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Rule based chatbot design methods: A review

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The use of chatbots in various sectors including the health sector is becoming important. Rule based chatbots are one of the commonly used chatbots which is easier to implement and with less error. For example, in assisting by providing preliminary diagnostics to the youth and advising them to provide appropriate medical care and awareness creation. In resource limited environment where there is a shortage of medical experts as well as other resources, rule based chatbot can be a supportive tool to support patients and health workers. In addition, in infections like sexually transmitted infections, having an anonymous chatbot is ideal for supporting the youth who fear to openly visit health centers due to stigma and discrimination. Hence, a rule based chatbot can be designed to support them in providing preliminary diagnostics, advising them to visit health centers as well as creating awareness from reliable sources. Hence, this paper, reviews key rule based chatbot design approaches, their advantages and disadvantages.

Keywords: AI; AI chatbot; Sexual and Reproductive Health (SRH); Machine Learning; Healthcare Access

1. Introduction

The application of artificial intelligence (AI) technology in healthcare has demonstrated significant potential to transform the delivery of healthcare services in recent years. AI chatbots represent one such technology that has drawn increasing attention, as they offer a novel and user-friendly way for patients to access information and support tailored to their individual needs [1, 2].

This paper presents a review of rule based Chatbot design approaches for improving healthcare services, with a focus on the delivery of sexual and reproductive health (SRH) services. Access to quality healthcare remains a significant challenge, particularly in developing countries. AI chatbots have emerged as a promising technology to bridge the healthcare gap by providing personalized support and information.

The healthcare systems in many parts of the world, especially in developing nations, face a range of urgent issues, such as limited access to care, shortages of healthcare workers, language barriers, and disparities in the quality of services provided [3, 4]. These challenges have a significant impact on the delivery of essen-

tial healthcare services, including sexual and reproductive health (SRH). While AI chatbots have the potential to help address some of these issues, the specific ways in which they can be leveraged to support SRH services are still being explored [5, 6].

By conducting a literature review, this paper aims to examine how AI chatbot support can be used to address issues related to reproductive health services. The review will analyze various methodologies and technologies used in chatbot applications, present an overview of AI tools employed in healthcare, and provide a comparative analysis of the different approaches. This comprehensive understanding of best practices in developing AI chatbots can help optimize resource allocation, improve healthcare outcomes, and enhance patient engagement within the healthcare sector, particularly for SRH services in developing countries where the number of doctors and resources are limited.

The goal of this systematic review is to examine the various roles and design approaches of AI chatbots in healthcare services, with a focus on identifying key trends, challenges, and opportunities. By synthesizing existing research, the review aims to provide a deeper understanding of how AI chatbot design strategies can be leveraged to address the urgent issues faced by global healthcare systems, such as limited access to care, language barriers, healthcare worker shortages, and quality disparities - all of which disproportionately impact developing nations. This knowledge can then be used to promote further research and development in the application of AI chatbots for SRH services and other areas of healthcare delivery, ultimately contributing to improved healthcare outcomes in underserved regions.

2. Literature review

This literature review was conducted to provide a comprehensive overview of the current state of research on AI chatbot design approaches for healthcare applications, with a particular focus on sexual and reproductive health (SRH) services. The review process involved a structured search of relevant databases, including PubMed, IEEE Xplore, and ACM Digital Library, using keywords such as "AI chatbot," "healthcare," "sexual and reproductive health," and related terms. The initial search yielded a large number of potentially relevant articles, which were then screened and filtered based on predefined inclusion and exclusion criteria to ensure the relevance and quality of the selected studies.

The literature review does not attempt to optimize the design and effectiveness of chatbots, as that would require experimental or development work. Rather, the purpose is to identify and compare the various approaches that have been employed in the development of AI chatbots for healthcare applications, as per the stated objective in the Introduction. Furthermore, for the sake of completeness, various aspects of chatbot development are reviewed.

One prominent design approach for AI chatbots in healthcare is based on natural language processing (NLP) techniques [5, 6]. These approaches involve the

use of advanced algorithms to analyze and understand human language, enabling chatbots to interpret user queries, extract relevant information, and provide accurate responses. NLP-based chatbots have demonstrated promising results in various healthcare applications, including symptom assessment, medication management, and mental health support. Another key design approach for AI chatbots in healthcare leverages machine learning and deep learning techniques [7, 8, 9]. By training chatbots on large datasets, these approaches enable them to learn patterns and make predictions based on the data. Machine learning and deep learning-based chatbots can be utilized for tasks such as medical diagnosis, risk prediction, and treatment recommendation. These approaches have the potential to improve the accuracy and efficiency of healthcare services by leveraging the power of data analysis and pattern recognition.

Another critical aspect of AI chatbot design in healthcare is context-aware approaches [10, 11, 12]. Context-aware chatbots take into account the specific circumstances and environment in which the user interacts with the system. This includes considering factors such as the user's location, time, and personal health history. By incorporating context awareness, chatbots can provide more personalized and relevant responses, leading to a more satisfactory user experience and improved healthcare outcomes.

The literature review also identifies two key design approaches for AI chatbots in healthcare: timeline-based and content-based approaches. The timeline-based approach [13] focuses on constructing AI chatbots that simulate human interaction by considering the chronological order of events and conversations. This approach involves capturing and modeling the temporal context of user interactions and tailoring chatbot responses accordingly. Studies have shown that incorporating a timeline-based design approach in healthcare chatbots enhances user experience and improves the accuracy of responses by considering the sequence of queries and information the user provides [14, 15].

The content-based approach, on the other hand, emphasizes the extraction and analysis of textual content from various healthcare sources, including medical literature, clinical guidelines, and patient records. By leveraging NLP techniques, AI chatbots can comprehensively understand medical information and provide accurate and reliable responses to user queries. The content-based approach enables chatbots to stay up-to-date with the latest medical knowledge and deliver personalized healthcare advice [16]. The literature also reveals a new field that has the potential to address urgent global healthcare issues: the use of AI chatbots in sexual and reproductive health services [17, 18]. The growth of AI chatbots in healthcare is illustrated through a timeline-based study, where early research concentrated on symptom analysis and general healthcare information. However, new studies have identified the unique requirements and obstacles in the field of sexual and reproductive health services, which has prompted the creation of content-based methodologies [18, 19, 20]. These strategies place a strong emphasis on giving precise and customized information about family planning, sexually transmitted diseases,

contraception, and reproductive rights.

3. Rule based chatbot methodologies

Artificial intelligence (AI) techniques including deep learning, machine learning, and natural language processing (NLP) are frequently used in healthcare contexts. It highlights how crucial these technologies are to allowing chatbots to easily and efficiently reply to customer inquiries [21, 22, 23].

3.1. *Comparative Metrics*

This subsection defines the metrics used to compare and evaluate different AI chatbot design approaches. Metrics may include accuracy, response time, user satisfaction, scalability, and adaptability.

3.2. *Comparative Analysis*

This subsection presents a comparative analysis of the identified chatbot design approaches, highlighting their strengths, weaknesses, and suitability for various healthcare scenarios. The basis of this comparison includes several key dimensions: the required dataset size, computational resources, development timeline, and expertise requirements.

This paper has selected rule-based expert systems as the best design approach for AI chatbots in healthcare services for the following reasons:

- **Structured and transparent decision-making**: Rule-based expert systems provide a clear and structured decision-making process, which is crucial in healthcare where accurate and reliable information is essential. By encoding medical guidelines and rules into the chatbot's knowledge base, it can ensure consistency and adherence to established protocols.
- **Ease of maintenance and updates**: As medical knowledge is constantly evolving, healthcare chatbots need to stay up-to-date with the latest guidelines and recommendations. Rule-based systems enable straightforward modifications and additions to the rule set, ensuring that the chatbot's responses align with current medical standards.
- **Advantages over other AI techniques**: Compared to other AI systems, such as neural networks and Bayesian networks, rule-based expert systems offer clear and structured decision-making, explicit representation of knowledge, and easy maintenance and updates. While they may have limitations in handling uncertainty and complex scenarios, the paper suggests that they are the best option for healthcare chatbots among the evaluated approaches.
- **Potential for integration with other AI techniques**: The paper acknowledges that while rule-based expert systems are the best option, it is

	Expert System	Artificial Neural Network	Bayesian Network
Required Dataset Size	•Rely on explicit knowledge provided by domain experts, and they do not typically require a large dataset for training. •The size of the dataset may not be a significant factor, as long as there is sufficient expert knowledge available.	•Generally requires a substantial amount of labeled training data to learn complex patterns effectively. •If we have a large dataset, a neural network can be used to make accurate predictions.	•Can handle datasets of various sizes. •They can work with smaller datasets, but they also benefit from larger datasets for more accurate probabilistic modeling.
Computational Resources	•Usually have low computational requirements as they rely on rules and logic-based reasoning. •They can be implemented on relatively modest computational resources.	•Can be computationally intensive, particularly if the model architecture is complex or the dataset is large.	•Less computationally demanding compared to neural networks. •They can be trained and used with modest computational resources, making them more accessible in terms of deployment.
Development Timeline	•Can be developed relatively quickly, especially when the expert knowledge is available. readily •The development process mainly involves capturing the knowledge in the form of rules or decision trees.	•Can be time-consuming, especially when working with large datasets. •The process involves designing the network architecture, training the model, and optimizing hyperparameters to achieve desirable performance.	•Requires a combination of expert knowledge and statistical analysis. •The time required depends on the complexity of the network structure, the integration of prior knowledge, and the analysis of data dependencies.
Expertise Requirements	•Requires domain experts who possess in-depth knowledge of prediction. •The focus is on encoding expert rules and decision-making processes into the system.	•Demand expertise in machine learning and deep learning techniques. •The development team needs knowledge of network architectures, training algorithms, and hyperparameter tuning.	•Require expertise in probabilistic modeling and statistical analysis. •The development team should be proficient in Bayesian inference, data analysis, and the interpretation of network structures.

Table 1. The difference between Expert system, Artificial Neural Network, and Bayesian Network

important to complement them with other AI techniques, such as natural language processing and machine learning. This integration can help enhance the chatbot's ability to handle uncertainty and adapt to diverse healthcare scenarios, addressing some of the limitations of rule-based systems.

4. Discussion

In this research paper, we explore different design approaches for developing AI chatbots in the context of healthcare services. One of the prominent design approaches discussed in the paper is the utilization of rule-based expert systems in the development of healthcare chatbots. Rule-based expert systems are particularly well-suited for healthcare applications due to their ability to capture and represent explicit knowledge and medical guidelines in the form of rules.

The systematic review highlights the advantages of using rule-based expert systems in AI chatbot design for healthcare services. Firstly, these systems provide a structured and transparent decision-making process, which is crucial in healthcare where accurate and reliable information is of utmost importance. By encoding medical guidelines and rules into the chatbot's knowledge base, it can ensure consistency and adherence to established protocols.

Secondly, rule-based expert systems in healthcare chatbots allow for easy maintenance and updates. As medical knowledge is constantly evolving, healthcare chatbots need to stay up-to-date with the latest guidelines and recommendations. Rule-based systems enable straightforward modifications and additions to the rule set, ensuring that the chatbot's responses align with current medical standards. However, the review also acknowledges some limitations of rule-based expert systems. These systems may struggle with handling uncertainty and complex scenarios that require nuanced decision-making. Additionally, they might face challenges in capturing fuzzy concepts or adapting to new situations that fall beyond the scope of predefined rules.

In future work, it would be valuable to explore the integration of advanced NLP techniques in healthcare chatbot design. This could involve leveraging state-of-the-art NLP models such as transformer-based architectures like BERT or GPT-3 to enhance the chatbot's ability to understand and respond to complex medical queries, including those with ambiguous or context-dependent language. Additionally, exploring techniques such as sentiment analysis and emotion detection could enable chatbots to provide more empathetic and personalized responses, improving the overall user experience.

5. Conclusion

In conclusion, this systematic review has thoroughly examined the diverse roles and design approaches of AI chatbots in healthcare services, particularly in addressing critical challenges faced by global healthcare systems, such as limited access to care,

Type	Pros	cons	Best Option
Expert Systems	•Clear and structured decision-making •Explicit representation of knowledge •Easy maintenance and updates	•Limited ability to handle uncertainty •Difficulty in capturing fuzzy concepts •Lack of adaptability to new situations	•Rule-based Expert Systems
Neural Networks	•Powerful pattern recognition capabilities •Ability to learn from large datasets •Adaptability and generalization	•Complex training and tuning •Lack of interpretability and explaining ability •Computationally intensive	•Feedforward Neural Networks
Bayesian Networks	•Probabilistic reasoning and uncertainty Modeling •Easier to interpret and explain	•Difficulty in learning complex structures •Limited ability to handle dynamic changes •Dependency on accurate prior knowledge	•Hybrid Bayesian Networks

Table 2. The pros and Cons of methodologies

healthcare worker shortages, language barriers, and quality disparities—issues that disproportionately affect developing nations.

This paper qualifies as a systematic literature review because it employs a structured methodology to identify, select, and analyze relevant studies. By focusing on specific research questions and applying rigorous inclusion criteria, this review min-

imizes bias and provides a comprehensive understanding of the current state of AI chatbot design in healthcare. In contrast, a comprehensive literature review might cover a broader range of topics without the same level of methodological rigor, potentially leading to a less focused analysis.

The insights gained from this review not only highlight the methodologies and technologies utilized in chatbot applications but also offer a comparative analysis of various design approaches. Such an understanding is essential for optimizing resource allocation, improving healthcare outcomes, and enhancing patient engagement, particularly within sexual and reproductive health (SRH) services in developing countries.

The findings of this systematic review are anticipated to inform future research and development efforts by identifying gaps in the literature and potential areas for innovation. By synthesizing existing research, we encourage further exploration of AI chatbot design strategies aimed at improving the delivery of SRH services and other critical healthcare domains. Ultimately, this knowledge can contribute to the development of innovative solutions that address the pressing challenges faced by global healthcare systems and enhance health outcomes in underserved regions.

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