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Development of a Smart System for Optimizing Treatment Using Forward Chaining Method

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ABSTRACT

The utilization of traditional herbal medicine among the inhabitants of Lombok is notably prevalent yet frequently hindered by a lack of comprehension regarding the efficacy of herbal remedies for specific ailments. Addressing this challenge, this study proposes the development of an Android application called ”sopherbal,” aimed at delivering personalized herbal plant recommendations via easily accessible mobile devices. Employing forward chaining methodology, the application identifies optimal herbal remedies based on ailment type, processing techniques, usage instructions, and recommended dosage and treatment duration. Notably, while effective in this context, the forward chaining approach entails certain trade-offs and hurdles. Previous research indicates that forward chaining facilitates accurate recommendation generation, and it may be constrained by its reliance on predefined rules and limited adaptability to complex, evolving scenarios. Despite these challenges, the ”sopherbal” application, featuring 50 Sasak medicinal plants curated for 15 common ailments, achieved an 86% validation rate, affirming its efficacy in bridging the gap between traditional herbal knowledge and modern healthcare needs.

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1. INTRODUCTION

Indonesia is a country with a tropical rainforest area of 143 million hectares with more than 28,000 plant species [1, 2]. Apart from that, it is recorded that around 80% of medicinal plants known globally come from Indonesia, with around 6,000 types of plants, and many Indonesian people have used medicinal plants for generations [3]. Knowledge about the properties of medicinal plants is the nation's cultural heritage that must be protected and preserved to expand knowledge in Indonesia's health sector. The World Health Organization (WHO) also supports using medicinal plants to advance health and sustainable development through the traditional medicine strategy program 2002-2005, with a continuation of the program 2014-2023 [4].

In the last decade, the use of herbal medicines derived from plants has increased [5]. Public interest in herbal medicines continues to increase significantly due to their safety and easy availability and the increasing movement to return to nature using medicinal plants to prevent and treat diseases, especially minor illnesses [6]. Herbal medicines can be used to reduce or treat minor illnesses such as fever, flu, diarrhea, dysentery, upper respiratory tract infections (ARI), worms, hepatitis, anemia, arthritis, production health problems (gynecology), and infectious diseases. Diseases such as malaria and therapy reduce the negative impact of HIV [5, 7]. The use of medicinal plants as herbal plants to prevent and treat disease is mostly concentrated in rural areas [8], such as in West Nusa Tenggara (NTB) Province, especially on Lombok Island, so that they can be utilized. In the use of medicinal plants, an understanding of the medicinal plants, how they are processed, and also the symptoms suffered by the patient, which are known to experts, is required. However, not all patients can consult with experts because resources are limited. Therefore, an intelligent system based on an expert system is needed to help patients provide suggestions or recommendations for medicinal plants based on the symptoms they experience. An expert system is developed to have an expert's knowledge in a particular field [9]. There are several studies related to the development of expert systems in the health sector, such as research [10–14] and others. This shows that expert systems have been widely used in the health sector. There are several expert system methods, one of which is forward chaining [15]. Forward chaining is a method in expert systems that produces solutions or decisions from the facts or information provided [16].

Based on the background above, in this research, the solution offered by researchers is the development of an intelligent system for optimizing medicinal plants using the forward chaining method. Several previous studies related to the topic raised, such as research [17]. This research focuses on designing an expert system for symptoms of gastrointestinal diseases using herbal plants. This research produced a website-based application for an expert system for herbal plant disease symptoms. Another research is research [18], in which this research applies the forward chaining method in diagnosing rhinitis. This research produces a website-based system. Other research related to the development of applications for medicinal plants and their benefits based on Android uses the Rapid Application Development (RAD) method with the PHP programming language, and the database used is MySQL to present types of medicinal plants and their properties, disease complaints, recommendations for medicinal plants, and suggestions sent via email [19]. Another research is research [20] related to the Android-based Simplicia and Traditional Medicine Recipe (Sidota) Dictionary application, providing information on making simplicia and herbal medicine recipes specifically intended for pharmacy students as a means of helping the community preserve herbal medicines. The Sidota application was developed using the waterfall method. The next research is research [20]. This research discusses the classification of medicinal plants and wild plants using the KNN method, and there are many other related studies, such as [21–23]. The difference between the research conducted and the previous one is that this research focuses on developing an intelligent system based on an expert system using the forward chaining method in optimizing the use of medicinal plants, which will later be developed on an Android-based system because Android offers practical and economical cost efficiency for the community [24]. Apart from that, what differentiates this research from previous research is the method used in testing, which uses an accuracy testing method using a confusion matrix and black box testing to determine whether the system being developed is working as it should.

Based on the background above, in this research, the solution offered by researchers is the development of an intelligent system for optimizing medicinal plants using the forward chaining method. Several previous studies related to the topic raised, such as research [17]. This research focuses on designing an expert system for symptoms of gastrointestinal diseases using herbal plants. This research produced a website-based application for an expert system for herbal plant disease symptoms. Another research is research [18], in which this research applies the forward chaining method in diagnosing rhinitis. This research produces a website-based system. Other research related to the development of applications for medicinal plants and their benefits based on Android uses the Rapid Application Development (RAD) method with the PHP programming language, and the database used is MySQL to present types of medicinal plants and their properties, disease complaints, recommendations for medicinal plants, and suggestions sent via email [19]. Another research is research [25] related to the Android-based Simplicia and Traditional Medicine Recipe (Sidota) Dictionary application, providing information on making simplicia and herbal medicine recipes specifically intended for pharmacy students as a means of helping the community preserve herbal medicines. The Sidota application was developed using the waterfall method. The next research is research [20]. This research discusses the classification of medicinal plants and wild plants using the KNN method, and there are many other related studies, such as [21–23]. The difference between the research conducted and the

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The novelty of this research is the forward chaining method, which provides treatment recommendations based on symptoms to optimize treatment with herbal plants based on valid clinical data and helps increase accuracy in providing treatment recommendations. Forward chains have the advantage of being designed based on rules, and relationships converge over time based on inputs and outputs. They offer assistance in optimal decision-making for the health sector [26]. In addition, the forward chaining method is more computationally efficient because it only uses the information available at that time. This makes it suitable for applications with many facts. Also, this method can provide real-time responses because it processes information directly as new facts become available. Forward chaining can learn from new data and adapt to changing environments or conditions, making it flexible and scalable. This method is also relatively easy to understand and implement and can help recognize patterns and trends in data. This research aims to develop an intelligent system to optimize medicinal plants using the Android-based forward chaining method. The contribution of this research is in the form of developing an intelligent system-based application that applies the forward chaining method to optimize the use of medicinal plants. This system is hoped to help the community increase their knowledge and assist in making decisions related to the symptoms they are experiencing.

2. RESEARCH METHOD

This research develops an intelligent system for optimizing medicinal plants using forward chaining. The forward chaining method is a technique used in artificial intelligence systems and rule-based programming to achieve a goal or conclusion by starting from existing facts and then applying the rules sequentially to produce more facts or consequences [27]. The stages in this research can be seen in Figure 1.

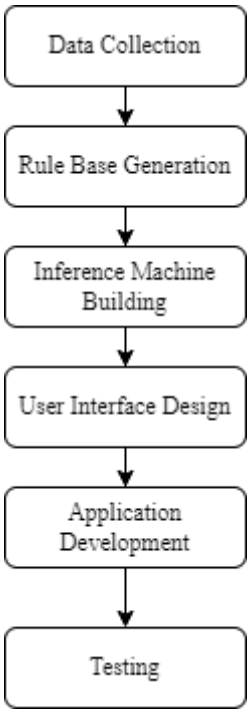

Figure 1. Research Stages

Figure 1 shows the stages carried out in this research, starting from data collection and rule-based generation inference machine building to testing. The research data used in this research are medicinal plant data, disease data, and symptom data. After collecting the data, proceed to the next stage: creating a rule base based on expert knowledge. These rules are used in developing inference engines. The inference engine applies rules that have been created to achieve certain goals. The inference engine accepts the facts obtained and uses them as input data. Then, using the given inference rules, the inference engine will look for correspondence between existing facts and relevant rules to produce output. How it works can be seen in Figure 2.

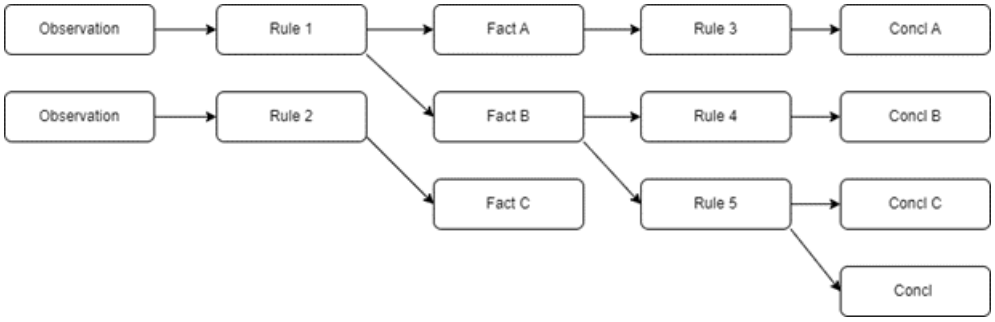

Figure 2. Inference Engines in Forward Chaining

Figure 2 shows how the inference engine works in forward chaining. Each rule obtained needs to be tested according to its conditions. If the rules obtained follow the rules, they are maintained, but if not, they are continued with the next rule. This process repeats until all rules are tested under various conditions. This allows advanced reasoning to work by recording initial information and final goals, executing processes sequentially until the goal is achieved. After the inference engine is built, the next stage is application development, from interface design to coding. The application was developed based on Android. After the application has been successfully developed, the application is then tested for accuracy using the confusion matrix method [28]. As for calculating accuracy using the confusion matrix, you can use Equation (1).

$$Accuracy = \frac{TP + TN}{TP + FP + TN + FN} \tag{1}$$

TP = True Positive
FP = False Positive
TN = True Negative
FN = False Negative

TP is the number of cases that are predicted to be true positive, FP is the number of cases that are predicted to be positive but are actually negative, TN is the number of cases that are predicted to be true negative, and FN is the number of cases that are predicted to be negative but are actually positive [29]. Apart from testing using a confusion matrix, testing is also carried out using the black box method, which is used to determine the extent to which the system has run according to expectations [30].

3. RESULT AND ANALYSIS

This medicinal plant recommendation application, which we call sopherbal, has four main features: its advantages compared to other similar applications. The four features are: 1) displays a feature in the form of a list of names of types of medicinal plants accompanied by pictures of the plant that can be utilized, 2) displays interactive features in the form of symptom input, which will be processed by the system to display several possible diagnoses and recommendations for medicinal plants in the form of types of plants, how to use and dosage, display The menu for the second feature is equipped with audio choices for voices in Indonesian and Sasak to make it easier for users, especially rural villagers and the elderly with literacy low Indonesian language, 3) the next feature displays several interactive images daily activities, minor illnesses that people often suffer from, and suggestions for their treatment, 4) The last feature is a scientific reference used in the data input for this system including scientific journal, pharmacy and medicinal ebook. This application development uses the forward chaining method, which simulates data or fact-driven reasoning and discovers answers with an if-then algorithm using data or facts [17], so the forward chaining method is appropriate to use for developing health applications.

3.1. Data Collection

This research applies the forward chaining method in system development. In developing this system, data, such as disease, symptom, and herbal plant data, is needed. The disease data can be seen in Table 1.This research applies the forward chaining method in system development. In developing this system, data, such as disease, symptom, and herbal plant data, is needed. The disease data can be seen in Table 1.

Table 1. Disease

Disease Code	Disease Name
P001	Malaria
P002	High blood pressure
P003	Typhus
P004	Scabies
P005	Deep Heat
...	...
P015	Hemorrhoids

Table 2 shows the disease data used in this study, where 15 diseases were discussed. Apart from disease data, there is also symptom data. Data on these symptoms can be seen in Table 2.

Table 2. Symptom

Symptom Code	Symptom Name
G001	Dizzy
G002	Nauseous
G003	Weak
G004	Hard to breathe
G005	Menstruation is not smooth.
...	...
G042	Body Temperature Greater than 37 C

Table 2 shows the 42 symptoms used in this study. The symptom and disease data are combined to create rules based on expert knowledge by applying the forward chaining method. The results of this combination are formed in the form of rules, the rules of which can be seen in Table 3.

Table 3. Rule

Rule	Disease	Symptom
1	P001	G002, G014, G015, G016, G017, G026
2	P002	G018, G019, G020
3	P003	G001, G002, G003, G004
4	P004	G011, G012, G013
...	...	...
14	P005	G021, G022, G023, G024, G025
15	P006	G026, G025, G027, G028, G029, G003

Table 3. Shows the rule data used in this research. In this study, there were 15 rules adapted to the disease.

3.2. Application Development

After obtaining the required data, the next stage is system development. The results of system development can be seen in Figure 3.

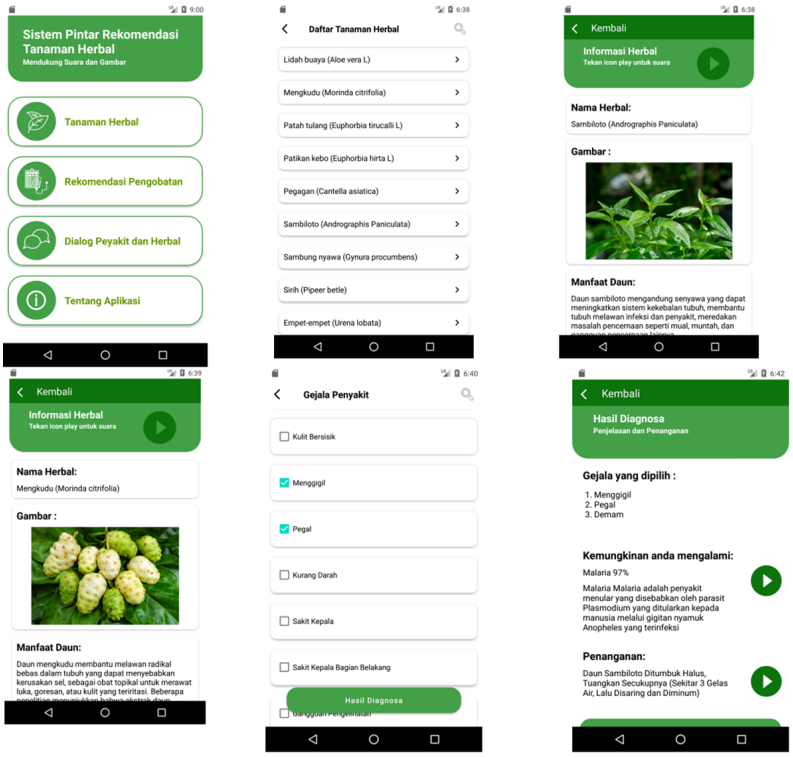

Figure 3. Application

Figure 3 shows the results of the system development in this research. The figure shows several features provided in this research, such as information on herbal plants, recommendations for treating diseases and herbal medicines, and so on. The application of forward chaining in this application is in the treatment recommendations menu. In this menu, the user will be asked to select the symptoms they are experiencing, and the system will provide the results of calculating the possibility of the disease they are experiencing and the method of handling it. An example can be seen in Figure 4.

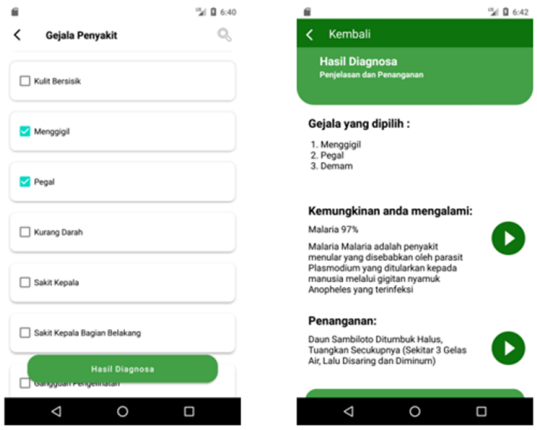

Figure 4. Examination Example

Figure 3 shows an example of checking disease symptoms and the results provided by the system. For these symptoms, users choose chills, aches, and fever. The system provides results in the form of a 97% chance of the user experiencing malaria, and the system also provides treatment.

3.3. Testing

The assessment in this research uses the confusion matrix method to calculate the accuracy value. This research was carried out with 173 scenarios with an accuracy value of 150, so the resulting accuracy value was 86%. Apart from testing with a confusion matrix, testing was also done using the black box method. Black box testing is carried out by running the unit or module and observing the suitability of the output produced. The results of black box testing on the Sopherbal medicinal plant recommendation system application for Android cellphone users are presented in Table 4.

Table 4. Black Box Testing Result

Interface	Test scenarios	Expected output	Results
Main page	Open the side menu	Side menu open	Succeed
List of medicinal plant	Open the side menu	View the list of displayed plants (50 lists of herbal plants)	Succeed
	Open the detailed description of each herbal plant	View the detailed description of each herbal plant, including the secondary metabolite composition, and utilize each body part of the herbal plant	Succeed
Symptoms	Open the side menu	Side menu open	Succeed
	View all symptom items.	View all symptom item	Succeed
	Symptom items can be selected.	The display of symptom items can be selected	Succeed
Diagnosis	View the detailed diagnosis of common diseases.	View the detailed diagnosis of common diseases from selected symptoms, including recommendations of herbal plants, herbal processing, dosage, and duration of use.	Succeed
Illustration dialog about minor illness	Open the side menu	Side menu open	Succeed
	View the dialog and illustration about some minor illness and their treatment.	View the dialog and illustration about some minor illness and their treatment.	Succeed
About application	Open the side menu	Side menu open	Succeed
	View the information about the application and detail the bibliography used in the application.	View the information about the application and detail the bibliography used in the application.	Succeed

Table 4 shows the scenario and results of the black box testing that has been carried out. Based on this table, all scenarios and expected results are as expected.

3.4. Analysis

The research results show that the system developed achieved an accuracy value of 86%, showing quite good performance in providing treatment recommendations using the forward chaining method. Furthermore, black box testing was also carried out smoothly and according to expectations. However, this research faces several obstacles related to the limitations of the forward chaining method used. One of the main limitations is its rules-based nature, which means that new rules must be created first to handle new problems. This suggests that although the system can solve clearly defined problems, it may lack flexibility in handling more complex or unexpected situations. Therefore, future research could consider developing or combining with other more adaptive methods to change and complexity, thereby improving the system's ability to face more varied and dynamic challenges in the context of treatment optimization.

4. CONCLUSION

The functional and system testing results show that the forward chaining method can be used to develop an herbal plant treatment recommendation system. The system that has been developed can provide solutions and information to lay people on herbal plant treatment recommendations. The level of accuracy obtained in the system being developed is 86%, which shows that the accuracy obtained is good. The results of black box testing also show that the system has worked as expected. However, this research faces several obstacles related to the limitations of the forward chaining method, namely that it is less flexible in handling more complex or unpredictable situations because the method is rule-based, and the problems faced must be formulated first. Therefore, future research is expected to consider development by combining more adaptive methods to change and complexity, such as a combination with Genetic Algorithms, Artificial Neural Networks, and others.

5. ACKNOWLEDGEMENTS

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6. DECLARATIONS

AUTHOR CONTIBUTION

MA Contributed to the design and development of the application, ENQ and NI were responsible for collecting data and detailed reviews regarding medicinal plant content, dosage, mode of action, and suitability of medicinal plants and diseases, ENQ contributed to the writing, MA and NI contributed to checking the writing.

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COMPETING INTEREST

The authors declare no competing interest during the research project and publication.

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