Mobile-Based Expert System For Human Diet Planning Using Optimum Neighbor

Marji[1], Dian Eka Ratnawati[2]
Informatics Engineering, Computer Science Faculty
Brawijaya University
Malang, East Java, Indonesia
marji@ub.ac.id[1], dian_ilkom@ub.ac.id[2]

***Abstract*—This research proposes an expert system method to recommend the quantity of every ingredients food for a normal human or specific diet patient. Our proposed method initial state was 100 pairs of generated random value. Afterward, the pair of value which contains minimum error rate was chosen. Our proposed method uses the generated optimum neighbor as the recommendation solution. Our proposed method was implemented as an android application, named SlimLine. Based on the experiment, SlimLine able to compose the food ingredients quantity with the macronutrient needs in the range about 25% above or below nutrition needs.**

Keywords*— *SlimLine, diet, optimum neighbor

I. Introduction

Normally, the budget for human diet depends on the food price. When the price of basic needs rises, the food ingredients price will escalate. That leads the escalation of living cost to fulfill the requirements of nutrients. Basically, high price of foods does not guarantee sufficient nutrients. The nutrients of cheap food ingredients could be as same as more expensive food ingredients, or even better. Diet problem is about finding the best proportion of food ingredients which could cover all daily nutrient needs with affordable cost [1].

Human diet planning is carried out by selecting the food items or groups of food items to be used in the diet and then the composition will be calculated. If nutrient quantities do not reach the desired nutritional requirements, foods are exchanged or quantities altered, and the composition recalculated. Iterations are repeated until a precise diet is obtained . In simple terms, Human diet problem is identical with Minimum-cost diet planning.

There are many cases about the diet problem which the proportion of the food ingredients nutrient is insufficient for daily nutrient requirements. The extreme cost restriction is the main reason. On the other side, nutritionists have the fulfillment of nutrients as a priority, rather than cost factor. Mostly to humans who have the disease (Such as Diabetes, Cardiovascular Disease, and so forth.), will put the fulfillment of nutrients as the top priority and put aside the cost. This issue contradicts with the concept of diet problem which strict on the cost restriction.

In summary, it can be express that the fulfillment of nutrients for a human is considerably important, rather than cost factor, especially, to humans who get disease. Rationally, human will choose the fulfillment of nutrients with the lowest cost possible. Low-cost in this case does not mean the minimum cost based on the budget which decided by the patient strictly. Low- cost is the possibility of the lowest cost possible with optimum nutrient fulfillment as the top priority.

Another issue is to get the right proportion of nutrient fulfillment; one must have a consultation with a nutritionist. Moreover, nutritionist must calculate the nutrient requirement and food ingredients portion manually, to find the right proportion for the patient. Nowadays, there is new paradigm which using the knowledge from experts to be employed in the computer system (desktop, web or mobile based). The expert system will simplify user and nutritionist effort in the nutrient consultation.

Nowadays, Smartphone utilization has been popular and become as a lifestyle in the society. Complex and inefficient algorithm are unreliable for Smartphone, which the hardware resource has a significant limitation. Therefore in this study, the main purpose of this research is to proposed a new way with a lightweight and straightforward algorithm to nutrient consultation using a software solution for diet planning specifically related to one who has disease. The software will be mobile-based, in this case, Android Platform, with offline mode to make it accessible to the user, whenever and wherever without internet connection. The software will acquire and optimize expert's knowledge. Hopefully, diet planning is accessible easily. On the other side, a nutritionist will be helped to calculate nutrient requirements and food ingredients proportion which is right, in ease.

II. Related Works

The research about diet problem was started by George Stigler which optimization of nutrient with affordable cost as the main reason behind the research. The problem has continued to be investigated by scientists and nutritionists on [2]-[18]. Some studies also propose computation algorithm on diet planning or diet problem cases. The study by Sufahani and Ismail [19], is to expand the current knowledge in menu planning and diet problems focusing on Malaysian recipes, fulfill the nutritional requirements and serve a variety of food serve each day. The other study by Mamat *et al.* [20] proposes an Optimized Human Diet Problem with Fuzzy Price Using Fuzzy Linear Programming Approach. The paper by Eghbali *et al.* [21] discusses the human diet problem in the fuzzy environment. The approach deals with multi-objective fuzzy

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linear programming problem using a fuzzy programming technique for its solution. Also the study by Mamat *et al.* [22] addresses a balanced diet planning by using fuzzy linear programming approach.

III. Proposed Method

In this research, patient budget was not strict, but only as a benchmark to determined the cost optimization to nutrient fulfillment. The algorithm design is shown in figure 1.

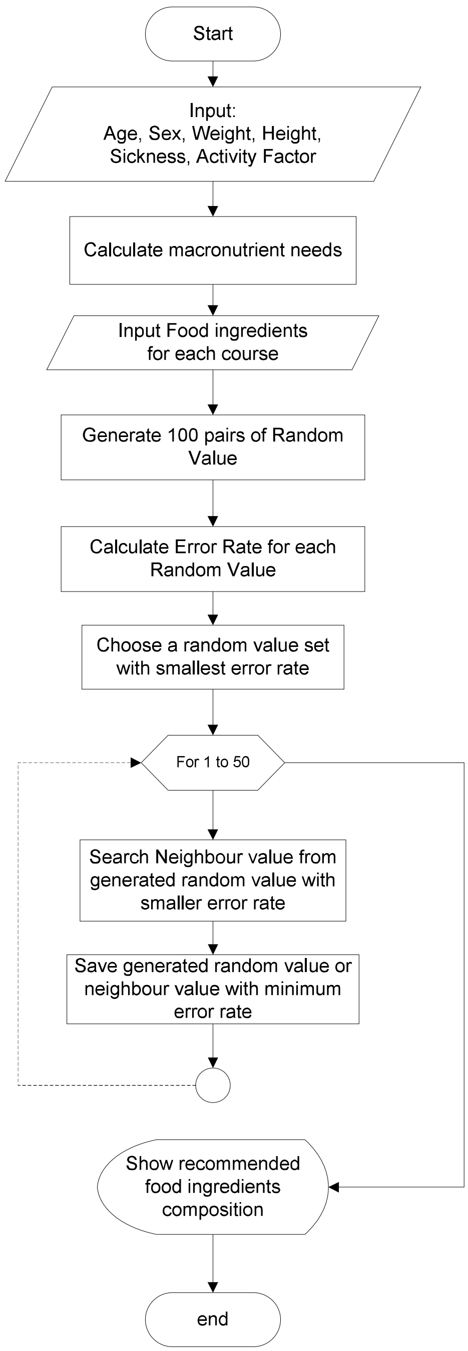


Fig. 1. Our Proposed Method Flowchart

General information required from the user includes factors like age, gender, weight, height, and activity level. The application starts by calculating the basal metabolic rate (BMR) using the Harris-Benedict [23] :

- Figure 1 : For Men
  BMR = 66.4730 + 13.7516w + 5.0033h -6.7550a
- For women
  BMR = 655.0955 + 9.5634w + 1.8496h -4.6756a

Where:
w = weight (kilograms),
s = height (centimeters)
a = age in years.

To determine user total daily calorie needs, multiply BMR with appropriate physical activity factor, as follows [24]:

- Sedentary (little or no exercise)
  Calorie = BMR x 1.2
- Lightly active (light exercise/sports 1-3 days/week)
  Calorie = BMR x 1.375
- Moderately active (moderate exercise)
  Calorie = BMR x 1.55
- Very active (hard exercise/sports 6-7 days a week)
  Calorie = BMR x 1.725
- Extra active (very hard exercise)
  Calorie = BMR x 1.9

The application set static distribution percentages of the three macronutrients which are protein, carbohydrates (CHO) and fat. The specific amounts of each macronutrient are then calculated Based on total daily calorie needs, using the following formulas [25]:

- Protein = (15% x Calorie)/4
- Cabohydrates (CHO) = (15% x Calorie)/4
- Fat = (15% x Calorie)/9

After the macronutrient was known, the user was able to choose desirable food ingredients for each course (Breakfast, lunch, dinner, snack 1, and snack 2). Next step, our proposed design algorithm executed. Our proposed design algorithm:

1. Generated the random value for each weight of each ingredient (grams), then, the nutrient fulfillment value would be calculated based on food composition.
2. Calculated the error from the generated value by calculating the total differences of macronutrient fulfillment from food with macronutrient which has been gotten before as the boundary. Error method which has been used was mean standard deviation of four elements; calorie, protein, fat, and carbohydrate; using the following formula:

$$error = \sum_{i=1}^{n} \frac{|x_i - y_i|}{n}$$

Where:
i = 1, 2, 3, 4
x_i: element computation by computer
y_i: element which should be consumed

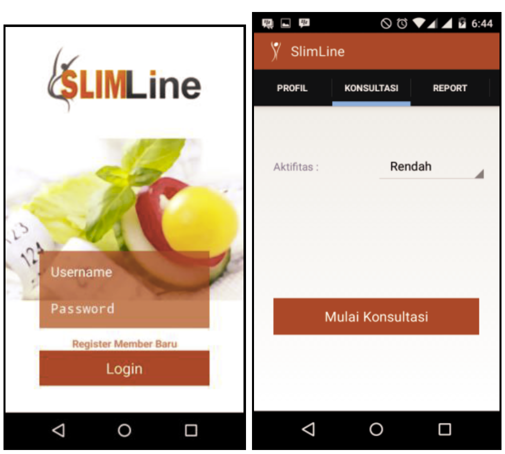
3. Based on the data with minimal error, the next step was searching the closest neighbor by adding or decrease 5 gram for each chosen food ingredients. This step made a bigger possibility of resulting smaller error.
4. After the neighbor value which contains a more minimal error rate was found, it was saved for the further comparison.
5. Repeated step 3 to 4, 100 times for optimum solution.
6. The next step was showing the value in a form of food ingredients recommendation display.

IV. Experiment and Discussion

A. Experiment Setup

In this research, an experiment has been done by comparing our proposed system with the nutrient menu consultation result which calculated manually by a nutritionist. To be a fair test, the data which has been used in the test comparison was similar. Data which has been used was ten real data which acquired from hospital where consisted of patients with such of diseases like diabetes, cardiovascular diseases, and liver disease. We assumed that patient had medium activity level.

There is an Android platform application that has been developed which named SlimLine. The screenshot of SlimLine shown in Figure 2. SlimLine has been published and distributed in Google Play store (https://play.google.com/store/apps/details?id=com.ptiik.SlimLine). SlimLine needs Android 4.2 version and up. To fulfill the requirements, Nexus 5 has been used as the Smartphone testing tool device.



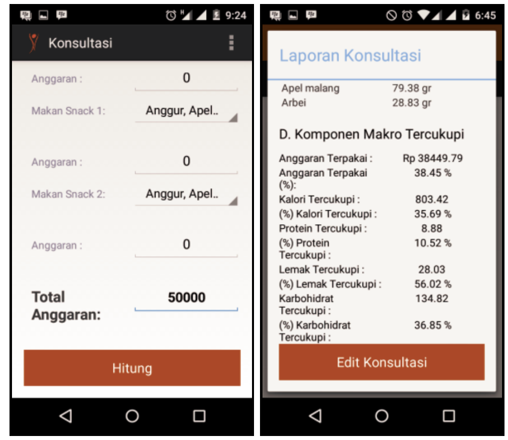


Fig. 2. SlimLine Screenshot

B. Experiment Result

As explained in the previous section about the use of randomization method, the result for every execution of application was different. The application was executed 10 times for every test case. We calculated the average result computation of nutrient fulfillment recommendation which has been done through the application. We also calculated the nutrient fulfillment which acquired from nutrient menu consultation. The comparison between application calculation and manual calculation by an expert are shown in Table 1. Based on table 1, a graphic was made to visualize the comparison result.

TABLE I. Macronutrient Calculation Comparison between Application and Manual Consultation

Macronutrient	**Nutrient fulfillment Average Percentage (%)**	
	Expert Recommendation	***Application Recommendation***
Calorie	76.33	100.36
Protein	84.12	104.45
Fat	92.70	126.89
Carbohydrate	64.34	81.77

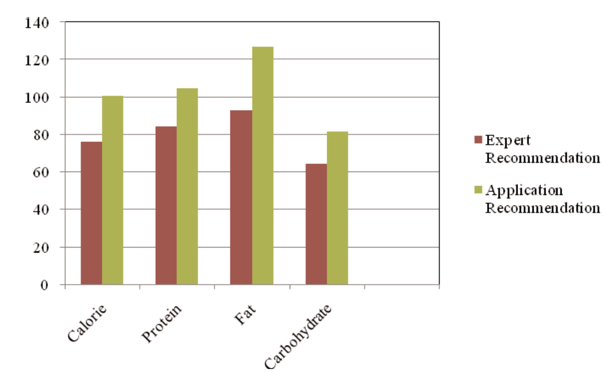


Fig. 3. Our Proposed Method Flowchart

C. Discussion

The application recommendation about macronutrient nutrient fulfillment provided a better results than manual calculation by an expert. On calorie and protein components, the application able to generated food composition which consisted nearly 100% nutrient fulfillment element. On Carbohydrate component, the application able to generated 81.77% nutrient fulfillment. On Fat component, the application able to generated 126.89% nutrient fulfillment. Based on the components, the application relatively give more superior recommendation than food composition result by the expert.

There was excessive nutrient fulfillment on the fat component. The food composition calculation by the application generated fat component which worse than an expert recommendation. It was caused by the minimum number detection in neighbor value searching based on the error rate of the fat component. It made the next neighbor searching constant (nothing changed).

V. CONCLUSION AND FUTURE WORKS

This paper provides an expert system method to recommends the quantity of every single ingredients for ordinary human and patients who has a specific diet. Our proposed method was implemented as an android application, named SlimLine. Based on the experiment result, SlimLine Application recommendation of nutrient requirements of Energy, Protein, Carbohydrate and Fat computation, relatively similar with expert's calculation, while Fat computation is worse than expert's calculation.

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Topic
Information Retrieval