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Optimizing the Diet of Diabetes Mellitus Sufferers Through Food Mapping Using the Fuzzy Sugeno Method

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ABSTRACT

This research focuses on developing optimal strategies for diet management for Diabetes Mellitus (DM) sufferers by utilizing the Fuzzy Sugeno method in food mapping. Diabetes Mellitus is a chronic metabolic disease that requires a careful management approach to diet to control blood sugar levels. In this study, we designed a system that uses Sugeno's fuzzy principles to categorize foods based on glycemic parameters, nutritional content, and individual patient characteristics. This method allows the formation of fuzzy rules that cover the variability and complexity in the preferences and health needs of each patient. The developed model was tested using DM patient data involving detailed information about diet, medical history and blood sugar response. Experimental results show that this approach can provide more personalized diet recommendations that suit individual health conditions. The application of the Fuzzy Sugeno method in food mapping for DM patients is expected to increase patient compliance with the recommended diet, reduce blood sugar levels, and overall, improve quality of life. Additionally, this approach also provides a foundation for the development of adaptive dietary management systems, which can continuously adapt to changing patient health needs over time.

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1. INTRODUCTION

Diabetes Mellitus (DM) is one of the main challenges in the global health sector, with a significant increase in prevalence in various countries. DM management requires a holistic approach, especially in managing the patient's diet to maintain blood sugar levels within normal limits. A proper diet plays an important role in controlling symptoms and preventing long-term complications that can occur in DM sufferers [1], [2], [3]. In using the Tsukamoto fuzzy method, the first thing to do is determine the membership function, then determine the rules and later the categories will be clustered into each group according to the rules applied [4], [5], [6].

Choosing foods that suit individual health needs is often a complex and confusing task for DM sufferers. Different health conditions, food preferences, and unique body responses demand a personalized and adaptive approach in designing dietary recommendations. Therefore, it is necessary to develop a system that is able to provide more specific dietary recommendations and according to the characteristics of each patient [7], [8], [9].

The Fuzzy Sugeno method, as an artificial intelligence technique, offers an approach that can handle uncertainty and complexity in decision making. By embracing fuzzy principles, these systems can map uncertain or ambiguous information, such as patient preferences and food characteristics, into categories that can be used to construct more accurate dietary recommendations [10], [11].

With this background, this research aims to optimize the diet management of DM sufferers through the application of the Fuzzy Sugeno method in food mapping. It is hoped that this research can make a positive contribution in improving the quality of life of DM sufferers, reducing the risk of complications, and leading to the development of a more adaptive and personalized diet management system [6], [12][13].

2. RESEARCH METHOD

To assist this research, a research phase framework is needed. The stages of this research are the steps that will be tried in solving the problems discussed. There are also stages of research used are as follows [25], [3], [14].

Figure 1. Research Framework

Based on the research stages above, the discussion of each stage in the research can be described as follows [23], [24] [15]:

1. Study Literature

   At this stage, a search is carried out for theoretical foundations obtained from various books and also the internet to complete the vocabulary of concepts and theories, so that they have a good and appropriate scientific foundation.

2. Data Collection

   The data collection methods used in this research are:

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a. Problem analysis
   Data collection in conducting research uses a questionnaire method, and the variables are the symptoms experienced by patients suffering from diabetes mellitus.
b. Literature review
   Collecting data by using or collecting written sources, by reading, studying and recording important things sourced from books, journals and the internet which are related to the problem being discussed in order to obtain a theoretical picture.

3. Designing the System
   At this stage, the system is designed using UML (Unified Modeling Language) modeling and at this stage the application interface to be created is designed.
4. System Testing
   At this stage the previously designed application has been completed and the application testing stage is carried out to see if there are any errors or damage to the application that has been designed.

2.1 Fuzzy Method Calculation

This research uses a fuzzy method to determine the percentage of diabetes mellitus suffered. The following is a description of the rules for the food mapping application for patients with diabetes mellitus [16]:

Table 1. Symptoms

Code	Symptom	Category	Weight
G01	Frequent urination, especially at night.	Light	0.3
G02	Often thirsty.	Light	0.2
G03	Often feel hungry.	Light	0.2
G04	Sudden weight loss.	Heavy	0.8
G05	Blurred vision.	Heavy	0.7
G06	Easily attacked by infectious diseases.	Currently	0.5
G07	Wounds that are difficult to heal.	Currently	0.4
G08	Feeling stiff or tingling in the legs.	Currently	0.6
G09	Constant fatigue	Light	0.3
G10	Feeling very tired.	Heavy	0.8
G11	Itching around the genitals.	Light	0.3
G12	Recurring thrush.	S Currently	0.6
G13	Pain or numbness in the feet and hands.	Heavy	0.9

1. Computing the Fuzzification Process

a. Light Category With Intervals 0,0 ≤ a ≤ 0,4
   $b = \frac{0,0 + 0,1 + 0,2 + 0,3 + 0,4}{5} = \frac{1}{5} = 0.2$
b. Medium Category With Interval 0,3 ≤ a ≤ 0,7
   $b = \frac{0,3 + 0,4 + 0,5 + 0,6 + 0,7}{5} = \frac{2.5}{5} = 0.5$
c. Weight Categories With Intervals 0,6 ≤ a ≤ 1
   $b = \frac{0,6 + 0,7 + 0,8 + 0,9 + 1}{5} = \frac{4}{5} = 0.8$

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2. Calculating Defuzzification Values

G02= Often thirsty
G03= Often feel hungry
G07= Wounds that are difficult to heal

a. Count F (G02)

$$F = \frac{0,2 - 0,0}{0,2 - 0,0} = 1$$

b. Count F (G03)

$$F = \frac{0,2 - 0,0}{0,2 - 0,0} = 1$$

c. Count F (G07)

$$F = \frac{0,4 - 0,3}{0,5 - 0,3} = 0,5$$

3. Computing the Defuzzification Process

= (FG02 * BNG02) + (FG03 * BNG03) + (FG07 * BNG07))
= ((1 * 0,2) + (1 * 0,2) + (0,5 * 0,4)) / 1+1+0,5
= 0,2+0,2+0,2/2,5
= 0,6 / 2,5 = 0,24

Disease severity = 0.24 * 100% = 24%. So based on these calculations, the fuzzy value of the input symptoms that lead to diabetes mellitus is 24%.

2.2 System Design Using UML (Unified Modeling Language)

This research uses a UML design consisting of Use Case Diagrams, Activity Diagrams, Squency Case Diagran, Activity Diagram, Squency Diagram dan Class Diagram [17],[18], [19].

1. Use case diagram

   To get information from a system being created, the author uses a use case diagram, as in the picture below:

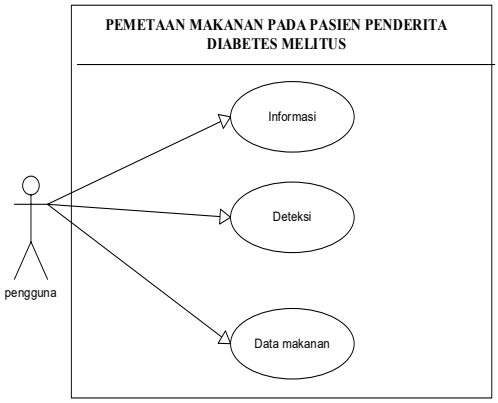

Figure 2. Use Case Diagram

2. Activity Diagram
   a. Activity Information Diagram

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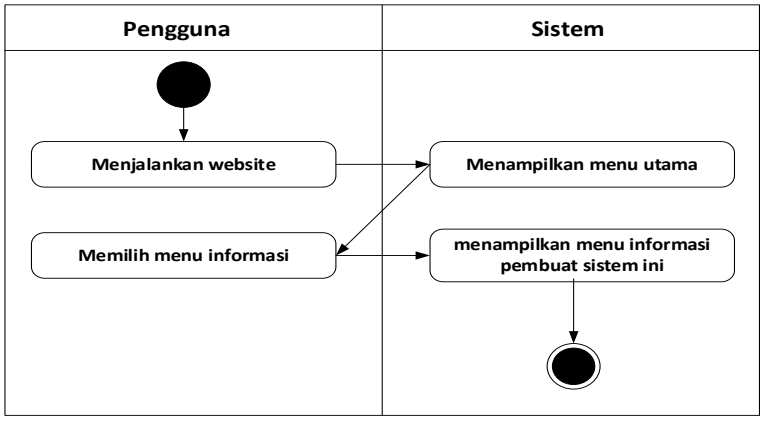

Figure 3. Activity Information Diagram

b. Activity Diagram Detection

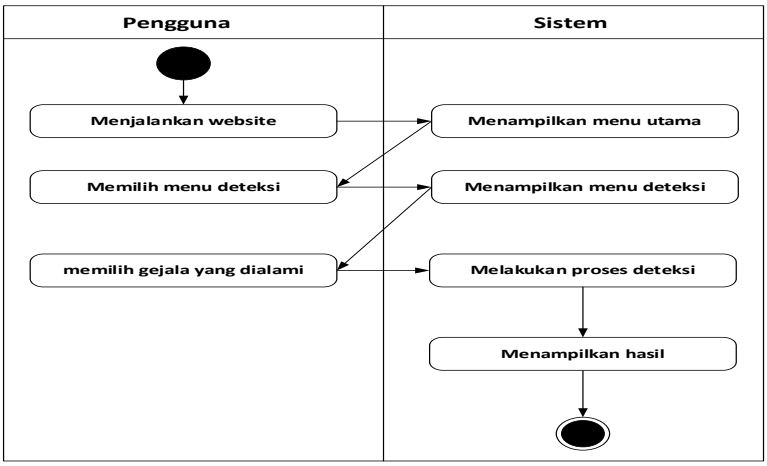

Figure 4. Activity Diagram Detection

c. Activity Diagram Food Data

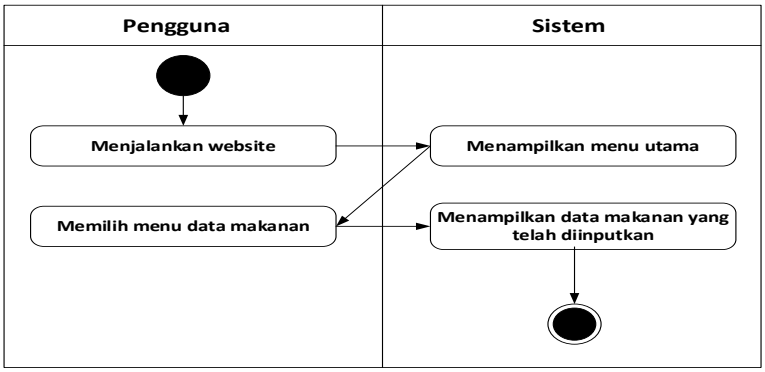

Figure 5. Activity Diagram food Data

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3. Squency Diagram
   The following is a sequence diagram for food mapping applications in patients with diabetes mellitus:

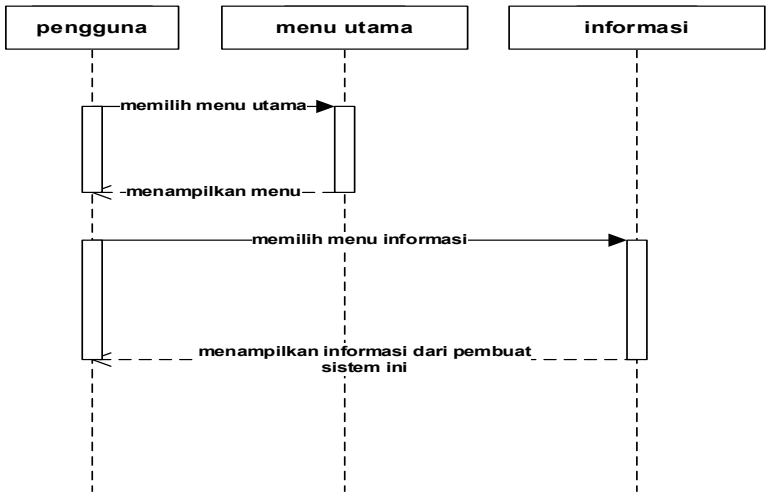

Figure 6. Squency Diagram

3. RESULTS AND DISCUSSIONS

In this section, it is explained the results of research and at the same time is given the comprehensive discussion. Results can be presented in figures, graphs, tables and others that make the reader understand easily. The discussion can be made in several sub-chapters [20],[21], [22].

3.1. Detection Application Display

The detection display is a menu that contains symptoms that lead to diabetes mellitus. The function of this display is to provide information about whether you have diabetes mellitus or not. The display can be seen in the image below.

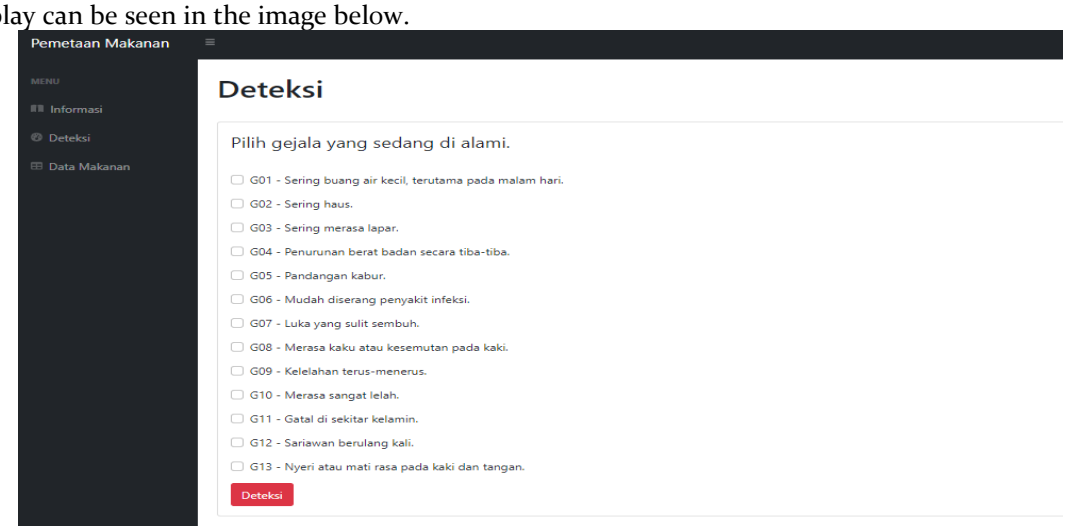

Figure 7. Detection Display

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3.2. Feeding Data Display

The food data display is a menu that contains data on foods that are good for consumption by diabetics. Users can add their own food to this system by clicking add food. The display can be seen in the image below.

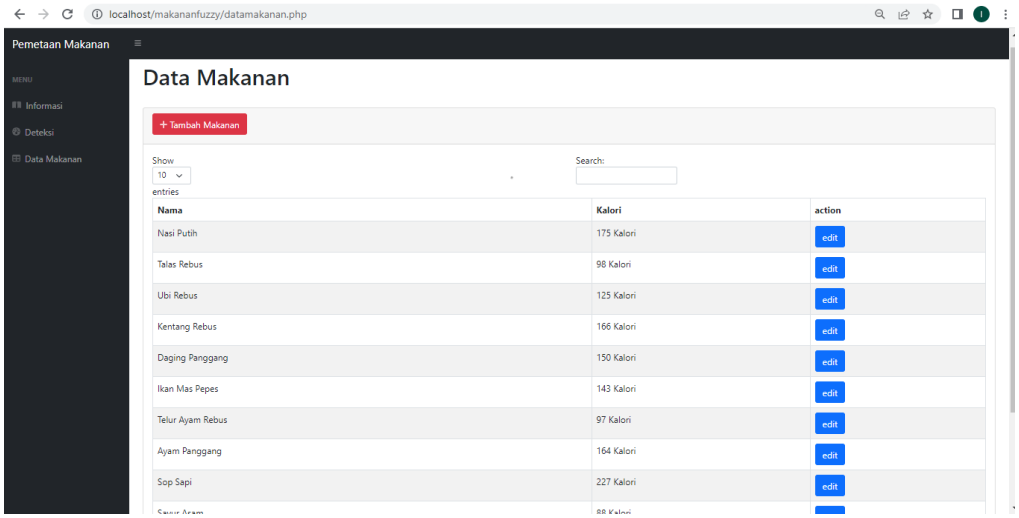

Figure 8. Food Data Display

3.3. Food Mapping Application Testing

Testing the food mapping application on patients suffering from diabetes mellitus is used to test the system in one of the menus where the data used is the process of detecting disease.

a. Detection Menu Display: the user will be shown a new display, namely the detection display. In this menu, users only need to select the symptom they are experiencing by clicking on the symptom.

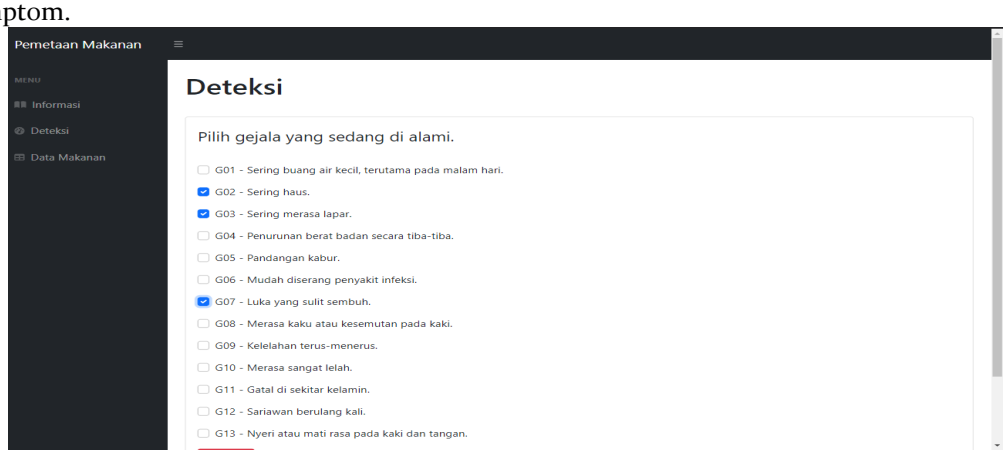

Figure 9. Deteksi

b. After completing the selection of symptoms experienced, the user will fill in the data display for gender, age, height (cm), weight (kg) and activities carried out with the aim of knowing the user's total calorie needs per day.

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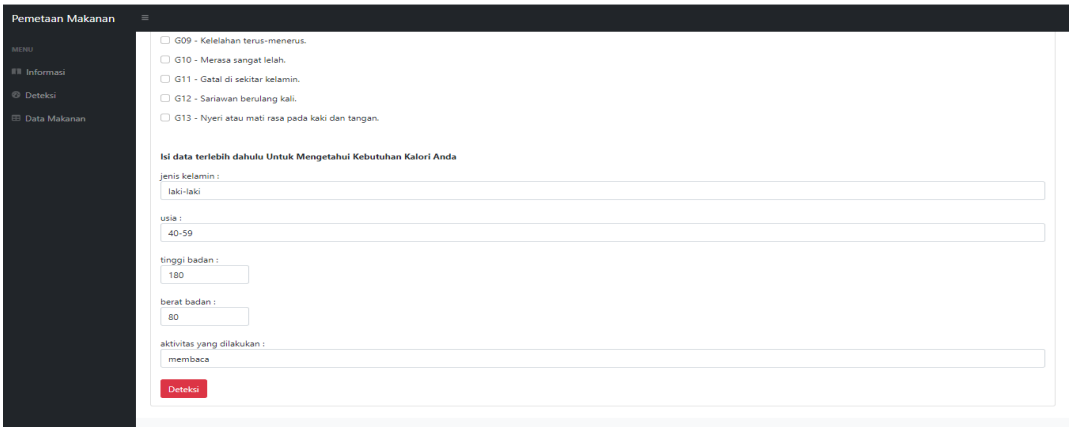

Figure 10. Deteksi (Advanced)

c. Then click detection and a new display will appear, namely the detection results display. In this display, the results of the detection of diabetes mellitus will appear in the form of percentage, the patient's ideal body weight, the total number of calories the patient needs and the patient's type of food.

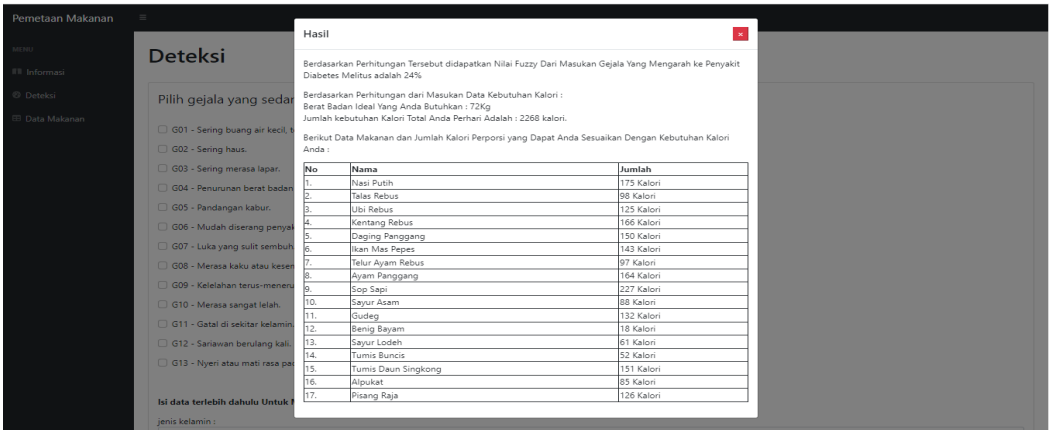

Figure 11. Detection Results Display

4. CONCLUSION

This research aims to optimize the diet management of Diabetes Mellitus (DM) sufferers through food mapping using the Fuzzy Sugeno method. Based on the research results, several important conclusions were obtained:

1. Diet Management Optimization:The application of the Fuzzy Sugeno method in food mapping can improve the optimization of diet management for DM sufferers. The model developed can provide diet recommendations that are more personalized and in accordance with individual health characteristics.
2. Personalized Diet Recommendations: This method allows personalization of dietary recommendations based on the variability of health conditions, food preferences, and body responses of DM sufferers. This can help improve patient compliance with their diet plan.

3. Improved Blood Sugar Management: The Fuzzy Sugeno-based food mapping system has proven effective in reducing fluctuations in blood sugar levels. More precise dietary recommendations can help control blood sugar more effectively, reducing the risk of long-term complications.
4. Flexibility and Adaptability: The Fuzzy Sugeno method provides flexibility and adaptability to changes in patient health needs over time. This provides the basis for the development of dynamic and adaptive dietary management systems.
5. Contribution to Quality of Life: By providing a more effective solution for diet management, this research is expected to make a positive contribution to the quality of life of DM sufferers. Reducing cognitive load in diet management can create a positive impact on aspects of daily life.

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