

# Expert System for Diagnosing Monkeypox Using the Tsukamoto Method and Forward Chaining

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## ABSTRACT

Monkeypox is a viral infectious disease that requires early detection to prevent wider transmission and ensure appropriate treatment. Limited public awareness and access to medical professionals may delay early diagnosis. Therefore, this study proposes the development of an Android-based expert system for early monkeypox diagnosis using the Forward Chaining inference method and the Tsukamoto fuzzy logic method. Forward Chaining is applied to perform rule-based reasoning based on user-input symptoms, while the Tsukamoto method is used to calculate the level of certainty of the diagnosis. The system was developed using the Waterfall model and tested with 20 case data samples. The evaluation results show that the system achieved an accuracy level of 85%, with 17 out of 20 diagnoses consistent with expert assessments. User testing involving 20 participants indicated that 90% of users found the application easy to use and informative. In addition, the system is capable of generating diagnostic results within 1–2 minutes, making it more efficient than manual consultation. The results demonstrate that the proposed system is effective and feasible as a decision-support tool for early monkeypox diagnosis.

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## I. Introduction

Monkeypox is a viral infectious disease that has attracted global attention due to the increasing number of reported cases in several countries. The disease is characterized by symptoms such as fever, skin rashes, swollen lymph nodes, and fatigue, making early diagnosis essential to prevent further transmission and ensure appropriate medical treatment. However, limited public knowledge and restricted access to medical experts may delay early detection, particularly in remote areas [1].

Advancements in information technology have enabled the development of intelligent systems to support medical diagnosis, including expert systems that simulate the decision-making capabilities of human experts. These systems can provide preliminary diagnostic assistance based on user-input symptoms and serve as decision-support tools rather than replacing professional medical consultation [2]. Previous studies have applied rule-based approaches, such as Forward Chaining, to perform structured reasoning by matching symptoms with predefined rules [3]. Other studies have utilized fuzzy logic methods, including the Tsukamoto method, to handle uncertainty and generate confidence levels in diagnostic results [4].

Despite these developments, most existing studies implement these methods independently, resulting in limitations in either reasoning transparency or uncertainty handling. Rule-based systems tend to lack flexibility in representing vague or uncertain symptoms, while fuzzy logic approaches may not fully capture structured reasoning processes. Furthermore, there is limited research that critically examines or integrates both methods specifically for monkeypox diagnosis, indicating a clear research gap in developing a hybrid approach that combines their strengths.

Therefore, this study proposes an Android-based expert system that integrates Forward Chaining and the Tsukamoto fuzzy logic method for early diagnosis of monkeypox. The selection of these methods is based on their complementary characteristics: Forward Chaining provides a transparent



and systematic reasoning mechanism [3], while the Tsukamoto method enables the quantification of uncertainty through measurable confidence values [4]. By combining these approaches, the proposed system aims to improve diagnostic accuracy and interpretability compared to single-method implementations.

The objective of this study is to develop a mobile-based diagnostic support system capable of providing early indications of monkeypox along with quantified certainty levels. This research contributes to the existing literature by explicitly integrating rule-based reasoning and fuzzy logic, addressing the identified research gap, and enhancing the effectiveness of early diagnostic support systems.

## II. The Proposed Method/Algorithm

This study proposes an Android-based expert system for the early diagnosis of monkeypox by integrating the Forward Chaining inference method and the Tsukamoto fuzzy logic method [5]. The proposed approach combines rule-based reasoning to identify potential diagnoses and fuzzy logic to calculate the level of certainty of the results [6]. The overall workflow of the system is illustrated in Figure 1.

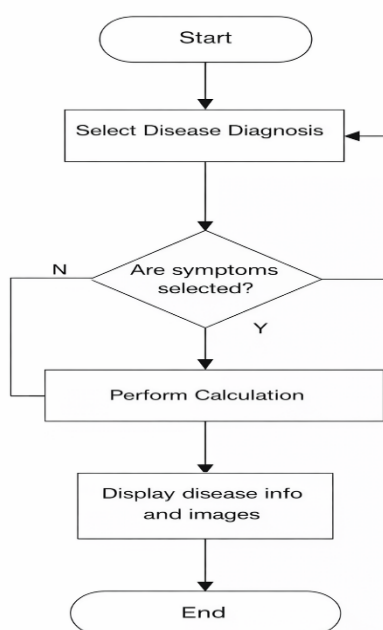


Fig 1. System Workflow of the Proposed Method

As shown in Figure 1, the process begins with the *start* stage, which marks the initial interaction between the user and the application. The user then selects the disease diagnosis menu (*select disease diagnosis*) to initiate the identification process. Subsequently, the system prompts the user to select the symptoms experienced through the application interface. The selected symptoms are stored as initial facts in the system's working memory [7]. In the next stage, the system performs input validation through the decision process *are symptoms selected?*. If the symptoms are not completely selected (N), the system redirects the user to the symptom selection stage until all required data are provided. This process ensures that the input data are sufficient for the inference process, thereby improving diagnostic accuracy. If the symptoms are complete (Y), the system proceeds to the calculation stage (*perform calculation*).

During the calculation stage, the system applies the Forward Chaining method to perform rule-based inference. This method operates in a data-driven manner, starting from known facts (user-input symptoms) and matching them with the rule base constructed from expert knowledge. Each rule, represented in IF-THEN form, is evaluated, and rules that satisfy all conditions are activated to generate preliminary diagnostic conclusions.

After identifying the relevant rules, the system applies the Tsukamoto fuzzy logic method to handle uncertainty in symptom intensity. Each symptom is transformed into a degree of membership through a fuzzification process. The system then calculates the firing strength of each activated rule and generates a crisp output value. A defuzzification process using a weighted average is performed to obtain the final diagnosis value along with its confidence level [8].

Finally, the system generates the diagnostic result along with its confidence level. As shown in the final stage of the flowchart, the application displays the diagnosis result, disease information, and supporting images related to monkeypox before ending the process. This integrated approach enables the system to provide early diagnostic support with measurable certainty values.

### III. Method

This study employed observation, interviews, and a literature review to support the development of the expert system. Observation was conducted to identify common symptoms of monkeypox and to understand diagnostic procedures performed by medical personnel. Interviews were conducted with two medical experts in infectious diseases to obtain information on symptom characteristics, diagnostic criteria, and decision-making rules. The acquired knowledge was validated by the experts to ensure the consistency and reliability of the rule base. A literature review was conducted by examining journals, books, and relevant references related to monkeypox, the Tsukamoto method, and Forward Chaining as the theoretical foundation of the system [9].

The dataset consists of 20 cases and was used for preliminary system testing. Although limited, this dataset provides an initial evaluation of system functionality and performance. Therefore, the results are exploratory and require further validation using a larger dataset. System development followed the Waterfall model (Linear Sequential Model) [10], selected due to the well-defined system requirements and the structured nature of the development process. The model consists of requirement analysis, design, implementation, verification, and maintenance stages, as illustrated in Figure 2.

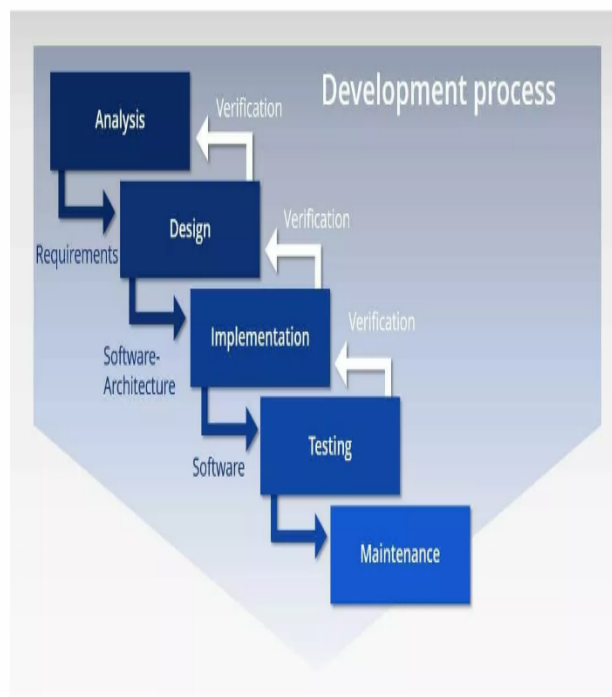


Fig 2. Waterfall Model

Figure 2. The requirement analysis stage focuses on identifying system functionality and user needs. The design stage involves the development of system architecture, database, and rule base. Implementation is carried out through coding and unit testing, while verification ensures that the

system meets the specified requirements. The maintenance stage addresses error correction and system performance improvement after deployment.

#### IV. Results and Discussion

##### A. Implementasi User Interface

The implementation of the user interface is designed to ensure usability and support the diagnostic process effectively. Rather than focusing solely on visual appearance, the interface is structured to facilitate accurate data input and efficient system interaction.

##### 1. Dashboard Page

The dashboard page serves as the main entry point of the application, providing access to core functionalities, including disease diagnosis, symptom analysis, and application information. The layout is designed to guide users in selecting the appropriate function with minimal complexity, thereby improving usability and reducing potential input errors

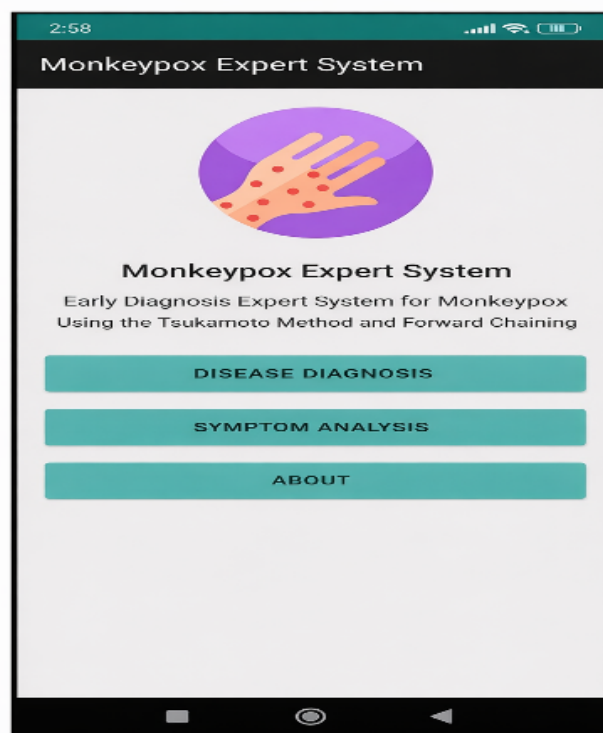


Fig 3. Main Dashboard of the Monkeypox Expert System Application

Figure 3 illustrates the main dashboard of the Android-based monkeypox expert system. The interface presents three primary navigation options: *Disease Diagnosis*, *Symptom Analysis*, and *About*. This structure supports a clear interaction flow, enabling users to directly access diagnostic features or explore additional information. The inclusion of visual elements and brief descriptions enhances user understanding of the system's purpose, contributing to improved user experience.

##### 2. Disease Diagnosis Page

The disease diagnosis page is designed to collect relevant patient data required for the diagnostic process. The input parameters include body temperature, number of rashes, and lymph node swelling, which represent key indicators used in the inference process.

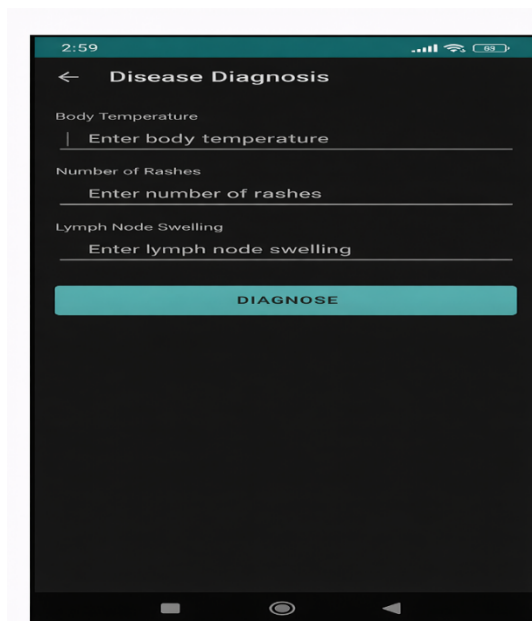


Fig 4. User Interface of the Disease Diagnosis Page for Inputting Patient Symptoms

Figure 4 shows the diagnosis interface where users input symptom data. Each input field is clearly defined to ensure data consistency and reduce ambiguity during data entry. The “DIAGNOSE” function initiates the inference process, where the system processes the input using Forward Chaining to identify relevant rules and applies the Tsukamoto method to calculate the confidence level of the diagnosis. This interface plays a critical role in ensuring that the collected data can be effectively utilized in the computational process, thereby influencing the accuracy of the diagnostic results.

### 3. Low-Level Disease Diagnosis Input Page

This page presents the diagnostic result after the system processes the input data provided by the user. The entered symptoms are analyzed using the Forward Chaining method to identify relevant rules, followed by the Tsukamoto fuzzy method to calculate the confidence level of the diagnosis. Based on the computation, the system classifies the possibility of monkeypox infection as low.

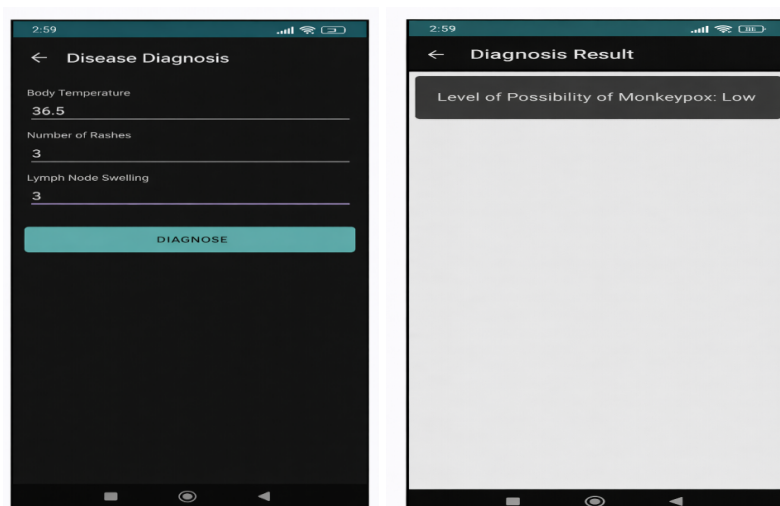


Fig 5. User Interface Showing Low-Level Monkeypox Diagnosis Result

Figure 5 illustrates the transition from symptom input to the diagnostic result. The system processes user inputs and generates a classification with a corresponding confidence level. The low-level result indicates that the combination of symptoms does not strongly satisfy the rule base conditions associated with monkeypox. This output demonstrates how the system differentiates diagnostic outcomes based on symptom intensity and rule evaluation, providing users with interpretable decision support.

#### 4. High-Level Disease Diagnosis Input Page

This page presents the diagnostic result when the input symptoms strongly indicate monkeypox infection. The system processes the input using Forward Chaining to activate relevant rules and applies the Tsukamoto method to compute the degree of certainty. The result shows a high level of possibility of monkeypox infection.

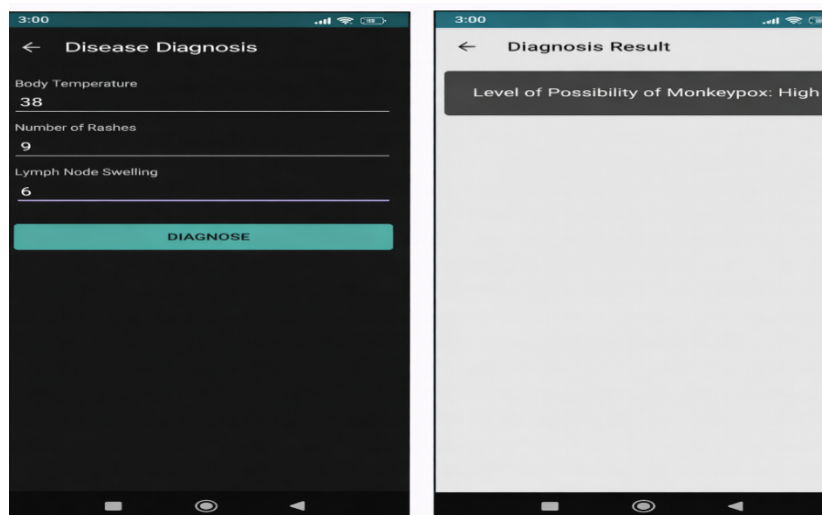


Fig 6. High-Level Monkeypox Diagnosis Input and Result Pages

Figure 6 shows the diagnostic process for higher symptom intensity inputs. The system evaluates the input data and produces a high-level classification, indicating that the symptoms strongly match the rule base conditions. The resulting confidence value reflects the strength of the activated rules and the fuzzy computation. This demonstrates the system's capability to distinguish between different risk levels and provide meaningful diagnostic feedback to users.

#### 5. Symptom Analysis Result Page

This page presents the results of symptom analysis based on user-input data, including the identified diagnosis and recommended actions. The system processes the selected symptoms using the Forward Chaining method to determine the appropriate rule set and applies the Tsukamoto fuzzy method to compute the confidence level of the diagnosis. The output includes both the classification result and actionable recommendations.

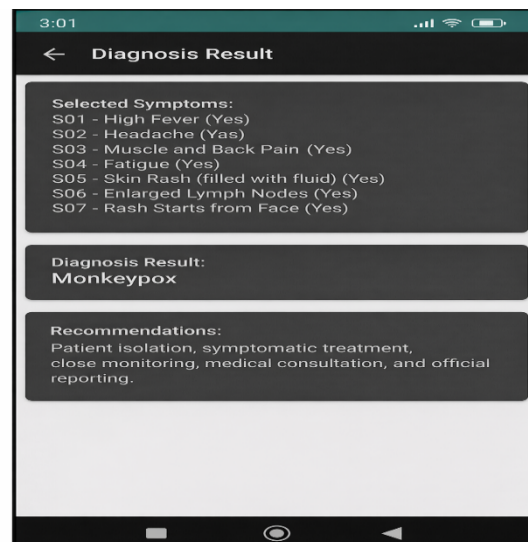


Fig 7. Symptom Analysis Result Page of the Monkeypox Expert System

Figure 7 illustrates the output of the symptom analysis process. The system identifies monkeypox as the most probable diagnosis based on the combination of symptoms provided, which strongly match the rule base. The confidence level is derived from the fuzzy computation, reflecting the degree of certainty in the diagnosis. In addition to the diagnostic result, the system generates recommendations such as isolation, symptomatic treatment, monitoring, medical consultation, and reporting. These recommendations are derived from expert-defined rules and are intended to support user decision-making. This feature demonstrates the system's capability not only to classify disease conditions but also to provide context-aware guidance based on the analysis results.

## V. Conclusion

Based on the results of this study, the proposed Android-based monkeypox expert system integrating the Forward Chaining and Tsukamoto methods demonstrates the ability to provide preliminary diagnostic support. The system achieved an accuracy of 85% based on testing with 20 case samples, where 17 results were consistent with expert assessments. This indicates that the system has potential as an initial decision-support tool for early monkeypox diagnosis. From an implementation perspective, the system is able to process user-input symptoms, apply rule-based inference, and generate outputs in the form of diagnosis results, confidence values, and recommended actions. User testing involving 20 participants also suggests that the application is generally easy to use and provides understandable information. However, the findings should be interpreted with caution due to several limitations. The dataset used in this study is relatively small, and the evaluation is limited to basic accuracy without comprehensive validation metrics such as precision, recall, or confusion matrix. In addition, no comparison with other diagnostic methods or baseline systems was conducted, which limits the ability to assess the relative performance of the proposed approach. Therefore, future work should focus on expanding the dataset, incorporating more rigorous evaluation metrics, and conducting comparative analysis with other methods to improve the reliability and generalizability of the system. Further refinement of the knowledge base and system features is also recommended to enhance diagnostic performance and usability.

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