Fuzzy logic implementation for diagnosis of Diabetes Mellitus disease at Puskesmas in East Jakarta

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Abstract. This study aims to implement the application of decision support system in the health sector that is Diabetes Mellitus disease diagnosis with Fuzzy Logic method, so that the layman can do diagnosis early and can immediately do the treatment. Decision Support System Techniques are developed to improve the effectiveness of decision makers. The sample in this research is 6 Puskesmas in East Jakarta. This application uses five variables as inputs consisting of plasma glucose concentration 2 hours, diastolic blood pressure, body mass index, diabetes pedigree function, pregnant and one variable as output. The data obtained is processed using fuzzy logic approach with matlab programming and created Graphical User Interface (GUI). Furthermore, the implementation is done in Puskesmas Kecamatan Pasar Rebo and Puskesmas Kecamatan Kramat Jati, Testing includes validation testing, questionnaire testing and application testing and then determined the accuracy value. The test results indicate that the diabetic disease diagnosis system built meets the expected basic criteria for the feasibility of system services in general and in line with the expectations of the Puskesmas management. This application has a value of 96% accuracy so that it can help improve the quality of services in Puskesmas and can satisfy users.

1. Introduction
Artificial Intelligence (AI) method is widely used in all fields including applications in the field of health/medicine. Soft computing technology is a field of interdisciplinary research studies in computational science and artificial intelligence. Some techniques in soft computing include expert systems, neural networks, fuzzy logic[1], [2], and genetic algorithms[3], many of which are developed for having the advantage of solving problems that contain uncertainty, inaccuracies and truth partial, included in the health field[4], [5].

Expert systems are a computer computing method that mimics how people solve problems, usually a complex problem, in accordance with their expertise [6], [7]. Just like humans, in solving the problems given, the expert system first receives inputs that is what problems will be solved then use certain methods to consider and assess the existing inputs to take a decision.

An expert system is created to mimic the expertise of an expert human being who works without any personal inclination because the computer has no feelings[8]–[10]. Fuzzy logic is one of the computer computing methods that adopt the term linguistic language used by humans in communicating in the process of reasoning[11]. The result is a Fuzzy logic structure and a knowledge base that works like a working human expert [12]–[17]. The results are then implemented at the Puskesmas in East Jakarta.

In general, the expert system is a system that adopts human knowledge into the computer so that the computer can be used to solve a problem as is done by an expert. Expert systems are created in a particular area of knowledge and for a particular skill that approaches human ability in one particular
area. The expert system tries to find a satisfactory solution as one expert does and can give an explanation of the steps taken and give a reason for the conclusions taken.

Fuzzy logic attracts the attention of many researchers to solve problems such as for ship navigation [18], for an integrated assessment of vocational talent for training participants groupings [19], to detect line paths on an automated robot guided vehicle (AGV) [20], and to solve problems in the fiscal field [21].

Diabetes Mellitus is a disease characterized by high blood sugar levels, caused by a disturbance to insulin secretion or insulin disruption or both. The body of a patient with diabetes mellitus cannot produce or cannot respond to the hormone insulin produced by the pancreas organ, so that blood sugar levels increase and can cause short-term and long-term complications in these patients. The problem that happened at Puskesmas in East Jakarta is the lack of complete equipment and number of specialist doctors in diagnosis of diabetes mellitus disease, so it is hoped that expert system of diabetes mellitus disease diagnosis to be developed can help solve the existing problems. The purpose of this study is conduct implementation and testing of expert system diagnose diabetes mellitus disease produced, including testing validation, testing the questionnaire and application testing.

2. Research Method
Research conducted is Research and Development (R & D). Research and development is defined as a research method used to produce a particular product and test the effectiveness of the product[22]. The data sample used in this research is secondary data from 6 Puskesmas in East Jakarta. From these 200 data is made expert system of diabetes mellitus diagnosis. The data obtained is processed using Mamdani’s Fuzzy Inference System (FIS) approach with the help of Matlab toolbox.

| No | Variable                                      | Value       | Classification | Domain |
|----|-----------------------------------------------|-------------|----------------|--------|
| 1  | Plasma Glucose Concentration a 2 hour         | 187 - 232   | Unnormal       | [6 10] |
|    |                                               | 141 – 186   | Medium         | [3 7]  |
|    |                                               | 44 – 140    | Normal         | [0 4]  |
| 2  | Diastolic Blood Pressure (mm Hg)              | 92 - 122    | Unnormal       | [6 10] |
|    |                                               | 81 – 91     | Medium         | [3 7]  |
|    |                                               | 30 – 80     | Normal         | [0 4]  |
| 3  | Body Mass Index                               | 34 – 67     | Unnormal       | [6 10] |
|    |                                               | 26 – 33     | Medium         | [3 7]  |
|    |                                               | 18 -25      | Normal         | [0 4]  |
| 4  | Diabetes Pedigree Function                    | 0.528 – 2.288 | Unnormal     | [6 10] |
|    |                                               | 0.500 – 0.527 | Medium       | [3 7]  |
|    |                                               | 0.084 – 0.499 | Normal       | [0 4]  |
| 5  | Pregnant                                      | 10 - 17     | Unnormal       | [6 10] |
|    |                                               | 5 – 9       | Medium         | [3 7]  |

The research steps are the development of Fuzzy Inference System (FIS) Mamdani consists of:

1. Domain problem
   a. The feasibility of a problem is not resolved or is difficult if the value of crisp
   b. Therefore, a fuzzy-based problem-solving approach is proposed
   c. At this stage also determined fuzzy variables that will be used in the system

2. Fuzzification
   a. This stage is the stage to change the crisp value of a parameter into a linguistic variable
   b. At this stage all fuzzy variables must be created into a fuzzy set
   c. Generally use multiple curves as a fuzzy representation of a variable. For example: Triangular Curve, Trapezoidal Curve, Gaussian Curve.
3. Creation of Fuzzy Rules
   a. A fuzzy rule is created to map each input to the output to be achieved
   b. Known as if-then fuzzy
   c. The creation of rules should be done with experts
4. Defuzzification
   a. Defuzzification is done to recover the crisp value of a number of rules that have been made
   b. It will depend on the method of Reasoning used: Mamdani
5. Evaluation
   a. Evaluation is done to test the output of the resulting application
   b. Evaluation can be done in two ways:
      1. Conducted with experts: by providing a combination of inputs to experts to then experts are asked to assess the results and be matched with the system
      2. Done without expert: if there is test data

Implementation of expert system for diagnosis of diabetes mellitus disease was conducted at Puskesmas Kecamatan Kramat Jati and Puskesmas Kecamatan Pasar Rebo. Expert system testing is done by inputting primary data from the results of examination of physicians at Puskesmas Kramat Jati and Puskesmas Pasar Rebo, then determine the accuracy value of the expert system produced. In addition to testing the application and testing the questionnaire.

3. Results and Analysis
   3.1. Research result
   The results of this study is a system of expert diagnosis of diabetes mellitus. Knowledge base in the design of this application is needed, which contains rules or rules useful in determining the decision as a result of system output. The design of these rules is a step after the formation of the fuzzy set.

   ![Figure 1. Rule Editor Diabetes Mellitus](image)

From the rules that have been prepared based on the doctor's decision as an expert later on can be used as a determination of decisions in the diagnosis of diabetes mellitus.
Next will be done diagnosis process diabetes mellitus disease that will produce the output of positive diabetes mellitus or negative diabetes mellitus. Here is a GUI (Graphical User Interface) for the diagnosis of diabetes mellitus.

![GUI Diagnosis of Diabetes Mellitus Disease](image)

**Figure 2.** GUI Diagnosis of Diabetes Mellitus Disease

### 3.2. Testing and Discussion

The first test is to test the functionality of all the features provided by the expert system either from the administrator or from the user side. The test results shown in Table IV.2 indicate that all expert system functionality is working properly. Then the feasibility of the expert system as a whole is tested by conducting acceptance level testing to potential users. Things included in testing to potential users include display, design, and ease of use.

| No | Assessment Elements                                      | Alternative Answers |
|----|----------------------------------------------------------|---------------------|
| 1  | Make it easy to diagnose Diabetes Mellitus disease       | VG: 70%  G: 30%  E: 0%  L: 0%  VL: 0% |
| 2  | Convenience in application usage                         | VG: 90%  G: 10%  E: 0%  L: 0%  VL: 0% |
| 3  | Expert systems work well according to their functions    | VG: 80%  G: 20%  E: 0%  L: 0%  VL: 0% |
| 4  | Expert systems provide useful data and information to users | VG: 70%  G: 30%  E: 0%  L: 0%  VL: 0% |
| 5  | System easy to use                                      | VG: 90%  G: 10%  E: 0%  L: 0%  VL: 0% |

Test results to potential users shown in Table 2 indicate that expert systems have met user expectations that they are eligible for use, with an excellent 80% user rating.

The second test conducted on the developed expert system is testing the validity of fuzzy logic algorithms developed. Validity test is done by comparing the prediction of expert system with doctor diagnosis result of primary data from Puskesmas Kecamatan Pasar Rebo and Puskesmas Kecamatan Kramat Jati. The result of validity test shows that algorithm is able to diagnose correctly 48 data from...
50 patient data of puskesmas. The level or value of the validity of the application program results can be calculated as follows:

\[
\text{Accuracy} = \frac{\text{the number of accurate data}}{\text{total number of data}} \times 100\% = \frac{48}{50} \times 100\% = 96\%
\]

Overall, based on the results of the implementation can be concluded that the diagnostic diabetes mellitus disease system built meet the basic criteria that are expected for the feasibility of a system service in general and in accordance with the expectations of Puskesmas management.

Of the fifty primary data being tested with different test result parameters, it was found that:
1. The accuracy of the expert system in diagnosing the Diabetes Mellitus disease yields a 96% value where there are 48 similar results between physician diagnosis and expert system diagnosis.
2. Rule is made only to determine the diagnosis of Diabetes Mellitus disease by looking at the results of laboratory tests, because to obtain optimal results require more complete reasoning from the experts.
3. Expert system expertise in diagnosing Diabetes Mellitus diseases is used to obtain Diabetes Mellitus health information so that patients can immediately take preventive measures in preventing or early treatment.

According to [25] the integration of fuzzy method with other methods gives some advantages to create decision more optimal.

4. Conclusion

Based on the discussion of research results that have been discussed in the previous chapter, then in this study can be drawn the following conclusions:

1. Expert systems have met user expectations that they are eligible for use, with an excellent 80% user rating.
2. Accuracy value of Expert System Fuzzy Inference System Mamdani method in diagnosis of Diabetes Mellitus disease of 96% and all functionality of the expert system is functioning properly.

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