DESIGN OF HEALTHCARE APPLICATION USING AI CHATBOT AND MEDICAL EXPERT SYSTEM

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ABSTRACT

This research article describes the design and development of a prototype application that employs healthcare chatbot and medical expert systems. It is a tool for doctors to give patients education and health treatment. This healthcare system's design comprises of two systems: the front-end system and the back-end system. The front-end system is composed of the healthcare chatbot, which serves as the user interface unit, and the medical explanation system, which outlines the guiding path. The medical knowledge base, the inference engine, the knowledge base editor, and the user management system make up the back-end system. System design applies knowledge engineering methodologies based on software engineering procedures, with Python, PHP, and MySQL serving as development tools. The system is a web application that can operate on any internet-connected platform, and it is improved through testing (α-Test). Engineers and four medical professionals have conducted experiments, simulated and evaluated various system tools in order to get information. It appears that the various systems of medical expert systems developed in this research can function properly according to the purpose for which each function is designed, and are ready to be put through the ethical process of human research in preparation for a future field test (β-Test) with patients.

Keyword: Healthcare Application, Chatbot, Medical Expert System, Knowledge Engineering

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1. INTRODUCTION

Developing medical and healthcare applications that utilize artificial intelligence (AI) technology to contribute expertise, counsel, or a diagnosis. and medical care. The Medical Expert System, also known as the Medical Knowledge-Based System, is a commonly researched and created technology that is computer software intended and developed to simulate the thinking behavior and conclusions of human physicians in order to solve problems and offer health care recommendations. Using a knowledge base and inference methods as the primary work components.

In a previous research, Abu Naser et al. [1,2,3] explored and created a specialized technique for diagnosing neck discomfort, urinary issues, and skin diseases. Abu El-Reesh et al. [4] investigated and developed an expert method for identifying infant and child shortness of breath. Aris et al. [5] investigated and constructed a differential diagnostic expert system with an educational objective. Audrey Mbogho et al. [6] investigated and created a diabetes management expert system. Using the Forward Chaining Method, C.P.C. Munaiseche et al. [7] investigated and built an expert system for identifying eye disorders. Eman A. Alsagheer and others [8] did research and made an expert system for diagnosing the most common psychiatric diseases. El Agha et al. [9] investigated and created a polymyalgia rheumatic expert system. Gudu, J. et al. [10] studied and created an expert system for the diagnosis and treatment of hypertension in pregnancy. Ike Mgbeafulike et al. [11] designed and constructed a specialized diagnostic and treatment system. Jimmy Singla and colleagues [12] have created an expert system for the detection of different ailments. Kenneth Ikechukwu et al. [13] created and established a Malaria and associated illness expert

system for developing country. Nabahin, A. et al. [14] investigated and created a specialized approach for diagnosing and treating hair loss. S.A. Fatumo et al. [15] conducted research and created an expert system for the medical detection of malaria and typhoid complications. The previous research has been planned and developed as a stand-alone software or web application, and it also has a relationship with people who are Q&A users. This research project proposes the creation and development of healthcare applications using a healthcare chatbot based on natural language processing and machine learning to assist in simulating communication as closely as possible to human interaction and use a system of medical professionals to assist in simulating the human problem-solving process in order to aid in the construction of knowledge bases among medical staff and be used as a resource. This should be an additional option that is beneficial. Its purpose is to encourage primary health care so that individuals may remain healthy and take comprehensive care of themselves.

2. SYSTEM DEVELOPMENT PROCESS

In this investigation, medical expert systems were utilized. As seen in Figure 1, it has been designed and developed using the knowledge engineering approach. Knowledge engineers in conjunction with medical professionals consider the medical problem's nature and domain, as depicted in Figure 2, and the method of acquiring medical knowledge, as depicted in Figure 3. Recognizing the significant aspects in the system's evolution, particularly as production rules to model medical human problem solving, separation of knowledge and reasoning and knowledge as the key to expertise as shown in Figure 4.

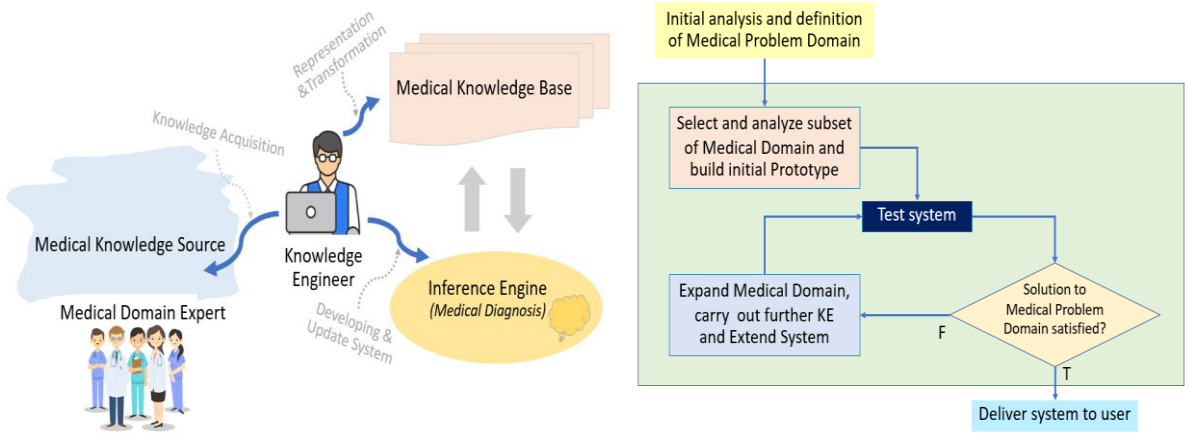

Figure 1. Knowledge Engineering and Medical Expert System Development

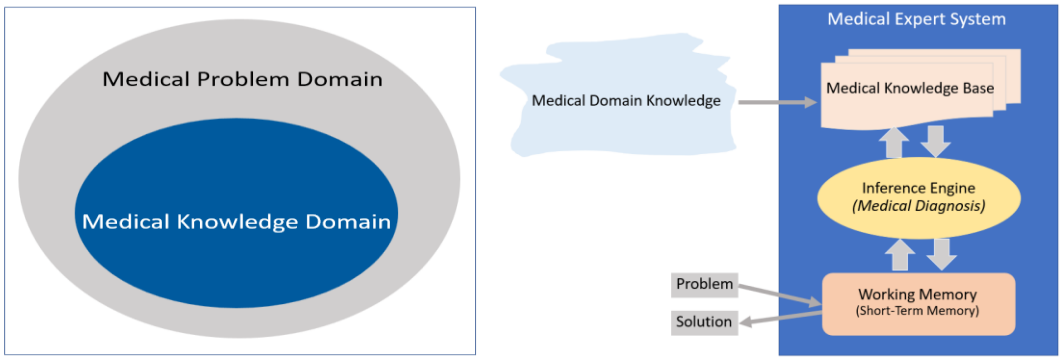

Figure 2. Medical Knowledge Domain and Schema of a Medical Expert System Kernel

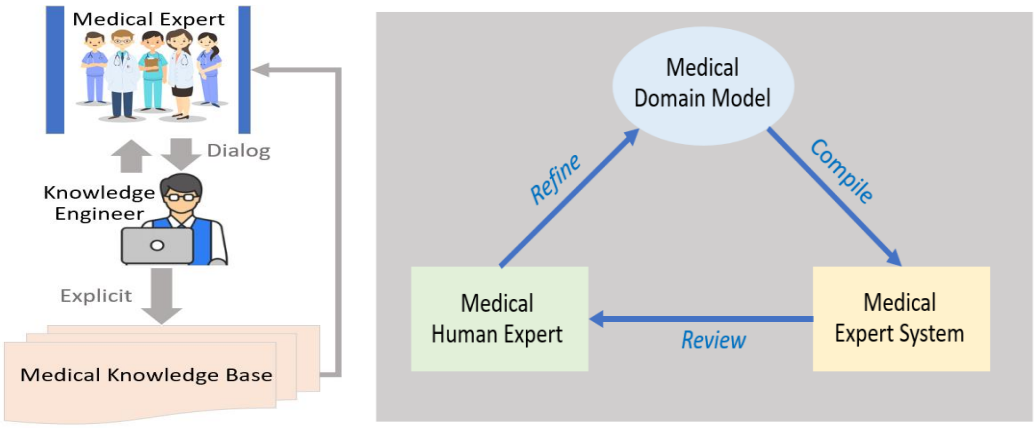

Figure 3. Knowledge Acquisition Process Using a Domain Model

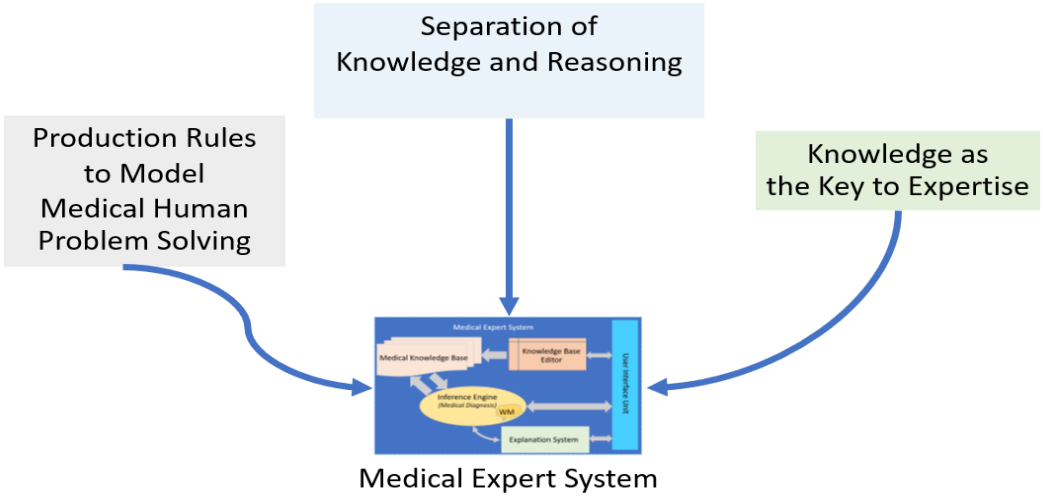

Figure 4. Convergence of Three Important Factors to create the Medical Expert System

As shown in Figure 5, the research system was developed using the usual phases of the computer engineering process. Evaluation, the examination of the matter, is covered. Determine the issue resolutions, objectives, scope, and stakeholders for each phase. The resources used for knowledge acquisition, which is the study of theories used for problem-solving, obtaining information from a domain expert who can construct a model for problem-solving, and considering choosing a form of solution, design, which is the design of the system architecture substitute for knowledge to be stored in the knowledge base, an inference mechanism and other components, selection of tools, and system implementation, which is the actual implementation of the system, are outlined in this section. This is a test of the knowledge base's functionality and engineers' and professionals' ability to utilize it. In the future, the system test phase will be undertaken to evaluate the system, which is a field test incorporating experimentation with the real system to be used on the patient. After the system satisfies the ethical standards for human research, it will be implemented and maintained.

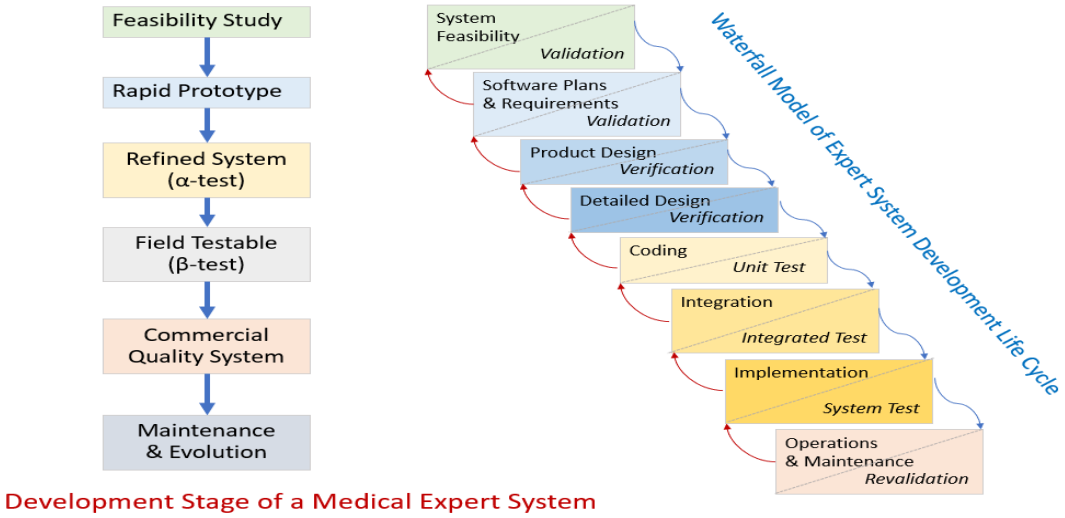

Figure 5. Development Process of a Medical Expert System

3. HEALTHCARE SYSTEM DESIGN

The concept of health care application design is explored in this research. The application of the theory of the expert system to designing the system to simulate the problem-solving process of a human physician is shown in Figure 6. Mechanisms for problem-solving in knowledge-based systems have been created and organized for system operation. It will mirror the problem-solving techniques of human specialists. A model of the human approach to problem-solving instead of the long-term memory of human beings with a set of rules that consist of cause and effect parts is called a product and replaces human short-term memory with a set of problem facts.

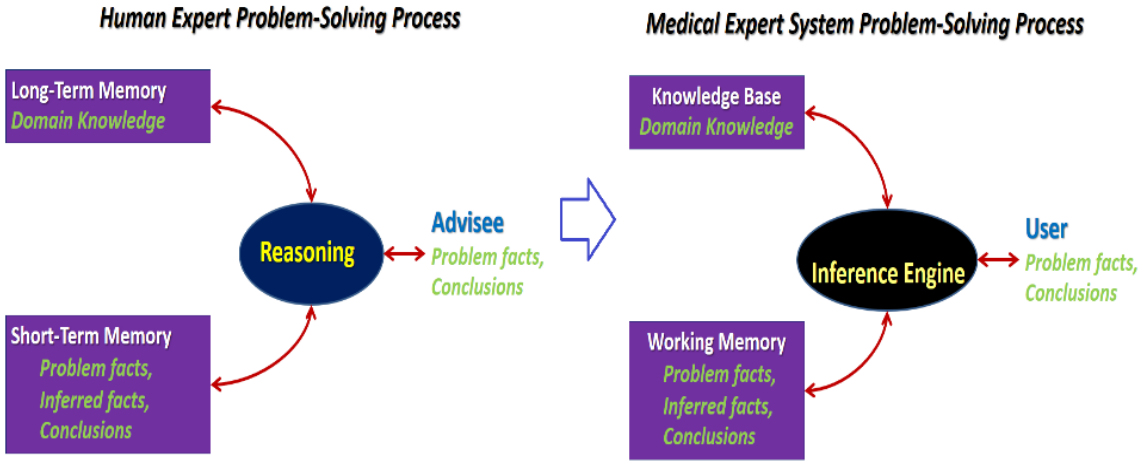

Figure 6. Human Expert Problem-Solving Mechanisms and Medical Expert Systems

A system of medical experts employing a rule-based system as a paradigm for problem-solving consists of three elements:

Knowledge Base (KB) : It imitates human long-term memory by substituting a set of rules for the production.

Working Memory (WM): This component simulates human short-term memory.

Inference Engine (IE): It is the component that simulates human reasoning. There is a rule selector and a rule interpreter for storing the problem's facts in memory. Use the rules in the knowledge base to deduce the problem's solution.

The production system serves as the foundation for the construction of a rule-based system that serves as a model for problem-solving in a medical expert system that employs knowledge representation in the form of rules (a rule-based expert system). Figure 7 illustrates the design of the rule-based system.

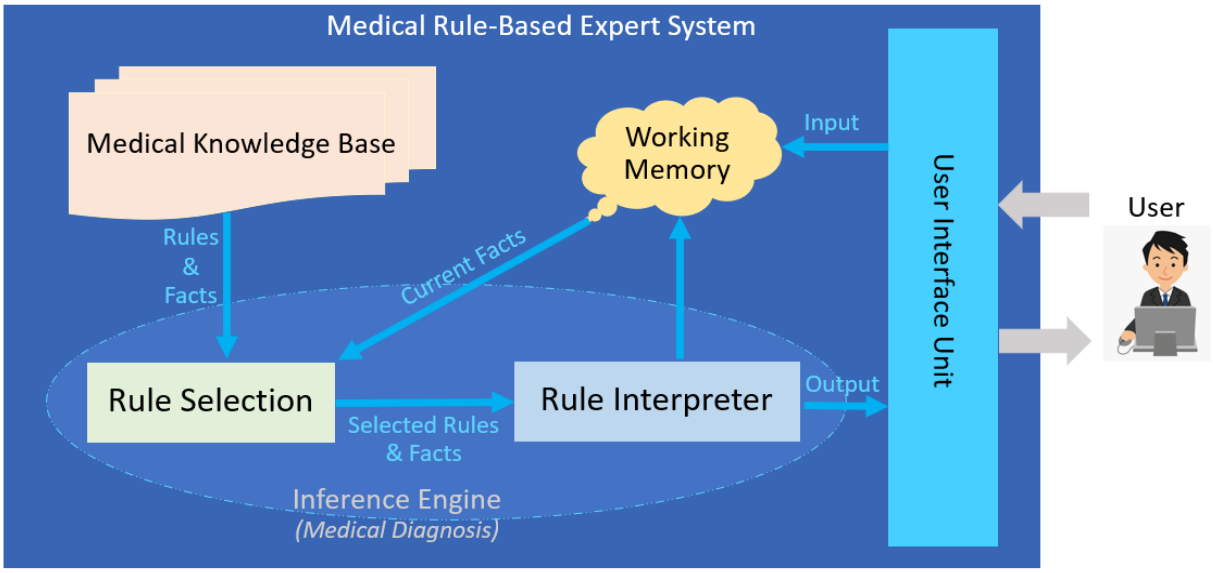

Figure 7. The Components of a Medical Rule-Based Expert System

Figure 8 shows the architecture of the medical expert system. It comprises of the following six systems:

1. Medical Knowledge Base: It is the section where medical knowledge is stored. Whether it is information earned from textbooks or experience, both are equally valuable.
2. Inference Engine: It supervises the utilization of knowledge inside the knowledge base. to resolve issues successfully.
3. Knowledge Base Editor: It is a part of knowledge management used to extract knowledge from textbooks, databases, or experts, and to ease the production, alteration, and addition of the system's knowledge base.
4. Explanation System: This section describes the inference process in detail for the user. How and why is the conclusion or response reached?
5. User Interface Unit: It improves communication between users and the system and acts as an intermediary between users and the system. This can help increase the system's user acceptability.
6. Working Memory: It is used to acquire information from users and information gained through inference.

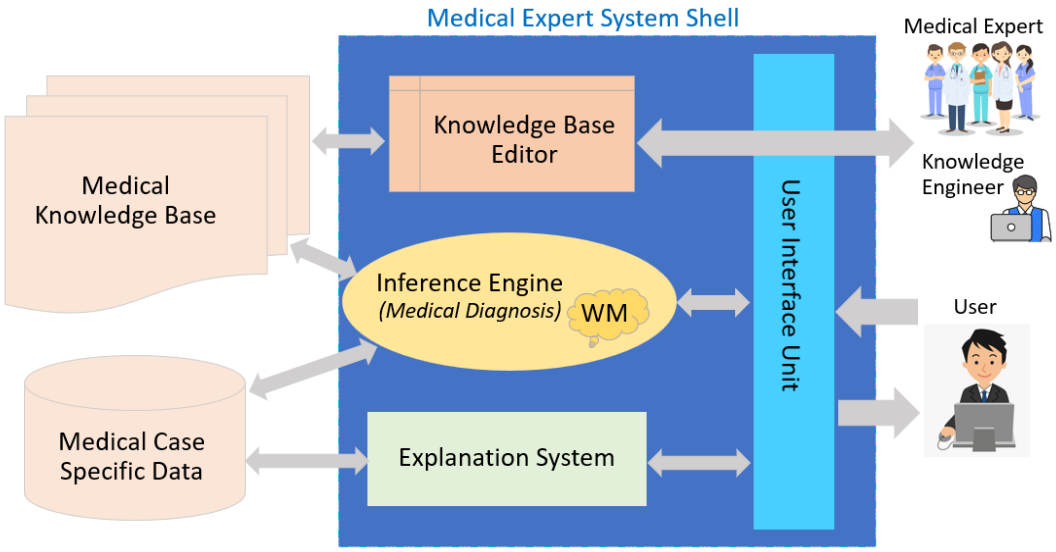

Figure 8. Architecture of Medical Knowledge-Based Expert System

As indicated in Figure 9, the working mode for developing a system of medical specialists for this study can be separated into two environments: the development environment and the consultation environment. with Figure 10 respectively. Figure 11 shows an overview of the working structure model of the system.

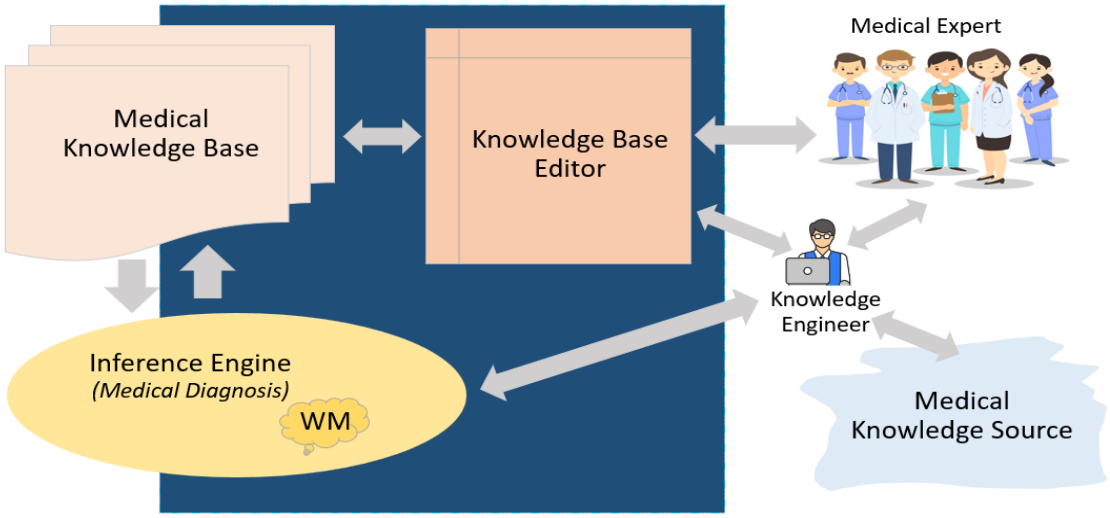

Figure 9. Development Environment for Medical Expert System

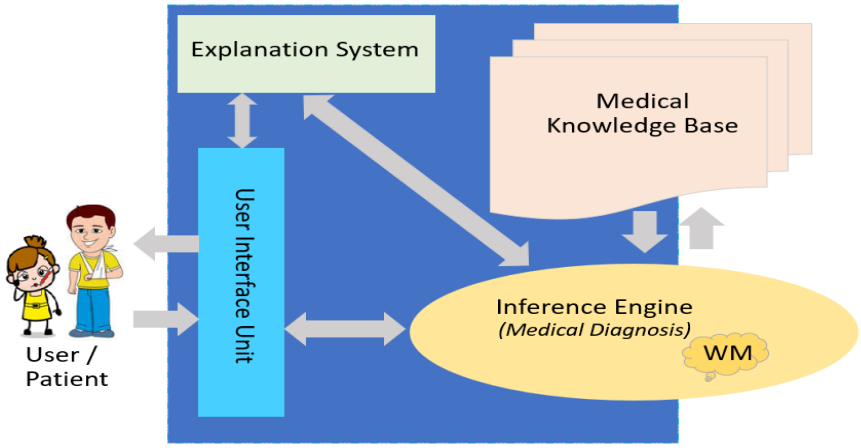

Figure 10. Consultation Environment for Medical Expert System

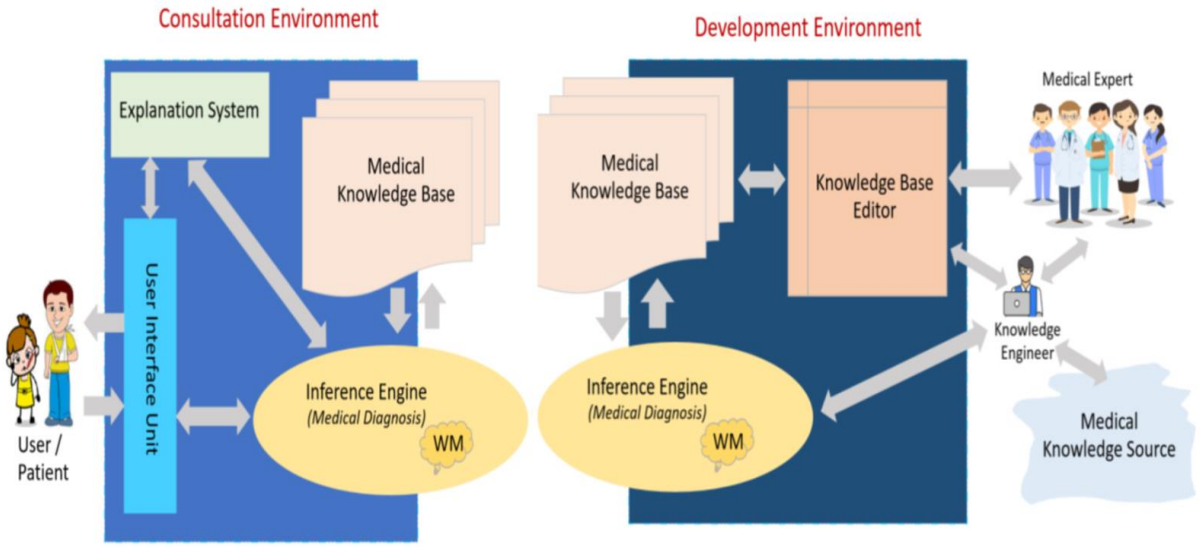

Figure 11. Working Structure Model of Medical Expert System

As part of this study, the User Interface Unit of the medical specialist system was developed. The process of replacing this system with a healthcare chatbot, which is an application of natural language processing and machine learning theory, is depicted in Figure 12. The study healthcare application will consist of a chatbot and an expert system, as depicted in Figure 13, in order to simulate the process of communicating with a human user. Prior to processing, the healthcare chatbot system's work process consists of four work systems for data preparation. (Pre-processing), which includes the word segmentation and stop word elimination subsystems, and the word vector process. Which method converts data from pre-processing stages into vector format by comparing vector similarity, user text, and vectors from a knowledge base? It will occur in accordance with the equation. The question classification method (question classification) use neural network approaches to get sentences with purpose by separating the task into training models of question sets and prediction, question themes, and response selection procedures (answer selection).

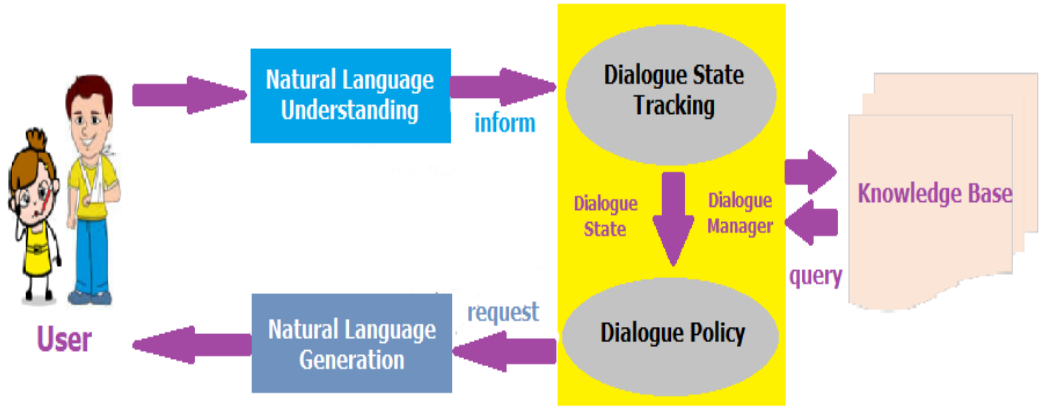

Figure 12. Healthcare Chatbot Process

Figure 13. Concepts for Healthcare Application Design in this Study

Following data preparation and before processing, incoming data will be converted to a vector format by the system. Using a neural network approach, the system will then utilize the incoming data to categorize the queries (Intent). By notifying the system of the nature of incoming queries (Intents). Once the intent is determined, the incoming data is already present. It will then choose a response from the knowledge base and deliver it back to the user. The system will explore its knowledge base for the solution after determining that the input is an Intent. Then, rate the similarity of the incoming data in decreasing order according to their degree of resemblance to the knowledge base. Figure 14 shows how this research's healthcare system is set up when the user interface unit is replaced with the healthcare chatbot and figure 15 shows healthcare application in this research.

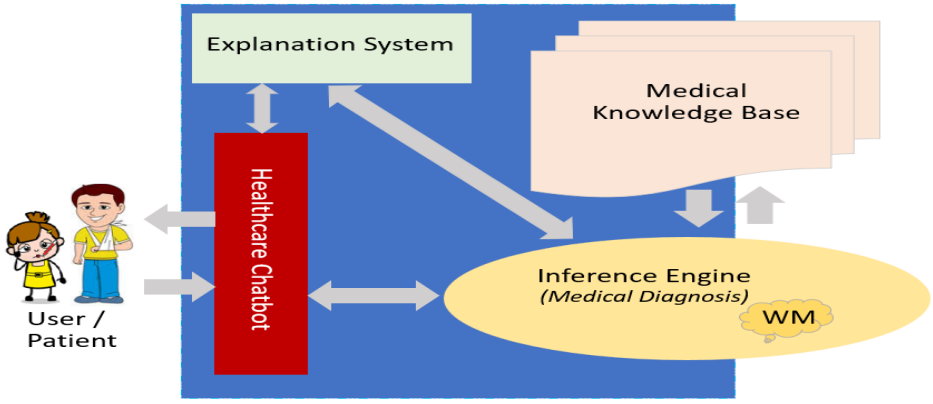

Figure 14. Consultation Environment for Medical Expert System and Healthcare Chatbot

Figure 15. Designed Healthcare Application in This Research

When the medical knowledge base was being made, this study used a clause-tree structure representation, which shows how the conclusion and premise of rules in a knowledge base relate to each other. Whenever the tree structure is built in the shape of a graph, it is made up of a square symbol called the root node, which stands in for the starting rule, and a circle symbol called the middle node. The intermediary rule is replaced by (intermediate node). The hexagonal symbol (terminal node) symbolizes the concluding rule, while the arrow symbol (link) illustrates the relationship between the rule's conclusion and premise. In this study, backward chaining inference, proceed ahead to determine the solution. Figure 16 in particular. The inference process starts with the main goal and works backwards to find evidence to support it. Figure 17 illustrates the approach and method of this knowledge inference process. Using interactive forward chaining inference is included in the medical knowledge inference engine architecture. Figure 18 demonstrates the algorithm for this knowledge inference process. The inference procedure begins with the problem's facts.

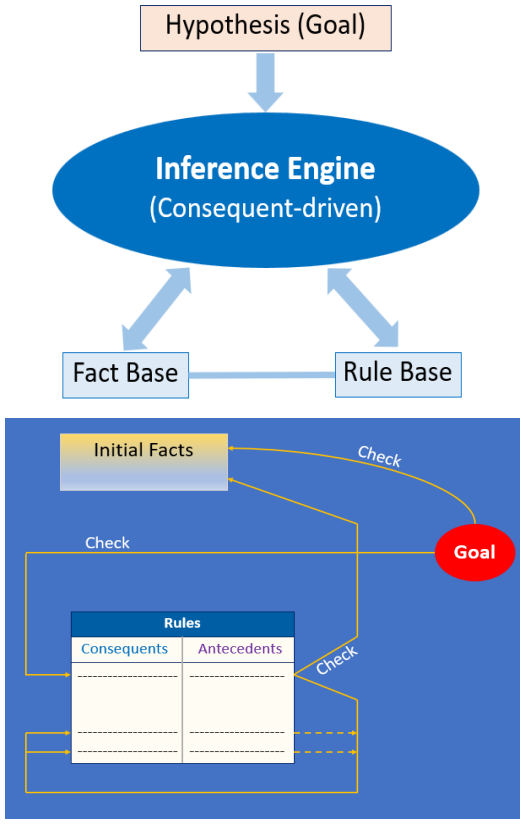

Figure 16. Backward Chaining Inference Strategy with given hypothesis (Goal)

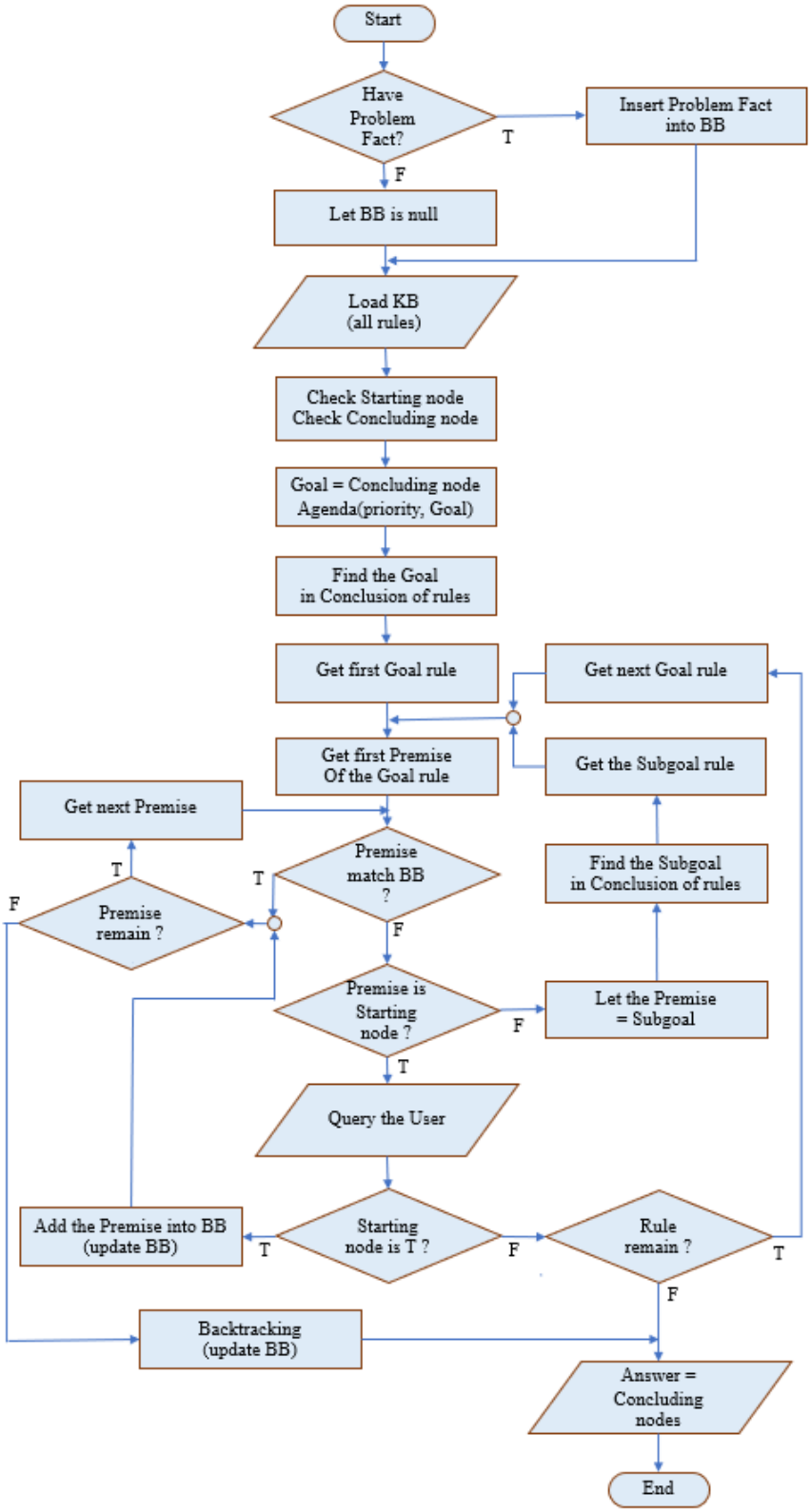

Figure 17. Designed Backward Chaining Inference Process

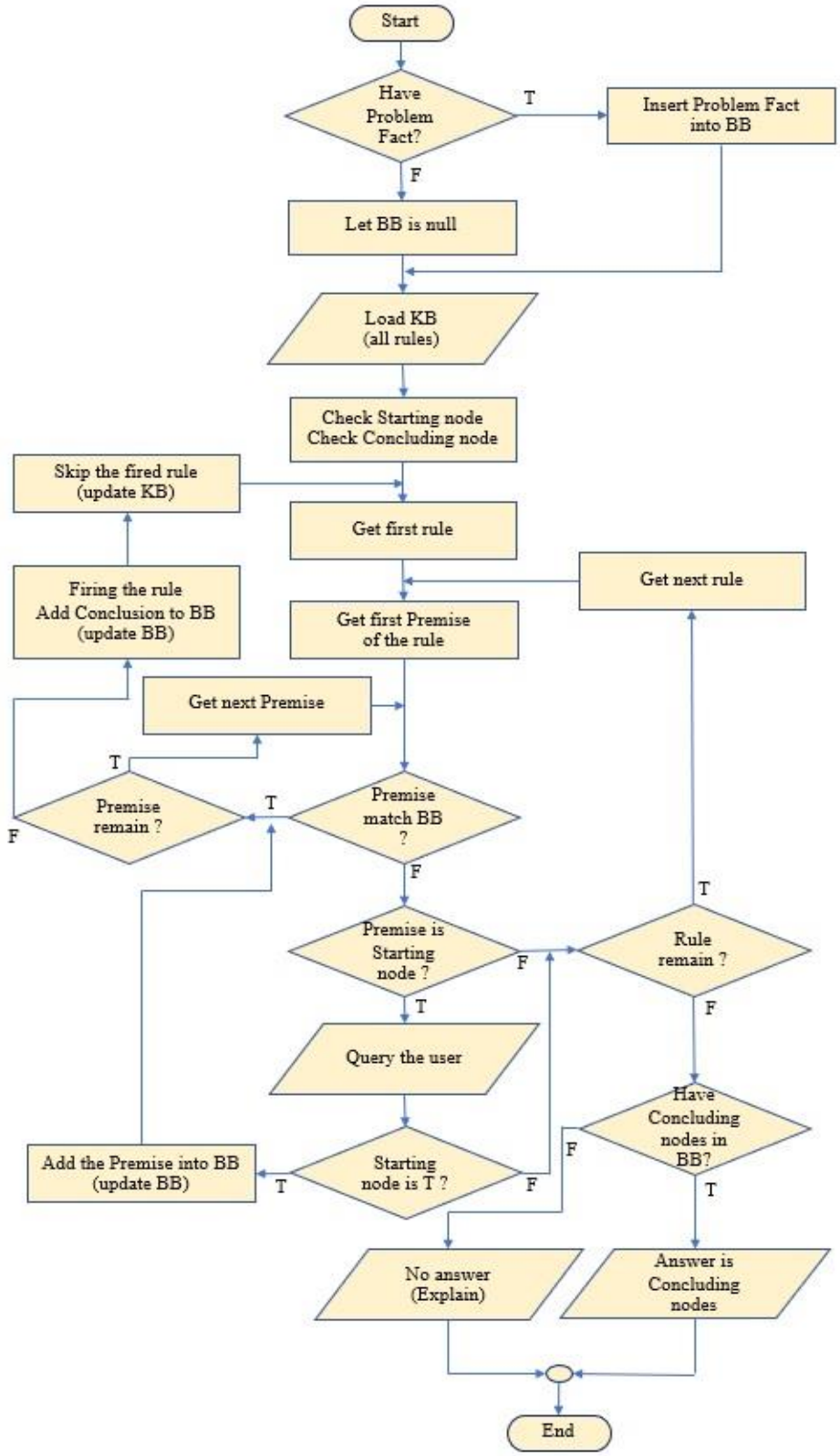

Figure 18. Designed Interactive Forward Chaining Inference Process

4. SYSTEM TESTING

The System Improvement Test (α-Test) was conducted by a knowledge engineer and four specialist physicians by testing, modeling, and analyzing the system's numerous tools, such as debug checks in the workflow of knowledge inference methods linking users with a healthcare chatbot, as well as physician evaluation of the knowledge-building process. It may include a mistake. Physicians will communicate errors in knowledge to knowledge engineers in an effort to improve. in order to have a comprehensive knowledge base that is ready to be assessed and tested. Specialist physicians and competent engineers will examine the system to make improvements. As seen in Figure 18, errors in the system development process can be summarized. In addition, there was an error due to a weakness in the process of generating facts and rules. There was a syntax mistake in the knowledge base's rules pattern. Content errors are caused by inaccuracies, redundancy, contradicting, or incomplete information, as well as errors arising from the imperfection of obtaining medical knowledge of knowledge engineer.

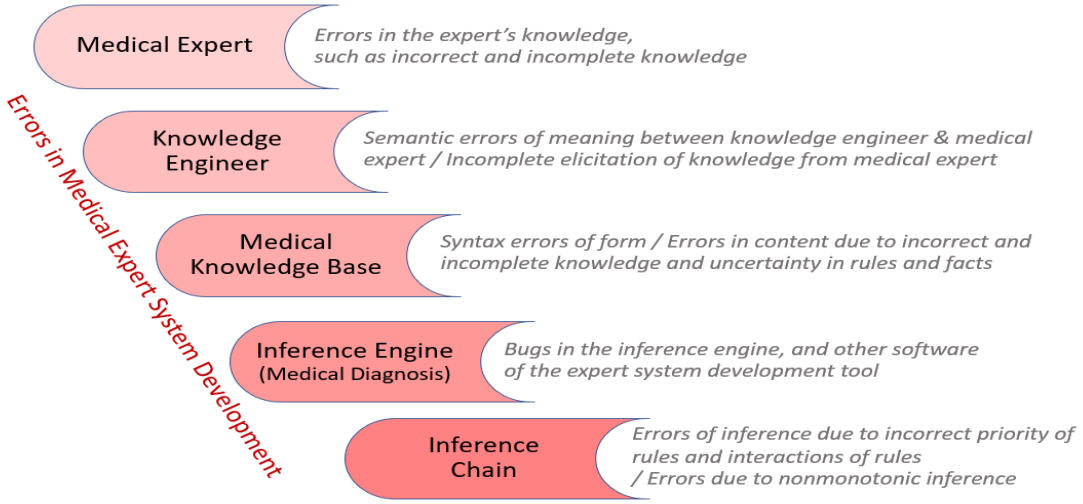

Figure 19. Errors Result in Medical Expert System Development

5. CONCLUSIONS AND DISCUSSION

This study focuses on the design and development of healthcare application prototypes utilizing interactive conversational robots and medical expert systems. It serves as a tool for doctors to assist patients with education and healthcare. The design of this hospital system's infrastructure The front-end system consists of the healthcare chatbot and the explanation system, while the back-end system consists of the medical knowledge base, the inference engine (medical diagnosis unit), the knowledge base editor, and the user management system. This system's design employs knowledge engineering methodologies based on software engineering procedures, with Python, PHP, and MySQL serving as development instruments. The system is a web application that is compatible with all internet-connected platforms. It appears that the various systems of medical experts' systems developed in this research are capable of functioning properly in accordance with the purpose for which every function is designed, based on testing to improve the system (α-Test) by knowledge engineers together with four medical professionals who have experimented, simulated, and examined various system tools. Knowledge engineers and four medical professionals have conducted tests, simulated and evaluated various system tools in order to get information. It appears that the numerous medical expert systems established as a result of this research are capable of functioning according to their intended purposes. However, prior to implementing the system of medical experts in this research, the system test plan must be approved by an ethics review board for human research. On real patients, do field testing or functional assessment of the system (β-Test) and utilize the data for system analysis and enhancement.

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