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Application of Forward Chaining and Rule-Based Reasoning Methods to Design an Expert System for Pregnant Women Disease Diagnosis in a Private Hospital

Abdul Tahir[1]✉, Donny Hendriyanto[2], Ana Faizah[3], Jamil Anshory[4], Rofiq Harun[5]

[1]Akademi Teknik Sorowako
[2]Universitas Andalas
[3]Universitas Batam
[4]Universitas Mulawarman
[5]Universitas Ichsan Gorontalo

abdultahir0101@gmail.com

Abstract

This research aims to discover how to create and implement an expert system for prenatal disease diagnosis. To prepare this study, the author employed several data collection techniques, including observation, interviews, and a literature review. The system to be designed was developed using an object-oriented paradigm and a Rapid Application Development (RAD) technique. Multiple development stages are involved in creating RAD, including requirement planning, workshop design, and implementation. Based on the study findings, it was discovered that the PHP programming language, MySQL database management system, Apache web server, UML tool, and RAD system development methodology were used to create an expert system for identifying illnesses in expectant mothers. The forward chaining method is used for this expert system, where the first stages are to create an inference tree and set rules. This system likewise computes the consistency test using the Bayes theorem method. With an 80% accuracy rate, SISPADIBU can be used as a diagnostic tool for disorders related to pregnancy. SISPADIBU can use the user-entered symptoms to present the diagnosis results. According to the survey results, 80% of users said that SISPADIBU was highly user-friendly, that the layout display was simple to use, and that it was constructive in educating users about pregnancy disorders.

Keywords: Expert Systems, Forward Chaining, Diseases Of Pregnant Women, Bayes Theorem.

1. Introduction

A hospital is a type of healthcare facility that offers emergency, outpatient, and inpatient care to fulfill the needs of each patient. A maternity and child hospital with amiable and professional personnel that provides the most significant health services and focuses solely on women and children is packaged together. Medical services are developed based on patient safety principles, which refer to the Indonesian Ministry of Health, the Indonesian Hospital Association, and World Health Organization (WHO) guidelines [1]. The number of patients undergoing examinations and patients suffering from the disease continues to increase, while there are only four doctors available and no additional doctors or experts every year, so time for consultations is limited. Users also have difficulty finding information and knowledge related to diseases in pregnant women [2]. Therefore, there is a need for an expert system in hospitals that can diagnose health problems in pregnant women and provide knowledge regarding diseases of pregnant women and their treatment [3]. This expert system for interpreting the diseases of pregnant women will adopt the working method of a specialist in obstetrics and gynecology in diagnosing the disease of a pregnant woman patient and, as far as possible, will be able to provide a detailed explanation of the disease [4]. In determining the quality of a system, a measuring aspect is needed that can be a reference for how satisfied users are with the use of the system. However, of course, an expert system for diagnosing pregnant women's diseases will not immediately replace the work role of a specialist obstetrician-gynecologist as a whole [5].

Design, or drafting, in the context of system development, is a series of procedures that aim to transform the results of a system analysis into a programming language [6]. The main goal of design or drafting in system development is to describe how the system components will be implemented. This design process involves preparing a plan or model that includes all system specifications, giving it a shape, and establishing the required structure. Therefore, system design is a crucial stage in system development that involves all aspects of the desired solution [7]. On the other hand, system development or building includes creating a new system or making changes and improvements to an existing system as a whole [8]. In this context, system development can

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involve developing a new system from scratch or upgrading and repairing a current system. This process includes the implementation of previously designed plans and models. So, system design can be considered an overall plan or model that consists of all system specifications and provides the required shape and structure [9]. This is a critical phase in systems development because it defines how the information system will be implemented to achieve the desired problem-solving solution. Thus, design translates system analysis results into a tangible form by creating a new system or improving an existing one [10].

Artificial intelligence (AI) can be defined as the concept of intelligent machines or devices, generally in the form of computers, capable of carrying out certain tasks that usually require human intelligence. Artificial Intelligence (AI) is becoming an essential component of the computing world and needs to be grounded in sound theoretical foundations and concepts. These concepts cover the data structures used to store knowledge, the algorithms needed to use that information, and the programming languages and methods employed to put those algorithms into practice [11]. Artificial intelligence is a science that aims to make computers capable of performing activities with the same level of intelligence as people typically do. It is not only a technology application. Thus, artificial intelligence (AI) spans several fields, such as computer vision, machine learning, natural language processing, and more [12]. A robust and theoretically sound approach to implementing artificial intelligence is essential to achieving reliable and efficient results. In this context, the conclusion can be drawn that artificial intelligence is a part of the world of computing that aims to create machines or computers that can execute tasks with a level of intelligence approaching or exceeding human capabilities [13]. This involves applying computer science principles and knowledge to create technology that can learn and adapt, thereby completing tasks like humans [14].

A computer program or software package designed to offer guidance and support in problem-solving within specific specialist domains, such as science, mathematics, engineering, medicine, education, and so on, is called an expert system [15]. An expert system is a computer program that solves problems that often need the expertise of subject matter specialists. It does this by applying knowledge, facts, and reasoning procedures. An expert is an individual who has special knowledge, understanding, experience, and methodology used to solve problems in a particular field [16]. Knowledge creators translate and present knowledge obtained from an expert, whether derived from the expert's problem-solving experience or other documented sources, into a format that the expert system can accept [17]. In this case, knowledge creators interpret and represent the knowledge obtained through answers to questions asked by experts or understanding analogical, systematic, and conceptual depictions obtained from reading several printed documents such as textbooks, journals, papers, etc. A system builder is a person whose job is to design an expert system user interface, translate knowledge that the knowledge builder has translated into a form appropriate and acceptable to the expert system, and implement it into an inference engine [18]. The system builder is also responsible for whether the expert system will be integrated with other computerized systems [19].

Pregnancy is a natural process that begins with fertilization, or the union of sperm and ovum, which is then continued with nidation or implantation in the uterus [20]. The average duration of pregnancy lasts 40 weeks, calculated from the time of fertilization until the baby's birth. This process is part of a series of fertilizations that aim to continue the offspring naturally, producing a fetus that will grow and develop in the mother's womb. The sperm's journey to reach the egg (ovum) is a struggle full of challenges [21]. Pregnancy begins with the successful meeting of sperm and egg, followed by nidation or implantation of the embryo into the uterine wall. Fetal growth and development begin at conception and continue until the beginning of labor [22]. A woman who has started the pregnancy period, which lasts from conception to the birth of the fetus, is said to be pregnant. A typical pregnancy lasts forty weeks, starting when the last menstrual cycle ends [23]. Fetal movements that are palpable or visible within the uterus and the fetal heartbeat that can be detected using an ultrasound, stethoscope, cardiotocography equipment, or EKG are specific indicators of pregnancy. Pregnant women who have high-risk factors may be considered at-risk, and special medical procedures may be required to monitor and manage the pregnancy [24]. Pregnancy risks include conditions that can affect the health of both mother and baby, so special care and extra monitoring are needed. In conclusion, pregnancy is a natural journey that begins with the union of sperm and egg, involves fetal growth, and has risks that need to be considered and managed carefully.

2. Research Methods

Data collection is a procedure carried out systematically and standardly to obtain the data needed for research. The author used various data collection techniques, such as literature study, interviews, and observation, to prepare this study. The author used Rapid Application Development (RAD) with an object-oriented system development methodology. There are multiple phases of system development when using the RAD technique. The first is the requirement planning stage, where the author interacts directly with related parties to understand the current system requirements. Next, the workshop design stage is to design a system solution that can solve the previously identified problems. The final stage is implementation, where the design of the expert system for diagnosing diseases in pregnant women is converted into a form that machines can understand, namely, a

program or program unit. In this process, the use of the RAD method allows system development that is fast and responsive to changing needs. We hope this overall methodology can produce an expert system that effectively and efficiently diagnoses diseases in pregnant women. The development of this system not only pays attention to technical aspects but also considers user needs and the problems to be resolved.

3. Results and Discussion

The service process in a hospital describes a structured system to provide comprehensive care to patients. After the patient registers and includes personal information, the employee carefully conveys the patient's data and medical records to the doctor, who will provide the consultation. During the consultation, the patient can talk to the doctor about the symptoms he is experiencing, allowing for a holistic understanding of his condition. The doctor, after conducting an evaluation, prescribes medication or treatment that is appropriate to the diagnosis. The next step involves the patient handing over the prescription and paying for the doctor's services to the employee. This process ensures transparency and patient involvement in their care decisions. After that, the patient continues to take the prescribed medications.

Meanwhile, employees periodically prepare monitoring reports containing relevant information regarding patient services. The employees then submit this report to the prominent director of the hospital, ensuring the continuous improvement of service quality. The system creates an efficient and organized workflow, paying particular attention to patient needs and well-being. Hospitals can keep raising the caliber of their medical services by incorporating a range of stakeholders, including patients, physicians, and chief directors.

Since it offers remedies to issues found, creating an expert system for hospital diagnosis of disorders in expectant mothers is also anticipated to have a favorable overall effect. First of all, adopting this expert system can increase the availability of accurate and fast information for specialist doctors, enabling them to make more precise and effective decisions in treating the health conditions of pregnant women. Furthermore, by improving the efficiency of the consultation process through an expert system, the limited time for consulting a doctor can be better optimized. This enhances the quality of service to patients and provides comfort and trust for pregnant women undergoing treatment at the hospital. Apart from providing direct solutions to problems, the processing and integrating anamnesis data and information related to diseases in pregnant women by an expert system will also contribute to developing medical knowledge in hospitals. Doctors and medical personnel can access information more efficiently, increasing their ability to provide care following the latest developments in pregnant women's health. Thus, developing this expert system is not only a technological solution but has an overall positive impact on the efficiency, accuracy, and quality of health services for pregnant women in hospitals.

The creation of an expert system for identifying illnesses in expectant mothers is the hospital system that is most supportively suggested. In designing this system, the author presents an overview and a rich picture of the proposed system as a strategic step to overcome the problems that have been identified. First, administrators are responsible for managing user data and ensuring the integrity and security of information related to system users. Furthermore, the administrator also has a role in collecting data on symptoms, diseases, and treatments so that the system has a comprehensive knowledge base. On the user side, the third step involves the disease diagnosis process by entering the symptoms experienced by the patient. Users can easily access the system, provide the necessary information, and carry out diagnoses without being limited by time constraints or difficulty finding information. The final step in the proposed rich picture system is that the system displays the diagnosis results. This information can guide specialist doctors on how to make more informed and appropriate decisions. Hopefully, this expert system can positively contribute to increasing the efficiency and accuracy of diagnosing diseases in pregnant women in hospitals, providing better services, and focusing on patient needs.

According to this activity diagram, the actor must first input their account and password to access the expert system before they may engage with it. After entering the login information, the system verifies the username and password. If the data is valid, the system will allow access to each actor's main page, providing ease in navigation and use of the system. However, if a mismatch occurs, the system will return to the login page, allowing users to correct their login information. Furthermore, the activity diagram involves all actors in the profile change process, an essential feature for personalizing the user experience. Actors can select the option "change profile," which leads to displaying the change profile form. After entering the required data, the actor decides to "update," the system provides a confirmation message: "Data changed successfully." Users can be confident that the changes they made have been successfully saved. On the admin side, the activity diagram shows their role in managing user, symptom, and disease data. Admins can select the user, symptom, or disease management menu, open a list of related data, and perform actions such as adding, changing, or deleting data as needed. The system saves the changes made by the admin, maintaining data integrity and ensuring accurate information. Overall, this activity diagram provides a comprehensive picture of the interactions between actors and the expert system, highlighting the secure login process, user profile personalization features, and the

admin's ability to manage data efficiently. These diagrams help understand the system workflow clearly and ensure a good user experience and organized data management.

In this diagram activity, the central role of the actor is admin, whose aim is to manage treatment data. The process begins with the admin selecting the medication management menu, which leads to the display of the medication data list. Admins can add, change, or delete treatment data as needed. The system will save the changes made by the admin after managing treatment data, ensuring reliability in the management of treatment-related information. Furthermore, the activity diagram involves the user in diagnosing the disease. The user starts by selecting the diagnosis menu, and the system displays a list of symptoms. The user selects the gestational age and relevant symptoms and then selects the submit option. The system then provides diagnosis results, allowing users to obtain information regarding health conditions they may be experiencing. The next step is for the user to see the diagnosis results provided by the system. After selecting the submit button, the system displays the diagnosis results, and the user can view relevant information regarding the diagnosed health condition. This provides users clarity regarding the following steps based on the diagnostic results provided. Finally, the activity diagram explains the process of exiting the system, where all actors can log out by selecting the logout menu. The system will log the actor out of the system and return to the login page. This step provides security and terminates the system's legitimate user or admin access. Overall, this activity diagram provides a clear picture of the interactions between actors and systems in treatment data management, disease diagnosis, display of diagnosis results, and safe exit from the system.

In the login sequence diagram, system users involving all actors are required to log in as an initial step before accessing the features in the system. The process begins with the user opening the application with a login page. After that, users input their password and username. Subsequently, the system confirms the login and password entered. Following each actor's function, the system will route the user to the main page if verification is successful. However, if validation fails, the system will return to the login page, allowing the user to enter the correct login information. In a sequence diagram involving the change profile feature, the actor selects "change profile," and the system retrieves user data to display in the change profile form. Once actors change profile data, they choose the option "update," the system saves the changes to the database, ensuring the integrity of up-to-date user data. Actors can select the user management menu in the user management sequence diagram. The system displays a list of user data, and actors can add, change, or delete user data. Once the actor has finished managing the user's data, they select the option "save," the system saves the changes into the database, maintaining the accuracy and completeness of the user's information. The actor chooses the symptom management menu in the symptom management sequence diagram. The system displays a list of symptom data; actors can add, change, or delete symptom data. Once the actor has finished managing the symptom data, they select the option "save," and the system saves the changes into the database, ensuring the availability and accuracy of the symptom information. Overall, this sequence diagram provides an overview of the steps carried out by actors in logging in and managing profiles, users, and symptoms in the system. This process is well structured, ensuring security, data integrity, and efficient accessibility of system features.

The actor can select the menu in the sequence diagram depicting disease management. The system then displays a list of disease data, allowing actors to add, change, or delete disease data. Once the actor has finished managing the disease data, they select the option "save," the system automatically saves the changes into the database, ensuring the integrity and up-to-date of the disease data. In the treatment management sequence diagram, the actor can select the related menu, and the system will display a list of treatment data. Actors have the option to add, change, or delete treatment data. Once the actor has finished managing the treatment data, they select the option "save," the system saves the changes to the database to ensure consistency and up-to-date treatment data. The actor's selection of the diagnosis option in the sequence diagram related to the diagnosis menu leads to the display of the patient's medical record list. After selecting "new," the system displays a diagnosis form. The actor determines the gestational age and relevant symptoms and then chooses "submit." The system then shows the diagnosis results along with treatment, providing helpful information for actors to understand the patient's health condition. In the diagnosis sequence diagram, without manually entering symptoms, the actor immediately selects the diagnosis menu and the "submit" option. The system responds by displaying the patient's diagnosis results, giving actors quick access without manually entering symptoms. Finally, all actors carry out the process of exiting the system, as explained in this sequence diagram. By selecting the logout option, the actor safely leaves the system, and the system redirects back to the login page, ensuring access security and user privacy. Overall, this sequence diagram describes the interaction between actors and systems in managing disease, treatment, and diagnosis data, as well as the logout process to exit the system safely.

Researchers chose the PHP language for coding and building web-based applications in the system implementation stage. PHP's advantages in supporting web system design enable developers to create dynamic, responsive applications that meet user needs. Developers select MySQL as the database software on a local web server, which acts as data storage for the system being developed. MySQL was chosen on its excellent performance and reliability in storing and managing data. In addition, researchers used the Mozilla Firefox

browser as a tool to display the application and test its functionality. These popular browsers ensure that applications can be accessed and tested according to user preferences and needs. Researchers applied the black box method at the testing stage to test each program unit separately. The main goal of the black box method is to ensure that every part of the program functions according to the design. By focusing on testing the functional requirements of each program unit, we can thoroughly test the implemented functions and features without paying attention to each unit's internal implementation. Thus, the implementation and testing stage is an essential step in ensuring the reliability, quality, and optimal performance of the system that has been developed.

Based on the research results, 13 people were suffering from placenta previa (P008), with 12 of them showing symptoms of red blood (G030). Of the 12 people diagnosed with moderate placental dissolution disease (P010), 10 exhibited red blood symptoms (G030). Fifteen patients were diagnosed with Hyperemesis Gravidarum Grade 3 (P003), and 10 exhibited slightly yellow eye symptoms (G013). Additionally, 9 out of the 10 patients diagnosed with severe pre-eclampsia (P013) showed symptoms of slightly yellow eyes (G013). The expert system application for diagnosing diseases in pregnant women achieved an accuracy rate of 80% through the conducted consistency tests. However, there were 14 errors from 35 trials carried out.

Nevertheless, these results can be considered good because the accuracy of 80% indicates an adequate level of success in detecting and diagnosing disease in pregnant women. This achievement also meets the good qualification criteria, which shows that this expert system can provide a diagnosis with adequate reliability. Thus, the expert system application can be considered a helpful tool in supporting disease diagnosis in pregnant women with sufficient accuracy.

According to a survey involving assistant doctors and midwives, as many as 80% stated that the Expert System for Disease Diagnosis in Pregnant Women (SISPADIBU) application was very user-friendly. According to our evaluation, the user experience with the program is satisfactory due to its well-designed and user-friendly interface. Additionally, respondents found the layout user-friendly and helpful in facilitating users' interaction with the program. In addition, the survey's results indicate that this application is valued highly for its ability to disseminate information about disorders associated with pregnancy. This positive response reflects that SISPADIBU is effective in providing diagnoses and successfully presenting information in a way that is easy to understand and useful for physician assistants and midwives. Given this positive feedback, developers can see it as an encouragement to continue developing and improving the app, perhaps by adding new features or improving existing functionality. The app's success in providing a good user experience and valuable knowledge indicates possible wider adoption among medical personnel and maternity nurses.

4. Conclusion

The author concludes that the PHP programming language, MySQL as a database management system, Apache as a web server, UML as a tool, and RAD as a system development methodology were used in designing and constructing the expert system for identifying disorders in pregnant women. Before implementing the forward chaining technique, the specialist system builds an inference tree and rules. The consistency test is additionally computed via the application of the Bayes theorem. With an accuracy rate of 80%, this method, known as SISPADIBU, can help diagnose disorders related to pregnancy. Based on the user's specified symptoms, SISPADIBU can display the diagnostic findings. From the survey results, 80% of users rated SISPADIBU as very user-friendly, with a layout that is easy to use and provides helpful knowledge regarding pregnancy diseases. Based on these conclusions, the author offers suggestions for developing this expert system: SISPADIBU can be developed into desktop and mobile-based applications to increase accessibility. Future researchers can use backward chaining, certainty factor, analytical hierarchy process (AHP), or fuzzy logic with breadth-first search or best-first search methods. Adding more complex and varied symptom and disease data is necessary to increase the system's accuracy in diagnosing various pregnancy conditions. Implementing these suggestions will enable SISPADIBU to continue developing and providing more incredible benefits in pregnancy disease diagnosis.

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