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Decision Support System for Optimizing Recruitment of New Employees Using the ELECTRE Method

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ABSTRACT

In the modern era, information technology is advancing rapidly. This development encompasses not only hardware and software technologies but also computational methods. One notable computational method that has gained traction is decision-making systems. These information systems are widely utilized in companies for making decisions, referred to as Decision Support Systems (DSS). Neko-Neko Bakery and Cake is a bakery located in Medan that offers a variety of breads and traditional snacks. Currently, the bakery faces ease in finding new employees, as numerous candidates are eager to apply for positions. In the recruitment process, it is essential for the company to establish criteria for selection and hiring. The accuracy percentage was determined through ten trials using the ELECTRE method, resulting in one error due to the similarity of candidates, which led to indistinguishable outcomes. With nine successful trials out of ten, the accuracy rate is calculated as (9/10) * 100% = 90% accuracy.

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1. INTRODUCTION

In today's advanced era, the rapid evolution of information technology encompasses not only hardware and software but also computational methodologies. Among these methodologies, decision-making systems have gained significant traction, particularly in the context of organizational decision-making processes. Decision Support Systems (DSS) are increasingly employed by companies to facilitate informed decision-making[1]. These systems provide a structured approach to analyzing complex data, enabling organizations to make strategic choices that enhance operational efficiency. Neko-Neko Bakery and Cake is a bakery that offers a diverse range of traditional snacks and breads. With the increasing number of job applicants, the company faces the challenge of effectively selecting new employees from a pool of candidates. The recruitment process necessitates a clear set of criteria for selection and hiring, which is crucial for maintaining the quality of the workforce and ensuring organizational goals are met[2]. The absence of a systematic approach in recruitment can lead to

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inefficiencies and misalignment with the company's needs. In recruitment, the process involves evaluating candidates based on specific criteria to identify the most suitable individuals for available positions. This includes assessing educational qualifications, age, health status, and appearance, among other factors. As articulated by Hwang and Yoon (2019)[3], employing a structured decision-making methodology can significantly enhance the effectiveness of candidate selection.

The ELECTRE method, a widely recognized multi-criteria decision-making (MCDM) technique, is particularly effective in addressing complex decision-making scenarios. It allows organizations to evaluate alternatives against multiple criteria, facilitating a more comprehensive assessment of candidates [4]. By applying the ELECTRE method, Neko-Neko Bakery and Cake can optimize its recruitment process, ensuring that the selected candidates align with the company's strategic objectives. This research aims to develop a web-based application that utilizes the ELECTRE method as a Decision Support System to streamline the recruitment of new employees at Neko-Neko Bakery and Cake. By implementing this system, the bakery seeks to improve the accuracy and efficiency of its hiring process, ultimately contributing to enhanced organizational performance.

2. RESEARCH METHOD

According to Satria et al. (2019), the ELECTRE method is a multi-criteria decision-making technique that provides a framework for ranking alternatives based on pairwise comparisons derived from each criterion. This method is particularly useful when there are multiple alternatives, allowing for the elimination of options that do not meet the established criteria. In other words, ELECTRE is applied in situations with numerous choices but limited criteria involved.

A choice is said to dominate another if one or more of its criteria are superior (when compared to the other choice) while the remaining criteria are comparable. As noted by Maulina Dewi & Perdana Windarto (2019), the ELECTRE method serves as a powerful tool for establishing rankings and identifying the best alternatives. The core principle of the ELECTRE method involves evaluating the outranking relationships by performing pairwise comparisons of the alternatives against each criterion.

The outranking relationship between alternatives A_i and A_j indicates that even if alternative A_i does not quantitatively dominate alternative A_j , it may still be preferred due to other contributing factors. An alternative is considered dominated if there exists another option that surpasses it in one or more criteria, while not falling short in others. The outranking process here involves generating a comprehensive assessment based on all pairwise comparisons for each criterion, where the most favorable criteria contribute to the best overall ranking.

The first step in the ELECTRE method is to perform pairwise comparisons for each alternative based on each criterion a_{ij}. The values obtained must be normalized to a comparable scale x_{ij}:

$$x_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{m} a_{ij}^2}} \quad \text{for } i = 1, 2, ..., m \text{ and } j = 1, 2, ..., n$$

After normalization, the next step involves defining the significance (weight) associated with each criterion based on the overall relevance (w_i) determined by the decision-maker.

The third step is to establish the concordance and discordance sets for each pair of preferences *k* and *l* (where k,l=1,2,3,...,m*k*,*l*=1,2,3,...,*m and k≠l*). The concordance is defined as:

$$C_{kl} = \{j | y_{kj} \geq y_{lj}\} \quad \text{for } j = 1, 2, ..., n$$

Conversely, the complement of this set is defined as discordance:

$$D_{kl} = \{j | y_{kj} < y_{lj}\} \quad \text{for } j = 1, 2, ..., n$$

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The fourth step involves calculating the values in the concordance and discordance matrices. The value of elements in the concordance matrix is determined by summing the weights associated with the concordance set, mathematically expressed as:

$$d_{kl} = \frac{\max |y_{kj} - y_{lj}| \quad \text{for } j \in D_{kl}}{\max |y_{kj} - y_{lj}| \quad \forall j}$$

To determine the values in the discordance matrix, the maximum difference between criteria scores in the discordance set is divided by the maximum score available, expressed as:

$$C_{kl} = \sum_{j \in C_{kl}} w_j \quad \text{for } j = 1, 2, ..., n$$

Next, the concordance and discordance matrices are established. The dominance matrix is built by applying an ideal threshold to the concordance values, ensuring that alternative A_k will only be preferred over A_l if the concordance value meets or exceeds the threshold c:

$$C_{kl} \geq c$$

The threshold value can be determined as the average concordance index:

$$c = \frac{1}{m(m-1)} \sum_{k=1}^{m} \sum_{l=1}^{m} C_{kl}$$

Based on this threshold, the elements of the dominance matrix F are defined as:

$$f_{kl} = 1 \quad \text{if } C_{kl} \geq c, \quad f_{kl} = 0 \quad \text{if } C_{kl} < c$$

Similarly, the dominance matrix G for discordance is defined using the threshold, where:

$$d = \frac{1}{m(m-1)} \sum_{k=1}^{m} \sum_{l=1}^{m} d_{kl}$$

Where the elements of the discordance matrix G are determined as follows:

$$g_{kl} = 1 \quad \text{if } d_{kl} \geq d, \quad g_{kl} = 0 \quad \text{if } d_{kl} < d$$

The final step involves determining the aggregate dominance matrix E, where each element is the product of the corresponding elements from matrices F and G:

$$e_{kl} = f_{kl} \times g_{kl}$$

Finally, the alternatives are eliminated based on the matrix E, which ranks the options. If e_{kl}=1, then alternative A_k is considered better than A_l. Hence, rows in matrix E where the sum is at least one can be eliminated, with the best alternative being the one that dominates all others.

3. RESULTS AND DISCUSSIONS

The analysis of the existing system encompasses a comprehensive examination of the system's workflow, covering both the model and the architecture of the model to be developed. The primary objective is to facilitate the implementation and testing of a web-based Decision Support System (DSS) for employee selection utilizing the ELECTRE method.

3.1. Flowchart of the Document

In the course of executing this research, several components are essential for the system, including input requirements, process requirements, and output requirements.

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- **Input Requirements:** This includes various data criteria necessary for evaluation.
- **Process Requirements:** This involves the scoring of each criterion.
- **Output Requirements:** This represents the results derived from the ELECTRE calculations.

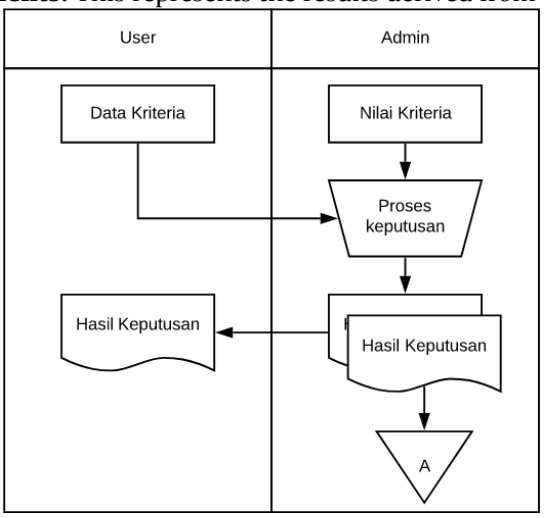

Figure 1. Flowchart of Documents

The system analysis aims to identify problems and requirements for the system to be constructed. Prior to building the system, several analytical stages are conducted to ascertain all necessary elements, ensuring that errors are minimized and that the resulting system is optimized. The system under development is a Decision Support System for the recruitment of new employees using the ELECTRE method.

3.2. Flowchart of the Proposed System

The flowchart for the Decision Support System in the hiring process is illustrated in the following figure.

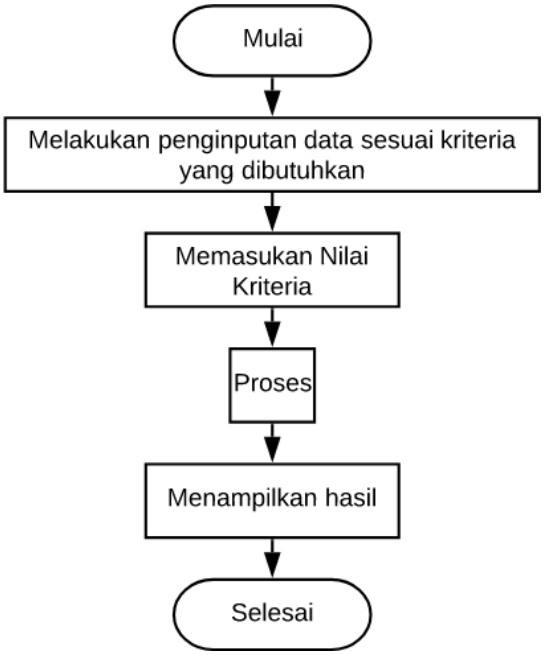

Figure 2. Flowchart of the Proposed System

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3.3. Data Requirements for Candidate Selection

For the successful implementation of this system, specific data is required for its construction:

1. **Employee Alternatives:** This includes the names of the candidates selected for evaluation along with the scores for each criterion. The candidates are:
    - Ari Kurniawan
    - Ade Riyen Tiarni
    - Sucipto
2. **Criteria Data:** This consists of variables that serve as measures for candidate evaluation, including:
    - Highest Educational Attainment
    - Age
    - Health Status
    - Appearance

3.4. Performance Evaluation Criteria

The performance evaluation criteria follow the standards set by the company, with corresponding scoring as outlined in Table 1.

Table 1. Evaluation Criteria

Weight	Score	Description
5	81–100	Excellent
4	61–80	Good
3	41–60	Satisfactory
2	21–40	Poor
1	<20	Very Poor

1. Highest Educational Attainment

This criterion evaluates the highest level of education obtained by candidates, ranging from high school diplomas to doctoral degrees, with supporting documentation required. The scoring for academic qualifications is detailed in Table 2.

Table 2. Highest Educational Criteria

No	Criterion	Score
1	No Schooling	20
2	Elementary/Junior High	40
3	High School	60
4	Diploma	70
5	Bachelor's Degree	100

2. Age

The age criterion assesses the suitability of each candidate based on their age groups, as shown in Table 3.

Table 3. Age Criteria

No	Criterion	Score
1	15 - 24 Years	50
2	25 - 35 Years	100

3. Health Status

This criterion evaluates the health history of the candidates. The scoring for health status is presented in Table 4.

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Table 4. Healte Status

No	Criterion	Score
1	Has Medical History	50
2	No Medical History	100

4. Appearance

Appearance is assessed as an important criterion, as it significantly influences consumer perception. Table 5 outlines the scoring for appearance.

Table 5. Appearance Criteria

No	Criterion	Score
1	Fair	50
2	Good	100

3.4 Calculation Using the ELECTRE Method

The following table represents the scoring of each alternative against the established criteria, as shown in Table 6.

Table 6. ELECTRE Calculation

Alternative	C1	C2	C3	C4
A1	1	5	5	2
A2	1	2	1	4
A3	1	3	3	2

Table 6 illustrates the compatibility ratings for each alternative across the criteria. The values assigned to each alternative for every criterion represent compatibility scores, where a higher score indicates a better fit. It is assumed that all criteria are considered as benefit criteria. The systematic analysis and structured approach to the Decision Support System using the ELECTRE method will enhance the recruitment process by providing a clear framework for evaluating candidates based on multiple criteria. This ensures a more objective and efficient selection process, ultimately contributing to the optimal performance of the organization.

3.5. Decision Maker

Decision Support System (DSS) developed for employee selection, the decision maker plays a crucial role by assigning preference weights to each criterion. These weights reflect the relative importance of each criterion in the overall evaluation process.

The assigned weights are as follows: **W = (5, 2, 2, 1)**

The decision matrix formed from the compatibility table is as follows:

$$X = \begin{bmatrix} 1 & 5 & 5 & 2 \\ 1 & 2 & 3 & 4 \\ 1 & 3 & 1 & 2 \end{bmatrix}$$

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To resolve the above problem using the ELECTRE method, we will proceed according to the previously described steps.

a. Normalization of the Decision Matrix

$$r_{11} = \frac{x_{11}}{\sqrt{\sum_{i=1}^{m} x_{i1}^2}} = \frac{1}{\sqrt{1^2 + 1^2 + 1^2}} = \frac{1}{1} = 1$$

$$r_{12} = \frac{x_{12}}{\sqrt{\sum_{i=1}^{m} x_{i2}^2}} = \frac{5}{\sqrt{5^2 + 2^2 + 3^2}} = \frac{5}{6{,}164} = 0{,}811$$

$$r_{13} = \frac{x_{13}}{\sqrt{\sum_{i=1}^{m} x_{i3}^2}} = \frac{5}{\sqrt{5^2 + 3^2 + 1^2}} = \frac{5}{5{,}916} = 0{,}845$$

$$r_{14} = \frac{x_{14}}{\sqrt{\sum_{i=1}^{m} x_{i4}^2}} = \frac{2}{\sqrt{2^2 + 4^2 + 2^2}} = \frac{2}{4{,}898} = 0{,}408$$

$$r_{21} = \frac{x_{21}}{\sqrt{\sum_{i=1}^{m} x_{i1}^2}} = \frac{1}{\sqrt{1^2 + 1^2 + 1^2}} = \frac{1}{1} = 1$$

$$r_{22} = \frac{x_{22}}{\sqrt{\sum_{i=1}^{m} x_{i2}^2}} = \frac{2}{\sqrt{5^2 + 2^2 + 3^2}} = \frac{2}{6{,}164} = 0{,}324$$

$$r_{23} = \frac{x_{23}}{\sqrt{\sum_{i=1}^{m} x_{i3}^2}} = \frac{3}{\sqrt{5^2 + 3^2 + 1^2}} = \frac{3}{5{,}916} = 0{,}338$$

$$r_{24} = \frac{x_{24}}{\sqrt{\sum_{i=1}^{m} x_{i4}^2}} = \frac{4}{\sqrt{2^2 + 4^2 + 2^2}} = \frac{4}{4{,}898} = 0{,}816$$

$$r_{31} = \frac{x_{31}}{\sqrt{\sum_{i=1}^{m} x_{i1}^2}} = \frac{1}{\sqrt{1^2 + 1^2 + 1^2}} = \frac{1}{1} = 1$$

$$r_{32} = \frac{x_{32}}{\sqrt{\sum_{i=1}^{m} x_{i2}^2}} = \frac{1}{\sqrt{5^2 + 3^2 + 1^2}} = \frac{1}{6{,}164} = 0{,}162$$

$$r_{33} = \frac{x_{33}}{\sqrt{\sum_{i=1}^{m} x_{i3}^2}} = \frac{4}{\sqrt{5^2 + 4^2 + 4^2}} = \frac{4}{5{,}916} = 0{,}676$$

$$r_{34} = \frac{x_{34}}{\sqrt{\sum_{i=1}^{m} x_{i4}^2}} = \frac{2}{\sqrt{2^2 + 4^2 + 2^2}} = \frac{2}{4{,}898} = 0{,}408$$

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From the calculations above, the resulting matrix is obtained.

$$R = \begin{matrix} 1 \\ [1 \\ 1 \end{matrix} \begin{matrix} 0{,}811 & 0{,}845 & 0{,}408 \\ 0{,}324 & 0{,}338 & 0{,}816] \\ 0{,}162 & 0{,}676 & 0{,}408 \end{matrix}$$

b. Weighting of the Normalized Matrix.

V=R.W

$$\begin{matrix} 1 \\ = [1 \\ 1 \end{matrix} \begin{matrix} 0{,}811 & 0{,}845 & 0{,}408 \\ 0{,}324 & 0{,}338 & 0{,}816] \\ 0{,}162 & 0{,}676 & 0{,}408 \end{matrix} . \begin{matrix} 5 & 0 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 & 0 \\ 0 & 0 & 4 & 0 & 0 \\ 0 & 0 & 0 & 4 & 0 \\ [0 & 0 & 0 & 0 & 3] \end{matrix}$$

$$= \begin{matrix} 5 \\ [5 \\ 5 \end{matrix} \begin{matrix} 2{,}433 & 3{,}380 & 1{,}632 \\ 0{,}972 & 1{,}352 & 3{,}276] \\ 0{,}378 & 2{,}704 & 1{,}632 \end{matrix}$$

c. Determining the Concordance and Discordance Index Sets.

Concordance**:** A criterion in an alternative is considered concordant if:

$C_{kl} = \{j|v_{kj} \geq v_{lj}\}$; untuk j=1,2,3,…,n

$C_{12} = \{j|v_{1j} \geq v_{2j}\}$; untuk j=1,2,3,…,5

$= \{1,2,3,4,5\}$

$C_{13} = \{j|v_{1j} \geq v_{3j}\}$; untuk j=1,2,3,…,5

$= \{2,3,4,5\}$

$C_{21} = \{j|v_{2j} \geq v_{1j}\}$; untuk j=1,2,3,…,5

$= \{5\}$

$C_{23} = \{j|v_{2j} \geq v_{3j}\}$; untuk j=1,2,3,…,5

$= \{3,4,5\}$

$C_{31} = \{j|v_{3j} \geq v_{1j}\}$; untuk j=1,2,3,…,5

$= \{1,2\}$

$C_{32} = \{j|v_{3j} \geq v_{2j}\}$; untuk j=1,2,3,…,5

$= \{1,2,4\}$

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Discordance: A criterion in an alternative is considered discordant if:

$D_{kl} = \{j | v_{kj} \geq v_{lj}\}$; untuk j=1,2,3,…,n

$D_{12} = \{j | v_{1j} \geq v_{2j}\}$; untuk j=1,2,3,…,5

$= \{\}$

$D_{13} = \{j | v_{1j} \geq v_{3j}\}$; untuk j=1,2,3,…,5

$= \{1\}$

$D_{21} = \{j | v_{2j} \geq v_{1j}\}$; untuk j=1,2,3,…,5

$= \{1,2,3,4\}$

$D_{23} = \{j | v_{2j} \geq v_{3j}\}$; untuk j=1,2,3,…,5

$= \{1,2\}$

$D_{31} = \{j | v_{3j} \geq v_{1j}\}$; untuk j=1,2,3,…,5

$= \{3,4,5\}$

$D_{32} = \{j | v_{3j} \geq v_{2j}\}$; untuk j=1,2,3,…,5

$= \{3,5\}$

d. Determining the Aggregate Dominance Matrix

The general formula for the elements of the aggregate dominance matrix is:

$$e_{kl} = f_{kl} \times e_{kl}$$

$e_{12} = f_{12} \times e_{12} = 1x0 = 0$

$e_{13} = f_{13} \times e_{13} = 1x0 = 0$

$e_{21} = f_{21} \times e_{21} = 0x1 = 0$

$e_{23} = f_{23} \times e_{23} = 0x1 = 0$

$e_{31} = f_{31} \times e_{31} = 1x0 = 0$

$e_{32} = f_{32} \times e_{32} = 1x1 = 1$

So

$$e = \begin{bmatrix} - & 0 & 0 \\ 0 & - & 0 \\ 0 & 1 & - \end{bmatrix}$$

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e. Elimination of Less Favorable Alternatives

The matrix *E* provides a ranking of options for each alternative, indicating that alternative A_k is better than A_l. Therefore, the rows in matrix *E* with the lowest sums can be eliminated. Consequently, the first and second rows can be eliminated, leaving only the third row. The value e_{32}=1 indicates that the third alternative is better than the second alternative.

Table 7. Results of the ELECTRE Calculation

Name	Matrix 1	Matrix 2	Matrix 3	Result
Ade Riyen Tiarni	-	2	1	Success
Sucipto	0	-	1	Failure
Ari Kurniawan	0	0	-	Failure

Thus, the decision maker will choose the third alternative (A1), which is Ade Riyen Tiarni. The accuracy percentage was determined from 10 trials of the ELECTRE calculation, resulting in 1 error. This error occurred because the candidates were similar or identical to each other, making the results unclear. Therefore, out of 10 trials, with 1 failure, we have 9 successful attempts. The accuracy level can be concluded as:

$$\frac{9}{10} \times 100\% = 90\% \text{ Accuracy Level.}$$

3.7 Decision Support System

The implementation involves applying various steps to develop the system. In the design and development of the web-based employee recruitment application using the ELECTRE method for Neko Neko Bakery & Cake, several forms are included, such as:

a. Login
b. Main Menu
c. Criteria
d. Candidate Input
e. Calculation
f. Password Management
g. Logout

This section discusses the stages involved in operating the system being created.

1. Login Interface

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The login interface is the first screen that appears, prompting the user for a username and password to access the subsequent screens. The appearance of the login screen is illustrated in Figure 3.

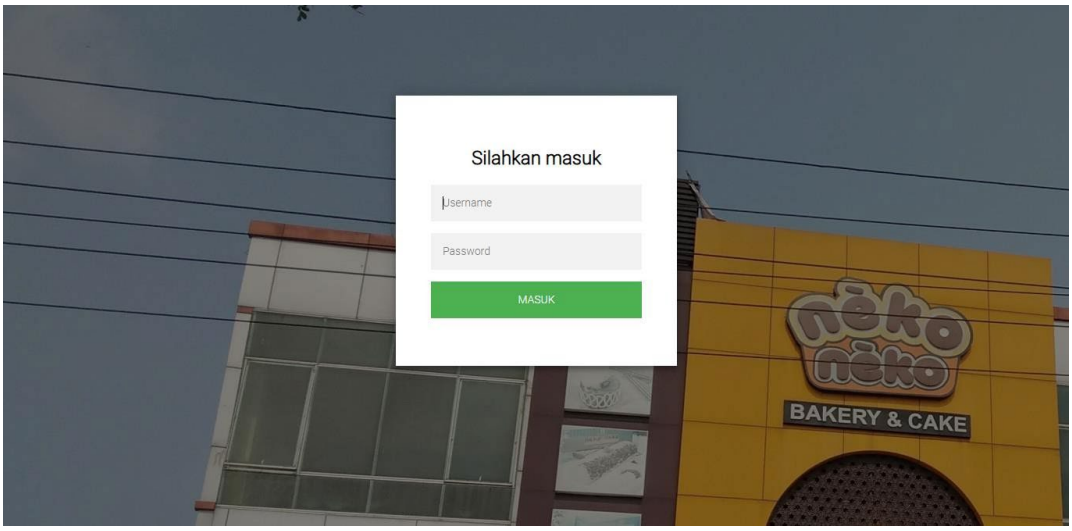

Figure 3. Login

2. Main Menu Interface

The main menu, or dashboard, is displayed after a successful login. It serves as the central navigation point for the application. The main menu interface can be seen in Figure 4.

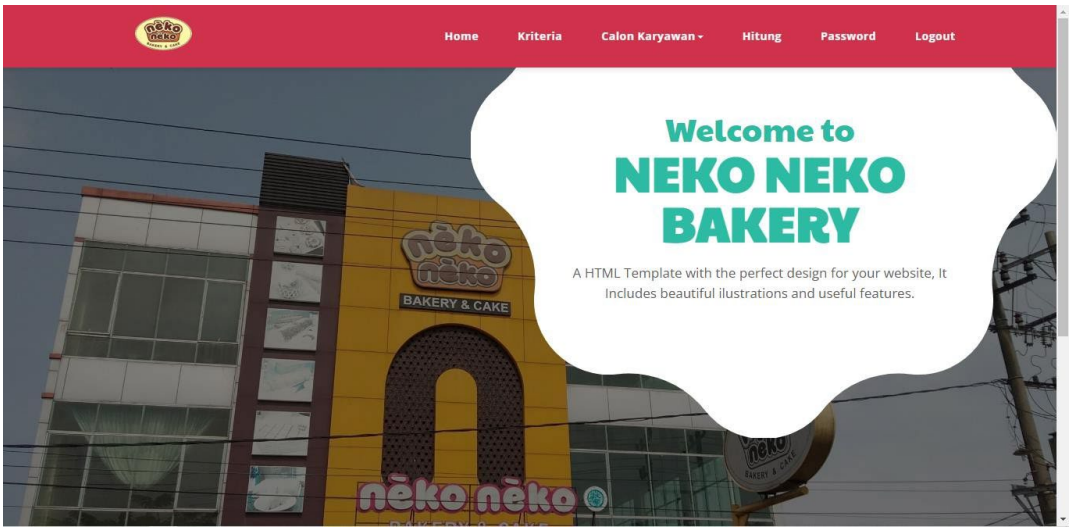

Figure 4. Main Menu

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3. Criteria Interface

In the criteria section, users can input the criteria that will contribute to the evaluation of new employees at Neko Neko Bakery & Cake. The criteria interface is shown in Figure 5.

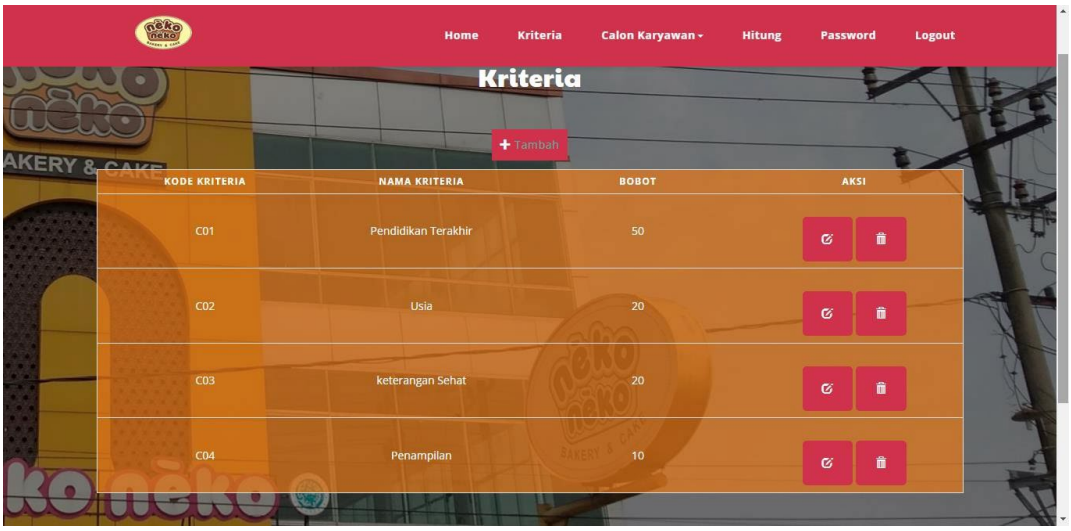

Figure 5. Criteria Interface

4. Candidate Interface

The candidate interface includes two menus: one for entering the names and addresses of candidates, referred to as the "Alternatives" menu, and another for inputting the scores for each candidate based on the predefined criteria, named the "*Alternative Weight Scores*" menu. Both interfaces are illustrated in Figures 6 and 7.

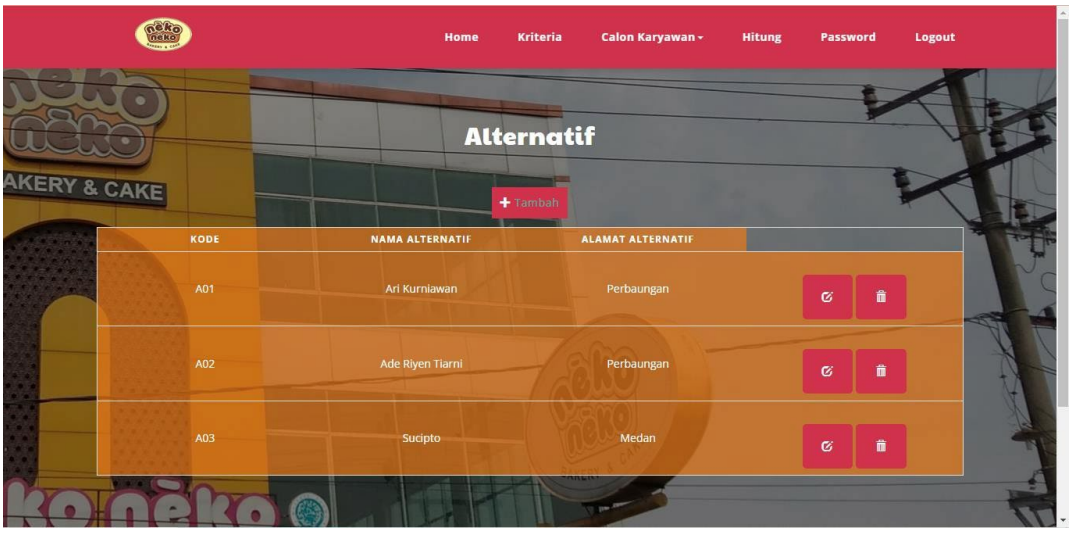

Figure 6. Alternative

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Figure 7. Alternative Weight Scores

5. Calculation Interface

In the calculation section, the results of the alternative weight scores are displayed using the ELECTRE method. The results can be seen in Figure 8.

Figure 8. ELECTRE method

6. Report Generation

The application also generates a report based on the calculation results, which can be printed. The report output is shown in Figure 9.

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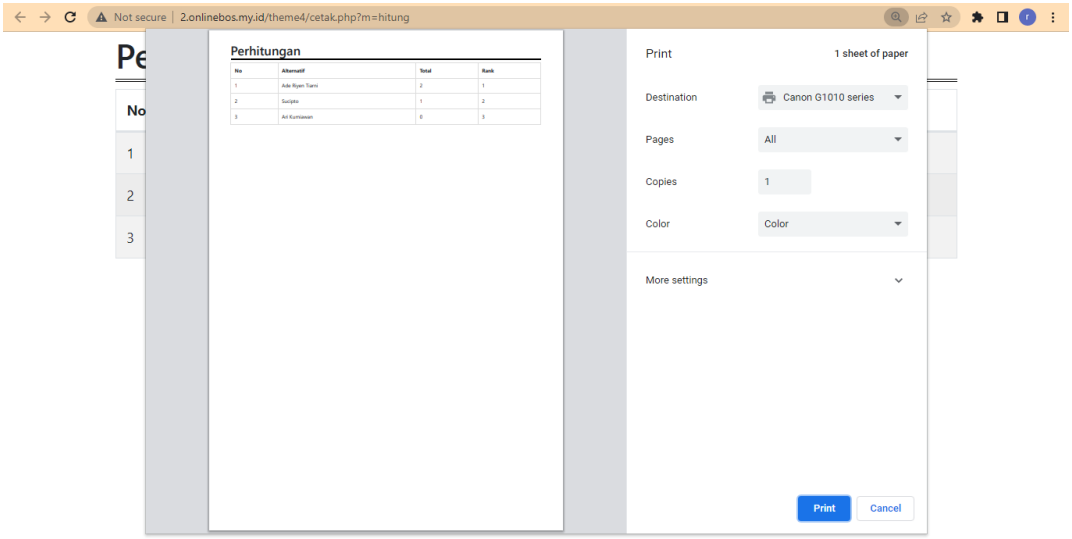

Figure 9. Report

3.8. Strengths and Weaknesses of the System

The strengths and weaknesses of the web-based employee recruitment application using the ELECTRE method for Neko Neko Bakery & Cake are as follows:

1. Strengths of the System
   - Easy Implementation: The application can be easily implemented due to the use of an SQL database, which simplifies data management and retrieval.
   - Lightweight Application: The application is designed to be lightweight, making it suitable for use on laptops or computers with lower specifications. This enhances accessibility for users with varying hardware capabilities.
2. Weaknesses of the System
   - Limited Testing Environment: The system has not been tested directly in the Neko Neko Bakery & Cake store, despite conducting preliminary research. This limits the validation of the application in a real-world scenario.
   - Local Access Only: Currently, the application can only be run locally on a computer and is not accessible publicly. This restricts its usability for remote access or broader deployment.

The results of the application testing indicate that while the system has several strengths, such as ease of implementation and suitability for lower-capacity devices, it also faces challenges that need to be addressed. Future work should focus on real-world testing and enabling public access to enhance its effectiveness in the recruitment process at Neko Neko Bakery & Cake.

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4. CONCLUSION

The research on the development of a web-based employee recruitment application using the ELECTRE method for Neko Neko Bakery & Cake has yielded several important insights and outcomes.

Firstly, the implementation of the ELECTRE method underscores the significance of structured decision-making in the recruitment process. By carefully defining the evaluation criteria and assigning appropriate weights to the alternatives, the application ensures that the selection of new employees is both systematic and objective. This approach enhances the accuracy of evaluations and aligns recruitment outcomes with the bakery's strategic goals.

Secondly, the design of this decision support system involved a thorough understanding of operational requirements, resulting in a user-friendly interface. This interface simplifies the recruitment process for administrators, allowing for efficient data input and analysis.

In conclusion, the web-based application developed for Neko Neko Bakery & Cake represents a significant advancement in their recruitment strategy. By leveraging the ELECTRE method, the bakery can make informed decisions that improve the quality of new hires while streamlining the overall recruitment process. Future enhancements could focus on real-world testing and expanding accessibility, further solidifying the application's role as a vital tool in the bakery's human resource management.

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