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Implementation Of The Case Based Reasoning (CBR) Expert System Method For Heart Disease Diagnosis Based On Patient Symptom History (Case Study Of Mitra Lewo Clinic)

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Abstract

Cardiovascular disease ranks among the primary causes of mortality in Indonesia. An expedient and precise diagnostic method is crucial, particularly in primary healthcare settings such as Klinik Mitra Lewo, which face constraints on medical personnel. This research aims to develop a web-based expert system using the Case-Based Reasoning (CBR) methodology to support preliminary diagnosis of heart disease based on a patient's symptom history. The CBR approach functions by juxtaposing new patient symptoms with historical cases via the stages of Retrieve, Reuse, Revise, and Retain. This system is developed using an Object-Oriented Software Engineering (OOSE) methodology and implemented in PHP using the CodeIgniter framework. System testing employs black-box testing techniques to verify that each functionality satisfies user requirements. The research findings demonstrate that the system can offer pertinent initial diagnostic recommendations and assist medical professionals in decision-making. Consequently, an expert system can be a valuable asset in healthcare, especially when medical resources are constrained.

Keywords : *Expert System, Case Based Reasoning (CBR), Heart Disease Diagnosis, Klinik Mitra Lewo, PHP, CodeIgniter*

INTRODUCTION

The swift progression of information technology has profoundly influenced multiple sectors, including healthcare. In the digital era, computer-based solutions are employed to facilitate medical services, including symptom identification and disease diagnosis. (Antoni, 2023; Dona, D., Maradona, H., & Masdewi, 2021) An implementation of this is the expert system, a knowledge-based system that replicates an expert's decision-making process. In medicine, expert systems have been extensively utilized to assist in identifying numerous ailments, including heart disease, which is among the leading causes of mortality globally. The World Health Organization (WHO) and the 2018 Basic Health Research (Riskesdas) report that the prevalence of heart disease in Indonesia is 1.5% of the entire population, highlighting the ongoing seriousness of this health issue. Klinik Mitra Lewo has documented 127 patients exhibiting symptoms or diagnosed with cardiac disease; however, the diagnostic process remains manual and contingent on physicians' expertise, resulting in time constraints and an elevated workload—an

interview with Dr. Rahmi Handayani, Sp.KJ indicated that the history of patient symptoms is essential for the preliminary diagnosis of cardiac disease. A computer-based system is required to facilitate the diagnostic process by employing patient symptom data as a foundation for decision-making.

Expert system

BHUIYAN, M. I., WAH, C. H., KAMARUDIN, N. S., ISMAIL, N. H., & AB NASIR (2024) and (Setiani, R., Djatmiko, W., Kurniawan, R. A., & Abdullayev, 2025) define an expert system as a computer system that emulates an expert's decision-making capabilities. This system integrates specialized knowledge and reasoning processes to address issues in particular domains. The primary objective of the expert system is to aid users in making more precise and efficient selections by leveraging a structured knowledge base, rather than to supplant human involvement.

Artificial Inteligence

Mustafa, E. M., Saad, M. M., & Rizkallah (2023) and (Hafizhan, A., & Fauzi, 2025)defines artificial intelligence (AI) as a domain of computer science dedicated to developing systems capable of executing activities that require human intelligence, including learning, reasoning, and problem-solving. In the realm of medical expert systems, AI enables computers to replicate physicians' cognitive processes for diagnosing conditions based on symptomatology and patient history.

Case Based Reasoning Method

Case-Based Reasoning (CBR) is an artificial intelligence methodology that addresses novel challenges by leveraging insights from prior examples. (Fadilah, N. E., Maulita, Y., & Khair, 2023; Rimanti, D., & Fahmi, 2022) The CBR process comprises four primary stages:

1. Retrieve: locating a previous case that closely parallels the current one.
2. Reutilization: employing the resolution from the previous case to tackle the current issue.
3. Revise: modifying the answer in accordance with real results.
4. Retain: archiving the new case in the knowledge base for subsequent reference.

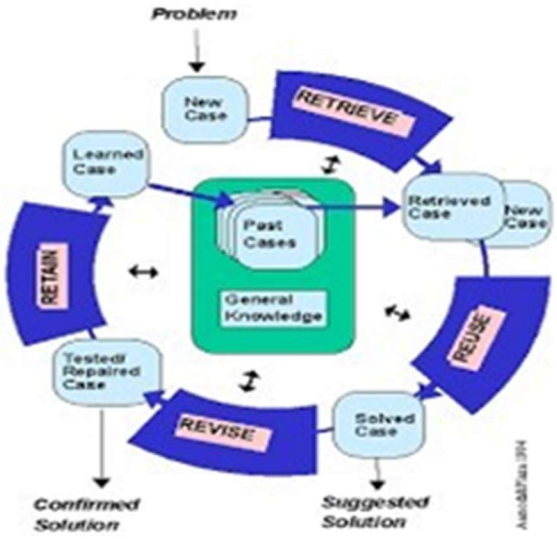

Figure 1. CBR Method Cycle

This method is appropriate for use in illness diagnosis systems, as each patient has a distinct symptom history and often exhibits parallels to prior cases. (Pratama, 2022)

Unified Modeling Language (UML)

Zhang, C., Zhu, Q., & Li (2023) states that the Unified Modeling Language (UML) is a standardized modeling language employed for the design and documentation of software systems. UML offers a standardized notation for modeling diverse facets of software systems.

a. A use case diagram is a modeling representation that depicts the interaction relationships between one or more actors and the system or application under development.
b. A class diagram is a principal diagram in UML that represents the static structure of a system.
c. An activity diagram is a modeling diagram that illustrates the workflow or process flow of a developed system. This diagram depicts the system's operations, rendering the actors' activities invisible.
d. A sequence diagram is a UML diagram that illustrates the interactions among system components in chronological order. This diagram depicts the communication between objects via message passing inside a defined scenario or process, from initiation to conclusion.

Numerous prior studies have used the Case-Based Reasoning (CBR) methodology to identify cardiac conditions; however, they face drawbacks, including a narrow range of disease classifications, fixed symptom weighting, and insufficient validation by qualified medical professionals. This project develops a web-based expert system that employs the CBR approach to

facilitate the preliminary diagnosis of heart disease based on patient symptom history at Klinik Mitra Lewo.

METHOD

The system development employs the Object Oriented Software Engineering (OOSE) paradigm. The OOSE methodology prioritizes use cases, facilitating comprehension through its straightforward notation while encompassing all stages of software engineering. The phases of system development are as follows:

1. Requirement Model, which entails the identification of system needs through the subsequent steps:
    a. Observational Study, a direct assessment of the procedure to ascertain the quantity of incentives available through the webpage.
    b. Literature Review, which involves examining texts and sources pertinent to web application development.
2. Analysis Model, wherein the gathered data is examined to ascertain system requirements and identify requisite items.
3. Design Model: At this phase, the system is constructed based on the analysis outcomes. This design encompasses system architecture, business processes, user interfaces, and interactions among system components. Modeling technologies, such as Unified Modeling Language (UML), are employed to facilitate the design process and comprise the following elements:
    a. Employ a Use Case Diagram to depict the interactions between users and the system.
    b. Class Diagram to represent data structures and interrelations among classes.
    c. Activity Diagram to illustrate the dynamic workflow of the system.
4. Implementation Model, wherein the design outcomes are transformed into executable code.
5. Model Testing: Following system implementation, testing is performed to verify its functionality and alignment with user requirements. Testing is conducted with the Black-Box Testing method, which emphasizes the system's functioning without scrutinizing its internal structure or code. This method relies on validating the system's inputs and outputs against established specifications.

RESULTS AND DISCUSSION

System Implementation

An expert system for diagnosing heart disease using the Case-Based Reasoning (CBR) technique has been successfully developed in PHP and MySQL. This system comprises two

primary participants: physicians and patients. Physicians possess comprehensive access rights to administer illness data, symptoms, relationships, and patient diagnostic reports. Patients can perform self-consultations via the online interface by selecting their symptoms, after which the system provides an initial diagnosis and medical treatment recommendations. The system interface is engineered to be intuitive and responsive for user convenience. The primary menu includes functionalities such as physician login, management of disease and symptom data, symptom correlations, compilation of diagnostic reports, and a patient information page on diseases.

System Testing

Testing was performed using the Black-Box Testing methodology, which focuses on the system's functionality without analyzing its internal code. The test findings indicate that all primary functionalities, including login, disease and symptom data management, diagnostic processes, and user reporting, operated as anticipated.

Diagnostic Accuracy Test Results

A performance evaluation of the system was conducted by comparing its diagnostic results with those of physicians at Klinik Mitra Lewo, utilizing data from 127 patients. The outcomes are displayed in the subsequent table:

Table 1. Results of the Diagnostic Comparison Test

No	Diagnosis Dokter	Number of Cases	Expert System Compliant	Expert System Not Suitable	Accuracy Level
1.	Aritmia	24	23	1	95.00%
2.	Heart failure	28	26	2	91.67%
3.	Heart Valve Disease	21	20	1	94.44%
4.	Non-Cardiac Cases	18	15	3	80.00%
5.	Perikariditis	19	18	1	93.75%
6.	Disease Jantung	17	16	1	92.86%
Total		**127**	**118**	**9**	**92.91%**

The testing findings indicate that the system attained an accuracy of 92.91%, demonstrating a robust correlation with the diagnosis provided by specialist physicians. The discrepancies noted in specific instances are ascribed to the resemblance of symptoms across different forms of heart disease.

Design

a. Use Case Diagram

The use case provides a comprehensive description of the functionality available to users of the heart disease detection expert system, which utilizes the Case-Based

Reasoning approach at Klinik Mitra Lewo. This use case encompasses interactions between system users (patients) and system administrators (doctors) during essential operations, including the diagnostic process, maintenance of symptom and disease data, provision of solutions, and reporting of diagnostic outcomes.

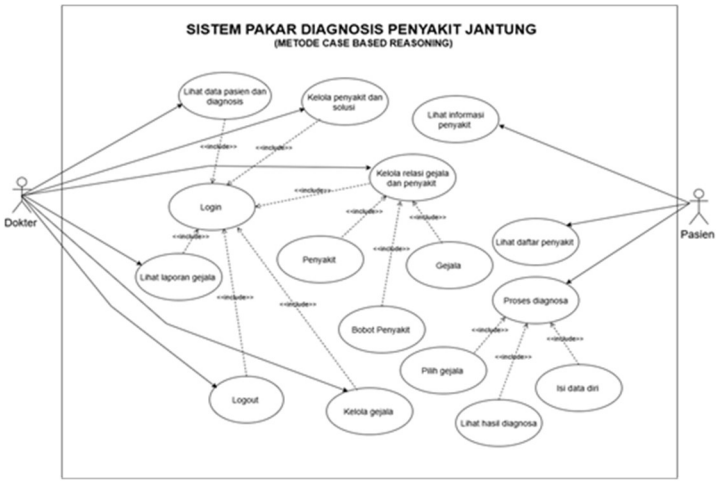

Figure 2. Use Case Diagram

Tabel 2. Spesifikasi Use Case Dokter Melakukan Login

Element	Description
Use Case Name	Login
Actor	Doctor
Description	This use case allows doctors to access the system by entering a valid username and password. After successfully logging in, doctors are directed to the dashboard page where they can
Pre-condition	The doctor is not logged in and is on the system login page.
Post-condition	The doctor successfully logged in and is on the dashboard page.
Main Flow	1.The doctor opens the login page.
Alternative Flow	1. If the username or password is incorrect, the system will display the error message "Incorrect username or password." 2. 1. If the username or password is incorrect, the system will display the error message "Incorrect username or password."

Table 3. Diagnostic Process Use Case Specifications

Element	Description
Use Case Name	Self-Diagnosis Process
Aktor	Patient
Deskripsi	Patients can select the symptoms they are experiencing. The system will then process the diagnosis using the CBR method and display the diagnostic results and treatment solutions.
Pre-condition	The patient has opened the diagnosis page.
Post-condition	The diagnostic results and solutions are displayed.
Main Flow	1. The patient opens the diagnosis page. 2. The system displays a personal data form. 3. The patient enters personal data. 4. The system saves the data and displays a list of symptoms. 5. The patient selects the symptoms they are experiencing. 6. The system processes the diagnosis using the CBR method.
Alternative Flow	1. If the personal data is not filled in completely, the system will display a validation message. 2. If no symptoms are selected, the system will display the message "You have not selected any symptoms, please select a symptom."
Special Notes	The personal data entered will be saved and used in the diagnostic report.

Table 4. Use case diagram specifications View Patient Data and Diagnosis

Element	Description
Use Case Name	View Patient Data and Diagnosis
Actor	Doctor
Description	Doctors can view, browse, and delete diagnostic report data consisting of patient information and heart disease
Pre-condition	The doctor has logged in and opened the “Patient Report”
Post-condition	Certain reports were successfully deleted along with their
Main Flow	1. The doctor opens the "Patient Report" menu. 2. The system displays a list of users and their diagnosis results. 3. The doctor selects the delete button on one of the entries. 4. The system displays a confirmation. 5. If approved, the data is deleted and the list is updated.
Alternative Flow	1. If the doctor cancels the deletion, the system will abort the process. 2. If the connection to the database fails, the system will display an error message.

Special Notes	The patient report page displays a combined list of patient data and diagnostic results. Therefore, when a doctor deletes one record from the list, all related patient information and diagnostic history will be deleted simultaneously. The system will ask for confirmation before the deletion process can proceed.

b. Activity

The activity diagram models the workflow and activities within the expert system. This section will elucidate each activity, outlining the procedures from initiation to completion, as well as the interconnections across activities that facilitate the business operations within the system. This encompasses procedures like data entry, symptom selection, diagnosis retrieval, and report creation, demonstrating the flow and interconnections that enable efficient operation.

Login Activity Diagram

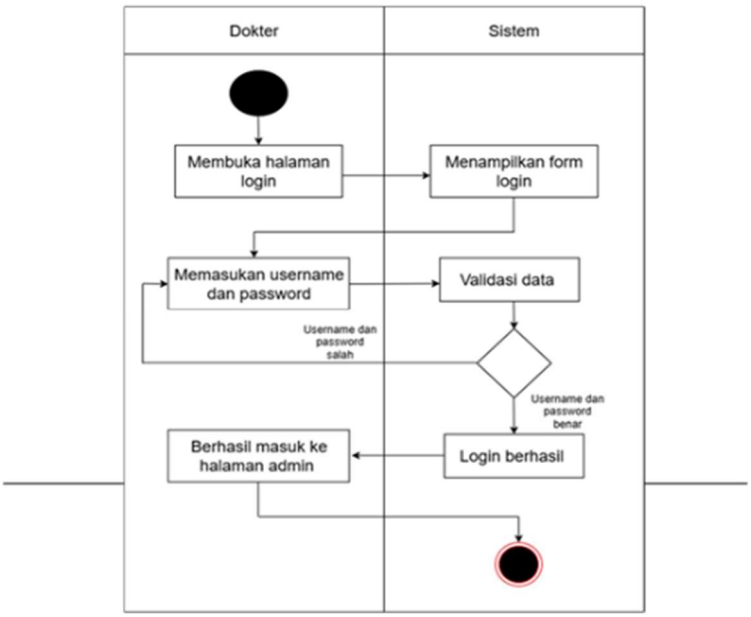

Figure 5. Login Activity Diagram

Activity Diagram of the Diagnostic Process

Figure 6. Activity Process Diagram

Activity Diagram View Patient Data and Diagnosis History

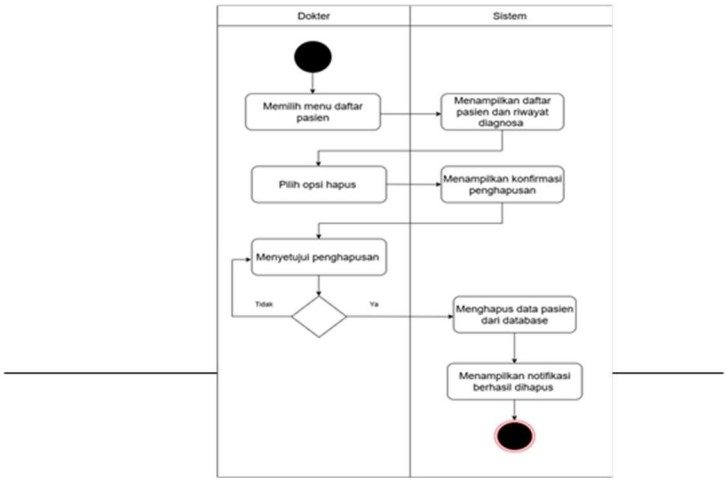

Figure 7. Activity Diagram View Patient Data and Diagnosis History

c. Sequence Diagram

The sequence diagram elucidates the chronological order of processes executed within the system to fulfill the objectives specified in the use case. This design utilizes approaches that conform to the specifications of the system created by Klinik Mitra Lewo. It delineates interactions across diverse components, including the sequence of exchanged messages that direct the execution of operations such as symptom input,

diagnosis processing, and result delivery, thereby providing clarity on each stage's contribution to the overall workflow.

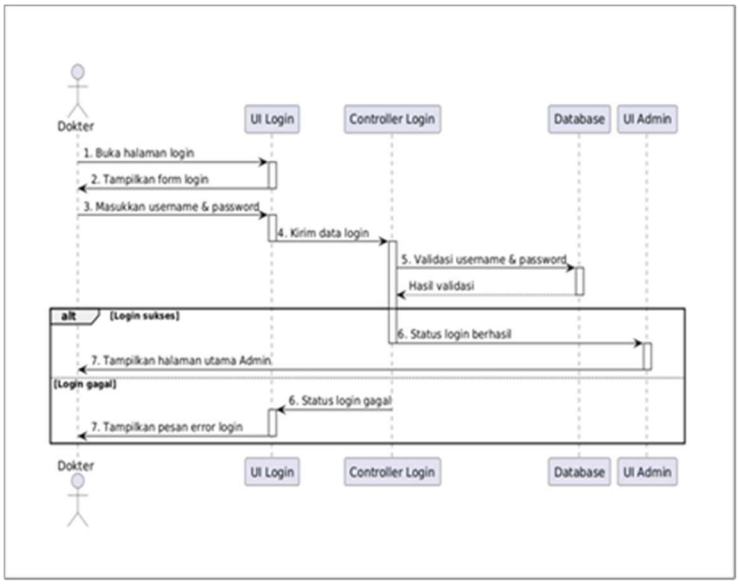

Figure 8. Login Sequence Diagram

d. Class Diagram

The class diagram delineates the study of utilized classes, with particular emphasis on entity classes. The class diagram in this expert system illustrates instances of items derived from the established classes. It delineates the characteristics and interrelations among these classes, demonstrating how various entities such as patients, symptoms, diseases, and diagnoses interact inside the system, so establishing a coherent framework for data administration and functionality.

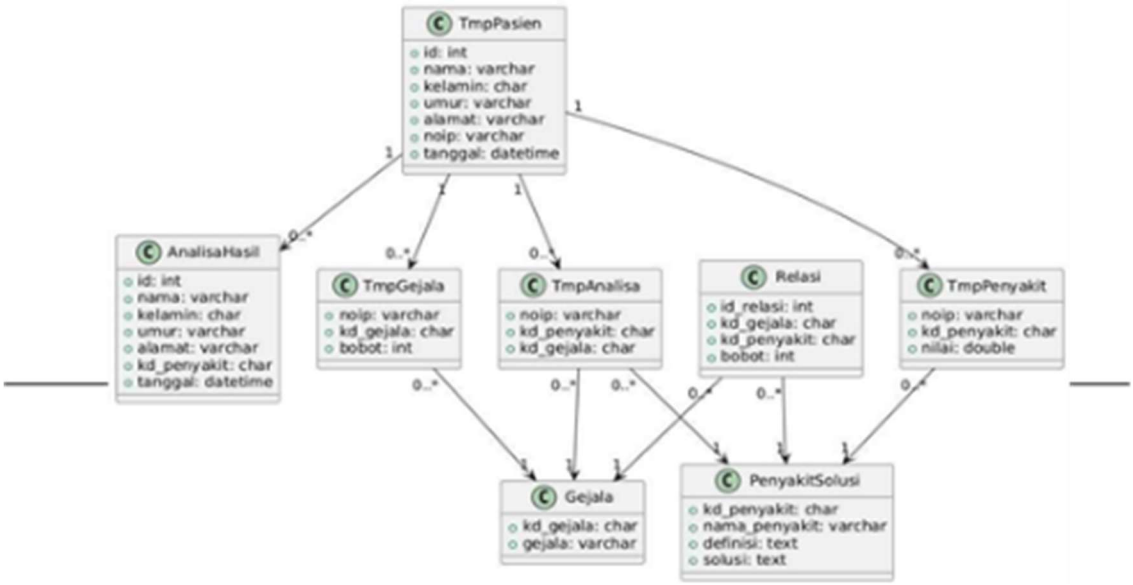

Figure 9. Class Diagram

e. Implementation

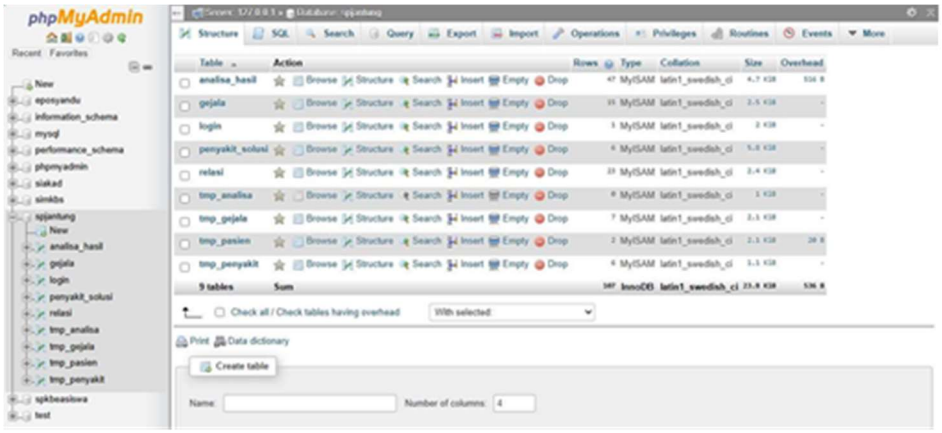

Figure 10. Database Table

f. Interface Implementation

During the implementation phase, the interface was developed based on the designs finalized in earlier stages to improve user comprehension of the system. This facilitates user navigation and interaction with the features, hence improving their overall experience and efficiency in utilizing the system.

a. Doctor Login Page

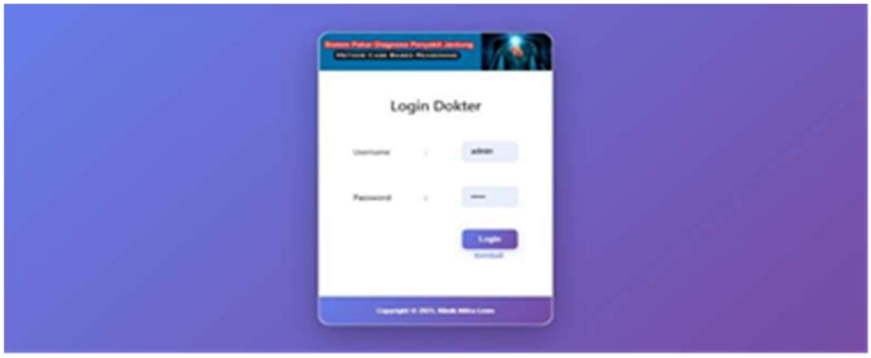

Figure 11. Doctor Login Page

b. Diagnostic Process Page

The diagnosis process page is a pivotal component of the expert system, intended for consultations based on the patient's symptoms. Users can select several symptoms that correspond to their condition from a list of checkboxes on this page. This feature facilitates an intuitive interaction, permitting precise symptom entry for reliable diagnosis.

Figure 12. Diagnostic Process Page

c. Disease data management and solutions page

This page allows users to add, view, modify, or delete illness data, including definitions and solutions. The input form at the top facilitates user entry of the disease code, disease name, definition, and management solution. This feature optimizes data administration, enabling users to effectively oversee the information within the system.

Figure 13. Manage Disease Data and Solutions Page

d. Diagnosis Report Page

This exhibit presents a list of individuals diagnosed with heart disease. The table contains data including serial number, username, gender, age, address, diagnosed illness, and diagnostic date. This style offers a concise summary of patient information, enhancing the evaluation and administration of diagnostic reports.

Figure 14. Diagnosis Report Page

g. Testing

The employed testing methodology is Black Box Testing, which assesses the system's functionality without regard to its internal architecture or code. Using this method, testers evaluate whether the system's output matches the given input. This methodology prioritizes user experience and ensures the system meets its designated specifications.

Table 5. Test Results Using the Black Box Testing Method

No	Functions Tested	Testing Method	Expected results	Test Results

1	Login Page View	Go to the login page	Displays a login form with username and password input and a login button.	Ok
2	Admin Dashboard Page View	Log in as admin	Can display the main admin dashboard.	Ok
3	Disease and Solution Page View	Click on the disease and solution menu	Displays a list of diseases and can add, edit, and delete.	Ok
4	Symptom Data Page View	Click the symptoms menu	Displays a list of symptoms and can add, edit, and delete them.	Ok
5	Page View Relationships	Click the relationship menu	Displays a table of the relationship between symptoms and diseases.	Ok
6	Symptom Report Page View	Click the symptom report menu	Displays a symptom input report from the diagnostic process.	Ok
7	User Report Page View	Click the user report menu	Displays a list of diagnostic results performed by the user.	Ok
8	Disease Addition Function	Click add disease in the disease and solution menu	New disease successfully stored.	Ok
9	Edit Function Penyakit	Click edit on one of the diseases	The edit form appears and the disease can be updated	Ok
10	Disease removal function	Click delete on one of the diseases	Disease successfully removed from database.	Ok
11	Add Symptoms Function	Click add in the symptoms menu	New symptom saved successfully.	Ok
12	Symptom Edit Function	Click edit on one of the symptoms	The edit form appears and symptoms can be updated..	Ok
13	Remove symptom function	Click delete on one of the symptoms	The symptom was successfully removed from the database.	Ok
14	Add Relation Function	Add a relationship of symptoms to disease	The relationship was successfully added and appears in the relationship list.	Ok
15	Admin Logout Function	Click the logout button	Admin is logged out of the system and redirected to the login	Ok

16	Incorrect Login Validation	Incorrect username or password input	An error message appears that the username and password are incorrect.	Ok

CONCLUSION

The web-based expert system has been successfully designed and constructed to aid in the diagnosis of heart disease, according to research on the implementation of an expert system using the Case-Based Reasoning (CBR) method for diagnosing heart disease based on patient symptom history at Klinik Mitra Lewo. By using a case-based approach from past data, this system may simulate expert reasoning and offer pertinent diagnosis recommendations. The four primary stages of the CBR approach are Retrieve, Reuse, Revise, and Retain. These stages use similarity computations based on symptom weights to automatically seek comparable cases. As a result, the technology can provide diagnostic results that nearly match expert analysis.

An accuracy of 92.91% was obtained in the accuracy test, which compared the system's diagnoses with those of physicians at Klinik Mitra Lewo. This figure shows how well the system can provide preliminary diagnosis results that correspond with the physicians' findings. In medical expert system research, an accuracy rate of 90% or more is considered excellent and acceptable from a scientific standpoint, indicating an error rate of less than 10%. As long as physicians validate the system's findings, a 92.91% accuracy rate in diagnosing heart disease is considered safe for use as a supplementary tool for initial diagnosis.

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