

Implementation of Hybrid Methods in the Application of Experimental Psychology for Analysis of Mental Endurance Conditions

Usman Nurhasan*, Anugrah Nur Rahmantlyo, Aflah Rahman Maulidiyah

Politeknik Negeri Malang
Malang, Indonesia

*usmannurhasan@polinema.ac.id

Abstract-Psychology is the study of behavior and mental processes of a person. In psychology, psychological tests or psychological tests are often used as part of the selection to determine the maximum performance of prospective employees based on mental endurance conditions from the factors of speed, accuracy, and consistency. One of the psychological test tools is the Mirror Tracer Apparatus which is used to determine the condition of a person's mental endurance with visual coordination in responding to the inverted image of an object seen through a mirror. Because the use of the Mirror Tracer Apparatus only uses one pattern, and the cost is quite expensive, an Experimental Psychology Implementation Application is created which is implemented in an Android-based application to make it easier with many patterns. This application is designed using a combination of two methods (Hybrid Method). The Fuzzy Mamdani method is used to generate a mental health condition level score, and the Template Matching method is to match the pattern of the resulting images with the template. These two methods aim to apply the psychological knowledge base to the application. Data processing is carried out by giving weight ratings to the experimental tools carried out by the user. The results of this study have been tested on psychologists, resulting in a score of 83% agreeing that the application can be used as an alternative test tool, and 92% of prospective new employees stated that the application can determine the condition of mental endurance.

Keywords: fuzzy mamdani, hybrid methods, mirror tracer, experimental psychology, template matching

Article info: submitted July 20, 2020, revised September 6, 2020, accepted November 2, 2020

1. Introduction

One of the benefits of using psychological tests is that they are used as a tool to determine human abilities and traits. Especially in industrial psychology, besides job placement selection, and adjustment of workers who are already working, and also to determine the conditions of work (performance requirements), it is necessary to carry out psychological tests that are useful for the purposes of prognosis diagnosis and therapy for private disorders [1]. According to Erik Saut H, humans are in a state of depression makes the condition of the human soul even more shaken, if the human soul is shaken it will be affected by the humans themselves. If our souls find coolness, calmness and happiness, it

will also have an impact on our health, psychology and passion for life. If the soul is prosperous, we will be healthy and happy. If our souls are uncomfortable then we become depressed and suffering humans.

To conduct a psychological test, it is necessary to carry out Experimental Psychology research in which this research manipulates one of the variables to study the existence of a causal relationship [2] [3]. Psychology Experiments are carried out to determine the effects of the deliberate treatment by the researcher, then the researcher predicts the consequences of a manipulation of the research variables. Experimental psychology research was conducted with a comparison of manipulated and non-manipulated treatments. The purpose of psychological research Experiments to

determine interests, abilities, and resources (manpower, funds, and time). Qualitative variables in psychological tests in companies at level testing are determined in the selection of prospective employees to determine the character and performance of prospective employees, namely conditions of mental endurance based on accuracy, and consistency [4]. In the section which position is low, the test is conducted in an easy level, while the job position is middle, the testing used is a medium level. Then, the job position with a high position is tested with a hard level. One of the tools used for experimental psychology that can be used to determine mental endurance conditions is the Mirror Tracer Apparatus. Mirror Tracer Apparatus is an experimental psychology tool used to measure motor learning, the process of which involves the human response mechanism itself [5] [6].

In this study, the Mirror Tracer tool is implemented into an android application. Data processing is carried out using a combination of two methods or a hybrid method. The method used is fuzzy mamdani and template matching. The use of these two methods is expected to represent the knowledge base of a psychologist's expert on the analysis of the mirror tracer experimental psychological test tool. The application of the Fuzzy method is used to determine the condition of mental endurance based on the score results in the Mirror Tracer application simulation. The scores obtained are processed using the Fuzzy Mamdani method, with its simple structure using the MIN-MAX or MAX-PRODUCT operation [7]. The variables required for this operation are the length of time to draw the pattern, as well as the number of error points. Then, to calculate the accuracy level of the pattern match of the resulting pattern file with the pattern template using the Template Matching method. It is expected that the implementation of experimental psychology to determine conditions of mental endurance using the Fuzzy Mamdani method in industrial psychology can determine the placement of workers in accordance with the conditions of mental endurance [8].

2. Methods

Cross-Industry Standard Process for Data Mining (CRISP-DM) is a standard that has been developed in 1996 which is shown to carry out process analysis of an industry as a problem-solving strategy of a business or research unit [9]. There are 6 phases in this CRISP-DM which are described in Figure 1. The process of developing this application adopts the CRISP-DM flow.

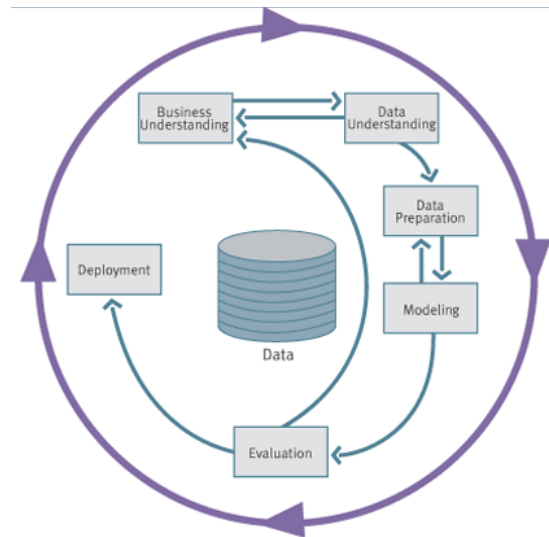


Figure 1. CRISP-DM phase

a. Business Understanding Phase

In experimental psychology using a mirror tracer tool, which tests using pattern images and requires a small cost, an application is made so that it can be efficient in replacing many pattern images, and it does not cost a lot. The purpose of this application is to implement the experimental psychology application in determining the condition of mental endurance with the factors of speed, accuracy, and consistency, using the Fuzzy Mamdani method based on the variable length of time to work and the number of error points, then matching the results of the input pattern image with the template pattern image using the Template method. Matching.

The limitations in implementing experimental psychology applications to determine conditions of mental endurance include the following:

- 1) The entity used in this application comes from experimental activities carried out by the subject.
- 2) This application implements the Experimental Psychology of the Mirror Tracer Tool.
- 3) The pattern template used to match the pattern file results comes from the psychologist's knowledge base

b. Data Understanding Phase

At this stage, the data collection is carried out first, all the necessary data will be processed thoroughly. Collecting pattern images data in the form of flat shapes, carried out by interviews with experts. Then, for the distraction process in testing the mirror tracer tool uses noise music data and quiet music. Quiet music is used to give a calm effect on the concentration of an object, and noise music is used to influence the heart rate on the object's concentration. The effect of quiet music and noise music are determined with different decibel levels

c. Data Processing Phase (Data Preparation Phase)

In this phase, data processing was carried out which was later be used in the modeling stage, so that later modeling can provide maximum results according to the desired target. The data that is processed is a pattern image in the form of a flat shape which is divided into 3 levels, namely the easy, medium, and hard level. The pattern division is divided based on the number of angles in the pattern image, a higher number of angles is associated to a harder level. Also, the distraction process by giving the effect of calm music and noise music is determined in decibels as in Table 1.

Table 1. Distraction Decibel Rate

No.	Kinds of Music	Decibel Level	Effects on Users
1	Musical instruments	30 dB	Make mind and mental calmer
2	Noise	80 dB	Affects the mind and has difficulty concentrating
3	Explosive Sound	120 dB	Affects heart rate

d. Modeling Phase

In this study, applying the modeling stage by making a test model using an Android-based tablet on the mirror tracer tool to prospective new employees. The test results in the results of the mental resistance level score using Fuzzy Mamdani logic because the suitability of data acquisition with fuzzy output is not linear or constant, such as Sugeno inference [10]. Then, calculate the percentage of pattern matches on the server using the Template Matching method. The template matching method is a method for comparing the reference image (template) with the test image [11].

e. Evaluation Phase

The evaluation is analyzed based on the knowledge base of the psychologist. Also, in the application, to determine the score results of the level of mental endurance conditions based on the parameters of the length of time when the user draws the pattern on the application, and the number of error points, namely the number of line pixel points that come out of the pattern path. Then, the server uses the Template Matching method to match the results of the input image with the template image obtained from psychologist data.













f. Deployment Phase

The deployment of this application is carried out by testing the application to prospective new employees, then providing a questionnaire to find out if the test results can be deemed to meet the requirements of the user, the application can be applied.

g. Data

The data used in this study are pattern image data in Table 2 for the Mirror Tracing Apparatus.

Table 2. Pattern Trial Data













No.	Pattern Name	Pattern	Level	Number of Angles
1	Square		Easy	4
2	Circle		Easy	0
3	Parallelogram		Easy	4
4	Triangle		Easy	3
5	Five Star		Medium	10
6	Six Star		Medium	12
7	Seven Star		Medium	14
8	Eight Star		Medium	16
9	Advanced Shaped 1		Hard	27
10	Advanced Shaped 2		Hard	26
11	Advanced Shaped 3		Hard	25
12	Advanced Shaped 4		Hard	26

h. Data processing

In this study, the data processed is pattern data on the Mirror Tracer tool consists of 2 parts, such as the pattern trial data and the template pattern data used for the template matching process. The division of the level is determined based on the number of angles in the pattern image, the higher number of angles of the pattern is associated to a more difficult level. Patterns with many angles are considered difficult because the process of testing the mirror tracer tool by drawing a pattern through a mirror image is the opposite direction of the user's point

of view when drawing. Therefore, when passing the corner, it is necessary to involve the user's motor response, in order to observe the effect of treatment on the user's mental endurance. The level on the test is determined based on request, if applying for a very difficult job requires construction and a high level of mental endurance, then use a higher level, namely the hard level, and vice versa based on the level of work that is easier using the easy level and the medium level. In the testing process, the level selection is determined by the psychologist concerned.

Table 3. Template Pattern Data

No.	Pattern Name	Pattern	Level	Number of Angles
1	Square		Easy	4
2	Circle		Easy	0
3	Parallelogram		Easy	4
4	Triangle		Easy	3
5	Five Star		Medium	10
6	Six Star		Medium	12
7	Seven Star		Medium	14
8	Eight Star		Medium	16
9	Advanced Shaped 1		Hard	27
10	Advanced Shaped 2		Hard	26
11	Advanced Shaped 3		Hard	25
12	Advanced Shaped 4		Hard	26

i. Fuzzy Mamdani

In this research, fuzzy mamdani logic is used to earn the output in the form of determining the condition of mental endurance, for the parameters obtained from the

results of interviews with psychology experts from the State University of Malang.

The Mamdani Method is also known as the Max-Min Method. To obtain the output, four stages are required:

- 1) *Fuzzy Set*
- a) **Time Variable:** Time variable is the point of measuring the length of time to draw the pattern in units (seconds) Times are grouped into fuzzy sets, shown in Figure 2, 3, and 4:

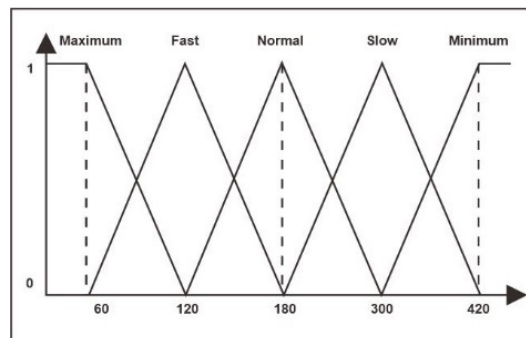


Figure 2. Graph of Easy Time Variable Membership Functions

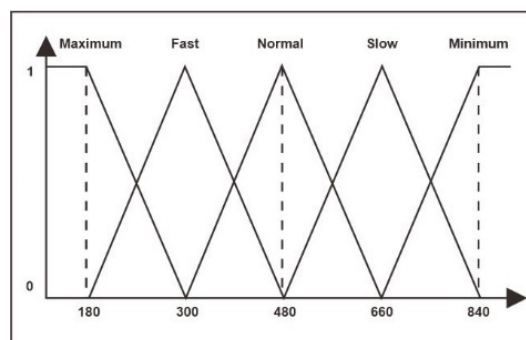


Figure 3. Graph of Medium Time Variable Membership Functions

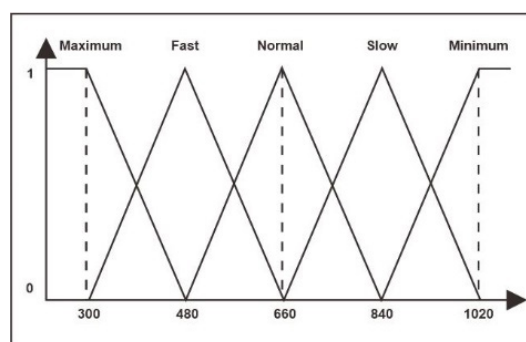


Figure 4. Graph of Hard Time Variable Membership Functions

- b) **Variable Number of Error Points:** In this research, the number of error points is obtained from the number of angles of each pattern and is grouped with a fuzzy set, shown in Figure 5, 6, and 7:

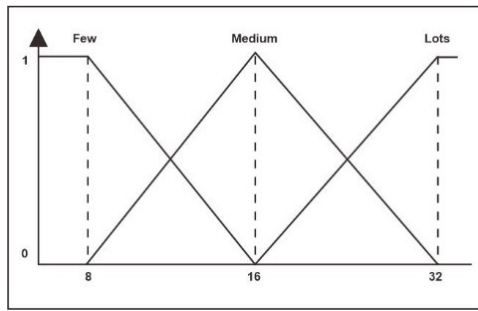


Figure 5. Graph of Membership Function variable the number of error points at the easy level

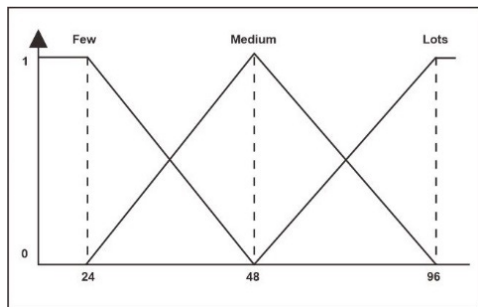


Figure 6. Graph of Membership Functions variable number of error points at medium level

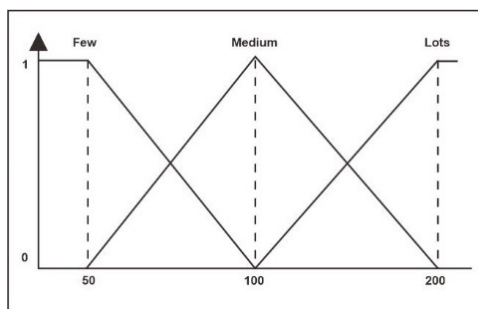


Figure 7. Graph of Membership Functions variable the number of error points on the hard level

c) **Variable Level of Mental Endurance Conditions:**

In this study, to determine the results of the level of mental endurance conditions based on time and the number of error points grouped with fuzzy sets, shown in Figure 8:

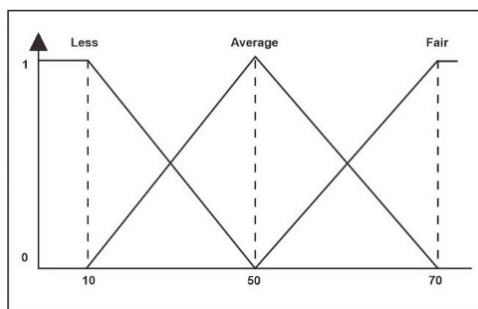


Figure 8. Graph of the membership function level of the state of endurance

2) **Implication Function**

According to Chen & Pham (2001), membership value as a result of operating two or more sets on the *Min* implication function is defined as follows:

$$\ominus \text{predicate}_i = \mu_{A_1|x_1} \cap \dots \cap A_n|x_n \tag{1}$$

There are 15 rules of implication function in the Fuzzy Mamdani Method, described in Table 4:

Table 4. Rule Base System

IF	Time	AND Error	THEN Fuzzy Output
1	Maximum	Few	Fair
2	Fast	Few	Fair
3	Normal	Few	Fair
4	Slow	Few	Average
5	Minimum	Few	Less
6	Maximum	Medium	Fair
7	Fast	Medium	Average
8	Normal	Medium	Average
9	Slow	Medium	Less
10	Minimum	Medium	Less
11	Maximum	Lots	Average
12	Fast	Lots	Average
13	Normal	Lots	Less
14	Slow	Lots	Less
15	Minimum	Lots	Less

3) **Composition of Rules**

In the process, a combination of fuzzy rules occurs to explain the consequent results obtained from each fuzzy rule which is modified with the respective fuzzy set solution and combined with other consequent modification results. The equation for determining the composition of the rules is as follows:

$$\mu_{sf}[xi] = \max(\mu_{sf}[xi], \mu_{kf}[xi]) \tag{2}$$

note:

$\mu_{sf}[xi]$: fuzzy solution membership value up to for number *i*

$\mu_{kf}[xi]$: the membership value of the fuzzy consequences of rule up to for number *i*

4) **Defuzzification**

In this study, the defuzzification process uses the Centroid method by taking the center point value (x^*) from the area in the membership function B. The centroid method formula is defined as:

$$x^* = \frac{\int x \mu_B(x) dx}{\int \mu_B(x) dx} \tag{3}$$

for continuous domains, and

for discrete domains.

$$x^* = \frac{\sum_{i=1}^n x_i \mu_B(x_i)}{\sum_{i=1}^n \mu_B(x_i)} \quad (4)$$

j. Template Matching

The Manual Template Matching calculation will be described based on the processes in template matching [12], namely:

1) Canvas Input Process

In the canvas input process, we make the input image from the user into a bitmap image, so that it can be read by the system. In this process, there is a change from the user's writing into an image or bitmap, so that it can be read by the system. After it is read into an image, the RGB reading process is carried out to distinguish between the three colors including red, green and blue.

2) Grayscale process

In converting the color to grayscale, it is necessary to calculate the pixels in an image that has RGB color information, then add the color by switching each color with a different number so that the average value is obtained in RGB color. The average value that will be used to color the image pixels so that it becomes a grayscale color.

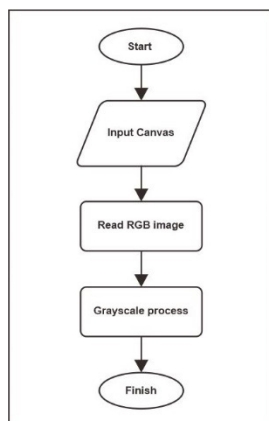


Figure 9. Canvas Input Process Flowchart

3) Binarization Process

The conversion of a true color (24 bit) image to a binary image (1 bit) is carried out by means of a thresholding operation. The floating operation groups the grayscale value of each pixel into two classes, namely black and white. Black represents the object color while white represents the background color.

4) Template Process

At the template process stage, there is a calculation between the image input and the image template, in which the calculation is to match the image input in order to obtain a value that matches the image template.

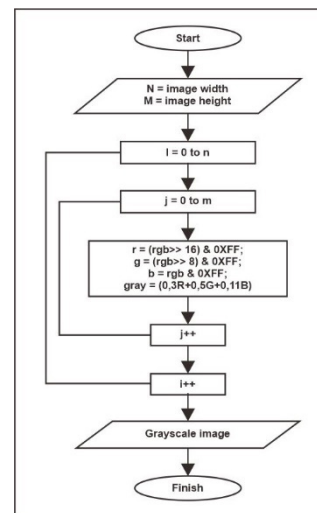


Figure 10. Grayscale process

The steps for calculating pixels in x, y coordinates in the Circle Pattern matrix A (input pattern) with matrix B (template pattern) as shown in Figure 10. The calculations between matrix A (input pattern) and matrix B (template pattern) is shown as follows:

$$(0-0)^2 + (1-1)^2 + (1-1)^2 + (0-0)^2 + (1-1)^2 + (0-0)^2 + (0-0)^2 + (1-1)^2 + (1-1)^2 + (0-0)^2 + (0-0)^2 + (1-1)^2 + (1-1)^2 + (0-0)^2 + (0-0)^2 + (1-1)^2 + (0-0)^2 + (0-0)^2 + (1-1)^2 + (1-1)^2 + (0-0)^2 = 0$$

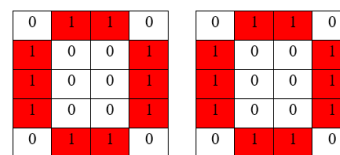


Figure 11. Input Patterns and Pattern Templates

3. Results

1. Results of the Fuzzy Mamdani Implementation Test on the Mirror Tracer Application

The process of calculating Fuzzy Mamdani in this study is used to determine the level of mental resistance conditions based on the length of time to draw the pattern, and the number of error points. The following is a picture of time input and the number of error points obtained after the user draws a pattern at the easy level.



Figure 12. Score results using Fuzzy Mamdani

In Figure 12. The result of Fuzzy Mamdani calculation is “High”, obtained from IF Time is Maximum and Few Error, then the results of the level of mental resistance conditions are Fair.

2. Results of Testing the Matching Template Implementation on the Server

Figure 13 shows the results of the input on the server after the user sends data from a smartphone device.

Data User Tanpa Noise	
Id	70
Nama	lalaafah@gmail.com
Tanggal	2020-07-10 01:43:39
Level	Easy
Nama Pola	Square
Lama Waktu	26 detik
Jumlah Error	0
Hasil Fuzzy	Tinggi

Figure 13. Results Input data from the application to the server

The template matching process in the research is run on the server, after the user presses the Continue button when calculating the Fuzzy Mamdani data name, time, number of error points, level, the result of the condition of the mental endurance condition, and the results of the image was sent to the server using the rest server for the history process.

Fuzzy Mamdani calculation details

Input image: uploads/Sample_1594345290350.jpg

Tracing

Percentage result: 0

doesn't match

Figure 14. Results Input data from the application to the server

Then the psychologist pressed the check tracing button in Figure 14. To run the pattern matching process use the Template Matching method by displaying the input image path with the template image as in Figure 14.

After pressing the submit button, it displayed the percentage difference between the input pattern and the template pattern in Figure 16.

Template Matching

id: 70

Image: uploads/Sample_1594345290350.jpg

Template: template/Square.jpg

Submit

Figure 15. Template Matching Process

Input image: uploads/Sample_1594345290350.jpg

Tracing

Percentage result: 2.45275

Match

Figure 16. Pattern Match Percentage Results

The result is not suitable when the percentage result of pattern difference is too high. On the contrary, if the result of the pattern difference percentage level is low, the result is suitable.

4. Discussion

This discussion aims to obtain conclusions from the results of the tests carried out on the application of hybrid methods in the application of experimental psychology for the analysis of mental endurance conditions that have been carried out. The following is an example of a case study for calculating the level of mental endurance using the Fuzzy Mamdani method. The data used is the processing time parameter of 63 seconds with the number of errors 39 at the easy level. Figure 17 shows the output of the application.

Hasil Gambar

-SCORE-

Time: 63

Error: 39

Tingkat Ketahanan Jiwa: Kurang

Check Result Close

Figure 17. Result of the Score of Mental Endurance Condition Level

In Figure 17, the score for the level of mental resilience is “Less”, the score is less obtained from 4 Calculation Steps for Fuzzy Mamdani as follows.

The first stage in Fuzzy Mamdani is to find the Fuzzy Set in the form of membership degrees in the time variable and the number of error points. The maximum value for Maximum Time set is 120 (seconds), and Minimum Time set is 420 (seconds). Time = 63 is in the Maximum and Fast Time area as shown in Figure 18.

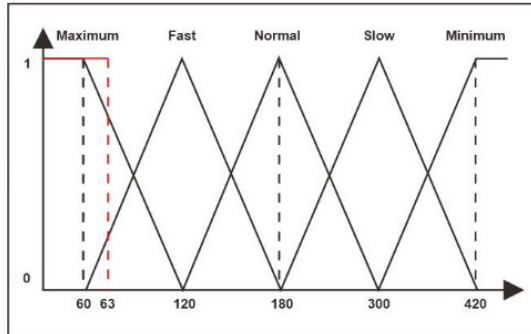


Figure 18. Graph of Easy Time Variable Membership Functions

At the number of points of error, the maximum value for the “Few” set is 16, and the “Lots” set is 32. The number of error points (Error) 39 is in the “Lots” membership area – shown in Figure 19.

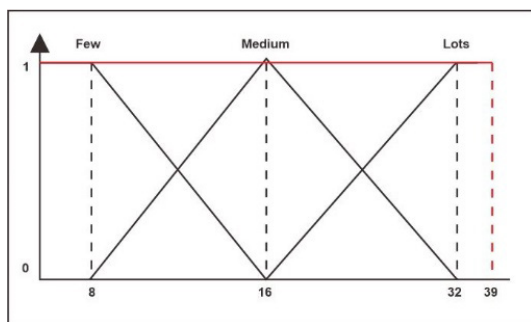


Figure 19. Graph of Variable Membership Functions Number of Easy Error Points

Then, we calculate the value of the degree of membership in the “Maximum” time variable in order to find the value of the intersection as in Figure 20.

$$\begin{aligned}\mu_{\text{MaximumTime}} [63] &= \frac{120-63}{120-60}, 60 < x < 120 \\ &= \frac{57}{60} \\ &= 0,95\end{aligned}$$

$$\begin{aligned}\mu_{\text{FastTime}} [63] &= \frac{63-60}{120-60}, 60 < x < 120 \\ &= \frac{3}{60} \\ &= 0,05\end{aligned}$$

Then, to calculate the value of the degree of membership in the variable number of error points in order to find the many value as in Figure 21.

Time Set	
Maximum :	0.95
Fast :	0.05
Normal :	0
Slow :	0
Minimum :	0

Figure 20. Calculation Results of Fuzzy Sets on Time Variables

$$\begin{aligned}\mu_{\text{Multiple Point of Error}} [39] &= 1, 39 \geq 32 \\ &= 1\end{aligned}$$

The set number of error points	
Few :	0
Medium :	0
Lots :	1

Figure 21. Calculation Results of Fuzzy Sets on the Variable Number of Error Points

Then, the second step of Fuzzy Mamdani is the Implication Function process in Table 4 rule which is used to find the *Min* value in Figure 22 found in the following rule:

$$\begin{aligned}[\text{R11}] \text{ IF Maximum Time AND Lots Error THEN Levels of Mental Endurance Condition is Average} \\ \alpha_{\text{Predicate6}} &= \mu_{\text{MaxTime}} \cap \mu_{\text{LotsErrors}} \\ &= \min(\mu_{\text{MaxTime}}(630) \\ &\quad \cap \mu_{\text{LotsErrors}}(39)) \\ &= \min(0,95 ; 1) \\ &= 0,95\end{aligned}$$

$$\begin{aligned}[\text{R12}] \text{ IF Fast Time AND Lots Error THEN Levels of Mental Endurance Condition is Fair} \\ \alpha_{\text{Predicate6}} &= \mu_{\text{FastTime}} \cap \mu_{\text{LotsErrors}} \\ &= \min(\mu_{\text{FastTime}} (63) \\ &\quad \cap \mu_{\text{LotsErrors}} (39)) \\ &= \min(0,05 ; 1) \\ &= 0,05\end{aligned}$$

After finding the Min Implication value, then the third step of Fuzzy Mamdani is conducted – looking for the Rule Composition by determining the Max value first from the value that has been obtained from the Min implication as in Figure 23.

Max Fair level = 0 max(0 ; 0)
 Max Average level = 0,95 max(0,95 ; 0,05)
 Max Less level = 0 max(0,0 ; 0,0)

Min1	Min2	Min3	Min4	Min5
0	0	0	0	0
Min6	Min7	Min8	Min9	Min10
0	0	0	0	0
Min11	Min12	Min13	Min14	Min15
0.95	0.05	0	0	0

Figure 22. Results of Min Implication Functions of Each Rule

Implications Min	
Max Fair:	0
Max Average :	0.95
Max Less:	0

Figure 23. Max Implication Results on Rule Composition

After determining the max value, then calculating the composition of the rules from the max value by finding the z value as follows:

At a $\mu_{moderatelevel}(x)$ z value can be determined as follows:

$$0,95 = \frac{(70 - z)}{70 - 50}$$

$$19 = z - 70$$

$$z = 89$$

The following Figure 24 is an implementation of the composition of rules on the server:

Composition of Rules	
Composition of Fair:	0
Composition of Average :	89
Composition of Less:	0

Figure 24. Rule Composition Results

Then, the fourth step of Fuzzy Mamdani is defuzzification in the fuzzy inference system which changed the output of the fuzzy set from stage 3 with the input of a set obtained from the composition of fuzzy rules into a number in the domain of the fuzzy set. The numbers

obtained from the defuzzification process were presented in the form of levels of mental resistance conditions including Fair, Average, and Less.

$$x^* = \frac{((0 * 0) + (89 * 0,95) + (0 * 0))}{(0 + 0,95 + 0)} = \frac{84,55}{0,95} = 89$$

The following Figure 25 is an implementation of defuzzification on the server:

Defuzzification	
Result :	89

Figure 25. Defuzzification Results

The value of 89 is included in the Less range, so it can be concluded that the level of the condition of mental endurance based on the time variable is 63 seconds, the number of error points is 39, and the level of the condition of mental endurance is Less.

After the score results in the application have been determined, then match the input image with the template image on the server using the Template Matching method by clicking the check tracing button, the server displayed a page to display the path of the input image file and the template image as shown in Figure 26.

Figure 26. Matching Input Images to Templates

After pressing the submit button, it displayed the percentage difference between the input pattern and the template pattern, shown in Figure 27.

Figure 27. Matching Template Percentage Results

The percentage result is that the higher the pattern difference percentage level, the result is not suitable, on the contrary, if the result is the lower the pattern difference percentage level, the result is suitable.

In the application of the Hybrid Method in the Experimental Psychology Application for the Analysis

of the Conditions of Mental Endurance, the User Acceptance Test (UAT) was tested using a questionnaire. User Acceptance Testing (UAT) is a very innovative methodology to prevent IT project failures [13]. Based on the Usability test using the questionnaire in Table 5 and Table 6 by answering the questions given were calculated by calculations in accordance with the formula [8]:

$$U = \frac{\text{Observation Score}}{\text{Expected value}} \times 100$$

note:

P = The number of respondents' answers to each question

Q = Expected value

U = Percentage Value

In the User Acceptance Test (UAT) questionnaire, there are 5 answer choices, namely SS (Strongly Agree) with a score of 5, S (Agree) with a score of 4, CS (Adequately Agree) with a score of 3, KS (Less Agree) with a score value 2, TS (Disagree) with a score of 1.

The following is the result of calculating the percentage of the UAT Test on a Psychologist:

Table 5. Psychologist Percentage Calculation Results

No.	Question	Percentage
1	In your opinion, is the mirror tracer application's appearance as expected?	80%
2	In your opinion, is the pattern drawing feature in this mirror tracer application complete?	70%
3	In your opinion, is the process of drawing on the canvas in this mirror tracer application as desired?	70%
4	Is the shape of the pattern on the canvas according to the level division?	80%
5	Are the timer and number of error points running as desired?	80%
6	Do you think that you have trouble starting the mirror tracer application?	50%
7	Are the features contained in the mirror tracer application easy to understand?	80%
8	Are the timer menu and the number of error points in this mirror tracer application running according to its function?	80%
9	Can this application help to psychological test the mirror tracer tool?	80%
Average		83%

The following is the result of calculating the percentage of the UAT Test on Prospective New Employees:

Table 6. Results of Percentage Calculation of Prospective New Employees

No.	Question	Percentage
1	Do you think the psychological test is important when applying for a job?	95%
2	Do you think the mirror tracer application can help to psychological test the mirror tracer tool?	92%

No.	Question	Percentage
3	Do you think the mirror tracer application can determine the state of life endurance?	97%
4	When doing a psychological test on the mirror tracer tool, do you find it difficult?	47%
5	Do you think the shape of the pattern affects the level of difficulty during the psychological test?	91%
6	Does the selection of the decisive level can determine different test results?	91%
7	Do you think the sound of the oxytron during drawing relaxes you?	99%
8	Do you think that loud music during the distraction process can interfere with concentration?	98%
9	Do you think the results of the length of time worked can affect the results of the level of mental resistance conditions?	95%
10	Do you think the number of points of error can affect the outcome of the state of endurance level?	94%
11	After trying the Mirror Tracer application, do the test results match your mental endurance character?	94%
12	Is this application easy to use / user friendly?	97%
13	Is the opening display in the mirror tracer application interesting?	100%
14	Is the mirror tracer application's canvas pattern interesting?	96%
15	Does the display of the score menu on the mirror tracer application help find out the results of the level of mental endurance conditions?	97%
Average		92%

5. Conclusion

Based on the results and discussions that have been carried out, it can be concluded that the application of experimental psychology implementation has been able to implement the mirror tracer tool for psychological tests in recruiting new employees, namely displaying the results of the level of mental endurance using Fuzzy Mamdani calculations with the variable length of time and the number of error points, then displays the percentage of matches between the input pattern image and the template image using the Template Matching method. Also, after testing the application of psychologists, getting a percentage of 83% agreed that the application could be used as an alternative test tool. And the results of testing applications for prospective new employees get a percentage of 92% agreeing that the application can be used to determine the condition of life endurance.

For further development, it can be conducted on the data management aspect of the new marker template by psychologists in real time. Given the limitations of the application that is made in the form of a static marker. The improvements can also be made to the use of other algorithms. Hence, the performance comparisons and analysis results can be carried out in order to earn better results.

Acknowledgement

Our gratitude goes to the students of the Information Technology Department, State Polytechnic of Malang. Especially to the UPT Research and Community Service (UPT PPM) Polinema which has provided assistance for the implementation of this research.

References

- [1] P. Dasar, "Peralatan eksperimen kognitif laboratorium psikologi ugm," 2014.
- [2] S. Y. Wiwien Dinar Pratisti, *Psikologi Eksperimen: Konsep, Teori, dan Aplikasi*. Muhammadiyah University Press, 2015.
- [3] L. Seniati, A. Yulianto, and B. N. Setiadi, "Psikologi Eksperimen," no. January, pp. 1–195, 2005.
- [4] M. S. Julius and E. Adi-Japha, "A developmental perspective in learning the mirror-drawing task," *Front. Hum. Neurosci.*, vol. 10, no. MAR2016, pp. 1–13, 2016, doi: 10.3389/fnhum.2016.00083.
- [5] "mirror- drawing task.," pp. 1–3.
- [6] E. W. Jacobs, "The Versatile Mirror Drawing Apparatus," *Teach. Psychol.*, vol. 12, no. 3, pp. 169–170, Oct. 1985, doi: 10.1207/s15328023top1203_17.
- [7] U. Nurhasan, D. Suryani, and E. L. Amalia, "Sistem Cerdas Tes Kepribadian Kraepelin," *J. Teknol. Inf.*, vol. 8, no. 2, pp. 145–154, 2017.
- [8] A. E. Knightly, "The process of learning as shown by the mirror- drawing experiment," no. February, 2014.
- [9] C. Pete *et al.*, "Crisp-Dm 1.0," *Cris. Consort.*, p. 76, 2000.
- [10] H. Junaedi, M. Hariadi, and I. K. E. Purnama, "Penerapan Sinematografi Dalam Penempatan Posisi Kamera Dengan Menggunakan Logika Fuzzy," *Khazanah Inform. J. Ilmu Komput. dan Inform.*, vol. 4, no. 2, p. 55, 2018, doi: 10.23917/khif.v4i2.7028.
- [11] B. Sugandi and S. Dewi, "Sistem Inspeksi Kecacatan pada Kaleng Menggunakan Filter Warna HSL dan Template Matching," *Khazanah Inform. J. Ilmu Komput. dan Inform.*, vol. 4, no. 2, p. 124, 2018, doi: 10.23917/khif.v4i2.7119.
- [12] A. P. Kusuma and - Darmanto, "Pengenalan Angka Pada Sistem Operasi Android Dengan Menggunakan Metode Template Matching," *Regist. J. Ilm. Teknol. Sist. Inf.*, vol. 2, no. 2, p. 68, 2016, doi: 10.26594/r.v2i2.549.
- [13] R. Munthe, P. Insap Santosa, and R. Ferdiana, "Usulan Metode Evaluasi User Acceptance Testing (UAT) dalam Pengembangan Perangkat Lunak," *Jl. Udayana Kampus Teng.*, no. 0362, p. 27213, 2015.