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Healthy Food Recommender System for Obesity Using Ontology and Semantic Web Rule Language

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Abstract−Today's lifestyle and eating patterns tend to be irregular due to busyness. People prefer eating foods that are fast and easy to obtain, but often lack knowledge of the nutritional content in them. These eating patterns lead to unbalanced nutrition and can cause various health problems and diseases, such as overweight and obesity. Due to a lack of information, people often turn to drugs instead of learning about healthy diets, making it difficult for them to determine what menu to choose or what type of food to consume. While there have been many studies to recommend healthy food based on user preferences, there is currently no recommender system that includes serving size and budget for each daily food recommendation that is implemented in a chatbot framework. This study proposes using ontology and the Semantic Web Rule Language (SWRL) to store knowledge in the ontology and then process it using SWRL to produce food recommendations based on user preferences. From a sample of user data which obtained 170 recommended meal menus. System performance is pretty good. Based on the validation results from nutritionists, the precision value was 0.852941, the recall was 1, and F-score of 0.920634 So that a healthy food recommendation system can be used to help the user follows a diet that meets his nutritional needs and is within his budget needed.

Keywords: Ontology; Semantic Web Rule Language; Recommender System; Obesity; Dietary

1. INTRODUCTION

Along with the development of the times, the lifestyle and eating patterns of Indonesian people have become very irregular. People are increasingly choosing to eat with western patterns rather than traditional patterns, particularly in large cities with a large number of fast-food restaurants. People tend to prefer to eat foods that are fast and easy to get, but they do not know what nutritional content is in them [1, 2]. Such eating patterns lead to unbalanced nutritional quality and cause various health problems and diseases, such as overweight and obesity [3, 4].

Obesity is the accumulation of very high levels of fat in the body, which makes the body weight exceed the ideal limit [3, 5]. Obesity is becoming a public health problem at this time [6, 7]. People do not understand what foods to eat and what not to eat because of a lack of diet information. People tend to take drugs rather than learn about a healthy diet due to a lack of information [8]. Obese sufferers need to adjust their diet and learn what types of food are suitable for consumption to prevent obesity from getting worse [9]. Obese sufferers must be selective in choosing the type of food they must consume, so that it sometimes makes it difficult for them to determine the selection of menus or the type of food they must consume [10, 11]. Recommender systems have been developed to assist users in finding items that suit their needs. We created a recommender system to recommend healthy menus using ontology and Semantic Rule Web Language (SWRL) in this study. Ontology is widely used as a representation of knowledge in knowledge-based recommender systems, such as for tourism recommendations [12], query functional refinement in a conversational recommender system [13], consumer product recommendations by utilizing high-level requirements [14], and laptop recommendations based on product functional requirements [15].

In previous research, Agapito et al. [16] presented DIETOS, a dietary recommender system based on the user's health conditions and emerging chronic diseases. The system uses a questionnaire to create a user's health profile and make recommendations taking into account their medical condition. The system developed in this study can improve the health and quality of life of individuals who do not have disease or of patients who have chronic diseases.

Meanwhile, Bianchini et al. [17] used content-based filtering to create a recommendation menu according to user preferences. There is also an ontology-based method for associating recipe types with user profiles, for example, based on what restrictions a user may not eat. This study succeeded in showing the results of increased accuracy and efficiency compared to the existing model.

Besides that, Subramaniamswam et al. [18] use an ontological knowledge base and tailored filtering mechanisms with a hybrid filtering mechanism approach. There are 3 types of filtering, collaborative filtering, content-based filtering, and knowledge-based filtering, to recommend healthy foods according to the personal preferences of the user and the nutritional value of each recommended food. There is also feedback from users to provide further menu recommendations and restrictions on what users don't eat. Research [18] was successful in helping travelers who have long-term illnesses or who are on a strict diet.

Sambola et al. [19] use ontology and semantic rules for making a recommendation menu by considering several measurements, height, weight, and BMI. Research [19] allowed the system to identify the most suitable diet for each user's preferences and to list recipes whose ingredients and nutritional values match the recommended dietary restrictions.

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In line with that, Ali et al. [20] used a type-2 fuzzy ontology to recommend menus. This research uses Web Ontology Language (OWL) and Semantic Rule Web Language (SWRL) to convey knowledge for decision-making. This research shows that the proposed system is efficient for extracting user risk factors and diabetes prescriptions.

In this study, we propose the development of a healthy food recommender system using ontology and SWRL for obese people. This system aims to help people who lack information about a healthy diet. Sambola et al. [19] and Ali et al. [20] have developed a healthy food recommender system using ontology and SWRL but have not included the serving size and budget for each serving of food per day. In this study, a healthy food menu recommender system for people with obesity, also known as overweight, will be developed using ontology and SWRL. This recommender system includes a serving size and budget for each menu that is recommended every day and is implemented in the chatbot framework, making it easier for users to calculate the budget and nutrition needed for each day.

2. RESEARCH METHODOLOGY

2.1 System Design

Figure 1 shows the stages carried out in our research. The first stage was data collection, collecting information related to the food domain and other information such as information on individuals, for example in the form of weight, height, age, budget, gender, allergies, and physical activity of users. Then the next stage is the process of creating knowledge, which consists of creating SWRL rules and ontologies. The results are then validated by an expert nutritionist in order to recommend appropriate foods to users and evaluate attributes.

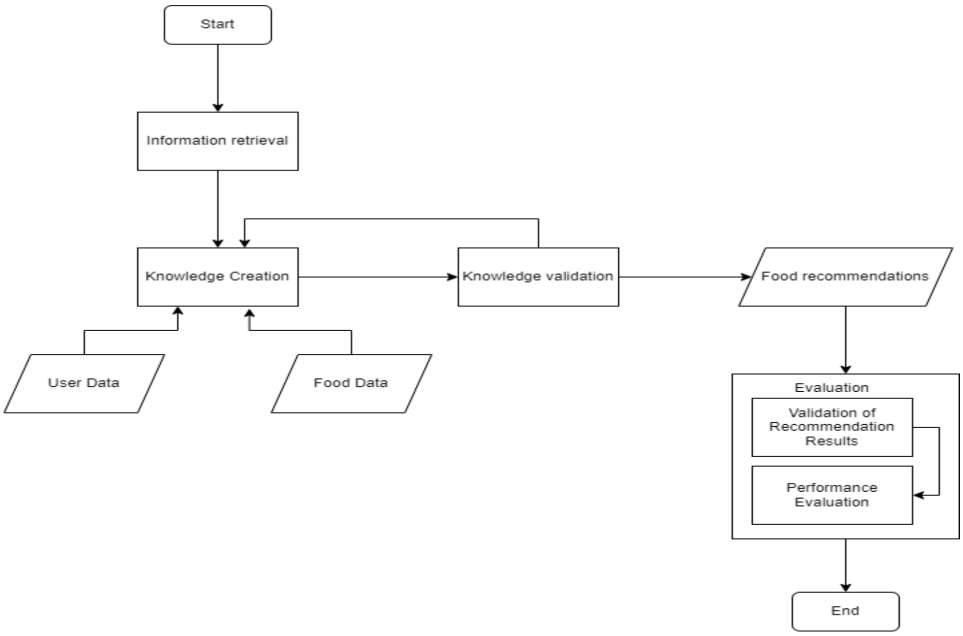

Figure 1. Flowchart of System

Figure 2 describes the flow of the healthy food recommender system. Users and the system can interact using the chatbot interface via the Telegram platform. The user provides the system with input in the form of user data, and the results are sent to the handler to be converted into a query. Then it is matched with the chatbot's decision to produce menu recommendations.

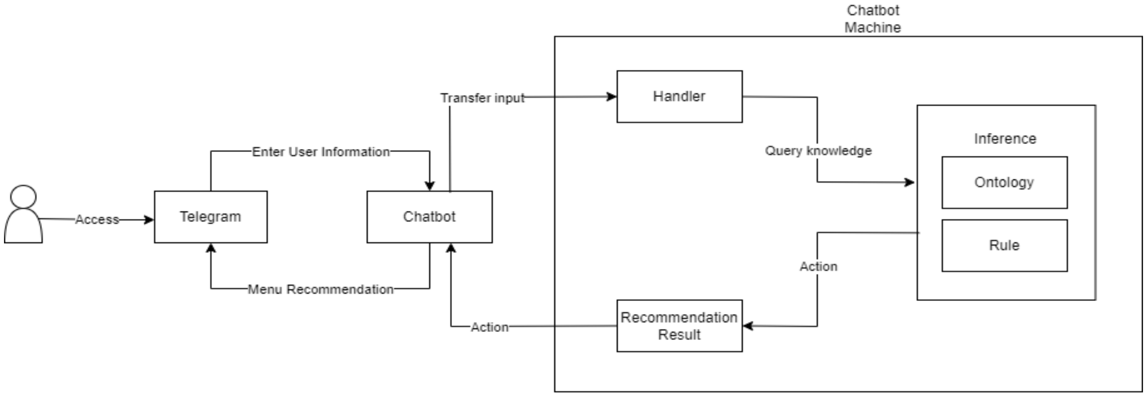

Figure 1. Overview of the Healthy Food Recommender System

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2.2 Knowledge Creation

Figure 3 shows the ontology design for a healthy food recommender system for obese people. Person, Type, **BMI_Level**, and Menu are the four main classes. The Person class represents the user's preference information, such as constraints on what should be considered for the user. Then the Type class is used for food selection for users who have long-term illnesses. The **BMI_Level** class is a classification of users based on the results of calculating BMI values, which are then classified into the BMI Level subclass, obesity, because this research only focuses on obesity. In the Menu class to store food-related information such as price and type of food.

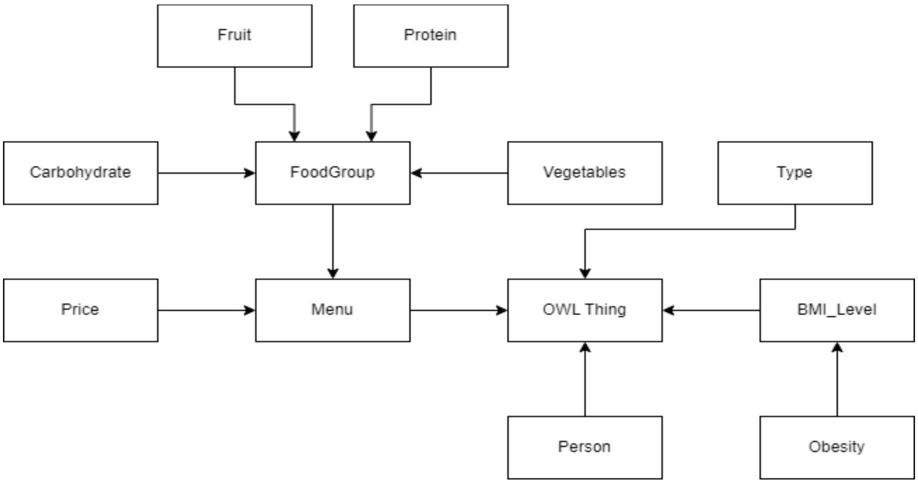

Figure 2. Ontology Design

We use protégé tools to compose an ontology. Figure 4 shows some classes in ontology. The ontology has 4 main classes: **BMI_Level**, type, menu, and person.

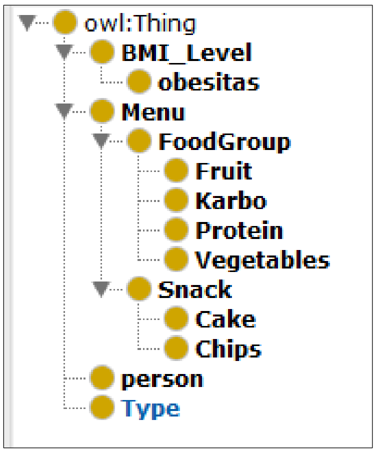

Figure 4. The Classes in Ontology

2.3 Creating SWRL rules

The user's daily calorie needs are divided based on the percentage agreed upon by the nutritionist: 25% of the daily calorie requirement for breakfast, 25% of the daily calorie requirement for lunch, 20% for dinner, and 30% for snacks. Users with the BMI level of obesity are not recommended for afternoon snacks; the afternoon snack calories will be met at breakfast, so the percentage of food at breakfast will be 35%. Distribution of daily calorie needs using rule (1)

obesity(?p), swrlb:multiply(?nbc, ?c, 0.35), swrlb:multiply(?nsc, ?c, 0.2), swrlb:multiply(?ndc, ?c, 0.2), hasCalorie(?p, ?c), swrlb:multiply(?nlc, ?c, 0.25)
-> LunchCal(?p, ?nlc),
SnackCal(?p, ?nsc),
BFCalorie(?p, ?nbc),
DinnerCal(?p, ?ndc) (1)

In taking menu items, users in the BMI class Level of Obesity added the rule item? f is food in the low-fat category, LevelNutrient (?f, LowFats), as in rule (2). The menu items for the main meals, namely breakfast, lunch, and dinner, consist of carbohydrate items, protein items, and vegetable items.

person(?p), obesity(?p), hasAlergi(?p, "none"), BFCalorie(?p, ?c) ,
swrlb:multiply(?pcf1, ?c, 0.005),Karbo(?f), Vegetables(?f2), Protein(?f1),

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LevelNutrient(?f, LowFats),LevelNutrient(?f1, LowFats) ,LevelNutrient(?f2, LowFats) ,
hasNutrientCal(?f, ?nc) ,hasNutrientCal(?f1, ?nc1) ,hasNutrientCal(?f2, ?nc2),
swrlb:add(?tc, ?nc, ?nc1), swrlb:add(?tc1, ?tc, ?nc2),
swrlb:roundHalfToEven(?tcf, ?tc1),swrlb:subtract(?bba, ?c, ?pcf1),
swrlb:roundHalfToEven(?pf1, ?bba) , swrlb:add(?ba, ?pcf1, ?c) ,
swrlb:roundHalfToEven(?pf, ?ba),swrlb:greaterThan(?tcf, ?pf1) ,swrlb:greaterThan(?pf, ?tcf)
→ hasBreakfastMenu(?p, ?f), hasBreakfastMenu(?f, ?f1),hasBreakfastMenu(?f1, ?f2) (2)

Each menu recommendation has a different property object for storage: the SnackA property for a morning snack; SnackB for an afternoon snack; hasBreakfastMenu for the breakfast menu; hasLunchMenu for the lunch menu; hasDinnerMenu for the dinner menu.

2.4 Knowledge Validation

The results of the knowledge design that has been made are then validated by a nutritionist who is an expert in the field of nutrition. The purpose of carrying out the knowledge validation process, by discussing with experts and conducting knowledge presentations, is to ensure that the knowledge that has been created is suitable for the preferences and needs of user nutrition. Then, with the help of a domain advisor, figure out how to manually evaluate and recommend a set of diets based on our ontology [19].

3. RESULT AND DISCUSSION

3.1 Test Result

The system is put to the test by having nutritionists validate the findings of dietary suggestions and by advisors evaluating attributes to determine whether the results are accurate. If the results differ from what the system anticipated, it is reviewed again until there is widespread agreement [19]. In order to conduct the testing, user samples were taken from Google Media Form and divided by a range of 18 to 65 years. 33 customer data points, including name, gender, age, weight, height, allergies, physical activity, and budget, are tested. The chatbot then processes the data to provide 1 staple meal and 2 snacks as recommendations for each meal. Three menu options are chosen at random and given in tabular form together with user information and each menu's nutritional information during the validation process by a nutritionist.

$$Precision = \frac{TP}{TP+FP} = \frac{145}{145+25} = 0.852941 \quad (1)$$

The results of the validation of 170 recommended menus showed that there were 145 recommended menus accepted by nutritionists and 25 menus not recommended by advisors and nutritionists because there were still foods that were not allowed for obese users. The validation results are used to calculate system performance, (4) with a precision of 0.852941, (5) with a recall value of 1, and (6) with an F-score of 0.920634.

$$Recall = \frac{TP}{TP+FN} = \frac{145}{145+0} = 1 \quad (2)$$

$$F - Score = 2 \times \frac{Precision \times Recall}{Precision + Recall} = 2 \times \frac{0.852941 \times 1}{0.852941 + 1} = 0.920634 \quad (3)$$

3.2 Application Implementation

This system recommends food for obese people; therefore, it is necessary to answer the questions needed for the system to recommend food that is suitable for users. Figure 5(a) is a question about the user's personal data, such as age, weight, and height. The question in Figure 5(b) is about physical activity. Figures 5(c) describe questions about allergies. All of these questions are used to determine which foods the system recommends to the user.

(a)

(b)

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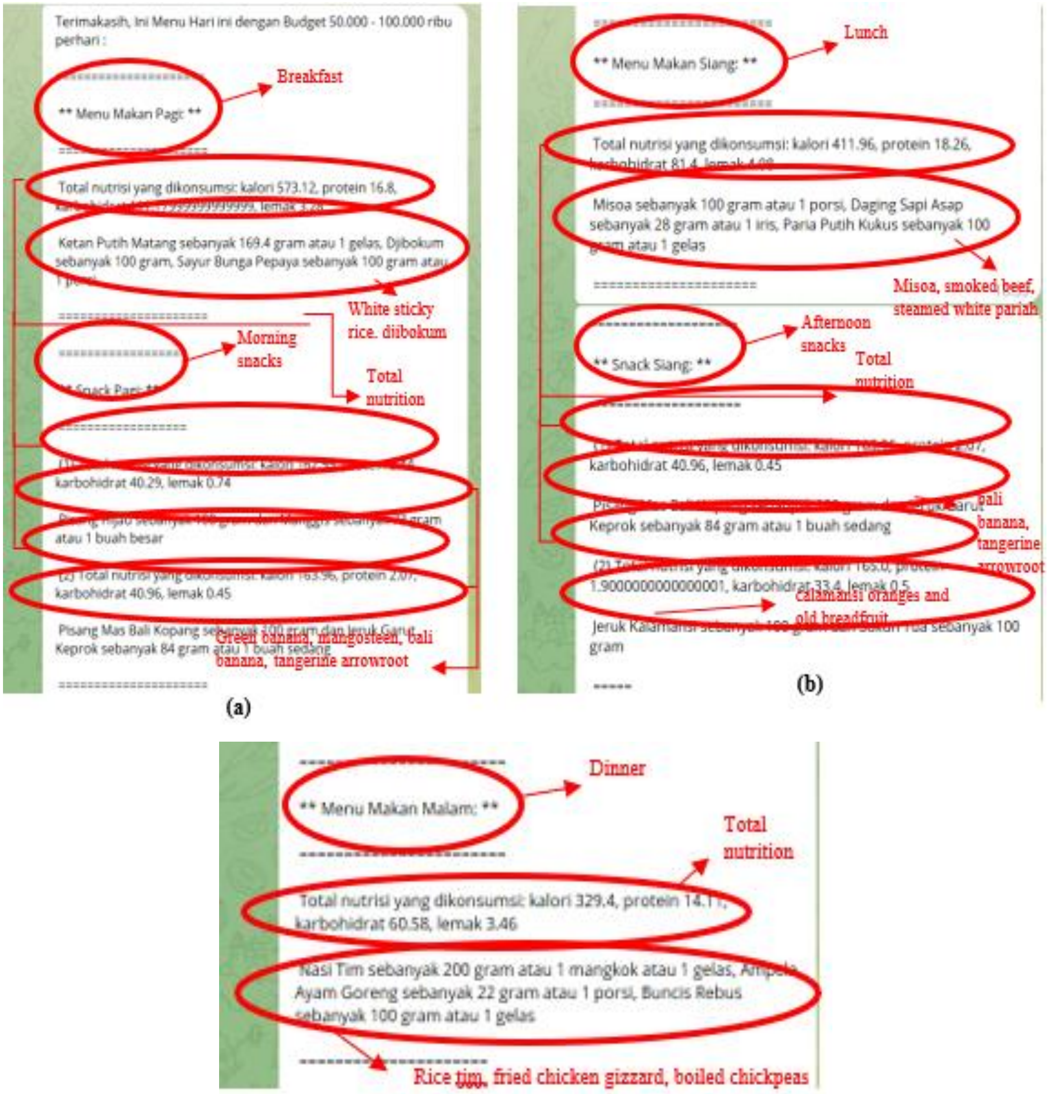
(c)

Figure 5. (a) question of the user's personal data, (b) additional questions about the user's physical activity, (c) additional questions about user allergies

Then Figure 6(a) explains the menu for breakfast, morning snacks and the nutritional content of the recommended foods. Figure 6(b) describes the menu for lunch, afternoon snacks and their nutritional content. Figure 6(c) describe the dinner menu without snacks because it is not recommended that obese people consume snacks at night.



(c)

Figure 6. (a) the menu for breakfast and morning snacks resulting from the interaction of Figure 5, (b) the menu for lunch and afternoon snacks resulting from the interaction in Figure 5, (c) the dinner menu resulting from the interaction in Figure 5.

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4. CONCLUSION

From the tests that have been carried out using sample user data obtained from the Google form questionnaire, there are 33 users' records. The system has succeeded in providing recommendations with three menu choices for each meal consisting of one staple food and two snacks. The results validated by nutritionists were 145 out of 170 menus accepted and 25 menus not recommended. Thus, the precision and recall values are 0.852941 and 1. This precision and recall values are fairly good, thus we draw the conclusion that the system we suggest can make food recommendations based on the user's key nutrients and can be used as a tool to help users implement suitable healthy eating patterns and spending limits.

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