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Boarding House Decision Support System with Simple Additive Weighting

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Abstract. A Decision Support System (DSS) for boarding house selection tailored explicitly for first responders is essential due to the unique needs and challenges these individuals face in their demanding and high-stakes professions. Given the numerous alternatives and extensive availability of boarding houses, deciding on the most suitable one based on personal preferences is a complex and time-consuming task. This study proposes Simple Additive Weighting (SAW) to develop a decision support system to address this problem. The proposed approach aims to assist users in deciding on the best boarding houses based on weighted criteria preferences. A case study of Ciputra Hospital CitraGarden City, boarding house selection, is explored and discussed as proof of concept and viability. The system was tested using the white-box method and evaluated on 50 hospital employees with the End User Computing Satisfaction (EUCS). The EUCS results indicated high satisfaction levels across content, accuracy, format, ease of use, and timeliness (average 89.78%). This study demonstrates the potential of a SAW-based personalized Boarding House DSS which is also applicable for other domains than first responders.

Keywords: boarding house, decision support system, EUCS, first responder, hospital worker, SAW

1. Introduction

Integrating advanced technological solutions has become a transformative force in the dynamic landscape of hospitality and accommodation services (Stylos & Zwiegelaar, 2019). At the forefront of this transformation lies the Boarding House Decision Support System (DSS), a sophisticated platform designed to assist users in selecting a boarding house that suits their preferences the most (Mukhlis et al., 2019). With the convergence of data-driven insights and user preferences, the Boarding House DSS emerges as a pivotal tool that simplifies the selection processes through computational operations to deliver objective and accurate decisions.

The Simple Additive Weighting (SAW) method emerges as a salient cornerstone within Decision Support Systems (DSS), offering a pragmatic approach to evaluating complex decision scenarios (Afshari et al., 2010; Huang, 2011). Grounded in the principles of multi-criteria decision analysis, SAW affords decision-makers a structured framework to navigate the intricate interplay of various criteria (Kaliszewski & Podkopaev, 2016). Simple Additive Weighting (SAW) is a straightforward and widely used decision-making technique that assigns weights to criteria and aggregates the scores of alternatives based on these weights (Fanny & Istiono, 2022; Ramadhan et al., 2023).

In the context of Boarding House DSS, (Mukhlis et al., 2019) demonstrated the use of SAW for boarding house decision support systems using SAW. The study aimed at boarding house selection for migrants in a new area, assuming general scenarios in searching for boarding houses. However, there are yet-to-be-developed applications of the DSS that use actual boarding house data for implementation and testing. In addition, the study addresses the problem by making ungrounded assumptions and simplification. Moreover, specific use cases of boarding house selection require specific solutions that cater to particular needs. Public health workers and first responders are examples of specific use cases where general scenarios of boarding house selection are not applicable.

This study addresses the boarding house selection problem for first responders, particularly paramedics (hospital workers), using a case study of Ciputra Hospital CitraGarden City, located in West Jakarta, Indonesia. Initial surveys of 40 hospital workers in Ciputra Hospital CitraGarden City reveal the five most preferred criteria for a boarding house: price, distance, room size, number of facilities, and number of rules, as hospital workers are expected to be able to provide emergency response at any time required. The proximity boarding house benefits the case, including housing rules and facilities. Interviews further expose the need of these hospital workers for a Boarding House DSS that could assist them in selecting the most suitable boarding house based on their preferences and needs.

The proposed Boarding House DSS in this study is developed in web technology. Actual boarding house data are collected from the Mamikos website (www.mamikos.com). The DSS is tested with the white-box method to ensure correctness and functionalities. The system is evaluated using End User Computing Satisfaction (EUCS) on hospital workers. The rest of this paper is organized as follows. Section 2 describes the case study, and Section 3 presents the preliminaries. Section 4 explains the research methods. Section 5 discusses the experimental results and discussion. Finally, Section 6 concludes this paper with suggestions for future work.

2. Case Study Description

Ciputra Hospital CitraGarden City has around 200 workers working on a shift system with 24 (twenty-four) hours of operational time. Healthcare settings operate around the clock to provide critical medical services, respond to emergencies, and ensure patients receive timely care. Living close to the hospital offers several key benefits for hospital workers: rapid response to emergencies, reduced commute time, availability for on-call shifts, and flexibility for shift work. Around 280 boarding houses are available near the hospital at the time of the writing. This information was obtained from the Mamikos website (www.mamikos.com) on 22 July 2023.

Initial interviews with hospital workers reveal that the five most considered criteria in choosing the

boarding house are price, distance, room size, number of facilities, and number of rules. Moreover, the interviews unveil the complexity of choosing the boarding house due to the combination and trade-off between the alternatives (user preferences). Further analysis of each criterion is conducted to define the criteria for the Boarding House DSS accurately, and the results are the following.

Price: The price criterion is the rental price of the boarding house. The currency used is the Indonesian Rupiahs. The price criterion includes cost because the lower the price of a boarding house, the more workers want to rent it.

Distance: The criterion for the distance to the office is the distance between the boarding house and the Ciputra Hospital CitraGarden City location. The distance used in the system is calculated using Google Maps, and the distance used is the closest in (km). The criterion for distance to the office is cost because the closer the distance to the office and the boarding house, the less energy and time it takes to return to work.

Room size: The criterion for the area of a boarding house is how wide the room for rent is. The area of the room is measured in m^2. The room area criteria include benefits because the wider the boarding room, the more flexible the tenants are.

Number of Facilities: The criterion for the number of facilities is how many facilities the boarding house tenant gets. The facilities in question include facilities in boarding rooms (mattresses, tables, cupboards, etc.) to public facilities other than in boarding rooms (WiFi, parking lot, CCTV, kitchen, etc.). The criterion for the number of facilities includes benefits because the more facilities the boarding house tenant gets, the better it is for the boarding house tenant.

Number of Rules: The criterion for the number of rules is how many rules are applied in the boarding house. The criterion for the number of rules includes cost because workers will have more freedom to live in boarding houses if the boarding rules are few or not strict.

3. Preliminaries

3.1. Simple Additive Weighting (SAW)

The Simple Additive Weighting (SAW) method, also known as the weighted sum method, has the basic concept of finding the weighted sum of each criterion for each alternative for all attributes (Kaliszewski & Podkopaev, 2016). The steps used to complete the SAW method are as follows (Huang, 2011):

1. Determine the data that will be the criteria for SAW calculations on objects to be recommended (C_j). The data used as criteria in this study are price, distance, room size, number of facilities, and number of rules. This data will be a column in the decision matrix (x).
2. Determine each data to be processed using SAW (A_i) calculations. This data will be a row in the decision matrix (x).
3. Determine the weight (w) of all the criteria used as a reference for system recommendations.
4. Create a decision matrix (x) from the value of each alternative A_i on each criterion C_j determined to be x_{ij}.
5. There are two types of criteria: benefits and costs.
    a. If j is a type of benefit criterion, then
    $$r_{ij} = \frac{x_{ij}}{\text{Max}\, x_{ij}} \quad (1)$$
    b. If j is a type of cost criterion, then
    $$r_{ij} = \frac{\text{Min}\, x_{ij}}{x_{ij}} \quad (2)$$
6. Each criterion value normalized r_{ij} will form a normalized matrix (R).
7. Calculate the final preference value
$$V_i = \sum_{j=1}^{n} w_j r_{ij} \quad (3)$$
8. A preference value column (V) will be formed from the results of these calculations.

3.2. End User Computing Satisfaction (EUCS)

End User Computing Satisfaction (EUCS) measures user satisfaction when using a system or application by comparing expectations and reality for the system. The EUCS method has the advantage of placing more emphasis on user satisfaction by evaluating the system, including content, accuracy, appearance or format, ease of use, and timeliness (Abdinnour-Helm et al., 2005). The details of dimensions measured by the EUCS method are the following (Doll & Torkzadeh, 1988).

Content: This dimension is based on measuring the contents of the system and whether it meets the needs. The more complete and according to the needs presented, it can increase user satisfaction.

Accuracy: This dimension is based on the accuracy provided by the system. A system with a good level of accuracy is a system that has a low error rate when processing data.

Format: This dimension is based on the appearance and aesthetics of the system. An attractive appearance and ease of understanding and using the interface can increase user satisfaction and effectiveness.

Ease of Use: This dimension is based on the user's ease of use in the system. The ease of using the system includes the entire process from the beginning of the data entry process to the end of the data processing results used by the user.

Timeliness: This dimension measures the system's timeliness in presenting the required information. The faster a system processes input data and produces output, the better the system.

4. Methods

Based on the initial survey and interviews conducted with Ciputra Hospital CitraGarden City workers, the five criteria are chosen for the Boarding House DSS: price, distance, room size, number of facilities, and number of rules. Since there are qualitative criteria: facilities, and rules, the DSS is designed to address facilities as the number of facilities provided and rules as the number of rules applied. Quantization of criteria is necessary for the SAW calculation to produce a recommendation that leads to the decision-making process. Forty boarding houses data are gathered from the Mamikos website (www.mamikos.com) for implementation and testing. The boarding house data are limited to those located nearby the hospital only, as provided by Mamikos.

The design of the Boarding House DSS uses a flowchart, as shown in Fig. 1. The system starts by fetching boarding house data from the database. Boarding house data can be added, modified, and deleted by the system administrator. When users do not have weight preferences for each criterion, the system produces recommendations based on equal weight. Users can input their weight preferences for each criterion used in the SAW calculation producing more specific recommendations. There are two tables for the DSS: boarding houses (tb_dorm) and weight preferences (tb_preference). The tb_dorm table stores data related to boarding houses, i.e., boarding house name, price, distance, room size, number of facilities, number of rules, and link to the data source. The tb_preference table is a temporary table used to sort the alternatives of boarding houses in descending order.

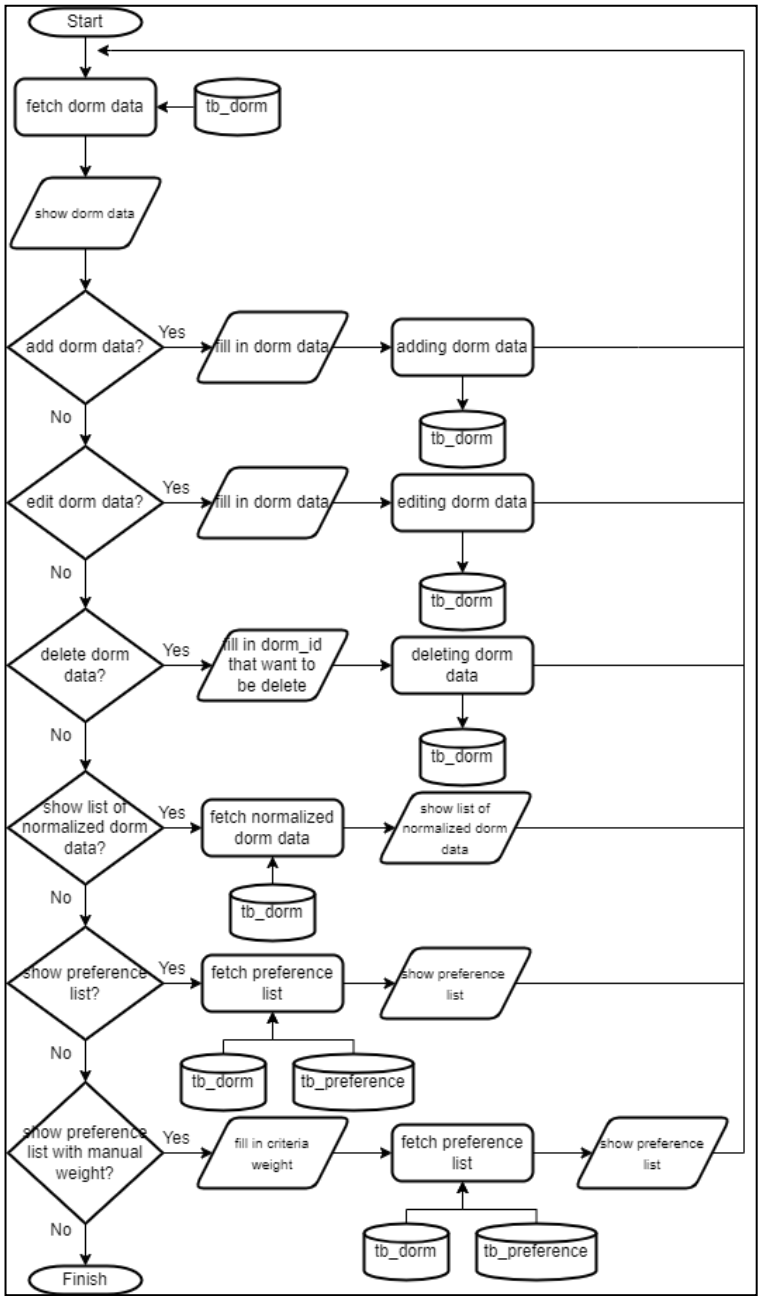


Fig. 1: Boarding house decision support system main flowchart.

The implementation of the design of the decision support system uses the web programming language (HTML and PHP) and MySQL database. The system design does not cater to user personalization. Hence there is no login and account page in the system. Figures 2-3 show the implementation of the boarding house ranking results web page and manual weight preferences web page. Fig. 2 lists the highest to the lowest preference (V_i) score calculated with SAW for each alternative (A_i). Fig. 3 shows the manual weight preferences web page where users can insert their preferred weight for each criterion.

Fig. 2: Boarding house ranking results.

Fig. 3: Manual weight preferences.

White-box testing is conducted to test system correctness and functionalities. Moreover, the SAW implementation is tested using a test case with five test data. Table 1 shows the weights for testing the SAW in the decision support system. The details of the test data are given in Table 2. Formula 1 calculates the normalized value for room size and number of facilities. Formula 2 calculates the normalized value for price, distance, and number of rules. The results of the normalized matrix R are presented in Table 3.

Table 1: Test weight

Price	Distance	Number of Rules	Room Size	Number of Facilities
30%	20%	5%	20%	25%

Table 2: Test data

Boarding House	Price (IDR)	Distance (km)	Number of Rules	Room Size (m^2)	Number of Facilities
Dorm 1	820,000	1.1	9	12	27
Dorm 2	1,900,000	0.8	8	16	40
Dorm 3	450,000	1.1	9	8	22
Dorm 4	800,000	0.85	5	9	15
Dorm 5	850,000	1.6	13	6	39

Table 3: SAW calculation for normalized matrix R

Boarding House	Price (IDR)	Distance (km)	Number of Rules	Room Size (m^2)	Number of Facilities
Dorm 1	0.54878	0.72727	0.55556	0.75000	0.67500
Dorm 2	0.23684	1.00000	0.62500	1.00000	1.00000
Dorm 3	1.00000	0.72727	0.55556	0.50000	0.55000
Dorm 4	0.56250	0.94118	1.00000	0.56000	0.37500
Dorm 5	0.52941	0.50000	0.38461	0.37500	0.97500

The evaluation is carried out by distributing questionnaires using a Google form filled out by 50 respondents. Respondents are Ciputra Hospital Citragarden City workers specifically searching for a boarding house. The EUCS questionnaires consist of 12 questions that emphasize five dimensions: Content, Accuracy, Format (interface format), Ease of Use (ease of using the system), and Timeliness (Time). Table 4 lists the questions developed for the EUCS evaluation.

Table 4: EUCS questionnaire

Dimension	Code	Description
Content	Q1	The system produces precise information that needed.
	Q2	The information content meets the need.
	Q3	The system provides sufficient information.
Accuracy	Q4	The system is accurate.
	Q5	You are satisfied with the accuracy of the system.
Format	Q6	The system presents the output in a useful format.
	Q7	The information is clear.
Ease of Use	Q8	The system is easy to use.
	Q9	The system is user friendly.
	Q10	The menus of the system are easy to understand.
Timeliness	Q11	The system gives information in time.
	Q12	The system provides up-to-date information.

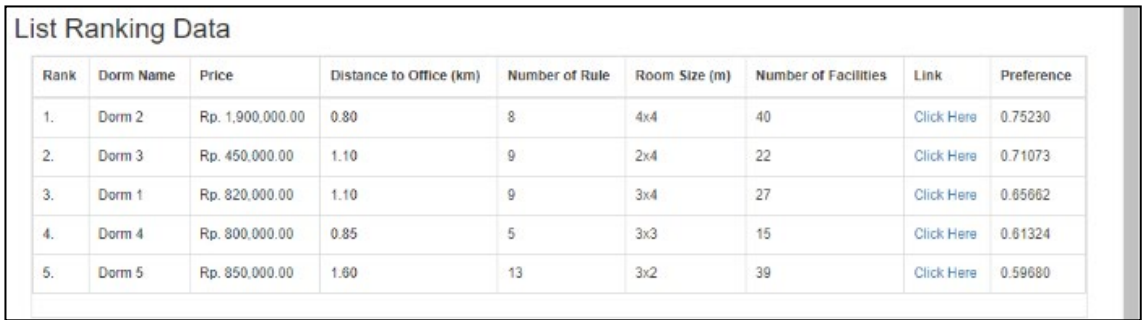
5. Results and Discussion

Details on the SAW test calculations for the preference value for each alternative are as follows.

- Dorm 1 = 0.554878 × 0.30) + (0.72727 × 0.20) + (0.55556 × 0.05) + (0.75000 × 0.20) + (0.67500 × 0.25) = 0.65662
- Dorm 2 = (0.23684 × 0.30) + (1.00000 × 0.20) + (0.62500 × 0.05) + (1.00000 × 0.20) + (1.00000 × 0.25) = 0.75230
- Dorm 3 = (1.00000 × 0.30) + (0.72727 × 0.20) + (0.55556 × 0.05) + (0.50000 × 0.20) + (0.55000 × 0.25) = 0.71073
- Dorm 4 = (0.56250 × 0.30) + (0.94118 × 0.20) + (1.00000 × 0.05) + (0.56250 × 0.20) + (0.37500 × 0.25) = 0.61324
- Dorm 5 = (0.52941 × 0.30) + (0.50000 × 0.20) + (0.38462 × 0.05) + (0.37500 × 0.20) + (0.97500 × 0.25) = 0.59680

Based on the preference calculations for the alternatives, the best boarding house, according to the SAW, is Dorm 2, with a preference value of 0.75325. The SAW test results show the correct use of SAW in the decision support system, as shown in Fig. 4. The results are sorted in descending from the highest to the lowest preference value calculated by the system. The most suitable boarding house ranked by the system in this test is Dorm 2, with a preference value of 0.75230. This proves the successful implementation of SAW in the Boarding House DSS and the development of the system in

producing recommendations to assist the decision-making process.



List Ranking Data

Rank	Dorm Name	Price	Distance to Office (km)	Number of Rule	Room Size (m)	Number of Facilities	Link	Preference
1.	Dorm 2	Rp. 1,900,000.00	0.80	8	4x4	40	Click Here	0.75230
2.	Dorm 3	Rp. 450,000.00	1.10	9	2x4	22	Click Here	0.71073
3.	Dorm 1	Rp. 820,000.00	1.10	9	3x4	27	Click Here	0.65662
4.	Dorm 4	Rp. 800,000.00	0.85	5	3x3	15	Click Here	0.61324
5.	Dorm 5	Rp. 850,000.00	1.60	13	3x2	39	Click Here	0.59680

Fig. 4: SAW test results.

The EUCS questionnaire results are displayed in Table 5. Based on the data calculated above, it can be concluded that the decision support system for choosing a dorm at Ciputra Hospital CitraGarden City got a good score with a dimension score for Content 91.6%, Accuracy 91.2%, Format 84.4%, Ease of Use 89.3%, and for Timeliness 92.4%. In Conclusion, this research got an average evaluation score of 89.78%, implying that the users accept the Boarding House DSS.

Table 5: EUCS evaluation results

Dimension	Code	Totally Disagree	Disagree	Neutral	Agree	Totally Agree
Content	Q1	0	0	1	13	36
	Q2	0	0	4	14	32
	Q3	0	0	6	14	30
Accuracy	Q4	0	0	1	18	31
	Q5	0	0	5	14	31
Format	Q6	0	0	3	14	33
	Q7	0	0	3	12	35
Ease of Use	Q8	0	0	3	12	35
	Q9	0	0	7	13	30
	Q10	0	2	8	13	27
Timeliness	Q11	0	2	4	11	33
	Q12	0	0	4	5	41

The results of this study showcase the practicality and accuracy of SAW for decision support systems. As proof of concept, a case study of boarding house selection for hospital workers is explored and discussed. This study extends the previous study on Boarding House DSS and reveals the five most preferred criteria for a Boarding House DSS according to public health workers (hospital workers). These criteria are obtained through sound methodology by surveying 40 Ciputra Hospital CitraGarden City hospital workers. Although the system, by default, applies a balanced weight for each criterion, users can adjust the weight for each criterion according to their preferences. Testing of the system and SAW implementation using 40 boarding houses data collected from Mamikos confirms the correctness and functionalities of the system.

The limitation of this study is the availability of boarding house data in an accessible way through developer API (application programming interface). Boarding houses data from Mamikos are collected manually for the Boarding House DSS. Single source of boarding house data is another limitation in this study, as there are no known data sources for boarding houses. The Boarding House DSS applies to other domains of first responders, i.e., police officers, emergency medical technicians, and firefighters. In cases where these first responders need to find a boarding house, the Boarding House

DSS developed in this study can be applied directly. However, further study and analysis of the specific use cases of each first responder domain are necessary to produce sound research statements and use methods to process qualitative criteria, e.g., room quality, ambiance, community, etc., that are not directly processable by methods like SAW only.

6. Conclusions

This study addresses the boarding house selection problem by developing Boarding House DSS with simple additive weighting (SAW). The use case of boarding house selection for Ciputra Hospital CitraGarden City hospital workers is explored for the Boarding House DSS in this study. The more detailed requirements of first responders like paramedics (hospital workers) are valuable for the Boarding House DSS. The design and implementation of the decision support system have been tested using the white-box method, and the SAW implementation is tested successfully, producing the correct calculations. The evaluation of the system through EUCS yields an average score of 89.78%, indicating high satisfaction and acceptance. In cases where the Boarding House DSS is applied for more general scenarios other than first responder domains, users can adjust the weight preferences according to their needs. Future work is on applying the Boarding House DSS for other first responder domains to expand the knowledge in this field further. Using more boarding house data sources and automatic data collection from various sources is essential for the feasibility of the application. The dynamic adjustment of criteria where users can add and remove particular criteria can improve overall user satisfaction and acceptance.

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