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Research Article

Designing a Web-Based Expert System Using the Forward Chaining Method for Early Diagnosing Diabetes Mellitus

Nurmansyah Putra Bachtyar [1] and Ery Sadewa Yudha Wrahatnala [2,*]

[1] Department of Informatics Engineering, Universitas 17 Agustus 1945 Surabaya, Indonesia
[2] Universitas 17 Agustus 1945 Surabaya, Indonesia
* Corresponding author nurmansyahbachtyar@gmail.com

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Abstract

The high number of people with diabetes in 2021 has caught the attention of the public and hospitals. According to data from the INTERNATIONAL DIABETES FEDERATION, there are 19,000,000 people with diabetes in Indonesia aged 20-79 years in 2021. This number is the fifth largest in the world. Then, there are 94,000 people with diabetes in Surabaya City. Thus, the rate of people with diabetes mellitus in Surabaya City is high. Diabetes mellitus is a metabolic disorder marked by elevated blood sugar levels caused by disruptions in insulin secretion, insulin action, or both. Consequently, there is a need for a system capable of diagnosing diabetes mellitus similar to a doctor. This system is known as an expert system. Using the Forward Chaining method is used to search or track information forward and combine rules to produce a logical conclusion and diagnosis goal. As an initial check can be done with the help of an expert system. So an expert system website was developed that can run with an internet connection and is easily accessible anywhere and anytime as a diabetes mellitus disease diagnosis system.

Keywords: Expert System, Forward Chaining, Diabetes Mellitus, Disease.

1. Introduction

The high number of people with diabetes in 2021 has caught the attention of the public and hospitals. According to data from the INTERNATIONAL DIABETES FEDERATION, there are 19,000,000 people with diabetes in Indonesia aged 20-79 years in 2021. This number is the fifth largest in the world. Then, there are 94,000 people with diabetes in Surabaya City.

One of the factors causing diabetes mellitus is an unhealthy lifestyle, which results in a chronic increase in blood sugar levels above normal limits over a long period of time. Other factors that play a role are decreased physical activity, which results in an imbalance between energy intake and expenditure, and dietary changes as risk factors that contribute to diabetes (Mahmud et al., 2018). In addition, factors that make it easier for a person to develop diabetes include economic, environmental, and behavioral factors, among others: Diet, physical activity, and workplace (Garnita, 2012). Diabetes is a complaint that should not be underestimated and must be treated immediately. However, it can cause various complications that endanger the lives of its victims. If diabetes is not treated properly (Widodo et al., 2021). In general, many people do not realize that they have diabetes and accept the condition without realizing its impact. Therefore, there is a need for a system that is able to diagnose diabetes in a manner similar to a doctor. In this case, an expert system is used as the solution.

An expert system is software that mimics the learning process and knowledge of an expert or doctor in solving a particular problem. Expert systems use knowledge that is owned concretely. Experts in this case refer to individuals who have deep expertise in their fields. An example is a doctor. Here, a doctor is a health science expert who understands and can diagnose a patient's illness to provide optimal solutions and appropriate treatment (Sihotang, 2014). It is important to understand that these expert systems do not have an absolute level of correctness, as they generally provide results that are close to that level of correctness. However, they are still reliable and provide benefits in terms of time efficiency in making the best decisions (Andriyani et al., 2022).

In addition, the expert system to diagnose diabetes can also be analyzed by forward chaining method and C4.5 algorithm. The forward chaining method is used to find or trace information forward and combine rules to make logical conclusions and diagnoses. The C4.5 algorithm is a widely used classification algorithm

for decision trees because its main advantage is to build easy-to-use decision trees with reasonable accuracy and efficiency in processing discrete and numeric type attributes (Mujahidin & Pribadi, 2017).

Similar research has been conducted with the title Expert System Application for Diagnosing Diabetes Mellitus Disease with Web-Based Certainty Factor Algorithm. The result of this research is the development of a website-based expert system that has a function to provide diabetes diagnosis based on existing symptoms (Andriyani et al., 2022), Based on previous research, the ability to analyze the correct symptoms is very important in preventing diabetes. Therefore, early detection of diabetes mellitus is very important. Early testing can be done with an expert system. Therefore, a expert system website has been developed that works with an internet connection and is easily accessible as a diabetes diagnosis system anywhere and anytime.

2. Methods

2.1. Research Stages

To get a clearer picture of the direction of this research, you can refer to Figure 1 which shows the following research stages:

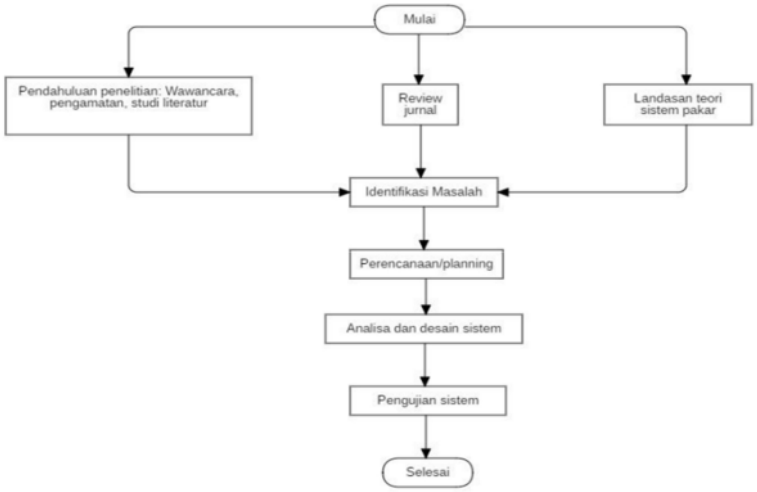

Fig. 1. Research Stages.

1. Research introduction
   Conducting interview interactions, conducting library research, and observing problems directly in order to obtain the necessary data.
2. Journal review
   Search for references needed during research in journals.
3. Theoretical foundation
   The theoretical foundation is a collection of materials that provide support in a study.
4. Problem identification
   This research aims to identify problems to be encountered and find solutions.
5. Planning
   Design and design what systems are needed in this expert system.
6. System analysis and design
   At this stage, the symptoms of the disease and the names of the 9 types of diseases are analyzed and adjusted. Next, the interface design of the expert system application that will be used to diagnose diabetes mellitus is carried out.
7. System testing
   At this stage, testing of the program is done to determine whether it is appropriate or not.

2.2. Problem Identification

The stage begins by analyzing problems that can later be used to describe system requirements in the context of information system development. The information obtained must also be true to what is happening in the field. At this stage, literature studies, observations, and interviews are carried out to collect the required data related to the research.

2.3. Data Collection Techniques

To support the research process, data relevant to the core of the problem is required. Therefore, several data collection techniques were used to increase effectiveness and efficiency, including:

1. Observation

   The observation stage begins with planning which includes submitting a request for permission to conduct observations at Haji Surabaya Hospital. After permission is granted, the next step is to determine the observation schedule in accordance with the mutual agreement. Then meet the SIMRS section. From the results of these observations, data were obtained that many patients with Diabetes Mellitus disease.

2. Interview

   Interviews were conducted with doctors who have knowledge about diabetes mellitus and the SIMRS department. The purpose of this step is to obtain data that cannot be found through literature study. Furthermore, the data collected will be organized into a rule base that will be used in the system.

3. Literature Study

   After successfully collecting data through observations and interviews, the next step is to conduct a study and search for references that are the basis for connecting research topics. The reference search was conducted through research journals and books relevant to the development of a web-based expert system to diagnose diabetes mellitus early using the Forward Chaining method. The purpose of this step is to gain a deeper understanding and in-depth information about this research through the data and knowledge obtained.

2.4. System Requirement Specifications

The focus of the system requirements specification is on the software to be developed by the author, with the aim of improving the quality of system processes. The author designs the interface layout to be used on the website.

1. Functional Requirements

   Functional requirements refer to the type of requirements that cover the various processes that can be carried out by the expert system. Here are some of the system requirements developed:

Table 1
Functional requirements

Code	Functional Requirements	Actor
KF-1	The system has the ability to display the login form.	Admin, User
KF-2	The system can display the registration form	User
KF-3	The system can manage (create, change, delete) user data	Admin
KF-4	The system can manage (create, change, delete) admin data	Admin
KF-5	The system can manage (create, modify, delete) symptom data	Admin

Code	Functional Requirements	Actor
KF-6	The system can manage (create, modify, delete) disease data	Admin
KF-7	The system can manage rule generation	Admin
KF-8	The system can manage the disease diagnosis process	User, Admin
KF-9	The system can provide disease diagnosis results	User, Admin

2. non-functional requirements

Non-functional requirements involve constraints on the services or functions provided by the system, with criteria from the usability reliability, performance, design-constraints sections.

2.5. System Design

1. Knowledge Base Modeling
   Implementation algorithm design is an iterative process that involves creative and analytical thinking. The goal is to transform algorithm concepts and ideas into executable program code that solves the targeted problem.
   a. Forward Chaining
      Forward chaining is an algorithm used in knowledge-based systems to perform forward reasoning. It uses existing rules in the knowledge base and known facts to generate new facts (Arfajsyah et al., 2018).
      Below are the steps of the Forward Chaining method implementation algorithm using the PHP programming language:
      1. Initialize the initial facts and knowledge base: You need to determine the initial known facts and store them in an array. In addition, you also need to specify a knowledge base consisting of rules that state the relationships between the facts.
      2. Check the existence of facts in the knowledge base: You need to check whether a fact exists in the knowledge base.
      3. Implement the forward chaining process: Perform the forward chaining process to generate new facts. This involves iterating through the rules in the knowledge base and checking if the preconditions of each rule are met. If the preconditions are met and the conclusion is not already present in the generated fact, add the conclusion to the generated fact.
      4. Output the result of reasoning: Print the knowledge base and facts formed as a result of reasoning.

      In the above implementation, the forward chaining process will run as long as there are changes in the generated facts. Each prerequisite of each rule will be checked based on the information contained in the knowledge base or previously generated. If all the prerequisites are met, then the conclusions will be added to the generated facts (Desi et al., 2011).

   b. Algorithm C4.5
      There are several steps that must be followed in making the C4.5 algorithm, namely:
      1. Prepare training data. Training data is generally obtained from historical records or past data that has been categorized into specific classes (Mujahidin & Pribadi, 2017).
      2. This process involves calculating the root of the tree by taking the square root of the selected attributes, as well as calculating the gain value for each attribute. At this stage, the first root will be determined based on the attribute with the highest gain value (Mujahidin & Pribadi, 2017). Before calculating the gain value of an attribute, the first step is to calculate the entropy value. The entropy value is calculated using the formula listed in equation 1:

$$Entropy\ (S) = \sum_{i=1}^{n} - pi * log_2\ pi \quad (1)$$

Description:
S : case set
n : number of partitions s
pi : the proportion of Si to S

3. Calculating the gain value using equation 2:

$$Gain(S, A) = Entropy\ (S) - \sum_{2}^{n} \left|\frac{Si}{S}\right| * Entropy\ (Si) \quad (2)$$

4. Repeat step two and step three until all records are partitioned.
5. The decision tree partitioning process will stop when:
   - All records in node N get the same class.
   - There are no attributes in the records that can be further partitioned.
   - There are no empty records in the branch.

2. Class Diagrams

Class Diagrams are made to provide a visual representation of the class structure in the system and display all the needs required by the system. The following is a class diagram of entity relations which can be seen in the following figure:

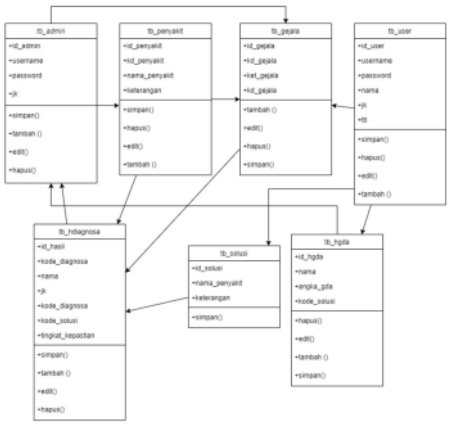

Fig. 2. Class diagram

3. Results and Discussion

3.1. Implementation Of System Design

After designing the interface design, the next step is to proceed with the system implementation process. In this step, the implementation of the design that has been compiled into the system is carried out.

1. Home Page View

   This page appears for the first time when a user accesses this system. On this page, there is a button to start diagnosing which, if clicked, will directly lead to the diagnosis page.

Fig. 3. Home page view

2. Login Page View

   On this page, users have the ability to perform an authentication process to gain access and use the facilities provided in this system.

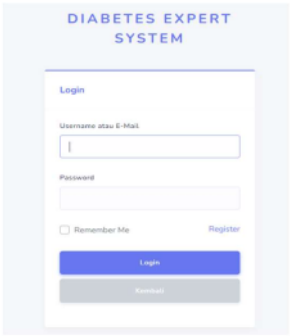

Fig. 4. Login page view

3. Diagnosis Page View

   On this page, users can select questions that match their symptoms. The order in which the questions appear is based on the tree structure present in the system, so the process can go directly to the disease that has symptoms corresponding to the question. This allows users to reach a diagnosis quickly and efficiently.

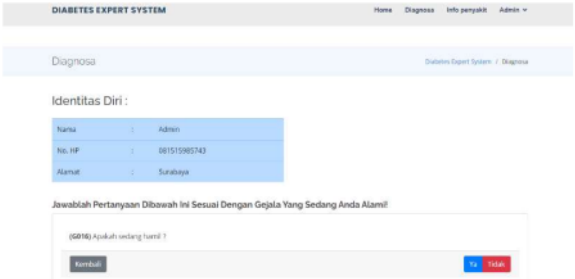

Fig. 5. Diagnosis page view

4. Diagnosis Result Page View

On this page, the diagnostic results experienced by the user appear which are obtained from the previous symptoms selected by the user. On this page, there is a list of questions selected by the user, the name of the disease, as well as a description and solution of the disease.

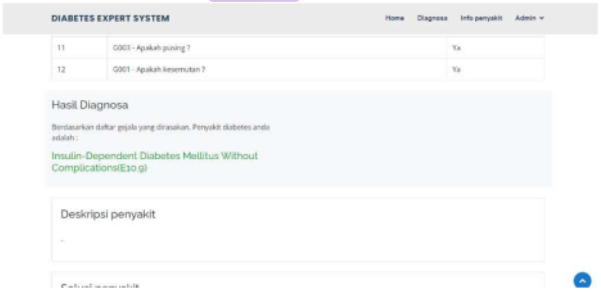

Fig. 6. Diagnosis result page view

5. Administrator Dashboard Page View

This page can only be accessed by administrators who are in charge of managing various data, such as symptom data, disease data, knowledge data, report data, and user data.

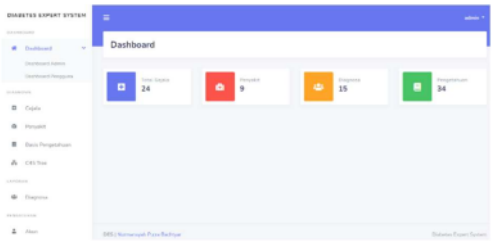

Fig. 7. Administrator dashboard page view

3.2. Black Box Testing

This test aims to evaluate the system that has been built to determine the performance and functionality of the system. This test is important to detect possible errors and ensure that all system components operate as expected. The test results can be found in the following table:

Table 2.
Black box testing

No	Process Name	Action	Expected Objectives	Results
1	Login	Access the system with the account that has been created	Log in to the home page	The system is running well
2	Diagnosis Page	Pressing the diagnosis button	The system displays the diagnosis menu	The system is running well

No	Process Name	Action	Expected Objectives	Results
3	Diagnosis result page	Select appropriate symptoms and complete questions to see results	The system displays the diagnosis results of the selected symptoms along with some information	The system is running well

3.3. System Accuracy Testing

Testing is carried out to see the suitability of the results, by comparing the results of diagnoses from experts and from expert systems, the test results can be seen through the following table:

Table 3.
System accuracy testing

No	Symptoms	System	Expert	Status
1	G014, G019	Non-Insulin-Dependent Diabetes Mellitus With Renal Complications	Non-Insulin-Dependent Diabetes Mellitus With Renal Complications	Accurate
2	G004, G001, G010	Insulin-Dependent Diabetes Mellitus	Insulin-Dependent Diabetes Mellitus	Accurate

4. Conclusions And Suggestions

4.1. Concusions

This diabetes mellitus expert system that uses the Forward Chaining method aims to provide early information to patients with diabetes mellitus about the symptoms and types of diseases they are experiencing. The development of this information system uses the C4.5 method, where the formation of the process flow can be done automatically through the calculation of the algorithm according to the dataset entered.

From the results of this study, it can be concluded that the use of the forward chaining method using tree techniques in organizing the flow of questions selected by the user, is quite effective for diagnosing diabetes mellitus.

4.2. Suggestions

Some suggestions from this research include the following:

1. Hopefully, this system can be widely used by the community and hospitals with the support of reliable servers or hosting.
2. It is hoped that this system is developed with other programming languages or other frameworks with android development so that this expert system can be implemented more widely..

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