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Implementation Analytical Hierarchy Process Algorithm for Design and Development Website Hero Mage Recommendation for Mobile Legends

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***Abstract*— Mobile Legends is a Multiplayer Online Battle Arena genre game that is currently hot. There are 122 heroes in Mobile Legends which are divided into 6 roles. The currently popular role is mage, where this mage role occupies 3 of the 5 most used in the MPL S11 tournament. Purchasing heroes can be done with a currency called battlepoints amounting to 32,000. The collection of battlepoints is limited to one week, and there is no refund feature for hero purchases, meaning that if the player makes the wrong hero purchase, the player has to collect the currency again to be able to buy another hero. The Mobile Legends mage hero recommendation system is a system that can provide assistance in purchasing heroes that suit user preferences. Recommendation results are provided based on input provided by the user and processed using the Analytical Hierarchy Process method. The evaluation results using the End User Computing Satisfaction method obtained a percentage of 88.64%, which indicates that the system has been well developed and can be used to provide mage hero recommendations for the Mobile Legends game.**

Keywords*— *Analytical Hierarchy Process, Game, Mobile Legends, Recommendation system

I. INTRODUCTION

Game is one of the forms of entertainment, and games are created with the purpose of entertaining the players who engage with them. Games have evolved significantly, starting from traditional games to digital games [1]. One of the popular MOBA (Multiplayer Online Battle Arena) games is Mobile Legends: Bang Bang, commonly referred to as ML, which recently concluded the M4 World Championship tournament on January 15, 2023. This tournament broke the record for the highest number of viewers, with 4,268,018 viewers, surpassing the previous ML tournament's viewership record of 2.84 million viewers. Mobile Legends is a MOBA game developed and published by Moonton. In this game, players engage in 5 vs. 5 battles against other players with the goal of destroying the enemy team's base to achieve victory, and each match typically lasts around 15-20 minutes.

Mobile Legends features a total of 122 heroes, divided into 6 roles, including Tank, Mage, Marksman, Fighter, Assassin, Identify applicable funding agency here. If none, delete this.
and Support. One of the roles with a substantial number of heroes is "mage," with 25 heroes falling into this category. Mages rely on using skills with short cooldowns to deal magic damage to enemies. Mages are often preferred due to their high damage output in the early game, the ability to control opponents' movements, and being considered easy to use. Mages are quite popular in tournaments, as evidenced by statistics from liquipedia website where in MPL Indonesia Season 11 tournament, where 3 out of the top 5 most-picked heroes were mages

II. METHODOLOGY

A. Recommendation System

In 1990, the concept of recommender systems was introduced as providing recommendations about relevant information to users by using information from user with similar taste [9]. Recommender system algorithms predict how users will react to some choices. There are four entities in a recommender system: items, users, utility matrix, and transactions [10]. The main feature in a recommender system is the ability to predict user preferences by processing user data and data from other users with similar preferences

[11]. Recommender systems are divided into 3 types, namely [12]:

1) Content Based Filtering, providing recommendations by marking existing items or products with keywords then analyzing user desires through information in the database, then suggesting items or products that match their wishes.
2) Collaborative-Based Filtering, providing recommendations to users based on the wishes of other users who have similar characteristics.
3) Hybrid Collaborative Filtering, combines content based filtering with collaborative based filtering to provide recommendations to users.

B. *Multiple Criteria Decision Making (MCDM)*

Multi-Criteria Decision Making (MCDM) is a technique for making decisions among several alternative options. The elements found in MCDM are as follows [13].

1) *Attribute* or criteria, providing characteristics for objects or alternatives.
2) Objectives, is a target to achieve a goal..
3) Goals, determining solution to a problem.

There are two categories in MCDM, namely Multiple Attribute Decision Making (MADM) and Multiple Objective Decision Making (MODM). The steps taken for decision-making in MCDM are as follows [14].

1) Determining the main goals.
2) Determining value of criteria and alternative .
3) Determining best alternative to reach main goals.

C. *Analytical Hierarchy Process (AHP)*

Analytical Hierarchy Process (AHP) is a method used for decision-making by ranking the existing decision alternatives, and then the criteria with the highest values are chosen as recommendations [15]. AHP helps break down complex problems into several components structured in a hierarchy for a systematic approach. [16]. AHP method steps are as follows. AHP method steps are as follows [17].

1) Describing the problem and the desired solution.
2) Creating a hierarchy structure that begins with the main goal.
3) Creating pairwise comparison matrices that reflect the relationships of each element to the criteria located one level above them. Pairwise comparison mattrices can be seen in Table I.

TABLE I
PAIRWISE COMPARISON MATRICES

	Criteria 1	Criteria 2	Criteria 3	Criteria n
Criteria 1	K11	K12	K13	K1n
Criteria 2	K21	K22	K23	K2n
Criteria 3	K31	K32	K33	K3n
Criteria m	Km1	Km2	Km3	Kmn

4) Defining pairwise comparisons using

$$n \times \left[\frac{n-1}{2}\right] \quad (1)$$

n is number of elements being compared. The pairwise comparison rating scale can be seen in Table II.

TABLE II
PAIRWISE COMPARISON RATING SCALE

Intensitas Importance	Description
1	Both elements are important
3	One element is slightly more important than another element
5	One element is more important than another element
7	One element is very much more important than another element
9	One element is absolutely more important than another element
2,4,6,8	Intermediate Values
Reverse	If activity A receive 1 points compared to B, Then B have inverse value compared to A

5) Calculate eigen value and the consistency level. If the value is not consistent, then data is reevaluated.
6) Repeating steps 3, 4, and 5 for all hierarchy levels.
7) Calculate eigen vector for every pairwise comparison matrices to determine every element priority. The calculation process is carried out by summing the values in each column to obtain the normalization matrix, and then summing the values in each row and dividing the result by the number of elements to obtain the average.

If A is pairwise comparison matrices, then vector weight can be calculated as follows.

$$(A)\left(\mathrm{w}^T\right) = (n)\left(\mathrm{w}^T\right) \quad (2)$$

A = Pairwise comparison matrices
w^T = vector weight n = number of criteria can be approximated by means of:

a) Normalizing every column j in A matrices

$$\Sigma_i \ \mathrm{a}\,(i,j) = 1 \quad (3)$$

a(i,j) = normalized column a matrices called A'.

b) Calculate average for every row i in A'

$$w_i = \frac{1}{n}\Sigma_i \ \mathrm{a}\,(i,j) \quad (4)$$

n = number of criteria

w = vector weight

with w_i as weight goals to i from vector weight.

8) Checking hierarchy consistency

If A is pairwise comparison matrices and w is vectro weight, then consistency value from w vector can be tested by:

a) Calculate: $(A)\,(w^T)$

$$\lambda = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{\text{i element in } (A)\,(w^T)}{\text{i element in } w^T}\right) \quad (5)$$

λ = eigen value max

n = number of criteria

b) Calculate consistency index

$$\text{CI} = \frac{\lambda - n}{n-1} \quad (6)$$

CI = consistency indeks

λ = eigen value max

n = number of criteria

c) Random index RI_n are average value of CI.

TABLE III
RANDOM INDEX (RI_n)

n	2	3	4	5	...
RI_n	0	0.5	0.90	1.12	...

d) Calculate consistency ratio

$$CR = \frac{CI}{RI_n} \quad (7)$$

CR = consistency ratio

CI = consistency index

RI_n = random index

- If CI = 0, then hierarchy is consistent.
- If CR ¡= 0.1, Then hierarchy reasonably consistent.
- IF CR ¿ 0.1, then hierarchy is not consistent.

D. . Likert Scale

The Likert scale is a scale commonly used in survey-based research. In the Likert scale, respondents specify their level of agreement on a symmetric scale ranging from ”strongly agree” to ”strongly disagree” for the given statements [18]. The Likert scale typically focuses on multiple categories on the scale, and whether the data obtained is in the form of ordinal data or data that needs to be evaluated on an interval scale [19]. The following is the formula for calculating the Likert Scale [20]:

$$\text{Score percentage} = \frac{T \times Pn}{Y} \times 100\% \quad (8)$$

T = The total number of respondents for a category.
Pn = Likert category points.
Y = Total number of respondents × likert highest score.

After obtaining the percentage score, the next step is to determine the interval for interpreting the percentage, and this can be done using the formula [20].

$$I = \frac{100\%}{\text{likert highest score (5)}} = 20 \quad (9)$$

Therefore, the interpretation of the percentage criteria is as follows.

- 0% - 20.99% = very poor
- 21% - 40.99% = poor
- 41% - 60.99% = fair
- 61% - 80.99% = good
- 81% - 100% = very good

E. End User Computing Satisfaction (EUCS)

According to Sugiyono, the suitable number of respondents in a research study ranges from 30 to 500 respondents [21]. *End User Computing Satisfaction* EUCS is a method for measuring the level of user satisfaction with an information system by comparing expectations and the reality of the system [22]. EUCS is defined as the overall evaluation of system users based on their experience with the developed system [23]. EUCS itself consists of five components [24].

1) Content
Assessing the level of user satisfaction from the aspects of the system’s functions and modules, or the content of a system that can be utilized by users and the information generated from that system.
2) Accuracy
Evaluating the level of user satisfaction from the aspect of data accuracy when the system receives input and transforms it into information.
3) Format
Assessing the level of user satisfaction from the aspect of the visual and aesthetic aspects of the system’s interface, as well as the format of reports or information generated by the system to ensure an attractive and user-friendly

interface, which can indirectly impact the system's effectiveness.

4) Ease of Use

Evaluating the level of user satisfaction from the aspect of user-friendliness, including the data input process, data processing, and the ease of finding the required information.

5) Timeliness

Assessing the level of user satisfaction regarding the availability of the developed system in providing data and information needed in a timely manner.

In the research process, there are several stages that are carried out, namely:

1) Literature Studies

In this stage, a study of reliable sources such as journals, books, academic works, essays, and others is conducted. 2) Knowledge Acquisition

In this stage, information is collected from professional players, books, computer files, and documents. This knowledge includes information about heroes and the weight values used.

3) Knowledge Representation

In this stage, approved hero weight result is displayed

TABLE IV
HERO WEIGHT

Nama	Offense Rating	Skill Stun	Skill Escape	Skill Heal
Kagura	8	3	2	0
Alice	5	1	1	1
Nana	8	2	1	0
Harith	7	0	1	0
Eudora	10	1	0	0
Gord	9	1	0	0
Cyclops	8	1	0	0
Aurora	10	3	0	0
Odette	8	1	1	0
Zhask	6	0	1	0
Pharsa	9	1	1	0
Valir	8	2	1	0
Change	9	0	0	0
Vale	10	2	0	0
Lunox	10	0	2	1
Esmeralda	4	1	1	0
Luo Yi	6	1	1	0
Yve	5	1	0	0
Valentina	9	1	1	1
Xavier	8	1	0	0
Novaria	10	0	1	0
Lylia	8	0	1	0
Vexana	9	2	0	0
Kadita	10	1	2	0
Cecilion	9	1	0	1

4) System Design

In this stage, the design for website development begins, including the creation of flowcharts, database structures, and the website's interface.

5) System Development

In this stage, the system development process is carried out according to the previously created design using PHP programming language, Code Igniter 3 framework, and MySQL as the database.

6) System Implementation

Integrating AHP Algorithm into the sistem to get recommendation based on user input.

7) Testing

In this stage, sistem testing is done by doing manual calculation and comparing it to sistem result.

8) Evaluation

The evaluation is conducted by distributing a user satisfaction questionnaire for the developed system, applying the Likert scale within the questionnaire.

HOMEPAGE FLOWCHART

In homepage, user will be displayed homepage page. There will be 4 main button which is hero recommendation button, heroes list button, feedback button, and how to use button.

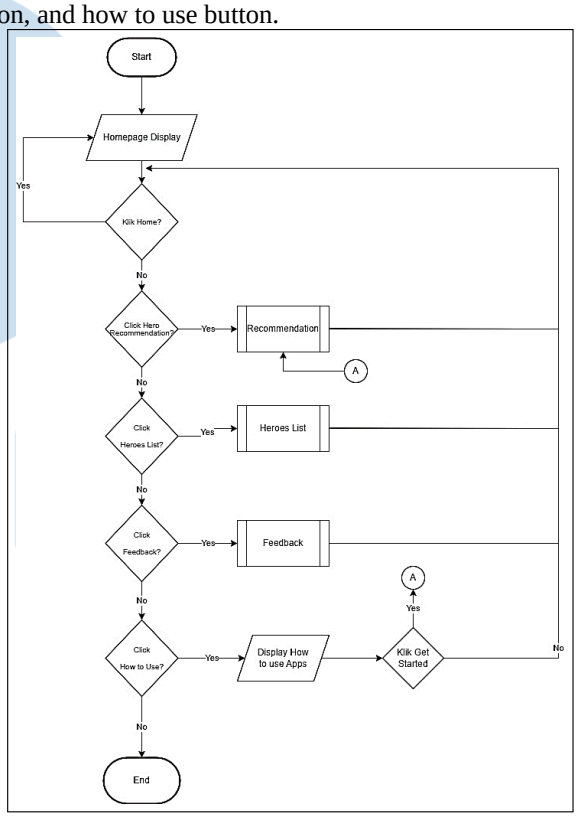

Fig. 1. Homepage flowchart

III. RESULT AND DISCUSSION

A. *Sistem Testing*

The system testing process is carried out by manually calculating the Analytical Hierarchy Process method and conducting user satisfaction tests by distributing questionnaires based on the End User

Computing Satisfaction method, and then calculating satisfaction using the Likert scale method.

B. Manual Calculation Testing

Data that will be used in manual calculation can be seen in Table V.

From the entered data, the steps taken involve creating a pairwise matrix and summing each column. The results of creating the pairwise matrix and summing each column can be seen in Table VI.

TABLE V
AHP CALCULATION DATA

Code	Description	Value
BD SS	Offense Rating to Skill Stun	4
BD SE	Offense Rating to Skill Escape	4
BD SH	Offense Rating to Skill Heal	5
SS SE	Skill Stun to Skill Escape	0.5
SS SH	Skill Stun to Skill Heal	2
SE SH	Skill Escape to Skill Heal	1

TABLE VI
PAIRWISE MATRICES

	BD	SS	SE	SH
BD	1	4	4	5
SS	0.25	1	0.5	2
SE	0.25	2	1	1
SH	0.2	0.5	1	1
Total	1.7	7.5	6.5	9

After obtaining the pairwise matrix, the next step is to normalize the matrix by dividing the values in each column by the sum of the column values. The results of the normalization calculation can be seen in Table VII.

BD / Total BD = 1/1.7 = 0.588
SS / Total BD = 0.25/1.7 = 0.147
SE / Total BD = 0.25/1.7 = 0.147
SH / Total BD = 0.2/1.7 = 0.117
the exact same calculation will be done for column 2 to 4.

TABLE VII
NORMALIZED MATRICES

	BD	SS	SE	SH
BD	0.588	0.533	0.615	0.555
SS	0.147	0.133	0.076	0.222
SE	0.147	0.266	0.153	0.111
SH	0.117	0.066	0.153	0.111

Then, the eigenvalue (w) is determined by summing the values in each row of the normalized matrix and dividing by the number of criteria used (4 criteria). The calculated values of W for each row can be seen in Table VIII.

BD = (0.588+0.533+0.615+0.555)/4 = 0.572
SS = (0.147+0.133+0.076+0.222)/4 = 0.144
SE = (0.147+0.266+0.153+0.111)/4 = 0.169
SH = (0.117+0.066+0.153+0.111)/4 = 0.111

TABLE VIII
EIGEN VECTOR (W)

Code	w value
BD	0.572
SS	0.144
SE	0.169
SH	0.111

Next is to check the consistency level of the hierarchy by means of

1) Calculate (A)(w^T) by multiplying the pairwise matrix with the eigenvalue matrix (w). The result of this multiplication can be seen in Fig 2.

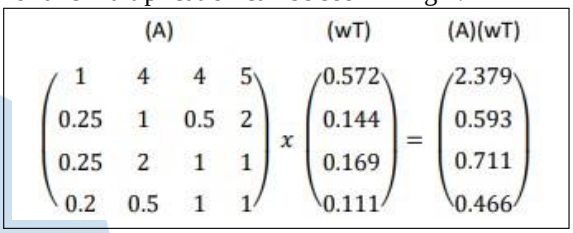

Fig. 2. (A)(wT) calculation

2) Then, calculate the value of t by dividing the result of the calculation (A)(w^T) by w, and then add the results and divide by 4.

t BD = 2.379/0.572 = 4.159
t SS = 0.593/0.144 = 4.118
t SE = 0.711/0.169 = 4.207
t SH = 0.466/0.111 = 4.198
t max = (4.159+4.118+4.207+4.198)/4 = 4.1705

3) Calculate consistency index.

CI = (4.1705 - 4) / 3 = 0.0568

4) After obtaining consistency index, calculate consistency ratio by dividing consistency index with random index value (0.9).

CR = (0.0568 / 0.9) = 0.0631

The consistency ratio value is 0.0631, which is below 0.1, so the input is valid and can be used for the next process. The next process is to multiply the value w with the weights in the system.

Kagura = (8×0.572)+(3×0.144)+(2×0.169)+(0×0.111) = 5.359
Alice = (5×0.572)+(1×0.144)+(1×0.169)+(1×0.111) = 3.292
Nana = (8×0.572)+(2×0.144)+(1×0.169)+(0×0.111) = 5.044
Harith = (7×0.572)+(0×0.144)+(1×0.169)+(0×0.111) = 4.181
Eudora = (10×0.572)+(1×0.144)+(0×0.169)+(0×0.111) = 5.876

The following is the calculation performed for each hero.

The results of the sorted calculation can be seen in Table IX. ased on the table above, the top 10 heroes with the highest final values are Kadita, Lunox,

Aurora, Vale, Novaria, Eudora, Valentina, Pharsa, Vexana, and Cecilion. The final results closely approximate the values obtained when the system performs the calculation, with the same order as shown in Figure 3.

C. User Satisfaction Test

User satisfaction testing was conducted by distributing questionnaires to application users using Google Forms. The questionnaire respondents are Mobile Legends players, and the total number of questionnaire respondents obtained was 34. The questionnaire questions are based on the dimensions following the EUCS method, which are content, accuracy, format, ease of use, and timeliness. The responses to the questionnaire statements follow the Likert Scale, starting with strongly disagree (SD), disagree (D), neutral (N), agree (A), and strongly agree (SA). The list of statements and the questionnaire results can be seen in Table 10.

TABLE IX
FINAL SCORE SORT RESULT

Name	Final Score
Kadita	6.215
Lunox	6.182
Aurora	6.165
Vale	6.021
Novaria	5.9
Eudora	5.876
Valentina	5.585
Pharsa	5.472
Vexana	5.447
Cecilion	5.415
Kagura	5.359
Gord	5.303
Change	5.158
Valir	5.044
Nana	5.044
Odette	4.899
Lylia	4.754
Cyclops	4.729
Xavier	4.729
Harith	4.181
Luo Yi	3.753
Zhask	3.608
Alice	3.292
Yve	3.01
Esmeralda	2.607

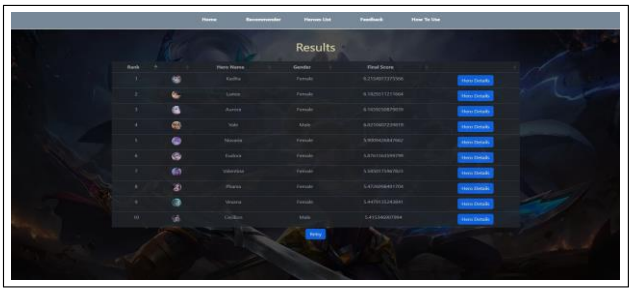

Fig. 3. Website result

TABLE X
USER SATISFACTION TEST RESULT

Dimension	Statement	SD	D	N	A	SA
Content	The hero mage recommendation system application provides information tailored to your needs.	0	1	1	14	18
Content	The hero mage recommendation system application presents information that is clear and comprehensive.	0	1	4	12	17
Accuracy	The mage hero recommendations displayed by the mage hero recommendation system application are correct and accurate.	0	0	6	10	18
Accuracy	Every link you click on in the mage hero recommendation system application displays a relevant web page.	0	0	2	9	23
Format	The design and format provided in the system make it easy for me to use the mage hero recommendation system application.	0	0	5	13	16
Format	The menu structure and options displayed in the mage hero recommendation system application are easy to understand.	0	0	2	14	18
Ease of Use	The mage hero recommendation system application is very easy to use.	0	0	5	9	20
Ease of Use	The mage hero recommendation system application is easily accessible from anywhere and at any time.	0	0	1	10	23
Timeliness	The mage hero recommendation system	0	1	8	7	18

	application saves me time in finding the desired hero.					
Timeliness	The mage hero recommendation system application displays information quickly.	0	0	5	7	22

Based on the user satisfaction test conducted, the satisfaction percentages for each EUCS variable were obtained using the Likert Scale formula. These percentages can be seen in Table XI.

TABLE XI
EUCS DIMENSION PERCENTAGE RESULT

Dimension	Percentage
Content	87.6%
Accuracy	89.6%
Format	87.9%
Ease of Use	90.8%
Timeliness	87.3%

The final user satisfaction percentage is calculated by averaging all the final percentages of each variable.

$$\text{Final Percentage} = \frac{87.6\%+89.6\%+87.9\%+90.8\%+87.3\%}{5} \quad (10)$$

$$= 88.64\%$$

Based on the user satisfaction percentage obtained in equation 10, the user satisfaction percentage is 88.64%, indicating that the developed system is already very good.

IV. CONCLUSION

Based on the conducted research, it can be summarized that:

1) The mage hero recommendation system for Mobile Legends game using the Analytical Hierarchy Process method has been successfully developed. The system can provide mage hero recommendations to users based on user preferences and hero weights confirmed by experts. System verification was performed by comparing manual calculations with the results generated by the system.
2) User satisfaction was measured by distributing questionnaires and obtaining responses from 34 respondents. Measurement using the End User Computing Satisfaction method resulted in an overall satisfaction percentage of 88.64%, concluding that the developed system has been constructed very well and can be used to provide mage hero recommendations for the Mobile Legends game.

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