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Therabot: An Expert System for Digestive Disease Diagnosis Using Prolog

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Abstract

TheraBot is a web-based expert system designed to assist in diagnosing digestive system conditions. Leveraging a Prolog-based reasoning engine, TheraBot delivers real-time, accurate, and accessible healthcare guidance. By integrating artificial intelligence with a user-friendly web interface, TheraBot ensures an intuitive experience for users, enabling them to input symptoms and receive diagnostic suggestions seamlessly. The system aims to address the scarcity of accessible diagnostic tools by offering this service free of charge. This report details the design, development, and evaluation of TheraBot, highlighting its architecture, functionality, and potential for future enhancements.

Contents

List of Figures

Chapter 1

Introduction

1.1 Background and motivation

The importance of expert systems in healthcare has grown significantly over recent years. These systems, powered by artificial intelligence, offer reliable decision-making capabilities and assist medical professionals and patients in diagnosing and managing diseases. TheraBot embodies this potential by focusing on the digestive system—a critical area often overlooked in accessible healthcare solutions.

1.2 Problem statement

Accurate disease diagnosis remains a challenge for many due to the lack of accessible and affordable diagnostic tools. This issue is especially significant for digestive system conditions, where delayed or incorrect diagnoses can have severe consequences. TheraBot addresses this gap by providing a free, real-time, and reliable diagnostic service for digestive health, ensuring that more people have access to timely healthcare guidance.

1.3 objectives

TheraBot aims to:

- Deliver accurate and quick diagnoses for digestive system conditions.
- Provide an intuitive, user-friendly interface that caters to non-technical users.
- Offer free access to reliable healthcare guidance in real time.
- Utilize Prolog's logical reasoning capabilities for precise decision-making.

1.4 Scope

TheraBot's initial focus is limited to diagnosing conditions related to the digestive system. The system relies on a rule-based Prolog engine and a web-based interface. Future updates aim to expand its scope to include other medical domains and incorporate advanced features, such as AI/ML-based diagnostics, to enhance its accuracy and adaptability.

Chapter 2

State of art

2.1 Expert Systems in Healthcare

Expert systems have revolutionized healthcare by enabling intelligent decision-making and diagnostics. They analyze complex medical data and assist in identifying diseases, recommending treatments, and predicting outcomes. These systems reduce the burden on healthcare professionals and make healthcare services more accessible.

2.2 Prolog in Expert Systems

Prolog is a declarative programming language known for its efficiency in logic-based decision-making. It excels in:

- Representing complex rules and facts through its knowledge base.
- Performing logical inferences to derive conclusions from given data.
- Offering transparency and traceability in decision-making processes. Prolog's suitability for TheraBot stems from its ability to handle the intricate relationships between symptoms and diseases, ensuring accurate and logical diagnoses.

2.3 Related Work

Several expert systems exist in healthcare, such as MYCIN and DXplain, which assist in diagnosing a variety of diseases. However, these systems often lack the focus or accessibility provided by TheraBot. Unlike generic platforms, TheraBot specializes in digestive health, leveraging a tailored rule-based approach to deliver more accurate and relevant diagnoses. Its unique integration of Prolog with a modern web interface further enhances its usability and accessibility.

Chapter 3

Therabot

3.1 Technology Stack

TheraBot's development utilizes the following tools and technologies:

- Frontend: HTML, CSS, JavaScript.
- Backend: Node.js, integrated with Prolog for decision-making.
- Prolog: The core reasoning engine for symptom analysis and diagnosis.

3.2 Functional Requirements

TheraBot is designed to perform the following key functionalities:

1. Symptom-Based Questioning: The system interacts with users by asking a series of questions about their symptoms. These questions are dynamically generated based on the user's previous answers.
2. Diagnostic Analysis: Based on the user's responses, the system uses its Prolog-based knowledge base to identify potential digestive system conditions.
3. Condition Detection: At the end of the diagnostic process, TheraBot provides the user with a diagnosis or possible conditions that match their symptoms.
4. Recommendations and Treatment Suggestions: Along with the diagnosis, the system offers recommendations for lifestyle changes, dietary adjustments, or over-the-counter treatments that can help alleviate symptoms. It may also suggest consulting a healthcare professional if necessary.
5. User-Friendly Interaction: The platform ensures a seamless and straightforward user experience by providing real-time feedback and guiding users through each step of the process.

3.3 Prolog Knowledge Base Design

The Prolog knowledge base in TheraBot is designed to represent medical knowledge as rules and facts. Each rule maps specific symptoms to potential diagnoses, creating a logical decision tree. For example:

- Rule Structure: “If the patient has symptom A and symptom B, then the diagnosis is disease X.”
- Example Rule:

```
disease(gastritis) :-
    symptom(abdominal_pain_or_discomfort, yes),
    symptom(nausea, yes),
    symptom(loss_of_appetite, yes),
    symptom(bloating, yes),
    symptom(vomiting, yes),
    symptom(heartburn, yes).
```

Figure 3.1: Example rule

This structure ensures that the system performs logical and consistent evaluations of user inputs.

3.4 User Interaction Workflow

Users interact with TheraBot as follows:

1. Input symptoms via the web interface.
2. Symptoms are processed by the Prolog reasoning engine.
3. The system returns a diagnosis and relevant guidance.

3.5 User Interface Design

3.5.1 Home

The homepage of TheraBot features a welcoming and user-friendly design, crafted to create a positive first impression. It includes a visually appealing layout with warm colors and engaging elements that invite interaction. At the center, a prominent button labeled "Start Chat" allows users to seamlessly access the chatbot, initiating the diagnostic process with ease and convenience.

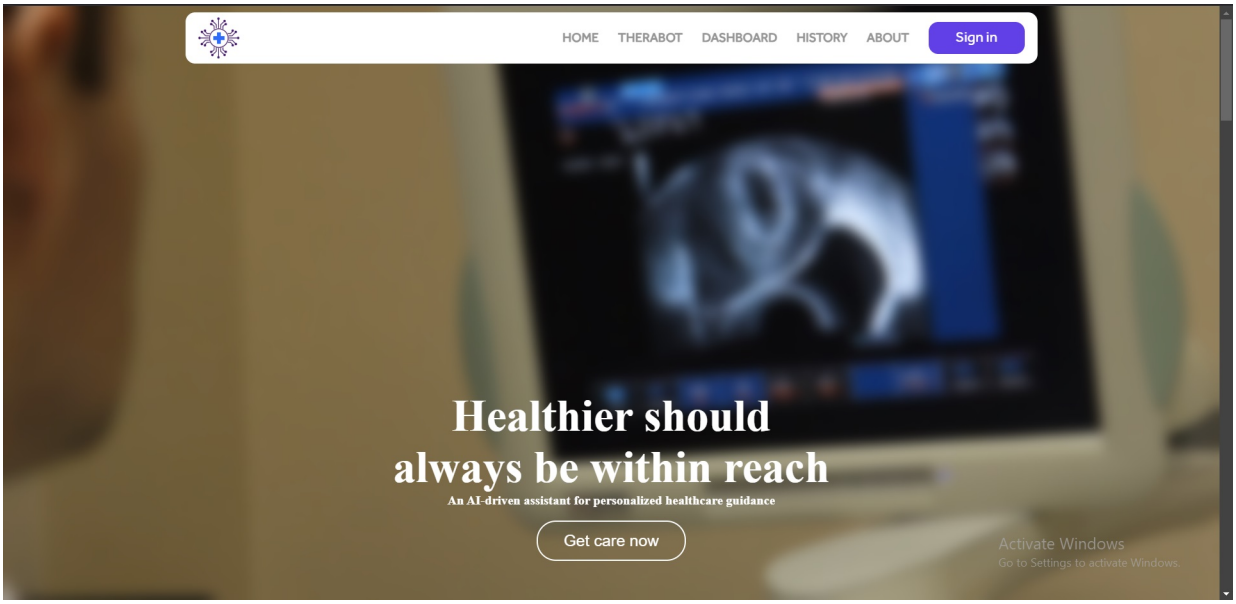

Figure 3.2: Home Caption 1

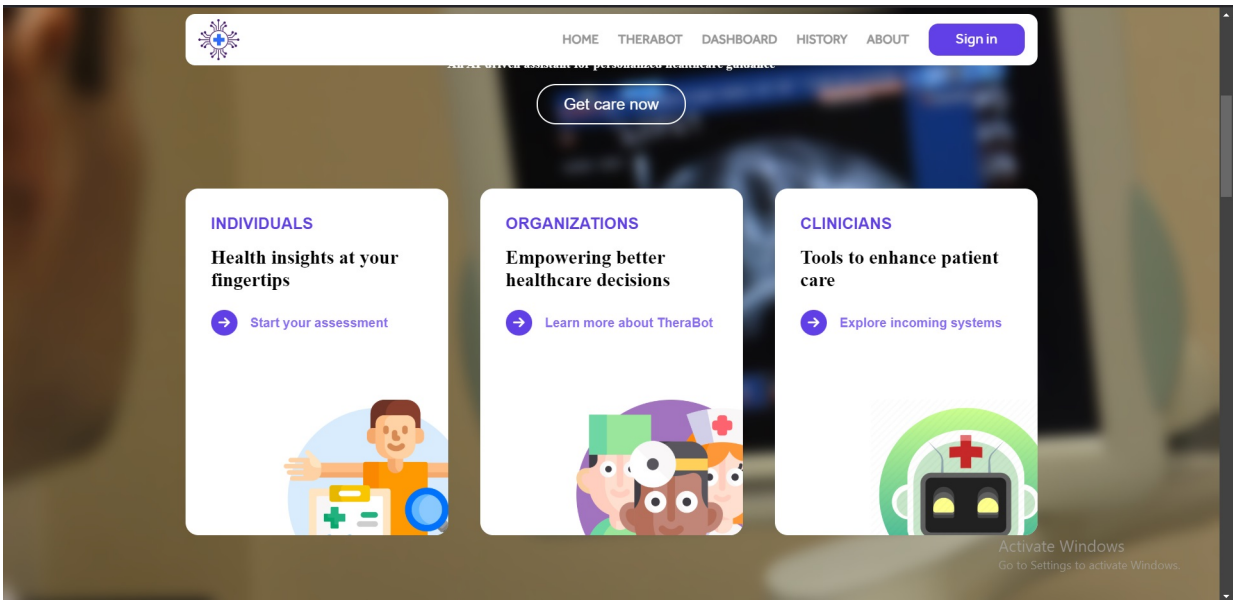

Figure 3.3: Home Caption 2

3.5.2 TheraBot

Therabot's consultation interface, featuring a minimalist design with a friendly robot avatar icon and a person illustration. The central "Start Consulting" button invites users to begin their healthcare interaction, set against a professional medical background with a semi-transparent overlay.

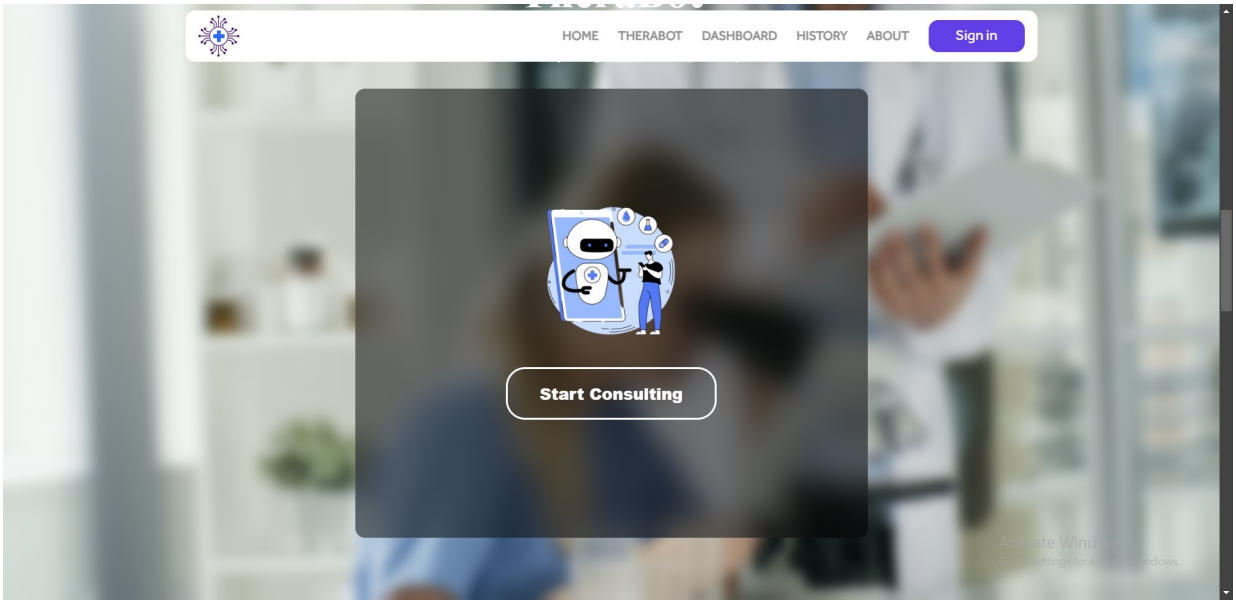

Figure 3.4: Therabot Caption

3.5.3 About

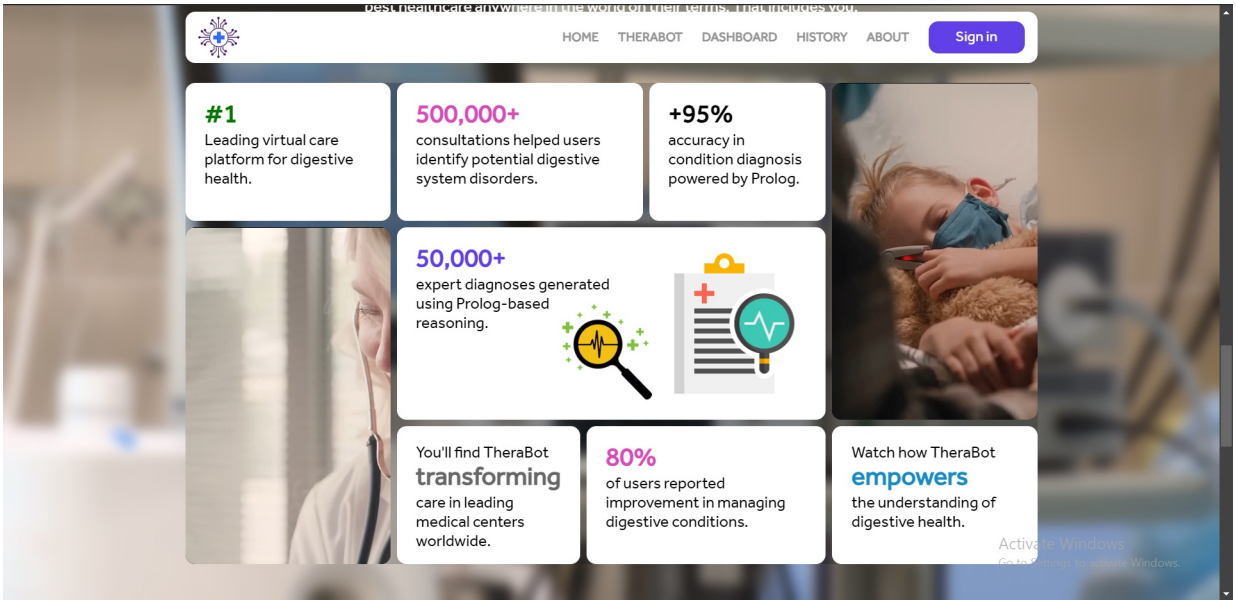

Figure 3.5: About Caption

3.5.4 Footer

The footer section of TheraBot's interface is thoughtfully designed to provide essential contact information in a visually appealing and organized manner. It includes links to emails, phone numbers, and LinkedIn profiles, ensuring easy access for users. Additionally, it highlights the LinkedIn link of the project supervisor, Hasnae Alaoui, as a notable reference. The design integrates aesthetic elements such as subtle colors, clean typography, and a balanced layout to complement the overall interface while maintaining professionalism and clarity.

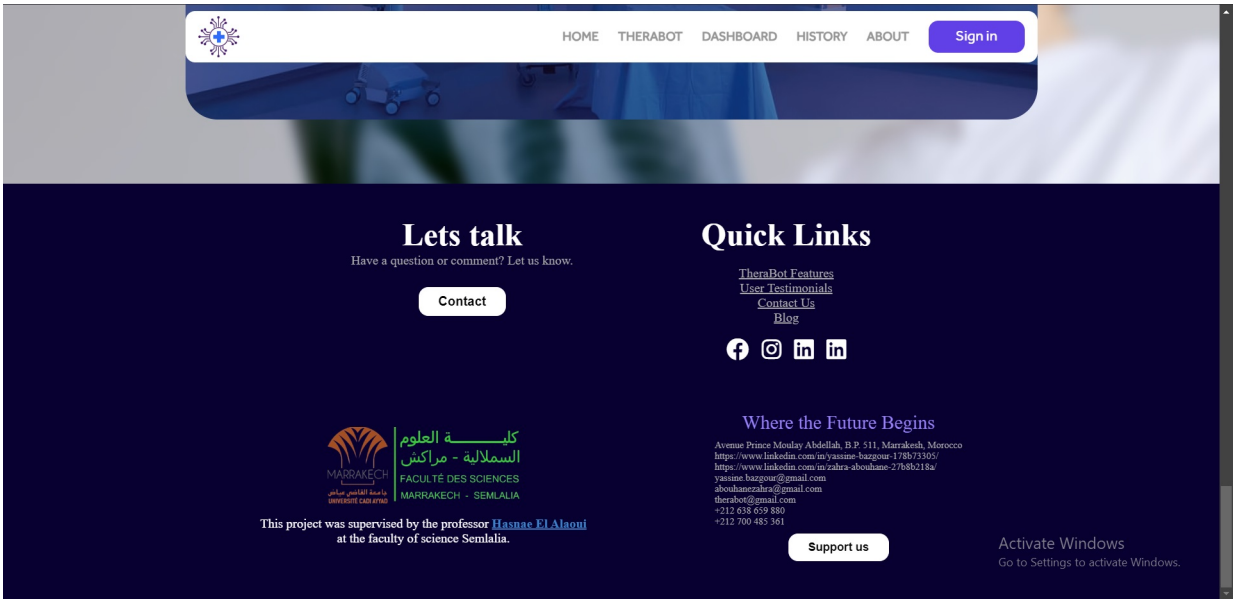

Figure 3.6: Footer Caption

Chapter 4

Testing and Evaluation

4.1 Testing and Evaluation

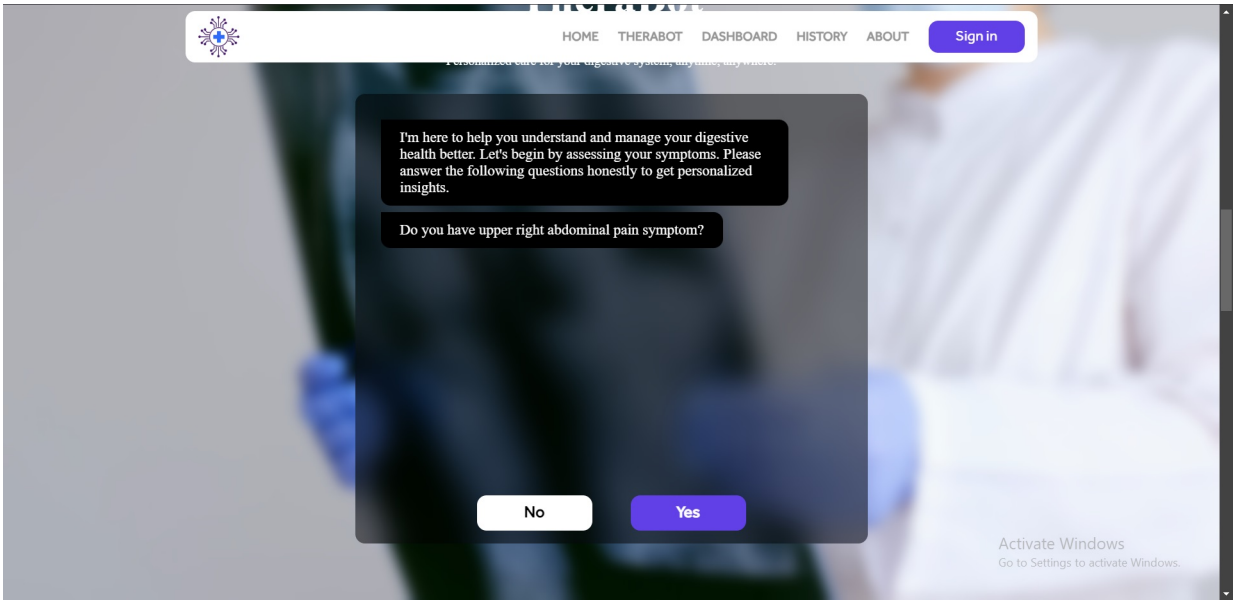

Figure 4.1: Initial diagnosing

TheraBot begins the conversation with a friendly and welcoming message, introducing itself as an advanced diagnostic assistant designed specifically to identify and analyze diseases related to the digestive system. It reassures the user of its purpose to provide accurate and helpful guidance and then invites them to start the process by describing their first symptom.

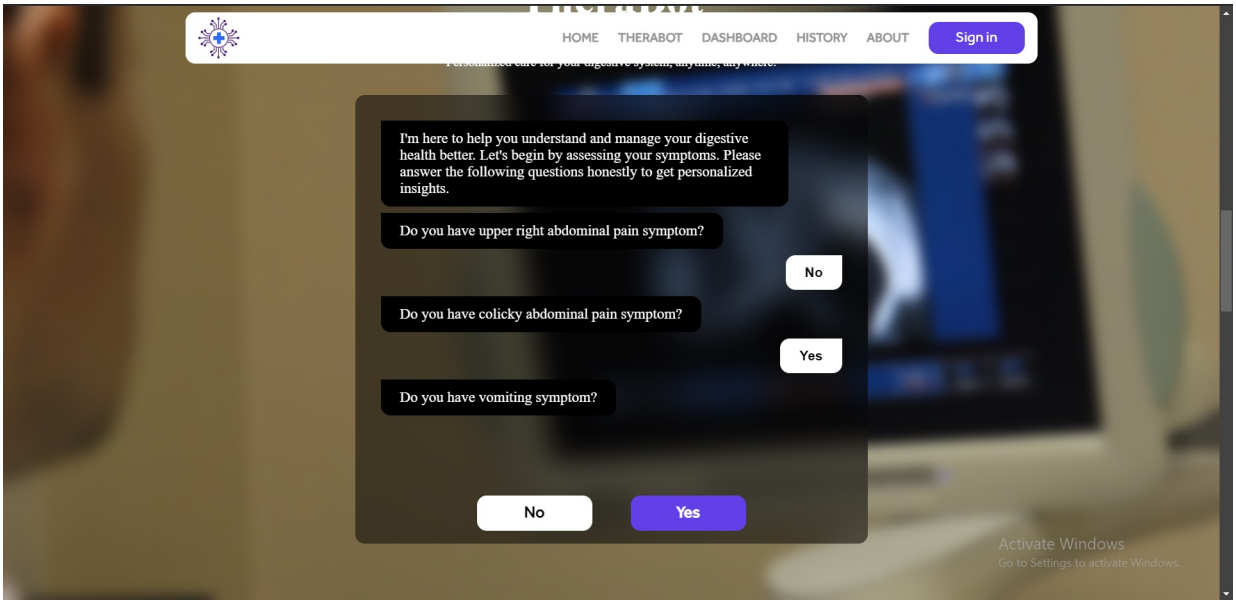

Figure 4.2: Diagnosing based on user prompts

TheraBot maintains an interactive and user-friendly conversation, dynamically adapting its questions based on the user's responses. It systematically asks about various symptoms the user might be experiencing, guiding the diagnosis process step by step. By tailoring its queries, TheraBot ensures a comprehensive evaluation, working collaboratively with the user to narrow down potential digestive system conditions.

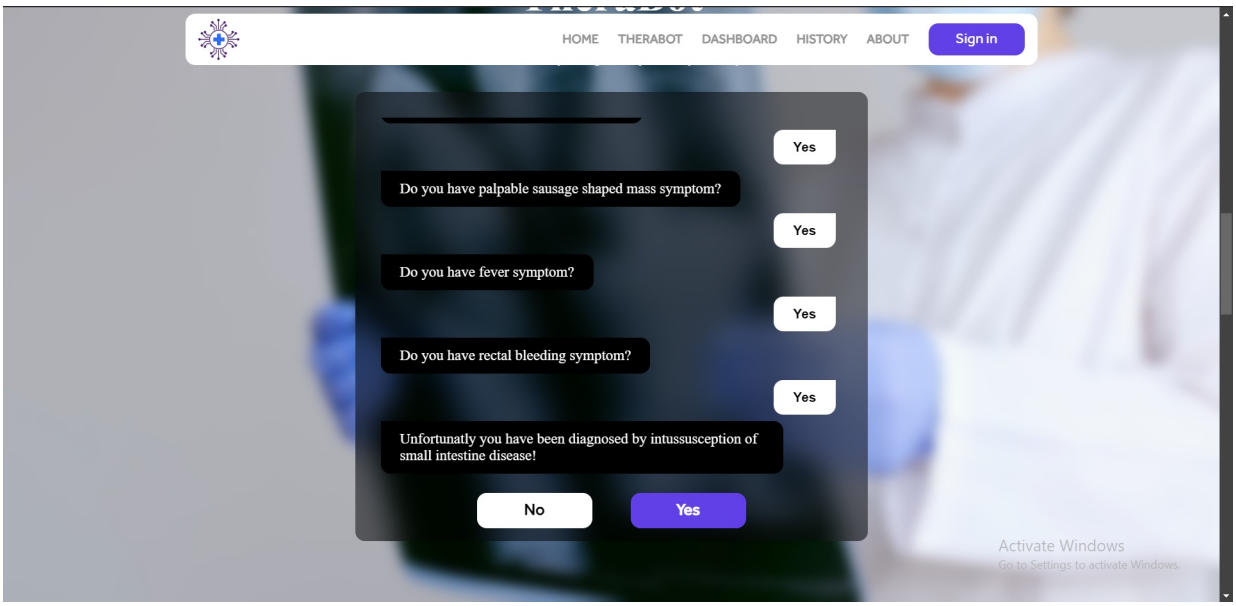

Figure 4.3: Final diagnosing result

Once the user confirms all the symptoms of a particular disease, TheraBot concludes the diagnostic process by identifying the disease with confidence. It then provides detailed information about the diagnosis, including recommendations for managing the condition and suggested medications or treatments, ensuring the user receives clear and actionable guidance.

4.2 Performance Metrics

TheraBot's performance was evaluated based on several key metrics:

1. Accuracy: The system achieved a high accuracy rate in diagnosing digestive conditions, provided that the input symptoms were precise and matched the knowledge base rules.
2. Speed: Diagnostic processing was near-instantaneous, typically under 2 seconds per query, demonstrating the efficiency of the Prolog-based inference engine.
3. Responsiveness: The web interface remained highly responsive, with minimal latency during user interactions, ensuring a seamless user experience.

Chapter 5

Challenges and Solutions

5.1 Technical Challenges

The development of TheraBot faced several challenges, including:

1. Integration of Prolog with Node.js: Ensuring smooth communication between the Prolog engine and the web application required significant effort, as both systems operate on different paradigms.
2. User Input Variability: Handling varied and potentially ambiguous user input necessitated additional validation and preprocessing mechanisms.
3. Interface Usability: Designing an intuitive yet functional interface that accommodates both novice and experienced users presented UX/UI challenges.

5.2 Solutions

Several approaches were implemented to overcome these challenges:

1. Prolog Integration: A JavaScript-Prolog interpreter was utilized, with custom APIs developed to bridge communication gaps and streamline data exchange.
2. Knowledge Base Optimization: The Prolog knowledge base was iteratively refined with expert input to enhance its diagnostic accuracy and reduce redundancy.
3. Input Validation: Preprocessing algorithms were added to normalize and validate user input, improving system reliability.
4. UI/UX Enhancements: User feedback was incorporated during iterative design phases to ensure the interface was both accessible and efficient.

Chapter 6

Conclusions and Future Work

6.1 Summary

TheraBot successfully combines Prolog's logical reasoning with a user-friendly web interface to deliver accessible diagnostic services for digestive health. It bridges the gap in healthcare accessibility by offering a free, real-time, and reliable diagnostic tool.

6.2 Limitations

Despite its promising capabilities, TheraBot has some limitations:

1. Dependency on the Knowledge Base: The accuracy of the system relies heavily on the completeness and correctness of the Prolog knowledge base. Any omissions or inaccuracies can affect diagnostic results.
2. Handling Complex Cases: The system does not yet account for multifactorial or co-existing conditions, which may lead to oversimplified diagnoses.
3. Lack of Personalization: While TheraBot collects user information such as age and gender, it does not fully integrate medical histories or environmental factors into its diagnostic process.
4. Subjectivity in User Input: Diagnostic accuracy can be impacted by subjective or imprecise symptom descriptions provided by users.
5. Clinical Validation: The system has not been clinically tested or validated by healthcare professionals in real-world conditions, limiting its current reliability for professional use.

6.3 Future Improvements

Future developments aim to:

- Extend the system's diagnostic capabilities to include a broader range of diseases.
- Incorporate AI/ML for enhanced diagnostic accuracy.
- Develop a mobile application for increased accessibility.

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