.969728, and AUCPR 0.637993. Based on these models, the results obtained in the testing data are precision 0.807143, recall 0.763514, f1-score 0.784722, ROC-AUC 0.97371, and AUCPR 0.759228. From observations of the results at each stage of the experiment, it can also be concluded that the AUCPR value is better in describing the performance of the model than the ROC-AUC value.

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The e-Learning Quality Model to Examine Students' Behavioral Intention to Use Online Learning Platform in a Higher Education Institution

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Abstract-The paper aims at understanding the behavioral intentions of students in using e-learning in a public university in Indonesia. We apply the e-learning quality model to observe the quality factors that trigger intentions. The quality factors include assurance, empathy, responsiveness, reliability, and website content. Understanding how these quality learning factors may affect a student's behavior intention to use e-learning is important to bring e-learning implementation success. We collected 502 responses from university students at a public university in Indonesia that implements a Moodle-based e-learning platform – namely ShareITS. Out of 5 (five) quality learning factors, we found only 2 (two) that significantly affect the e-learning quality – i.e., responsiveness and website content. The result shows that the teacher-student engagement in the e-learning platform and also the better visual design of ShareITS can improve the quality of the e-learning platform.

Keywords: behavioral intention, e-learning, higher education, learning quality model, service quality

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1. Introduction

E-learning is a symbol of modernized education in the world. Specifically, during the Covid-19 pandemic faced by people all over the world, unavoidably has changed the commonly found learning practices into learning at home. At last, e-learning becomes the last resort to learn at home, specifically designed to support the learning process [1].

Institut Teknologi Sepuluh Nopember (ITS) is one of the higher education institutions in Surabaya City, East Java Province, Republic of Indonesia, that has long been adopting e-learning in Moodle Platform called ShareITS since 2006 [2]. The Moodle-based ShareITS offers various features or services supporting modern education processes, given the lecturing and evaluation or assessment. The ShareITS users expect to run courses effectively using the platform [3].

To maintain the quality of the learning process, the quality of media instruction needs to improve during the course delivery. The e-learning quality will be perceived as a "good quality" when the quality of information presented in the e-learning program is of high quality, and the frequency of its adoption is relatively prominent. These two indicators will help the students to optimize the lecturing processes [4].

Meanwhile, the frequency of adoption of e-learning in ITS from 2006 to 2017 was found lagging as the percentage of users was only 41% [5]. Such a low percentage of ShareITS utilization is a challenge faced by ITS at present, and as e-learning utilization concerns with quality aspects, it is necessary to identify the e-learning service quality.

The research was to identify the service quality of ShareITS that is supposed to be an effective lecturing media. Among several findings from the previous research using ShareITS as a case study revealed that from the lecturer's perspective, it is relatively not handy to deliver courses using ShareITS [5]. The results from observation with 70 lecturers in ITS highlighted that only about 23% utilized ShareITS, and only two of the five hypotheses were accepted. The research suggested that the desire to adopt e-learning was concerned with benefits from an online learning process. There was another accepted hypothesis, i.e., the one concerning unfairness perceived by lecturers delivering e-learning in terms of rewards that significantly affect the sustainability of e-learning adoption. Such a threat needs to be well managed by the decision-makers in online lecturing programs so that ShareITS can be consistently optimized to face the advancing digital era.

Besides, this research is consistent with the ongoing

plan to develop ShareITS into a MOOC-Based e-learning System. Accordingly, the quality of ShareITS needs to be precisely measured as it will be used as a basis for preparing the MOOC implementation preparation. There have been many failures in implementing MOOC [6]. However, the focus of the previous works was mainly aiming at finding factors and causes to adopt ShareITS based on behavioral intention and acceptance analysis using the technology acceptance model, i.e., TAM and UTAUT [3], [7]. This study will focus on the implementation of the e-learning quality (eLQ) model to identify e-learning service quality and find out whether or not there is a relationship between quality and behavioral intention [8] in order to be able to give recommendations as constructive inputs to preparation of MOOC implementation.

The adopted eLQ Model refers to the concept of e-service quality to assess services using the internet [9]. E-service quality focuses on web-based service quality based on dimensions of expectation, hope, and perception of customers in operational processes and analysis on customers' satisfaction in an electronic business environment [10]. The eLQ model proposed a concept of e-service quality assessment and adopted the concept into the e-learning quality employing the e-learning quality model [11].

This research aims at identifying the e-learning service quality of ShareITS and analyze the relationship between e-learning service quality and behavioral intention through the application eLQ model in the perspectives of e-learning service users. Indeed, the model used in this research is none other than to measure the success of ICT implementation, such as an ISSM model yet in the context of education and Delone and McLean's IS success model as well [12]. Besides, previous research has even developed a quality gate instrument to support the successful implementation of e-learning in educational institutions [13]. However, this research focuses not on technology but also focuses on the aspects of the quality of e-learning services.

In [11], there are variables of web content, assurance, responsiveness, reliability, empathy, e-Learning Quality, satisfaction [14], and behavioral intention. However, in this study, the researcher modified the eLQ model by deleting the dimension of satisfaction since it is preferred that mandatory use concept in information system adoption to focus on the measurement of e-learning quality respected to behavioral intention. On the one hand, user participation and involvement are essential predictors of voluntary use system; but on the other hand, user participation and involvement would seem less important in the mandatory use system than in the voluntary use system. Therefore, the user satisfaction which would need more user participation and involvement will not be considered in this research.

The research hypothesis was formulated to identify the relations among independent, intervening, and dependent variables. Based on the research model, the variables, indicators, and statements were constructed in order to measure the e-learning service quality through

ShareITS. The variables in the eLQ Model comprised of independent, intervening, and dependent variables with statement items. These items later derived structured questionnaires.

2. Methods

This section discusses the method adopted in the research. There are four main phases, i.e., the preparation phase, the data collection phase, the data analysis phase, and the research result interpretation phase. The last also covers recommendations to e-learning service in order to improve online lecturing quality. Those four phases are then summarized in two phases, i.e., the designing phase and the implementation phase.

a. Designing Phase

In this phase, there were two main processes, i.e., conceptual model design and data collection. The conceptual model was designed to determine the conceptual method to adopt and guides during the model conformity test in the research focuses on the learning or education sector [15]. The conceptual model served as a reference during the research that has been adopted from the eLQ model [11].

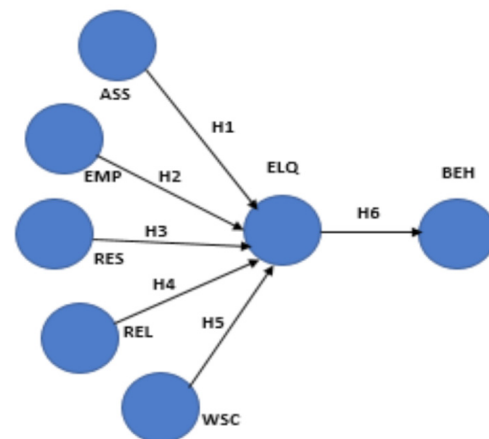


Figure 1. Research Hypotheses on eLQ Model

Fig. 1 shows that the research was to prove six hypotheses (H1 through H6) containing seven observation dimensions, as depicted in Table 1. The hypotheses are:

- H1:** Assurance has a significant positive relationship to the e-learning quality.
- H2:** Empathy has a significant positive relationship to the e-learning quality.
- H3:** Responsiveness has a significant positive relationship to the e-learning quality.
- H4:** Reliability has a significant positive relation to the e-learning quality.
- H5:** Website Content has a significant positive relation to e-learning quality.
- H6:** E-learning quality has a significant positive relationship to behavioral intention.

Table 1. The Description for Each Hypothesis

Dimensions	Code	Definitions
Behavioral Intention	BEH	This variable is for identifying the behavioral intention of e-learning utilization [16].
e-Learning Quality	ELQ	This variable is used for measuring web service quality and has been developed in previous research. It represents the whole perception of quality, guideline clarity, information, and functionality of features of the e-learning system [17].
Assurance	ASS	The variable represents the assurance of information during the learning processes involving good people, processes, and systems that will affect e-learning service quality [14].
Empathy	EMP	The variable shows commitment to share information about various instructional materials. It shows good e-learning utilization that will affect e-learning service quality [18].
Responsiveness	RES	This variable represents a quick response from good people and a system that will affect e-learning service quality [11].
Reliability	REL	The variable indicates the reliability of people and the system involved in a good lecturing process that will affect e-learning service quality [11].
Website Content	WSC	Content of a good website that will affect e-learning service quality [19].

Table 2. List of Questions in Questionnaire

Variables	Statement
Behavioral Intention	1) I would recommend this e-learning system to someone else
	2) I would likely enroll in other online courses that are available
e-Learning Quality	1) Your perception of the overall quality of the instruction you get from the e-learning system is excellent
	2) The e-learning system seems to be up to date
	3) The e-learning system works well
	4) The e-learning system has explicit instruction
Assurance	1) The instructor is knowledgeable in his/her field
	2) The instructor is fair and impartial in grading
	3) The instructor answers all the questions thoroughly
	4) I am confident the instructor has an expert understanding of the material
	5) Our e-learning system enables a comfortable storing and sharing of documents with my colleagues
	6) Our e-learning system supports an effective and efficient sharing of information with my colleagues
	7) Our e-learning system enables easy and comfortable communication with my colleagues
	8) The e-learning offers a variety of ways to assess my learning (quizzes, written work, oral presentation, etc.)
Empathy	1) The instructor is genuinely concerned about the students
	2) The instructor understands the individual needs of students
	3) The instructor has the student's best long-term interests in mind
	4) The instructor encourages and motivates students to do their best
Responsiveness	1) The instructor quickly and efficiently responds to student needs
	2) The instructor is willing to go out of his or her way to help students
	3) The service delivered through the e-learning pages is quick
	4) The instructor always welcomes student questions and comments
Reliability	1) The instructor consistently provides good lectures
	2) The instructor is dependable
	3) The instructor reliably corrects information when needed
	4) The e-learning system provides services as promised
	5) The e-learning system is easy to navigate
	6) The e-learning system provides useful and reliable information
	7) The e-learning system makes it easy to find what I need
Website Content	1) The e-learning system uses audio elements properly
	2) The e-learning system uses video elements properly
	3) The e-learning system uses animations/ graphics properly
	4) The e-learning system uses multimedia features properly
	5) The e-learning system provides useful information
	6) The e-learning system provides accurate information
	7) The e-learning system provides high-quality information
	8) The information on the e-learning system is relevant to me
	9) There is a reliable search system on the e-learning system
	10) The e-learning system is well structured

This research adopted a quantitative method. The data were collected by distributing questionnaires to students of undergraduate degree programs using ShareITS. The measurement range was Likert scale 1 through 4; by deleting scale three, known as a neutral scale or neutral response, might lead to a central tendency effect, specifically to those in doubt with their response, and such deletion is supposed to prevent unreliable results of questionnaire data processing. Table 2 depicts the question statements used in the research model.

Then, the descriptive analysis was conducted by analyzing quantitative data collected from respondents that had completed the research questionnaires. The questionnaires were distributed both online and offline. The questionnaires were tested twice for validity and reliability. The first testing adopted 120 sample respondents, 80 of them completed the questionnaires online, and the rest 40 sample respondents did offline. The second testing adopted 100 sample respondents, 60 of them completed the questionnaires online, and the rest 40 sample respondents did offline. At first, there were 50 items of questions. After the questionnaires were tested twice, both online and offline, it was found that there 40 questions reliable to be addressed to the primary respondents.

After the questionnaires had been identified to be valid and reliable, the questionnaires were re-distributed. The research collected 502 ITS students of undergraduate programs enrolled in 10 faculties and actively attending the first semester to the eight-semester.

Implementation Phase

Having distributed the questionnaires, the researchers found attractive matters addressed by respondents utilizing the ShareITS e-learning system. It was found during the implementation phase that the online subjects lectured through ShareITS were not open to the public or voluntary as required in MOOC, except some subjects incorporated managed by the Ministry in charge of education in Indonesia after subject to feasibility testing [20]. Therefore, the number of MOOC subjects in the ShareITS platform is practically not many. 95% of the students utilized ShareITS due to encouragement by their lecturers and the rest 5% followed such online lecturing based on personal initiative.

In general, 82% of the respondents stated that they followed online lecturing on 1-2 subjects. On average, each of the respondents took 6-7 subjects, and only two subjects were lectured online through the ShareITS platform, and only 15% attended six subjects online. The degree of ShareITS utilization was only 21%. 73% of the respondents confirmed that the e-learning service quality was perceived well. The research would explore the factors perceived to be well using the conceptual model to assess what factors affected the expected e-learning service quality.

Then, the research model was tested to prove which hypotheses were accepted based on the conceptual research model. Several tests were performed, including reliability

and validity testing, classical assumption testing, and inferential analysis.

The reliability and validity testing was adopted using the SPSS Software to ensure that the collected data in the research were reliable and valid. The testing results showed that all of the statement items were reliable and valid. Having completed the reliability and validity testing, the researcher conducted a classical assumption testing.

The classical assumption testing was adopted to assure that the multiple linear regression in the research was sound. The tested aspects were normality, multicollinearity, and heteroscedasticity. After that, an inferential analysis was performed.

The research performed several tests, i.e., convergent validity, Average Variance Extracted (AVE), discriminant validity, and composite validity. The results of AVE testing was good as the value of each tested variable was > 0.5 . The discriminant validity was good as all variables to variable constructs had better value than the ones of other variables—the composite Cronchbach Alpha ≥ 0.60 . In short, it was conclusive that the variables in the research were reliable and valid to represent the original data.

Having completed the outer model testing, the researcher proceeded to the goodness fit index testing. It represented how good was the model for the research. The research adopted the Standardized Root Mean Square Residual (SRMR) method. The goodness fit index value assessed employing the SRMR method in the research showed that the value of the estimation model was 0.087 (acceptable). Having identified the result of goodness fit index testing, the researcher proceeded with the inner model testing. The result of the inner model testing showed that not all variables had a positive regression coefficient, and the significance value was 1.647.

3. Result and Discussion

There are three main stages in this research, analysis, and testing. They are descriptive analytics, reliability, and validity test, classical assumption test, and inferential analysis.

Descriptive analytics is used to represent the results of data processing descriptively to know the patterns and demographics of research respondents. After conducting descriptive analytics, the data then being tested its reliability and validity.

Reliability and validity tests are used to ensure that the data used in the research is reliable and valid. This test uses SPSS software, and the results obtained are all items reliable and valid statement. After conducting reliability and validity testing, the classical assumption test then being tested.

The classical assumption test is used to assure that multiple linear regression in the research is sound. There are three parts of the classical assumption test, which are the normality test, multicollinearity test, and heteroscedasticity test. This test uses Minitab software, and

the results obtained are all data test results that fulfill the multicollinearity test and heteroscedasticity test, while for the normality test results, there is one variable that is not normally distributed. However, some researchers suggest that allow if it does not fulfill one test in the classical assumption test. After conducting the classical assumption test, the inferential analytics then being tested. Inferential analytics in this research using SmartPLS software. Inferential analytics has two tests, i.e., the outer model and the inner model [21].

a. Outer Model Test

The outer model test is used to measure the reliability and validity of statement items in each variable. The result of convergent validity is found valid because all statement items have value above 0.5 (see Table 3). The results AVE (Average Variance Extracted) is found acceptable because all variables have values above 0.5. The results of discriminant validity are declared good because all the variables to the construct of the intended variable have a greater value than the value of other variable constructs. The result of composite reliability is reliable because it has a composite reliability value $\geq 0,70$ and Cronchbach Alpha value $\geq 0,60$. So it can be concluded that the variables in this research can represent the original data.

Table 3. Outer Model Result

Item	Loading factor	Convergent Validity
ASS	<i>AVE = 0,559 ; Alpha = 0,736; CR = 0,835</i>	
ASS5		0.708
ASS6		0.840
ASS7		0.731
ASS8		0.705
EMP	<i>AVE = 0,618; Alpha = 0,796; CR = 0,866</i>	
EMP1		0.765
EMP2		0.780
EMP3		0.821
EMP4		0.778
RES	<i>AVE = 0,507; Alpha = 0,686; CR = 0,804</i>	
RES1		0.742
RES2		0.767
RES3		0.618
RES4		0.712
REL	<i>AVE = 0,548; Alpha = 0,720; CR = 0,827</i>	
REL2		0.603
REL4		0.715

Item	Loading factor	Convergent Validity
ASS	<i>AVE = 0,559 ; Alpha = 0,736; CR = 0,835</i>	
REL6		0.835
REL7		0.787
WSC	<i>AVE = 0,543; Alpha = 0,707; CR =0,823</i>	
WSC1		0.759
WSC6		0.791
WSC7		0.826
WSC8		0.655
ELQ	<i>AVE = 0,610; Alpha = 0,788; CR = 0,862</i>	
ELQ1		0.754
ELQ2		0.758
ELQ3		0.812
ELQ4		0.800
BEH	<i>AVE = 1,000; Alpha = 1,000; CR =1,000</i>	
NBEH3		1.000

b. Goodness Fit Test

After doing the outer model test, the goodness-fit index was applied to measure how well the model in this research. A good model is shown by the value estimation model of the selected model measurement method—this research, using the SRMR measurement method (Standardized Root Mean Square Residual). The value of goodness fit index performed by the SRMR method in this research yielded an estimation model value of 0.087 (See Table 4). So it can be concluded that the model in this research is acceptable.

Table 4. Goodness Fit Test Result

Goodness of fit	Cut off value	Result
Standardized Root Mean Square Residual (SRMR)	$0,05 \leq SRMR \leq 0,10$	$0,087$
	<i>acceptable fit</i>	
	$0 \leq SRMR \leq 0,05 = good fit$	

c. Inner Model Test

The inner model test then being tested. The result of the inner model test showed that is not all variable relations have a positive regression coefficient value and significance value greater than 1.647. Of the six hypotheses, there are only two hypotheses that have a positive regression coefficient value and a significance value greater than 1.647, which means having a positive and significant relationship.

Table 5 shows that the correlation of variables that have a positive and significant effect are: (1) Responsiveness to e-learning quality, and (2) Website Content to e-learning quality.

Table 5. Inner Model Test Result

Variable Correlation	Coefficient Parameters	T-Table	T-Statistics	P-value
ASS → ELQ	0.031	1.964	0.641	0.522
EMP → ELQ	0.084	1.964	1.640	0.102
RES → ELQ	0.329	1.964	7.191	0.000
REL → ELQ	-0.003	1.964	0.064	0.949
WSC → ELQ	0.343	1.964	7.137	0.000
ELQ → BEH	-0.159	1.964	2.819	0.005

Table 6 shows the results of R-square.

- The variable of behavioral intention has an R-Square value of 0.025. The result shows that behavioral intention variables can be explained by the variability of assurance, empathy, responsiveness, reliability, website content, and e-learning quality of 2.5%.
- The variable of e-learning quality has an R-Square value of 0.411. The result shows that the variable of e-learning quality can be explained by the variability of assurance, empathy, responsiveness, reliability, and website content 41.1%.

Table 6. R-square Test Result

<i>R-square Of Latent Variable</i>	
BEH	0.025
ELQ	0.411

Then, the hypothesis testing will be applied to know the acceptance or rejection of the hypotheses prepared by the researcher based on the conceptual model of research through the bootstrapping process on the structural model using SmartPLS software.

Table 7. Hypotheses Results

Hypotheses	Result
<i>Assurance -> E-Learning Quality</i>	Rejected
<i>Empathy -> E-Learning Quality</i>	Rejected
<i>Responsiveness -> E-Learning Quality</i>	Accepted
<i>Reliability -> E-Learning Quality</i>	Rejected
<i>Website Content -> E-Learning Quality</i>	Accepted
<i>E-Learning Quality -> Behavioural Intention</i>	Rejected

Table 7 depicts two accepted hypotheses, which are the relationship responsiveness variable and e-learning quality, and the relationship website content variable and e-learning quality.

d. Effects of Variable Responsiveness to E-Learning Quality Variable

Based on the result of the inferential analysis presented in the previous implementation paragraph, it was found that the responsiveness variable positively and significantly affected the e-learning quality variable. It is evidenced by the value of a parameter coefficient of 0.329 and the value of T-stat that was greater than the one of T-Table

of 7,191 gained from inferential analysis to explain that the responsiveness variable has a significant relationship with the e-learning quality variable.

The value of the parameter coefficient was used to explain that the responsiveness variable has a positive effect on the e-learning quality variable. Accordingly, it was found that the relationship between the responsiveness variable and the e-learning quality variable was positive and significant. Based on such conclusion, correction and improvement in issues related to responsiveness would directly affect e-learning quality through ShareITS and a basis of recommendations in the preparation of MOOC implementation.

The following are four recommendations to improve responsiveness:

1. To provide a service to register a username and password. The recommendation is based on responses to open questions, i.e., the students were given the e-learning username and password of Share-ITS from the administrator in a pretty long time.
2. To expand bandwidth services and to perform regular server maintenance to facilitate better speed of access to the system. The recommendation arises based on responses to open questions, i.e., access to system loading is slow. It indeed calls for a better wifi connection to ITS and server maintenance to prevent 'down' condition when being accessed.
3. To have the enrollment process integrated with Integra. The recommendation is based on responses to open questions, i.e., an easy process in registering enrollment of a course.
4. To arrange a workshop on how to give responses to questions and comments in a forum in ShareITS. The recommendation emerges based on responses to open questions, i.e., Not all users receive questions and give comments.

e. Effect of Website Content Variable to E-Learning Quality Variable

Based on the results of the inferential analysis, it was found that the website content variable positively and significantly affected the e-learning quality variable. It was proved by the value of the parameter coefficient of 0.343 and the value of T-Stat that was greater than the one of T-Table of 7,137. The value of the parameter coefficient explained that the website content variable had a positive and significant effect on the e-learning quality variable. Therefore, if the website content were improved, it would directly affect the e-learning quality variable to be adopted to improve the service quality of ShareITS for ITS students. The acceptance of the hypothesis showed that there was a relationship between the website content of ShareITS and the e-learning quality variable that would be a basis for a recommendation in the preparation of MOOC implementation.

The following are four recommendations to improve website content variable:

1. To apply an embedded system for teleconference service as a substitute for classical face-to-face lecturing sessions. This recommendation is consistent with the expectation of the ShareITS administrator to implement MOOCs.
2. To offer an online certification service for non-ITS students who have completed online courses. This recommendation is consistent with the expectation of the ShareITS administrator to implement MOOCs.
3. To have the UI and UX clear course grouping. This recommendation is consistent with the expectation of e-learning service users based on the responses to open questions.
4. To present detailed information about the availability and number of courses that have been, are being, and will be offered. This recommendation is consistent with the expectation of e-learning service users based on the responses to open questions MOOC checklist rules provided by EdX.

4. Conclusion

Based on the results of research on implementing the e-learning quality (eLQ) model to identify the factors affecting ShareITS service quality, we conclude that factors of responsiveness and website content affected e-learning service quality. The administrator of ShareITS must consider those aspects to enhance the e-learning service quality. The results found that those two aspects focused on online learning supporting technology to assure responsiveness and appropriate content as expected by the users of ShareITS, instead of on human or organization as commonly experienced by other academic institutions.

The observation using the e-learning quality (eLQ) model showed that e-learning service quality had no relationship with behavioral intention to use it. The number of respondents in this research was quite sufficient, i.e., 502 respondents, to support the finding that e-learning service quality was not a determinant of behavioral intention within the e-learning quality model. It is consistent with the mandatory use theory and the existing condition of the ShareITS. However, the e-learning service quality may not perceive good when observed from the perspective of service quality only. It also needs to be viewed in terms of the degree of its utility. We suggest, therefore, to further explore the human behavior-related aspect using other models or to modify the conceptual research model to generate more complete results.

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Decision Support System for Selection of the Best Member at Junjung Biru Waste Bank Using the Composite Performance Index (CPI)

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Abstract-Junjung Biru Waste Bank conducts a selection of the best member biennially. The process is crucial, but it does not have a supporting system, which poses problems emerging from data redundancies and data loss. Among the problem is the difficulty for administrators in summarizing data of members who have transactions. To solve the problem, we devised and implemented a decision support system using the CPI (Composite Performance Index) method. The criteria are the amount of balance and active saving during a six-month interval. The results of this research is a web-based decision support system that produces a ranking order of members, which helps in selecting the best member.

Keywords: decision support system, member, composite performance index

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1. Introduction

Decision Support System (Decision Support System) has been developed since 1970. Decision Support System (DSS) supported by a computer-based information system can help someone improve their performance in decision making by choosing various alternative decisions by means of processing information available using a decision-making model. Decision Support System is defined as an information system that provides information, modeling and data manipulation [1].

Waste management is an activity carried out to handle waste from its generation to final disposal. In general, waste management activities include waste generation control, garbage collection, transportation, processing and final disposal. Community-based waste management is a waste management approach based on active community participation [2]. Junjung Biru garbage bank is a kindergarten school that has been established since 2003 only recently used the garbage payment method in 2013. According to the results of interviews conducted with the director of the Junjung Biru waste bank, the school has a focus on increasing environmental awareness and promoting a school payment method using trash collected by the students' parents. The main reasons of such initiative is due to the Junjung Biru garbage bank is located around low-income communities

such that the use of garbage as a payment method instead of money will reduce the burden of the parents. The Junjung Biru waste bank also received assistance from one of the national companies i.e. PERTAMINA through its CSR Development Partners Program as to improve the community's economy. The trash collected by the parents are organic waste and non-organic waste. Organic waste will be managed into compost and non-organic waste will be recycled into various accessories. In fact, everyone can be a member of the garbage bank not only the guardians of the students at the Junjung Biru school but also the general public around the Junjung Biru school.

Currently, Junjung Biru Waste Bank has 100 members consisting of kindergarten children who attend school in Junjung Biru and adolescents as well as the elderly living in the area Junjung Biru. To encourage the participant of Junjung Biru Waste Bank, it wants to give appreciation to the surrounding community in the form of reward as the best member. Rewards are given as gratitude for the good response of the community members who have made for this positive activity. Presently, Junjung Biru does not have a system to manage its members and how to determine the best members in the community. Therefore, the administration staff finds it difficult to select the best member. In addition, manually selecting it may cause an error due to there might be incorrect data input and miss calculation. The situation becoming more difficult since

the selection of the best members is conducted twice a year or once every 6 months.

To solve the problems, a decision support system is needed by the administrator of Junjung Biru waste banks to determine the best members who will be rewarded. In this research we proposed a web-based application as a decision support system (DSS) to tackle the problems of the community.

Decision support systems have several methods in determining decisions such as the Exponential Comparison (MPE) method, the Bayes method and the Composite Performance Index (CPI) method. These methods are often used in criteria-based decision making. The Bayes method has the advantage of being easy to understand, it only requires simple coding and is faster in calculations, but there is a weakness namely the less accurate results obtained, in other words, less evidence to prove the correctness of the answers generated from this method [8]. In addition, Bayes is also used when the alternative value is the real, measurable value [9]. Furthermore, the exponential comparison method (MPE) is used for uniform assessment similar to the Bayes method [10]. The Exponential Comparison method is used to determine the priority order of decision alternatives with multiple criteria and is very suitable for ordinal scale assessments, for example very good, good, poor and very poor) [11].

Several previous studies have also implemented decision support systems, in which one of the DSS methods used is the Composite Performance Index (CPI). One of the studies applied the CPI to provide teacher performance assessments, so that the use of information technology can be of maximum benefit to every level of society [3]. Another study also stated that DSS can minimize errors and subjectivity in choosing the best teacher and can provide more effective results regarding the selection of exemplary teachers as well as make it easier to select it [4].

Another study implemented DSS for selecting the best hotel in certain city. The study stated that the creation of decision support systems results an information of hotel ratings which can be used as a reference for the people under several criteria [5]. A study that specifically implemented CPI method also stated that it can help users to make decisions in determining promotion strategy with an outstanding performance [6]. Additionally, another research explained that the use of the CPI method makes it easier to determine decisions on multi-criteria problems such as selecting student council officers with multi criteria and alternative choices that are arranged into a hierarchy [7].

The Composite Performance Index (CPI) method is usually applied for assessment with non-uniform criteria [12]. The CPI has the advantage of determining ratings or ratings of various alternatives based on several criteria [13]. From some of the studies above, we conclude that this decision support system needed in uphold blue waste banks is a system using the CPI (Composite Performance

Index) method. The CPI (Composite Performance Index) method is a method of calculating decision-making based on a combined performance index that can be used to determine ratings or ratings of various alternatives i based on several criteria j . With the decision support system for selecting the best member, it can help Junjung Biru waste banks understand the best members and the process of calculating member data becoming more accurate and efficient so that it can motivate the surrounding community to participate the program as well as encourage them to protect the surrounding environment by collecting garbage. This decision support system is made in the form of a website application and the results of the calculation of the best members can be displayed in graphical form, making it easier for the admin to see the results and the printing process can be done immediately.

2. Method

a. Data Collection Method

In this research, the data collection is carried out through primary data in the form of observation and interviews. Observations are conducted directly at the Junjung Biru waste bank. At that place we are directly involved in the activities and observed it, the results of such activities become the data source. Observations are also carried out flexibly such that research data can be directly written into notes and using a voice recording device. Furthermore, we also conduct additional interviews with the director and teachers of the Junjung Biru school to explore the critical problem of how to determine the best member in the community to be awarded. In addition, we also use questionnaire as an instrument to measure the usability of the application system is made for the user. In addition to primary data, researchers also use secondary data in the form of data obtained indirectly from the object to help this research in the form of document studies, namely books and journals related to research.

b. CPI (Composite Performance Index) method

The Composite Performance Index (CPI) is a composite index that can be used to determine the assessment or rank of various alternatives i based on several criteria j [14]. The CPI method is formulated as follows:

a. Matrix Normalization

Matrix normalization is done by adjusting the Criteria Value with a predetermined weight value.

b. Menentukan nilai kriteria:

$$A_{ij} = x_{ij} / x_{ij}(\min) \times 100; \quad (1)$$

$$i = 1, 2, \dots, n \text{ and } j = 1, 2, \dots, m$$

c. Determining CPI Value:

$$I_i = 1A_{ij} B_j; \quad (2)$$

$$i = 1, 2, \dots, n \text{ dan } j = 1, 2, \dots, m$$

Information:

A_{ij} = The alternative value to i in the criteria j

X_{ij} = The initial value of the alternative i in the criteria

- j
- $X_{ij}(\min)$ = The alternative value to i on the minimum criterion to j
- B_j = Weighted criterion importance to j
- I_i = Criteria combined index on alternate keys i

c. Systems Development Method

The system development method used in this research is the Prototype method. The prototype method consists of 3 stages [15] as can be seen in Figure 1.

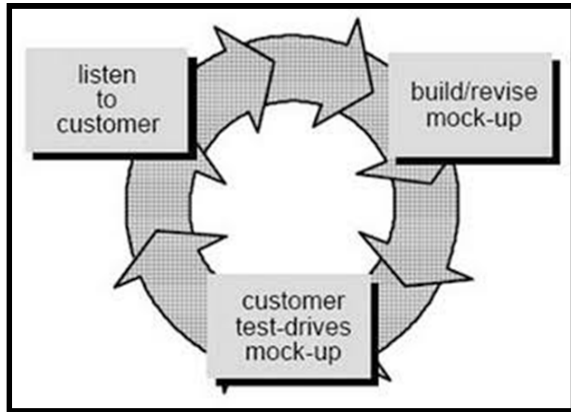


Figure 1. Prototype Model

From the Figure 1, the stages of the prototype are described as follows:

- a. Listen-to-Customer Stage
This stage is to identify the needs of potential users by designing business processes, identifying documents, main menus and user interface structures.
- b. Build / Revise-Mock-Up Stage
This stage begins with designing a database based on the menu and user interface design. The next process is translation into programming languages and determining the supporting software and hardware.
- c. Customer Test-Drive-Mock-Up Stage
At this stage, the simulation is carried out in coordination with potential users to find out to what extent the system can accommodate their needs. When there is a need for improvement, it returns to the Listen-to-Customer Stage and beyond until all user needs are properly accommodated.

3. Result

a. Listen to Customer stage

In this early stage, the researcher made direct observations to see the business process at the blue uphold waste bank. In addition, researchers also conducted interviews with the Directors and existing teachers to determine the assessment criteria and determine the best members. To get the best member, there are two criteria that are assessed. The first criterion, the amount of balance you have, then the second criterion is active savings, where this activity is taken from the number of deposit

transactions made, who is diligent in saving and making transactions. Of the two criteria, the best member will be obtained, but because there is no system for processing this decision support data, it is necessary to create a decision support system using the CPI (Composite Performance Index) method so that it can make it easier for admins to input data while helping uphold blue directors to be more fast in finding out the best members. This decision support system is website-based and the results of the best member data processing are displayed in graphical form.

b. Calculation analysis using the CPI method

The rank of criteria is determined based on several criteria. In the Junjung Biru waste bank, the criteria for the best member are determined based on the amount of balance and active deposit transactions of saving for 6 months. The criteria value is shown in table 1.

Table 1. Pairwise Comparison

Alternative	Criteria	
	C1 Total Balance	C2 Liveliness
A1	Rp 80.000	34
A2	Rp 30.000	16
A3	Rp 60.000	25

Furthermore, the degree of importance of each criterion in the Junjung Biru waste bank is also taken into account. Currently there are two criteria and these two criteria are equally important to determine the best members, the value of the degree of importance is 0.5 for each criteria.

Table 2. Weight of Interest (P) and Trends

Criteria	C1 Total Balance	C2 Liveliness
Weight	0.5	0.5
Trends	Positive	Positive

- 1) Calculation of the value of the balance amount
The trend in the criteria for the amount of balance is (+) where the higher the value, the better.

Trends (+) = Value N/Min Value * 100

Table 3. Calculation of Total Balance Value

Numb	Alternative	Balance Amount	N/Min	N/Min*100
1	A1	80.000	2.67	267
2	A2	30.000	1	100
3	A3	60.000	2	200

- 2) Calculation of Activity Value
The trend in activeness criteria is (+) where the higher the value the better.
Trends (+)= Value N/Min Value *100

Table 4. Calculation of Activity Value

Numb	Alternative	Balance Amount	N/Min	N/Min*100
1	A1	34	2.125	212.5
2	A2	16	1	100
3	A3	25	1.56	156

3) CPI calculation

$CPI = \frac{\text{value_criteria_number of balance} * \text{weight_count of balances} + \text{value_criteria_activity} * \text{weight_activity}}{\text{value_criteria_number of balance} * \text{weight_count of balances} + \text{value_criteria_activity} * \text{weight_activity}}$

Table 5. CPI Calculation Results

Numb	Alternative	CPI
1	A1	239,75
2	A3	178
3	A3	100

The final result after computing CPI, A1 gets the highest score and therefore, it becomes the best member at the Junjung Biru waste bank in this period. However, there are 2 people having the same value as the best member, we look again at the deposit transaction history from the second criterion and select the one who is the most active in saving and making deposit transactions each month.

c. Mock Up Build / Revise Stage

After analyzing the running business processes and determining whether to make the DSS system, the researchers proceeded to make a system design. This study uses a system design in the form of DFD (Data Flow Diagram) in Figure 2 and also ERD (Entity Relationship) in Figure 3. DFD is a network that describes a computerized system, manually process or can be a combination of the two, whose depiction is arranged in the form of a collection of components connected to each other according to the rules of the game [16]. Whereas ERD is a technique to model the data requirements of an organization, usually carried out by system analysts in the requirements analysis stage of a system development project [17]. After the analysis process, the next step is to design the data flow diagram DFD of the system, details of the system DFD can be seen in Figure 2.

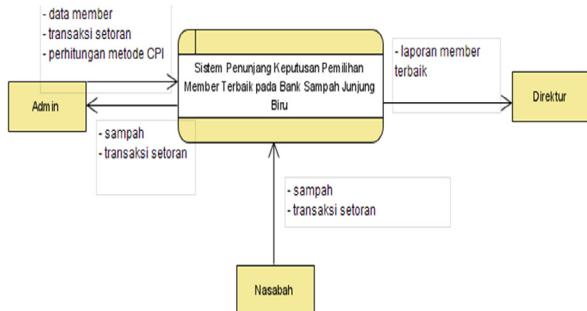


Figure 2. Data Flow Diagram

Figure 2 explains that there are 3 entities in the system, namely customers, admins and directors. In the Customer entity that provides waste to be inputted by the admin, the rupiah value is. then the customer can also provide a deposit for admin input. The admin who processes the best member data is taking member data and member deposit transaction data to find out the existing balance and also to be processed in the system using the CPI method, which then results in the best member being given to the Director Junjung Biru

Furthermore, in Figure 3, namely ERD (Entity Relationship Diagram) as follows:

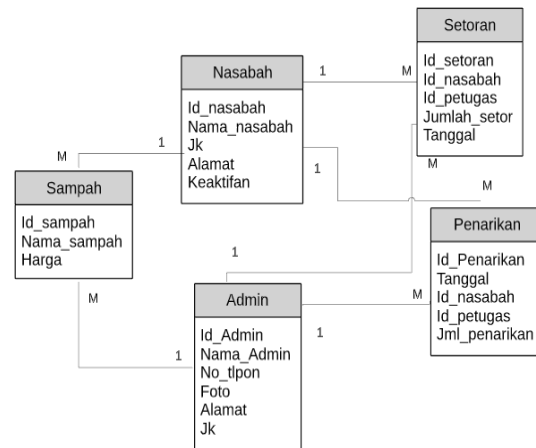


Figure 3. Entity Relationship Diagram

4. Discussion

The resulting discussion is the process of getting the best members at the website-based Junjung Biru waste bank using the CPI method with two criteria, namely by taking data on member deposit transactions that are carried out every month and from the number of balances owned by members and their activeness in saving garbage.

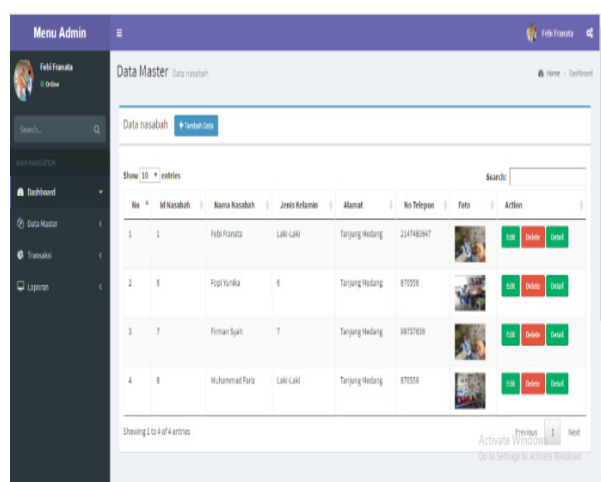


Figure 4. Member data

The member data in Figure 4 shows the data members of the Junjung Biru waste bank. The member

d can make deposit transactions as shown in Figure 5 below:

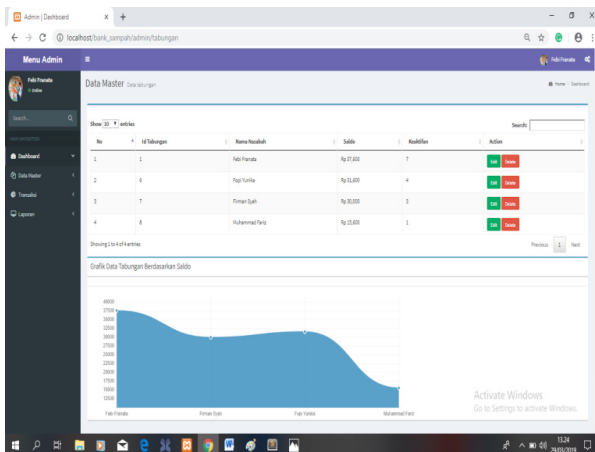


Figure 5. Member Deposit Transaction Data Form

Figure 5 shows the members who have made deposit transactions every month and it shows the deposit as well balances and member activeness level. We can also see a graph depicting the member balance from the highest one to the lowest one. Furthermore, for the calculation of the best members using the CPI method is shown in Figure 6 as follows:

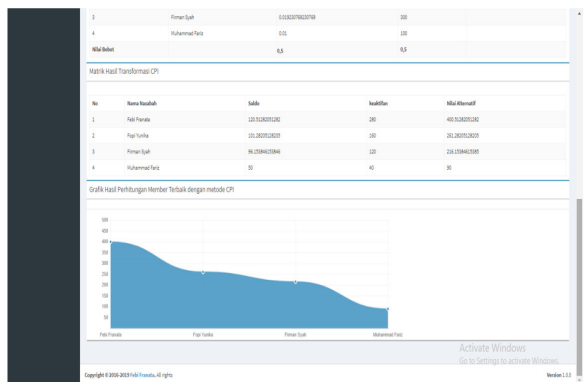


Figure 6. Best Member

Figure 6 explains how the CPI computes is like in the CPI calculation analysis which takes member data and also member deposit data then the CPI method is processed and the results are also illustrated with the best member charts according to the ranking order. Furthermore, the admin will perform the best member report to be given to the Director as shown in Figure 7.

After obtaining the best member, the admin prints the best member report and delivers it to the director.

To evaluate the functionality and usability of the web-based application system, we conduct several testing and analysis. The first testing of the application uses the black-box test. The black-box test is a method for testing software in terms of functional specifications without testing the design and program code [18]. The result of black-box is describe in Table 6.



LAPORAN TRANSAKSI
BANK SAMPAH JUNJUNG BIRRU
 Jl. Demak, Kel. Tuan Kentang, Jakabaring Palembang
 Telp. 081 2299 5054

Laporan Member Terbaik

No	Nama Nasabah	Saldo	Keaktifan	Nilai Alternatif
1	Febi Franata	63.4	133.333333333333	196.733333333333
2	Fopi Yunika	48.8	66.666666666667	115.466666666667
3	Firman Syah	40	50	90

Palembang, 25-Aug-2019
 Admin Regional

Andreanto

NIP. 192.12576.1.137

Figure 7. Best Member Report

Table 6. Blackbox Testing

Test Class	Test Items	Type of Testing	Received
Login	Password Verification	Black Box	✓
Customer data processing (Admin)	Add data	Black Box	✓
	Data update		✓
	See Data details		✓
Savings data processing (Admin)	Data update	Black Box	✓
Deposit Transaction Processing (Admin)	Add Transaction	Black Box	✓
Best Member Report Processing (Admin)	The system performs automatic calculations based on balance and activeness criteria data	Black Box	✓

In addition to the black-box testing, we conduct further evaluation for the developed system such as user acceptance and usability testing. The usability testing measures efficiency, ease of learning and the ability to remember how to interact without difficulty [19]. The attributes of usability testing include [20]:

- Learning, the level of ease with which users learn the website to fulfill basic tasks when they first use the website.
- Efficiency, the level of speed the user completes tasks after studying the website.
- Memorability, the level of ease in using the website well, after not using it for a long time.
- Errors, how many errors users have made and how users can easily fix errors.
- Satisfaction, the level of user satisfaction in using the website

Usability testing is carried out by giving the user a number of pre-prepared tasks or tasks when interacting

with the system being tested. This task was given to 3 respondents, namely 2 as admin and 1 as a Director who will be directly related to this system. The task given is “means of interaction” in usability measurement [21]. Below is table 7 for the given usability testing tasks:

Table 7. Task Usability Testing

Numb	Question	Score
System Aspects:		
1	Is the appearance of the website easy to understand?	3,40
2	Is the website easy to operate?	3,45
3	Are the colors on the website easy on the eyes and not boring?	3,30
User Aspects (User)		
4	Is the menu display on the website easy to understand?	3,50
5	Is the website easy to read?	3,44
Interaction Aspects:		
6	Is it easy to access every process that will be carried out such as input and ranking?	3,42
7.	Can the website be accessed to be printed and sent to the director?	3,40
8.	Can you access to see the best member report results?	3,54

Table 7 shows the value of user satisfaction or acceptance (acceptance) for each attribute so that this website is suitable for use by users

5. Conclusion

In this research we can conclude that the DSS for selecting the best member can be modeled using the CPI method. The CPI method is useful for solving problems in order of priority with multiple criteria. The results of this CPI method are output in the form of the best member ranking order which can help the admin to manage and determine the best members. In addition, the developed application can produce the best member reports accurately for the director. In the next research we plan to extend criteria of the best member selection and develop mobile application such that it can be easier and accessible for the administrators and director to support their work

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Utilization of Gas Sensor Array and Principal Component Analysis to Identify Fish Decomposition Level

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Abstract-Fish meat is a source of minerals and protein and contains excellent nutrients for the human body. However, non-fresh (rotting) fish are sometimes in the market for sale. Consuming rotting fish puts people at risk of getting diseases. This paper describes research to build a smelling device (e-nose) to identify fish freshness. It aims at detecting unsafe fish flesh to sort them out from being sold. We cut red snapper into cubes and put them into an open space at room temperature for five days. During the period, a gas sensor array acquired data of gas smell from the rotting fish. The output voltage of the sensors was processed using the differential baseline method. Later, feature extraction took the maximum value from the response of the gas sensor array, while the Principle Component Analysis (PCA) method identified the pattern. The results suggest that the gas sensor array responds to changes in the smell of fish meat that undergo a decay process. The PCA method is capable of recognizing the pattern of the maximum value characteristic of the gas sensor array response, as evidenced by the cumulative values of PC1 and PC2 reaching 95.95% with an accuracy rate of 98.2%. It shows the correlation between the aroma profiles of fish meat during the spoilage process, which produces a sharper aroma due to microbiological growth in the fish meat.

Keywords: gas sensor, sensor array, principle component analysis, TGS

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1. Introduction

Fish is a food item that is very popular with many people, besides it tastes good, fish also contains protein and high nutritional content including minerals, vitamins, and unsaturated fats [1], [2]. This will be different when the fish consumed is not fresh anymore or even not suitable for consumption because it has started to rot. This condition is a concern because it is related to health, because consuming fish meat that is no longer fresh can trigger disease in the human body. The freshness level of fish is influenced by the length of distribution, hygienic sanitation, transportation and also the handling method [3] so that it reaches consumers, the fish is no longer fresh. In principle, the condition of the freshness level of the fish begins when the fish dies, so that's when the freshness of the fish begins to decrease [4] even in the process of decay it can occur in just a few hours [5]. Meanwhile, the freshness of the meat will greatly affect whether the fish is suitable for consumption [6] especially in the food industry [7] [8]. The process of decay and freshness of the fish is influenced by microorganisms, whereas the effect of

the microorganisms itself depends on the species and size of the fish [9].

Decay process will usually give off an unpleasant aroma that can be smelled directly by our noses, but standardization in assessing the freshness of fish is still subjective [10]. The unpleasant smell is influenced by very complex chemical compounds [4]. So it requires a special instrument to detect the aroma of the fish, one of which is the gas sensor array system.

The gas sensor array system has a working principle similar to the sense of smell in humans by recognizing the response pattern to odors or aromas [11], namely the smell of various gas content in nature. The sensor array system will detect the aroma using several gas sensors arranged according to certain rules [12] and accessed individually and simultaneously so that independent sensors work [13]. Gas sensor array system known as electronic nose (e-nose) has great potential for detecting an aroma with simple techniques and preparation [14]. This system continues to develop, as reported on a review by Loutfi et al (2015) on the use of e-nose for food quality control [15] and also analysis of agricultural products including quality [16] and

evaluating the freshness of fish [17] and beef [18] [19] [20].

The output from the gas sensor array system will then be analyzed using the pattern recognition method, including using statistical methods such as Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), partial least squares (PLS), multiple linear regression (MLR), cluster analysis (CA), and using artificial neural network (ANN) methods, such as multi-layer perceptron (MLP), fuzzy inference systems (FIS), self-organizing map (SOM), radial basis function (RBF), genetic algorithms (GAS), neuro-fuzzy systems (NFS) and adaptive resonance theory (ART) [11].

Research related to the detection of fish freshness has been carried out with freshwater fish such as catfish, tilapia and pomfret, for the characteristics of the area of the sensor response when odor is on and five gas sensors are used [4]. Another study to detect the freshness of marine fish by using 3 gas sensors with classification using neural network [21] and classification of freshness of fish in cold storage [22] whereas in this study both utilize e-nose technology which is an array system of gas sensors to detect the level of fish spoilage with sea snapper with the characteristics used in the form of the maximum value of the sensor response and used more gas sensors, i.e. eight gas sensors.

2. Method

The research flow process, system design, materials, sensors and classification methods are discussed as follows.

a. Procedure and Data Retrieval

This research has several stages as shown in the research flow chart shown in Figure 1

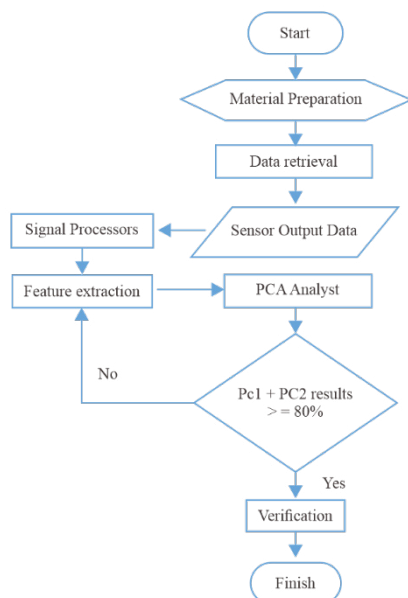


Figure 1. Research flow diagram

The material to be tested is inserted into the container or sample room and the gas sensor array device and data acquisition are placed in the measurement room. The

recorded data is then carried out by a signal processor before determining the characteristic value. With the characteristic values that have been obtained, analysis with PCA is carried out to determine how the system can discriminate against the freshness of a fish based on the detected odor. If the number of PC components is equal to or more than 80%, the system is declared capable of verifying the detected odor, otherwise it is possible to change the characteristic value.

b. System planning

The system used in this study is as shown in Figure 2. In the sensing system, there are 8 sensors, namely TGS2620, TGS2612, TGS832, TGS822, TGS2603, TGS2600, TGS813 and TGS826 which have different characteristics (Table 1). In addition to these gas sensors, there are also additional humidity sensors and temperature sensors to monitor environmental conditions. All these sensors are in one room which is also equipped with a pump to suck the sample aroma into the sensor room in the sensing process and another pump to suck in free air during the purging process, Figure 2.

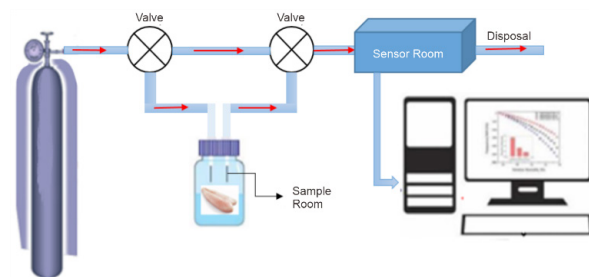


Figure 2. Block Diagram of the System

The sensor array is linked into the data acquisition system. The data acquisition system is set for the sensing process to be carried out for 150 seconds and when the purging process is set for 300 seconds. While the sample is placed in the sample room where it is connected to two valves, which will open and close the channel when the sensing and purging process occurs.

c. Material

The material used in this study is a type of fresh snapper which is then cut into 10 pieces with roughly the same weight, namely (10 ± 2) grams resembling dice and stored for five days in an open room at room temperature to be tested with sensor array system.

Of the samples that have been prepared, ten samples will be tested every day with repetition three times for each sample and carried out for five days. The first day of data collection was calculated when the fish samples were purchased.

d. Gas Sensor Array

The gas sensor array consists of several types of gas sensors that are non-selective. The gas sensor used in this study is a gas sensor type Tauguchi Gas Sensor (TGS).

The following is a breakdown of the functions of each gas sensor used as in Table 1.

Table 1. Types of gas sensors used

Number	Sensor Type	Gas type
1.	TGS 2620	Alcohol, solvent vapor
2.	TGS 2612	Methane, Propane, Butane
3.	TGS 832	Hydrocarbons
4.	TGS 822	Organic pollutant vapor
5.	TGS 2603	Air Pollutants
6.	TGS 2600	Air Pollutants
7.	TGS 813	Methane, Propane, Butane
8.	TGS 826	Ammonia

e. Sample Testing

Before taking data, the sensor is heated for about 30 minutes with the intention that the sensor is in a stable condition. After that the data recording process was carried out for 450 seconds with the sample placed in the sample room.

f. Data processing

In this process, the data that has been obtained from the recording results will be pre-processed to improve the baseline value. Next, determine the feature extraction in the form of the maximum value of the sensor response and proceed with pattern recognition.

g. Principle Component Analysis (PCA)

Principle Component Analysis (PCA) is an unsupervised method with a mathematical transformation, which is to explain how many variants are in an experimental data. Correlated data will be transformed into a set of values that are not linearly correlated which is called Principle Components (PC) [23]. PC values are not interrelated but sequential, so that the first order will contain the largest eigenvalues of all the original variable values [24].

Therefore, this PCA method will transform data into new coordinates, where the first coordinate is the Principle Component (PC1) value which has the largest eigenvalue. Whereas the second coordinate is the Principle Component (PC2) which has the second largest eigenvalue, and so on.

3. Result

a. Gas Sensor Array Response Test

At this stage, it is to determine the performance of the gas sensor array system on the spoilage process of fish meat. The results of the sensor array response for five days are shown in Figure 3.

Based on the results of the recording obtained as shown in Figure 3, it can be seen clearly that the high

response of the gas sensor array to changes in the condition of the fish meat from day one to day five. Especially for the TGS813, TGS2603, TGS832, TGS822, TGS2620 and TGS826 gas sensors. However, these results cannot be analyzed further before feature extraction is carried out.

The amount of data on the results of the gas sensor array response test for each day is 30 data as shown in Table 2.

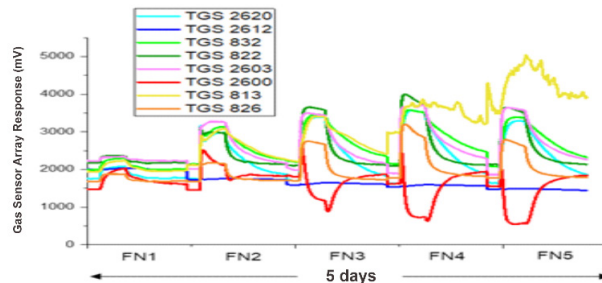


Figure 3. Graph of sensor response for 5 days of measurement.

b. Signal Processors

The data resulting from the response of the gas sensor array is then carried out in a preprocessing process using the baseline differential method to eliminate additive errors that come from the baseline value itself or from the sensor array response [25]. The equation form of this method is as follows.

$$X_{ij} = V_{ij}^{max} - V_{ij}^{min} \quad (1)$$

Where X_{ij} is the baseline manipulation, V_{ij}^{max} is the gas sensor array response to the sample, and V_{ij}^{min} is the baseline value.

In this preprocessing process what is done is to improve the baseline conditions from the initial results of recording the data obtained as shown in Figure 4, where the gas sensor array response looks different in the baseline conditions so that by manipulating the baseline value the gas sensor array response results will change to something like shown in Figure 5. This is done with the hope of optimizing the feature extraction in the next process.

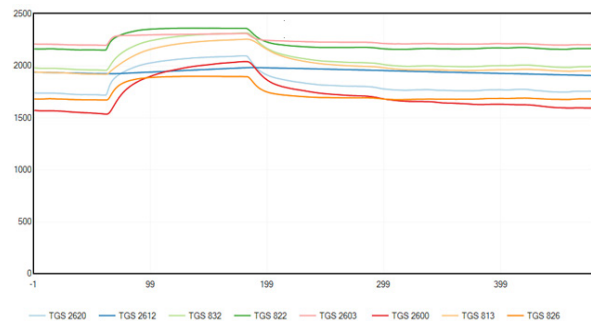


Figure 4. Graphic response of the recorded gas sensor array

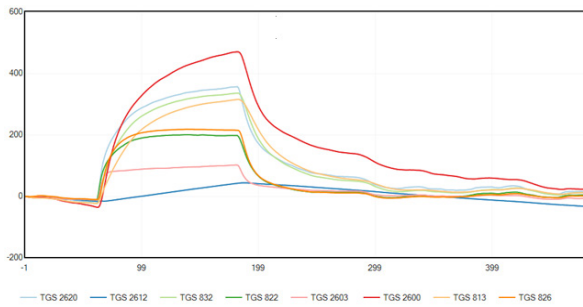


Figure 5. Graphic response of the preprocessed gas sensor array

The next step is to perform feature extraction of the gas sensor array response which has been pre-processed. For feature extraction in this study used is to take the maximum value of each gas sensor response. This maximum value will be used as input data in pattern recognition analysis using PCA. The result of feature extraction from the maximum value of the sensor array response is as shown in Figure 6 where the result is the result of one fish meat sample for five days of observation..

Based on these results, it can be seen that the response of the sensor array system tends to get bigger due to changes in the condition of the fish meat undergoing a process of decay. On the first day (FN1), it can be seen that the maximum values for all gas sensors are around 2000mV to 2300mV so that it appears to be piled on the graph. On the second day (FN2) the gas sensor response has begun to separate and it can be seen that the TGS2612 sensor shows the lowest maximum value response compared to other gas sensors, this condition continues until the fifth day (FN5). While the gas sensors TGS2620, TGS832, TGS822, TGS2603, TGS813 showed the highest response values with values ranging from 2300mV on the second day (FN2). For the third day (FN3), the highest response was shown by the TGS822 sensor with a value of 3684mV and on the fourth (FN4) and fifth (FN5) the highest response was shown by the TGS813 gas sensor with a value of around 6243mV.

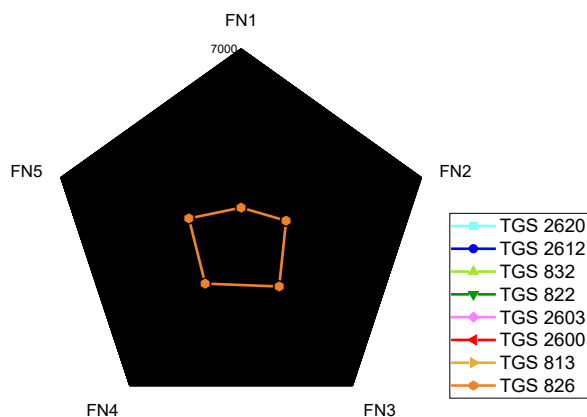


Figure 6. Graphic response to the maximum value of the gas sensor array for 1 sample for 5 days.

As for the distribution of the average maximum value of each sample can be seen in Figure 7.

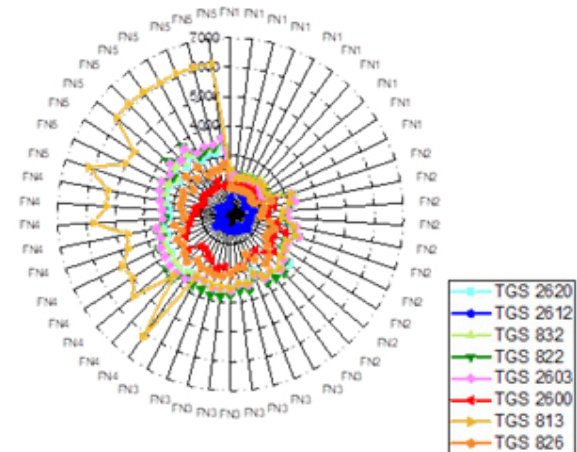


Figure 7. Graphic response to the maximum value of the gas sensor array for 10 samples in 5 days.

4. Discussion

The results of PCA analysis for the discrimination of fish odor samples for five days as shown in Figure 8 show that the cumulative value variance is 95.95% with the contribution value on PC1 of 86.05% and PC2 value of 9.90%. Based on the distribution of the data variance, it can be seen that the array of gas sensors in detecting odors from fish meat samples for five days are correlated. This is seen in the sample on the first day (FN1) where the data variant collects on the negative side of PC1 and is in the positive area on PC2. This condition indicates that the sample is still in fresh condition. While the data variant on the second day (FN2) seems to collect on the negative side of PC1 and PC2 although some data are in the positive area of PC2. For the data variant on the third day (FN3), it can be seen that some of them have collected the variant data on the second day of sample (FN2), but on the third day of data variant (FN3) all are on the negative side of PC1 and PC2. For variants of the sample data on the fourth (FN4) and fifth (FN5) days are dominant in the positive area of PC1 even though there is one data that is in the negative area of PC1.

Based on the results of discrimination with the PCA method, it is clear that changes in the condition of the sample are increasingly decaying based on the distribution of data from the covariance results. These results also indicate that this method is able to discriminate against the condition of fish meat based on odors detected using a gas sensor array system.

After the results of discrimination based on the PCA method were obtained, then the fish odor data set was tested to determine the accuracy and sensitivity level. Data from feature extraction that has been obtained are then distributed into two data sets for training and testing. The complete distribution of the data set can be seen in Table

2. While testing the data set with various methods in order to obtain the method with the highest level of validation which is expected to have a high degree of accuracy against the discrimination results of fish meat spoilage based on the odor detected using the array system sensor. For a comparison of several methods used as shown in Table 3.

Based on the comparison of methods as in Table 3, where the number of features used is 10 for each condition based on the day or with a total test data of 50 data sets. The fish odor classification process using the Quadratic Discriminant Analysis (QDA) method has the highest

validation value when compared to other methods, namely 94.10%. Therefore, the QDA method is used for the next process, namely the classification process whose results are as shown in Table 4.

Based on the results of the matrix configuration as in Table 4, it can be seen that from the actual data on the condition of the fish each day, the average sensitivity value is 98% with one detected data on the second day that is included in the third day category. Meanwhile, the level of accuracy from the prediction results obtained an average of 98.2%.

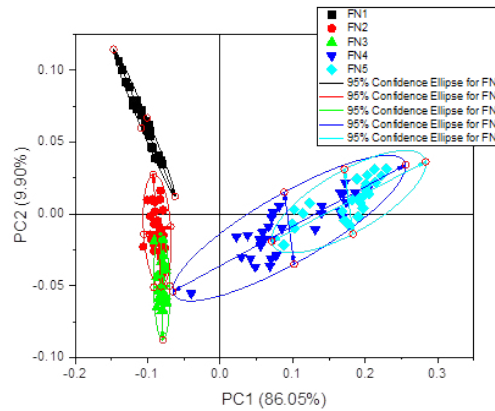


Figure 8. The distribution of data on the results of discrimination using the PCA method

Table 2. Distribution of the fish condition dataset

	Data Training	Data Test	Total
Day 1	20	10	30
Day 2	20	10	30
Day 3	20	10	30
Day 4	20	10	30
Day 5	20	10	30
Total	100	50	150

Table 3. Comparison of methods

Classification Method	LDA	QDA	LR	NB
Number of features	10	10	10	10
Parameter	Linear	Quadratic	Linear	Normal
Cross Validation	92,40%	94,10%	87,90%	82,90%

Table 4. Confusion matrix of the methods used

	Prediction					Sensitivity (%)
	Day 1	Day 2	Day 3	Day 4	Day 5	
Actual						
Day 1	10	0	0	0	0	100
Day 2	0	9	1	0	0	90
Day 3	0	0	10	0	0	100
Day 4	0	0	0	10	0	100
Day 5	0	0	0	0	10	100
						98
Accuracy (%)	100	100	90,9	100	100	98,2

The accuracy and sensitivity values obtained are high enough so that it can be said that the results of the evaluation of the QDA model are very maximal in classifying the level of fish meat rot.

5. Conclusion

Based on the results of this study, it can be concluded that the level of spoilage of fish meat can be detected by using a gas sensor array system combined with the PCA method. Discrimination using the PCA method obtained a cumulative value variance of 95.95%, which means that the system has been able to determine the diversity of data structures based on aroma with a value contribution of the first component or PC1 of 86.05% and the value of the second component or PC2 of 9.90%. These two components are the highest value components of the total value of the components in the PCA method. While the level of accuracy of this system in classifying fish conditions based on their aroma is 98.2%. This result shows that the proximity of the measurement results to the actual conditions is very good, while the sensitivity level is 98%, which means that the ability of the gas sensor array to respond to changes in value when measuring is high.

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