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ALTERNATIVES WEIGHTING IN ANALYTIC HIERARCHY PROCESS OF MOBILE CULINARY RECOMMENDATION SYSTEM USING FUZZY

Aryo Pinandito[1], Mahardeka Tri Ananta[2], Komang Candra Brata[3] and Lutfi Fanani[4]
Media, Game, and Mobile Technologies, Research Group, Mobile Application Development Lab., Fakultas Ilmu Komputer, Universitas Brawijaya, Malang, Indonesia
E-Mail: aryo@ub.ac.id

ABSTRACT

Analytic Hierarchy Process (AHP) is one of widely used method in supporting multi-criteria decision making. Allowing inclusion of many factors and criteria into the decision making process. Many situations in which AHP can be applied including ranking, prioritization, resource allocation, recommendation, and benchmarking. AHP utilizes scale in priority estimation for its alternatives and criteria. It is considered a problem if numerous alternatives were going to be judged manually by human. However, computing a recommendation using AHP with varying amount of alternatives and conditions has its own limitations especially in the alternatives priority judgment processes. In such a culinary recommendation system based on AHP in its recommendation method, it is possible to calculate a recommendation by using numerous food alternatives that is grouped into several categories and its priority estimation were computed based on several criteria. This research aims to develop a culinary recommendation system using AHP method in which the given alternatives weighting process were performed directly on the food alternatives or menus to represents the food category using fuzzy rather than evaluating the food categories itself. This research shows that a culinary recommendation system, which utilizes fuzzy in AHP alternatives weighting process, gives better recommendation result and accuracy.

Keywords: fuzzy, AHP, mobile, DSS, culinary.

INTRODUCTION

Mobile devices as a small form of computer can be used to change people's behaviors (Vinas, 2007) in such that people tend to spend more time with their mobile phone than other people. In 2013, 91% of American people owns at least one cell phone and 60% of them use their cell phone to access the Internet while 49% of their activities are getting directions, recommendations, or getting other location-based information (Duggan, 2013). In particular, research activities on mobile commerce and electronic commerce have significantly increasing since 2000, thus considered as popular and mature discipline. The capabilities of user infrastructure, faster processing times, larger storage capacity, and corresponding mobile interfaces need to be considered (Ngai, *et al.* 2007).

An effective decision making process demands accurate, timely, and relevant information. These kind of information are commonly provided by decision-making and decision-taking information system in enterprise. Such information system provide accurate and timely information necessarily to facilitate the decision making process. Thus, providing streamlined options for the decision maker would lead to more often positive outcomes (Ranisavljević, 2012).

Recommendation system represents user preferences in suggesting items to purchase or examine that best meet their need and preferences (Burke, 2002). Many recommendation systems implementing various methods, such as Analytic Hierarchy Process (AHP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) (Maharani, *et al.* 2014), ontology, or other several method in Artificial Intelligence (AI) (Simó, 2012). The methods were implemented so that the computation process could perform faster, more effective, more flexible, and more accurate in accordance to provide a better convenience to the user.

In tourism, food plays an implicit significance in attracting tourist. Its variation, quality (Ardabili, 2011), serving method, and appearance could lead into customer satisfaction (Gupta, 2013). Price differences, quality variations (Azar, 2011), and distance (Junker, 2009) may affects customers behavior in considering the alternatives that suit their interests and desires. As a result, many recommendation systems emerge to resolve decision-making issues in culinary.

This research proposes an alternative method and design of a culinary recommendation system based on user preferences in response to food price, food quality, and distance to the desired culinary places. AHP will be used to solve the decision-making problems by the distance, price, and rating to represents the quality as criteria. Food menus are categorized into several categories as the alternatives in the AHP computation process. However, this research utilizes a different approach in weighting of alternatives in a culinary recommendation system using AHP in response to provide the recommended food category. The recommended category will be represented by the most recommended menu in all preferred categories as alternatives in AHP computation. Considering the numerous and varying food menus inside the categories, which its preference values should be computed, thus the weighting process of menus will be done using fuzzy sets.

Another problem emerges from culinary recommendation system, which involves criteria such as distance, is the difficulties in capturing user location and estimates the distance between user location and the desired culinary places. However, there is such a recommendation system that is able to took user location

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and behaviour into account in its recommendation process (Gupta, 2013) by utilizing mobile device's Global Positioning System (GPS) sensor and HTML5 Geolocation API. If both user and the restaurant geolocation in spherical coordinates were known, then the distance between them could be computed using Haversine formula (Sinnott, 1984).

Google provides Google Maps Application Programming Interface (Google Maps API) that can be used on mobile device application running on Google Android operating system. The API allows application to display Point of Interest (POI) markers on a Google Map. Hence, it is possible to display the recommended culinary places as the results from the culinary recommendation system.

This paper is organized as follows. Section 1 provides full overview of this research. Section 2 provides brief literature review related to the recommendation system and method used in this research. Methodology used in this research will be described further in section 3. System prototypes and testing process will be illustrated together with the experimental result in section 4. Section 5 provides conclusions with possible future work and research issues.

LITERATURE REVIEW

Analytic hierarchy process (AHP)

Analytic Hierarchy Process (AHP) is one of the widely used methods in supporting multi-criteria decision making. Allowing inclusion of many factors and criteria into the decision making process. The comparison can be taken from using a fundamental scale that reflects the relative strength of personal preferences and feelings or by actual measurements to the problem. AHP has widely applicable in multi-criteria decision-making, planning and resource allocation, and in conflict resolution. AHP uses a functional hierarchy with human perception as its main input. With hierarchy, complex and unstructured problems are broken down into groups and then the groups are arranged into a hierarchy form (Maharani, 2014). Many situations in which AHP can be applied including recommendation, prioritization, benchmarking, resource allocation, and ranking. Hierarchy used in this research in generating a recommendation shown in Figure-1.

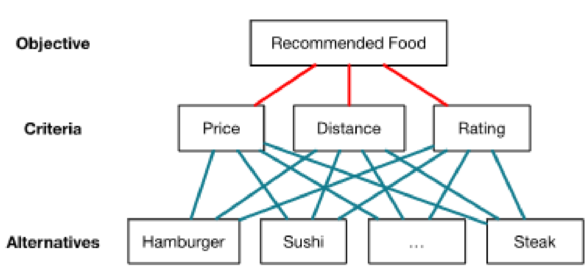

Figure-1. Problem hierarchy.

In determining the rank of criterion in a pairwise comparison, the calculation of Eigen Vector from the matrix represents a local priority scale to obtain the order of priority or importance of criterions and alternatives. Saaty (1980) had proved that Eigen Vector solution is the best approach in determining priority.

Fuzzy-AHP

Fuzzy Analytic Hierarchy Process (Fuzzy-AHP) method was originally introduced by Chang (1996) and developed by Zhu *et al*. (1999). Fuzzy-AHP embeds the fuzzy theory to basic AHP that was developed by Saaty (1987). This method systematically solves the selection problem that uses the concepts of fuzzy set theory and hierarchical structure analysis. Basically, Fuzzy AHP method represents the elaboration of a standard AHP method into fuzzy domain by using fuzzy numbers for calculating instead of real numbers. AHP is a widely used decision making tool in various multi-criteria decision making problems. It takes the pair-wise comparisons of different alternatives with respective to various criteria and provides a decision support tool for multi criteria decision problems. In a general AHP model, the objective is in the first level, the criteria and sub-criteria are in the second and third levels respectively.

Since basic AHP does not include vagueness for personal judgments, it has been improved by benefiting from fuzzy logic approach. In Fuzzy-AHP, the pair wise comparisons of both criteria and the alternatives are performed through the linguistic variables, which are represented by triangular numbers (Kilincci, 2011). Although there are some more techniques embedded in the Fuzzy-AHP, Buckley (1985) had implemented methods to determine the relative importance weights for both the criteria and the alternatives,. Table-1 explains the linguistic terms and corresponding triangular fuzzy number.

Table-1. Linguistic terms and the corresponding triangular fuzzy number.

Saaty Scale	Definition	Fuzzy Triangular Scale
1	Equally Important	(1,1,1)
3	Weakly Important	(2,3,4)
5	Fairly Important	(4,5,6)
7	Strongly Important	(6,7,8)
9	Absolutely Important	(9,9,9)
2 4 6 8	The intermittent values between two adjacent scales	(1,2,3) (3,4,5) (5,6,7) (7,8,9)

According to the corresponding triangular fuzzy numbers of these linguistic terms, for example if the decision maker states "Criterion 1 (C1) is Weakly Important than Criterion 2 (C2)", then it takes the fuzzy triangular scale as (2,3,4). On the contrary, in the pair wise contribution matrices of the criteria, comparison of C2 to C1 will take the fuzzy triangular scale as (1/4, 1/3, 1/2).

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Haversine formula

Haversine is a formula which is capable to measure the distance between two location coordinates on a curved surface in a great-circle such as the earth surface. Haversine formula is giving a great-circle distance equation between two points on a sphere from their longitudes and latitudes coordinates (Chopde *et al.* 2013). Haversine formula that is used to compute the distance between two given latitudes and longitudes is shown in equation (1).

$$d = 2R\sin^{-1}\left(\sqrt{\left(\sin\frac{\Delta\varphi}{2}\right)^2 + \cos\lambda_1\cos\lambda_2\left(\sin\frac{\Delta\lambda}{2}\right)^2}\right) \quad (1)$$

d = distance between two given latitude and longitude coordinates
φ = latitude
λ = longitude
R = radius of Earth or 6372.797560856 km

METHODOLOGY

System analysis and design

The recommendation system was designed and implemented using client-server architecture. The client application developed on a Google Android platform, while data and the recommender system itself reside on the server side. The client application is responsible to provide food categories as alternative, preferred criteria order, and several constraints. The recommender system, which resides in server side, was implemented as a web service and responsible in computing a recommendation based on user information given from the client application.

When starts using the client application, user is given a list of categories of food to choose from. Category of food is a collection of menus that have similar type or characteristics. The selected food categories will become the list of the alternative options that one of which will be recommended by the recommender system. User is also asked to provide a priority of criteria used in the recommendation process, i.e., the priority of price, distance, and rating of foods or culinary places. Additionally, users are also asked to provide their maximum budget for the menu and maximum distance that they would travel to. Maximum budget and distance information provided were taken into considerations as data input constraints of recommender system.

While using the client application, user geolocation in latitude and longitude is captured using device's built-in GPS sensor. This user geolocation information, selected food categories, along with give budget and distance constraints were sent towards the recommender system through the HyperText Transfer Protocol (HTTP) protocol. Selected food categories, along with user's maximum budget and distance information will act as parameters for querying data of menu from database. Retrieved data from database then being used as the alternatives that being recommended by the recommender system.

The system computes the recommended category of food as a recommendation result, and then issued a list of food menus from database in accordance with category of food that was recommended by the recommender system along with its price, rating, and geolocation information. This list is returned to the client application in JavaScript Object Notation (JSON) format. In the end, the client application is displaying the list visually on a map.

Data and data structure

The data used in the recommendation system consists of restaurants information along with its geolocation data, restaurant's menus, and menu's rating. The restaurant's menus are grouped into several categories. In terms of database, there are four data objects, i.e., restaurant or culinary place, menu, rating, and category. Rating object represents rating for the menu, and each menu may be given more than one rates. Category object represents category of menu. Each menu may belong to one or more categories, and one category may consists of one or more menus from one or more restaurants. Relationships between objects used in this research are shown in Figure-2.

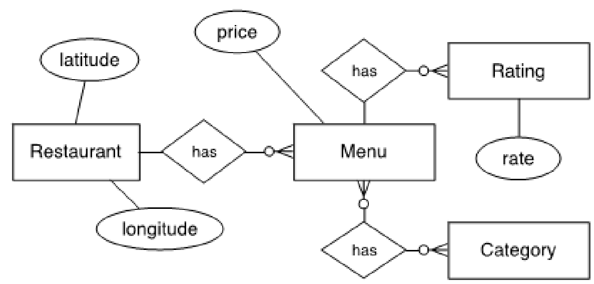

Figure-2. Entity relationship diagram.

Figure-2 shows that restaurant's latitude and longitude information is stored in Restaurant entity and each menu's price is stored in Menu entity. Menu's rating values are stored in rating entity, while menus grouping information is stored in Category entity. Restaurants, menus, rating, and categories data were obtained from online surveys and on-field data acquisitions in previous research. This research uses the same data sets as used in previous research.

Fuzzy modeling

In order to compute menus weight, a models of fuzzy triangular membership function set was designed. The given constraints, i.e., the maximum menu's price and the maximum distance were split into several level of triangular fuzzy sets. This research divides the rating, maximum price, and distance into 5 level, thus resulting 6 fuzzy sets as shown in Figure-3.

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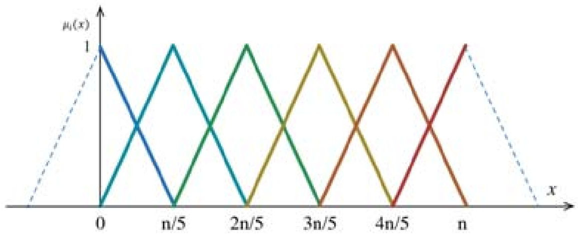

Figure-3. Designed fuzzy membership function.

Each membership function i has a peak (m_i), bottom (b_i) and top (t_i) threshold values of x, where $m_i < x < t_i$. Values of b_i, m_i, *and* t_i are defined in equation (2), (3), and (4) respectively, where n is the maximum defined value of x and p is the amount of level of x. The value of p is defined as 5 in this research. In the implementation, the value of n is reflecting the maximum value of rating, price, and distance.

$$b_i = \frac{n(i-1)}{p} \quad (2)$$

$$m_i = \frac{n\,i}{p} \quad (3)$$

$$t_i = \frac{n(i+1)}{p} \quad (4)$$

The membership function can be defined as in equation (5).

$$\mu_i(x) = \begin{cases} 0, & x \le b_i \lor x \ge t_i \\ \frac{x-b_i}{m_i-b_i}, & b_i < x \le m_i \\ \frac{t_i-x}{t_i-m_i}, & m_i < x < t_i \end{cases} \quad (5)$$

where: $0 < i < p \mid p \in Z$

i = fuzzy membership function index
μ_i = i-th fuzzy membership function
x = member value
b = bottom threshold value
t = top threshold value
m = optimal value
n = constraint or maximum value
p = the amount of level value of x

If the amount of level for is known, therefore each menu's weight based on its rating can be computed using a formula as shown in equation (6). Where is the value of i-th fuzzy set for rating criterion and its value is ranging between 0 and 1. The higher the index the higher its value.

$$w_r = \sum_{i=0}^{p} \mu_i(r) \cdot \frac{i}{p} \quad (6)$$

Contrary to the rating, the value of fuzzy sets for the price and distance criteria decreases as the index of fuzzy sets increases. Thus, the formula to compute menu's weight based on its price and distance is shown in equation (7).

$$w = \sum_{i=0}^{p} \mu_i(x) \cdot \left(1 - \frac{i}{p}\right) \quad (7)$$

w = computed weight value
i = fuzzy membership function index
μ_i = i-th fuzzy membership function degree
x = member (distance or price) value
p = the amount of level value of x

Recommendation process

In previous research (Pinandito, 2015), several food categories (categories of menu) were used as alternatives inside the AHP computation process. Weighting process of the given alternatives (food categories) were computed in accordance to the average price, distance, and rating of food menus from the given food categories. The weighting method in this research involves fuzzification process that splits criteria into several membership functions and classifying menus as AHP alternatives into fuzzy set and defuzzification process that computes menu's weight for each criteria.

The recommendation process involved in this research is explained as follows:

- Defining the hierarchy structure of the problem domain, including the objective, criteria, and alternatives. The objective is getting the recommended food category from given food categories as the alternatives. Criteria involved were price, distance, and rating.
- Compute Eigen Vector of criteria from a pairwise comparison matrix of given criteria based on the order of the given criteria. Each criterion was weighted using 1-9 Likert scale (Saaty, 1987). Computed Eigen Vector of criteria will be used to compute the final preference matrix of given alternatives.
- Compute Eigen Vector of alternatives for each respective price, distance, and rating criteria. The computation of Eigen Vector of alternatives are performed based on the food price, distance to the user, and its rating values. The weighting process is performed by using fuzzy.
- Compute final preference matrix by multiplying Eigen Vector matrix of alternatives with Eigen Vector matrix of criteria. Menu that has the largest preference value is the recommended result, thus represents the recommended category that accommodates the recommended menu.

Culinary data, which satisfies the given constraint and categories, were retrieved from database server. Retrieved data then used in the recommendation process computation.

IMPLEMENTATION AND TESTING

Recommendation input

Recommendation system developed in this research requires user to provide selections of maximum five food categories as alternative. Table 2 shows selected food categories used as input for the recommender system. These category selections are randomly selected and only used in the implementation and testing process.

Table-2. Selected categories.

Category ID	Category Name
51	Taco
5	Pasta
56	Ramen
14	Sushi
55	Iga

Priority of criteria are predefined in the distance (D), price (P), and rating (R) order. During implementation, distance factor is considered as the most important factor, followed by menu price, and menu rating. Therefore, using 1-5 Likert scale, distance, price, and rating has its weight of 5, 3, and 1 respectively. The latitude and longitude value, which represents user current location, that is used in the implementation and testing procedure were -7.9524318 and 112.6138575 respectively. In the real implementation of the recommendation system, this value should be automatically generated from device's GPS sensor. Constraints are also predefined during implementation. The maximum budget provided for one menu is set to Rp. 30000, and the maximum distance that user is willing to travel is set to 5 km.

Eigen vector of criteria

The recommendation system web service accepts input of criteria priority weight in the price, distance, and rating order. Therefore resulting in a criteria pairwise comparison matrix C as given in equation (8) and computed Eigen Vector of Criteria (EVC) as given in equation (9).

$$C = \begin{bmatrix} 1 & 0.6 & 3 \\ 1.67 & 1 & 5 \\ 0.33 & 0.2 & 1 \end{bmatrix} \tag{8}$$

$$EVC = \begin{bmatrix} 0.3333 \\ 0.5556 \\ 0.1111 \end{bmatrix} \tag{9}$$

EVC matrix is the preference matrix for the given criteria order. Later on, this matrix multiplied with the computed normalized alternatives-criteria preferences matrix to produce the final preference matrix.

Data retrieval

Data generation is very critical when dealing with thousands of restaurants and menus in dataset. This research uses only food price, travelling distance, and food rating as criteria, where the desired foods would be the alternatives of AHP.

Table-3. Data retrieved from database.

MID	CID	Menu Name	Price	Distance	Rating
4	5	Spaghetti Bolognaise	15500	3745.2	3.6
5	5	Lasagna	22900	3745.2	4.2
6	5	Cannelloni	18900	3745.2	4.3
32	14	Fujiyama Roll	22000	2967.3	3.8
33	14	Double Cheese Roll	26000	2967.3	4.0
34	14	Tako Roll	26000	2967.3	4.0
178	55	Iga Bakar Steak	14500	2487.9	4.2
189	14	Tamago Sashimi	18500	4499.9	4.4
190	14	Tuna Salad/ Spicy Gunkan	16500	4499.9	4.2
191	14	Salmon Salad/ Spicy Gunkan	17500	4499.9	4.0
192	14	Unagi/ Salmon Skin Maki	20000	4499.9	4.4
193	14	Kani/ Tamago Maki	10000	4499.9	4.0
194	14	Avocado Roll	21000	4499.9	3.8
195	14	Ebi Tempura Roll	28500	4499.9	3.8
196	14	Chicken Teriyaki Roll	25000	4499.9	3.6
197	14	California Roll	25500	4499.9	3.6
211	14	California Roll	20000	4271.9	3.8
212	14	Crunchy Sushi	15000	4271.9	3.8
213	14	Tuna/ Shrimp Crunchy Sushi	10000	4271.9	4.6
218	14	Italiano Roll	30000	2967.3	4.0

In getting more precise data estimation without losing significant information, we use a filter based on given constraint, i.e., users' maximum budget for the menu and the distance that they would travel to. The data retrieval and filtering query works with the following principles, i.e., select all alternatives attributes such as price, distance and rating by combining alternatives data with its corresponding restaurant while satisfying given maximum price and distance constraints. Finally, resulting data are ordered by its ID to maintain consistency across rows in classification and weighting process.

Table-2 shows data retrieved from database that satisfies given categories in Table-1. Price, distance, and its rating information were computed in database using a stored procedure during data retrieval. The rating value of menu is obtained by averaging all available rating value information for that specific menu in database. The distance value of menu is computed from the distance between the culinary place that sells the menu and user current location as specified. Later, user's current location information should be obtained from the GPS sensor reading on mobile device. Menu's distance value is computed using Haversine formula as shown in (1).

Returned values from the formula are all in meter unit. Price value is menu's current price.

Criteria fuzzy weighting

Each fuzzy membership function threshold value defined from given constraint value (n) of distance, price, and rating, i.e., 5000, 30000, and 5 respectively. The amount of fuzzy membership function level amount (p) has been defined as 5 levels. Every menu membership degree value for each membership function is obtained by inserting menu's price, distance, and rating as x into fuzzy membership function from equation (5). Thus, by inserting menu's rating membership degree into equation (6), the menu's weight for rating criteria is obtained. Menu's weights for the price and distance criteria were obtained by inserting menu's price membership degree into equation (7). Computed weights of price, distance, and rating criteria are shown in Table 4 column w_p, w_d, and w_r.

Generating recommendation result

In order to obtain the recommended alternative, criteria preference matrix derived from Table-4 column w_p, w_d, and w_r is normalized and multiplied with the EVC matrix as shown in equation (9), thus resulting single-column final preference matrix. Menu with the highest preference value become the recommended menu. Food category containing the recommended menu becomes the recommender system output. Retrieved data along with the final preference matrix resulting from multiplication between criteria preference matrix and EVC is shown in Table-4. The preference values are put into the corresponding menu.

Table-4. Final preferences.

MID	CID	Menu Name	Price	Distance	Rating	Computed Weight (w)			Final Weight
						w_p	w_d	w_r	
4	5	Spaghetti Bolognaise	15500	3745.2	3.6	0.0737	0.0595	0.0452	0.0626
5	5	Lasagna	22900	3745.2	4.2	0.0361	0.0595	0.0520	0.0509
6	5	Cannelloni	18900	3745.2	4.3	0.0564	0.0595	0.0541	0.0579
32	14	Fujiyama Roll	22000	2967.3	3.8	0.0407	0.0964	0.0474	0.0724
33	14	Double Cheese Roll	26000	2967.3	4.0	0.0203	0.0964	0.0499	0.0659
34	14	Tako Roll	26000	2967.3	4.0	0.0203	0.0964	0.0499	0.0659
178	55	Iga Bakar Steak	14500	2487.9	4.2	0.0788	0.1191	0.0524	0.0983
189	14	Tamago Sashimi	18500	4499.9	4.4	0.0585	0.0237	0.0549	0.0388
190	14	Tuna Salad/ Spicy Gunkan	16500	4499.9	4.2	0.0686	0.0237	0.0524	0.0419
191	14	Salmon Salad/ Spicy Gunkan	17500	4499.9	4.0	0.0635	0.0237	0.0499	0.0399
192	14	Unagi/ Salmon Skin Maki	20000	4499.9	4.4	0.0508	0.0237	0.0549	0.0362
193	14	Kani/ Tamago Maki	10000	4499.9	4.0	0.1017	0.0237	0.0499	0.0526
194	14	Avocado Roll	21000	4499.9	3.8	0.0458	0.0237	0.0474	0.0337
195	14	Ebi Tempura Roll	28500	4499.9	3.8	0.0076	0.0237	0.0474	0.0210
196	14	Chicken Teriyaki Roll	25000	4499.9	3.6	0.0254	0.0237	0.0449	0.0266
197	14	California Roll	25500	4499.9	3.6	0.0229	0.0237	0.0449	0.0258
211	14	California Roll	20000	4271.9	3.8	0.0508	0.0345	0.0474	0.0414
212	14	Crunchy Sushi	15000	4271.9	3.8	0.0763	0.0345	0.0474	0.0499
213	14	Tuna/ Shrimp Crunchy Sushi	10000	4271.9	4.6	0.1017	0.0345	0.0574	0.0594
218	14	Italiano Roll	30000	2967.3	4.0	0.0000	0.0964	0.0499	0.0591

Table 3 shows that "Iga Bakar Steak" has the highest weight value among others with the value of final weight of 0.0983. The recommended menu has a category ID value of 55. Therefore, the recommendation system should produce the recommended food category that has an ID value of 55 which is the category name is "Iga".

Recommendation result evaluation

This research computation result was comparatively evaluated using recommendation precision parameter. Proposed weighting method in this research shows that it produces better recommendation results compared to the previous recommendation system using AHP which is not involving the fuzzification process. In order to measure and evaluate the developed recommendation system accuracy, this research conducts an offline test method to users based on their judgements of given alternatives and criteria.

The alternatives input that used in the test were randomly generated as many as 30 sets of food alternatives. The order of food category on every set that used in the tests as the alternatives input does not matter. Users are asked to evaluate and select one best food alternatives for the given criteria in distance, price, and rating order. During the tests, the amount of menu alternatives retrieved from database is limited to 5 km in the distance and has Rp 30000 in their maximum price. The estimated distance between user and the culinary location that serve the menu is computed using Haversine formula by user location in -7.9524318 and 112.6138575 latitude and longitude coordinate respectively. The recommendation system service is implemented in the same environment as of previous recommendation system implementation.

The equal testing data sets were also used to conduct comparison tests between previous recommendation system using traditional AHP method (Pinandito, 2015) and current Fuzzy-AHP which differs in the weighting computation process. The evaluation results are shown in Table-4.

Based on expert judgment to the alternatives given, the recommendation systems developed using Fuzzy-AHP method has better accuracy to the desired results than using the AHP method itself. In previous research (Pinandito, 2015) in which the weighting process only utilizes averaging value of given criteria and constraints, the obtained accuracy rate is 30%. The accuracy of the recommendation system using Fuzzy-AHP reaches 66,67%. Table-5 also shows that 36.7% of both recommendation system gives an equal recommendation result.

Table-5. Recommendation system test results.

No	Food Category ID Alternatives Set	Recommended Result ID		
		AHP	Fuzzy-AHP	Expert Judgement
1	45, 54, 16, 56, 35	45	35	35
2	37, 29, 9, 41, 37	41	9	9
3	7, 38, 23, 51, 48	7	23	7
4	23, 6, 19, 15, 31	6	23	31
5	36, 49, 32, 26, 38	38	38	26
6	2, 44, 24, 53, 34	44	44	44
7	8, 51, 26, 21, 24	8	24	24
8	18, 55, 21, 40, 43	43	43	43
9	8, 21, 39, 11, 5	8	11	11
10	13, 10, 32, 25, 8	8	32	32
11	24, 14, 5, 35, 32	35	32	32
12	27, 15, 44, 31, 49	44	44	44
13	55, 12, 2, 8, 53	8	8	2
14	26, 13, 14, 17, 34	13	26	13
15	41, 46, 24, 40, 52	41	24	24
16	51, 5, 56, 14, 55	14	55	55
17	48, 35, 46, 12, 35	35	48	48
18	22, 11, 5, 47, 38	38	38	11
19	31, 44, 3, 34, 20	44	20	20
20	21, 15, 16, 14, 35	35	35	14
21	50, 9, 8, 10, 52	9	9	9
22	42, 51, 21, 30, 54	30	42	42
23	27, 23, 5, 28, 30	30	23	27
24	47, 55, 21, 19, 41	41	47	19
25	36, 14, 52, 19, 8	36	36	36
26	4, 12, 30, 51, 36	36	36	36
27	12, 54, 9, 29, 37	9	9	9
28	25, 30, 51, 53, 34	30	25	25
29	20, 15, 13, 3, 19	3	20	20
30	22, 11, 37, 52, 44	44	11	11

CONCLUSIONS

This research proposed a culinary recommendation system computation method that outcomes the limitation of using a traditional AHP in the process of alternatives weight computation. The proposed method involves the utilization of fuzzy classification method in the process of alternative weighting is able to produces better recommendation results in accordance to the user's expected results.

The combination of Fuzzy and AHP approach shows some advantages: (1) AHP helps decision-makers to decompose decision problems by forming a hierarchical decision-making structure, (2) The fuzzy approach helps in formulating user's judgement vagueness for specific menus selection, (3) The Fuzzy-AHP method implemented in this research culinary recommendation system helps to resolve disparity among each category of menu options and (4) It is possible that the recommendation system produces one or more food categories that are being recommended as of the weighting process are computed to the menus in which the menus that are being recommended is reflecting its food categories.

Even though its weighting processes involves heavier fuzzy clustering and weighting computations rather than simply averaging the values as in previous research, this research shows that fuzzy method utilization in alternatives weighting process with numerous and varying amount of alternatives is more effective compared to the original AHP process.

It is expected that the more fuzzy set used in the weighting computation process, the better weight value an alternatives would become. As contrary, the more fuzzy set used in the process, the longer the recommendation process time required. Further analysis and research could be conducted in optimizing the amount of fuzzy sets generated to cluster alternatives criteria values and compute its weight values in order to produce the desired result while balancing the amount of time and resources it takes.

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