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Artificial Cognition-based Medical Diagnosis and Treatment Recommendation System: A Review

NTD Dharmasiri [1#], NWAGN Nanayakkara[2], UI Abeyasinghe[3], NS Wisidagama[4], ML Karunarthne[5], DMM Ranasinghe[6]

[1,2,3,4,5] *Department of Computer Science, Faculty of Computing, General Sir John Kotelawala Defence University, Sri Lanka*

[6] *Department of Electrical and Computer Engineering, Faculty of Engineering Technology, Open University of Sri Lanka*

[#] 37-se-0014@kdu.ac.lk

Abstract— *In our rapidly evolving world, technological advancements and innovations have led to increasingly complex mechanisms. This research paper presents the implementation of an artificial cognition-based medical diagnosis and treatment recommendation system. The aim of the study is to leverage technological advancements in natural language processing, wearable devices, and image analysis to create a sophisticated system capable of accurately and efficiently diagnosing diseases and suggesting appropriate medical treatments. The methodology draws inspiration from IBM's Watson model and integrates cognitive systems that closely simulate human-like functions within computers. By adopting this approach, complex medical problems can be addressed with improved accuracy and expedience. The results demonstrate the system's capability to deliver reliable diagnoses and corresponding treatment recommendations. Overall, this research showcases how cutting-edge technological solutions can revolutionize medical practices, paving the way for more effective patient care and management.*

Keywords— **Artificial Intelligence, Cognitive Systems, Cognition, Recommendation systems, Healthcare**

I. INTRODUCTION

With the rapid development of technology, the applications and mechanisms which are developing are very advanced and also use different types of new approaches. With the evolution of Artificial Intelligence (AI), the concept called Artificial Cognition was introduced. Artificial Cognitive systems is a sub-domain of AI which is solely based on computer implementation of human perception, action and reasoning (Nirenburg, 2015). The primary distinction between a cognitivist system and other intelligent systems lies in its focus on human capabilities and perception when deployed in real-world scenarios.

The definition of cognition can be stated as the ability to identify how some things and activities be on only at the present but also in future. Then decision making process can be carried out based on the observations and the conclusions (David Vernon, Metta and Sandini, 2007). A cognitive system has the ability to work independently, and it is embedded with perception, action, deliberation and also it will have the ability to carry out the communication in a methodical and an independent manner.

The main two paradigms of cognition are emergent and cognitivist. These two mainly differ upon twelve characteristics and they can be stated as, computational operation, representational framework, semantic grounding, temporal constraints, inter-agent epistemology, embodiment, perception, action, anticipation, adaptation, motivation, and autonomy (David Vernon, Metta and Sandini, 2007). The paradigm which is based on both emergent and cognitivist is called the hybrid approach. It consists of features of the main two paradigms. There are different architectures for cognitive systems based on the paradigm used. Some of the common architectures of cognitive systems are SOAR, HUMANOID, EPIC, ACT-R,SASE, DARWIN, Cerebos and Kismet (D. Vernon, Metta and Sandini, 2007). Cognition is used for many applications in todays' world. Some of the cognition based applications are, Digital twins (Nirenburg, 2015), autonomous cars, autonomous weapons, AI based chatbots to automate banking systems, recommendation systems and brain-machine interfaces. The aim of this research is to identify cognitive systems, available architectures and to propose the most optimal and the cost-effective approach to be used when developing an Artificial Cognition based medical diagnosis and treatment recommendation system. Further, it is targeted to carry out a systematic literature review to find out about the developed systems, the architectures and other factors considered by other researchers through the studies conducted. The most

suitable approach will be based on all the factors identified through the literature review and the other findings observed through research.

This paper is structured into five sections as Introduction, Literature Review, Application to the proposed system, Methodology, Discussion and Conclusion. The introduction section will provide a basic introduction to what artificial cognition is and what are the available architectures and the applications of cognition. The literature review will provide a summary on the identified literature and the application section will provide justification regarding the proposed system, what architecture is the best and the features. The methodology will provide an insight how this research was carried out and the paper will be after the discussion.

II. LITERATURE REVIEW

This section provides you with a systematic literature review on the research work identified when carrying out a review on this topic. From the identified research work, the ten most appropriate and related set of research papers are reviewed and the summaries of those are included in this section.

The paper called 'Edge Cognitive Computing based Smart Healthcare System' by Min Chen, Wei Li and others (Chen et al., 2018) state that in order to provide healthcare services that are more effective and efficient, the study suggests a smart healthcare system based on edge cognitive computing, which combines edge computing with cognitive computing technology. The suggested system is built to take use of the enormous volumes of data produced by sensors, medical devices, and other sources to enable intelligent analysis and immediate medical diagnosis and treatment choices. The authors provide a detailed description of the system's edge devices, cloud platform, cognitive engines, and application interfaces in their architecture and component breakdown. They talk about the difficulties and opportunities of implementing such a system in the healthcare sector as well as possible advantages for patients, healthcare professionals, and other stakeholders.

Amandeep conducted a research on the topic 'The emerging role of cognitive computing in healthcare: A systematic literature review' (Behera, Bala and Dhir, 2019) intending to evaluate the developing role of cognitive computing in healthcare through a detailed examination of the literature. Natural language processing, machine learning, neural networks, and expert systems are just a few of the several types of cognitive computing technologies that are now being utilized or researched in the healthcare industry. The authors also note these technologies' advantages, including enhanced patient engagement, more individualized treatment regimens, and accurate diagnoses. The comprehensive and exacting way the literature review was carried out is one of the paper's strongest points. The search approach and inclusion criteria of the authors are clearly described, and they offer a thorough analysis of the papers they find. As a result, the outcomes are more trustworthy and legitimate. The article has the drawback of disregarding alternative uses of artificial intelligence (AI) in healthcare, such as computer vision and robotic process automation, and concentrating only on cognitive computing technology. Additionally, because the document was published in 2019, it was unable to accurately reflect the most recent changes and trends in the industry.

The paper called 'Cognitive Computing and the Future of Health Care' by Mohamed Nooman Ahmed, Andeep S. Toor, Kelsey O'Neil, and Dawson Friedland (Ahmed et al., 2017) possible uses of cognitive computing in the healthcare sector are compiled in this study. The authors demonstrate how these technologies might be utilized to enhance healthcare outcomes while laying out the fundamental concepts of cognitive computing, such as natural language processing, machine learning, and pattern recognition. The paper's ability to clearly and concisely summarize the numerous applications of cognitive computing in healthcare is one of its main advantages. Clinical decision assistance, drug development, image analysis in medicine, and patient interaction are only a few of the application cases covered by the authors. Give particular instances of how these technologies have been put to use in various fields, highlighting the advantages of such applications including improved precision, quicker diagnoses, and individualized treatment programs. The paper's emphasis on the moral and legal ramifications of adopting cognitive computing in healthcare is another one of its strong points. The writers are aware of the possible dangers and difficulties brought on by new technology, including worries about data privacy and the demand for openness in algorithmic decision- making. They also emphasize how important it is to make sure that these technologies are created and applied in an ethical and responsible way. The paper's rapid introduction of the subject is another drawback. Given the difficulty of the subject, a more thorough and nuanced examination of some of the points brought up might be beneficial to the article.

The paper developed by Shaohua and others on the topic 'Cognitive Computing and wireless Communications on

the Edge for Healthcare Service Robots'(Wan, Gu and Ni, 2020) is a novel application of edge and cognitive computing in healthcare service robots. The suggested system's architecture and design, which combines cognitive computing techniques, wireless communication protocols, and edge computing platforms, is presented by the authors. This paper carefully examines the potential advantages of this approach, including increased effectiveness, decreased latency, and enhanced data security. The need for strong data privacy and security measures is one of the difficulties and limitations related to the use of these technologies in healthcare settings that the authors also explore. Overall, the study offers a novel viewpoint on the applications of cognitive computing and edge computing in healthcare robots and might be of interest to both researchers and practitioners.

Laxmi and others conducted a research on the topic 'Cognitive computing-based COVID-19 detection on Internet of things enabled edge computing environment' (Laxmi Lydia et al., 2021) offers a novel method for discovering COVID-19 infections that makes use of cognitive computing and Internet of Things (IoT) technology. The suggested system's architecture and design, which combines cognitive computing techniques, IoT sensors, and edge computing platforms, is presented by the authors. This strategy's potential advantages, such as real-time monitoring, early illness identification, and decreased transmission risk, are extensively examined in the research. The authors also emphasize the necessity for trustworthy and accurate data sources as one of the difficulties and restrictions related to the use of these technologies in healthcare settings. Overall, the paper offers a novel viewpoint on the potential applications of cognitive computing and IoT in the fight against the COVID-19 pandemic.

The paper 'Cognitive Cybersecurity for CPS-IoT Enabled Healthcare Ecosystems' by Habtamu (Abie, 2019) provides a method for assuring the security of Internet of Things (IoT) and cyber-physical systems (CPS) in healthcare ecosystems. The authors emphasize how important it is to address cybersecurity issues in healthcare settings and suggest a cognitive cybersecurity strategy that makes use of machine learning algorithms to detect and prevent future intrusions. The proposed framework's implementation and design are fully addressed, as are any potential advantages like enhanced security and a decreased risk of data breaches. The necessity for close cooperation between cybersecurity specialists and healthcare practitioners is one of the constraints and obstacles connected with employing these technologies in healthcare settings that are also covered by the writers.

Syed and others conducted research on the topic 'Cognitive Smart Healthcare for Pathology Detection and Monitoring'(Amin et al., 2019) proposes a novel method for detecting and keeping track of problematic diseases that uses cognitive computing and smart medical equipment. The suggested system's architecture and design, which combines machine learning, cognitive computing, and smart medical devices, is presented by the authors. The study carefully examines the potential advantages of this strategy, which include better patient outcomes, quicker diagnostic times, and higher accuracy. The writers also go through the drawbacks and difficulties of using these technologies in healthcare environments. Overall, the work offers a novel viewpoint on the potential applications of cognitive computing and smart healthcare for the detection and monitoring of pathology.

The paper called 'Cognitive Computing: Architecture, Technologies and Intelligent Applications'(Chen, Herrera and Hwang, 2018) by Min and others aimed to learn about the fundamental ideas and building blocks of cognitive computing, such as artificial intelligence, machine learning, natural language processing, and algorithmic decision- making. The article offers a thorough examination of the cognitive computing architecture and a list of the tools and technologies needed to create intelligent applications. Additionally, the writers go over the different ways that cognitive computing is used in fields as diverse as banking, healthcare, and transportation. The essay is a valuable resource for academics and business professionals interested in cognitive computing, and it could be helpful for people trying to grasp the fundamental ideas and uses of this quickly developing technological area.

The paper called 'A Survey of Artificial Cognitive Systems: Implications for the Autonomous Development of Mental Capabilities in Computational Agents' gives a thorough examination of artificial cognitive systems. The fundamental ideas and essential elements of cognitive systems, such as perception, learning, reasoning, and action, are examined by the writers. The article offers a thorough analysis of the many theories and methodologies, such as connectionist and symbolic approaches, which are employed to create cognitive systems. The writers also go through the numerous ways artificial cognitive systems are used in fields as diverse as robotics, medicine, and education. The essay is a valuable resource for academics and industry experts studying

artificial cognitive systems, and it could be helpful for anybody attempting to comprehend the fundamental ideas and practical applications of this quickly developing field of technology.

The paper called 'Development and Evaluation of an Artificial Intelligence–Based Cognitive Exercise Game: A Pilot Study' by Sung, Eun and Jung(Eun, Kim and Kim, 2022) discusses the development and assessment of an artificial intelligence- powered game for cognitive training. By employing artificial intelligence to individually tailor the game to each participant, the scientists suggest a revolutionary method for cognitive training. The article explains how the game was created, including how executive function, memory, and attention were enhanced via cognitive training. The authors talk about the pilot research, which assessed how well the game increased cognitive ability. The findings imply that the game may enhance the cognitive capacities of elders. Overall, the paper describes a novel method of cognitive training that uses AI and offers circumstantial support for its potential efficacy.

III. METHODOLOGY

A real-world scenario where an artificial cognition-based medical diagnosis and treatment recommendation system could be useful is in the case of a large hospital with a high patient volume. When taking into account a hospital where thousands of patients arrive every day, each with a distinct set of symptoms and a different medical background. Doctors may not have enough time to thoroughly examine each case and develop the most effective diagnostic and treatment strategy because they have so many patients to see(Zhang et al., 2021). In addition, clinicians may overlook significant patterns or trends in patient data that an AI-based system may quickly spot. In this case, the hospital might put in place a system based on artificial cognition to help clinicians make diagnoses and treatment suggestions. Large volumes of patient data, such as symptoms, medical history, and test results, may be uploaded into the system, which would then utilize machine learning algorithms to assess the information and produce a diagnosis and treatment plan. Additionally, the system may continuously improve itself by gaining knowledge from fresh patient data. This would be especially helpful in situations with uncommon or rare illnesses since the system could examine a wide range of patient data and spot trends that might not be immediately apparent to human doctors (Li et al., 2021). In the end, the approach might aid medical professionals in making more precise diagnoses and more efficient treatment regimens, thereby enhancing patient outcomes and lowering total healthcare expenditures (Chen et al., 2018).

The IBM Watson cognitive computing platform architecture offers a reliable and scalable foundation for creating a medical diagnosis and treatment recommendation system based on artificial cognition in order to implement this cognitive system. Data collection and integration, Watson Assistant, Watson Discovery, Watson Machine Learning, integration with Electronic Medical Records (EMRs), deployment and maintenance are the high-level processes that might be followed to create such a system utilizing IBM Watson. Below is more information on these actions (Heart Disease Prediction Using Machine Learning | IEEE Conference Publication | IEEE Xplore, no date).

i. Data collection and integration:

The initial step would involve gathering and combining relevant patient data from various sources, such as electronic health records (EHRs), medical imaging, and test results. This data would require cleansing, normalization, and standardization before being imported into the IBM Watson platform. Building a medical diagnosis and treatment recommendation system based on artificial cognition requires collecting and integrating a lot of data. It can be challenging to get a thorough picture of a patient's medical history because patient data is frequently fragmented and kept in multiple systems. This problem must be solved by building the system to combine data from many sources, such as EHRs, medical imaging, and test results. The data must be cleaned, normalized, and standardized in order to ensure that it is reliable and practical. This include eliminating any unnecessary or irrelevant data, fixing typos, and consistently formatting the data. This procedure aids in ensuring that the system can evaluate the data effectively and produce insightful results.

ii. Watson Assistant:

IBM Watson Assistant may be used to construct the conversational interface that would let doctors and other healthcare professionals speak naturally to the system. The Watson Assistant would need to be trained on medical terminology and relevant patient data in order to ensure accurate and applicable responses.

Given that it enables healthcare practitioners to interact with the system using natural language, the Watson.

Assistant is a crucial part of an artificial cognition-based medical diagnosis and treatment recommendation system. This makes it simpler for physicians to get the data they require to decide how best to treat patients. The Watson Assistant needs to be trained on medical words and relevant patient data in order to ensure that it gives accurate and meaningful responses. This entails teaching the system how to identify medical jargon and comprehend the context in which it is being used. It also

entails teaching the system to spot trends in patient data and produce insightful conclusions based on that data.

iii. IBM's Watson Discovery:

Using Watson Discovery, huge amounts of patient data can be processed for trends and insights. The system would then be able to generate more accurate diagnosis and treatment recommendations based on each patient's unique medical history and symptoms.

With the help of IBM Watson Discovery, it is possible to analyse vast amounts of patient data for trends and insights. This data can be analysed to find patterns and correlations that human doctors would not immediately see. By using each patient's unique medical history and symptoms, the system is able to generate more accurate diagnoses and treatment recommendations. The system can examine medical studies and best practices using Watson Discovery, allowing it to keep current with the most recent information.

iv. Watson Machine Learning:

Machine learning models can be created and used with Watson Machine Learning to generate more accurate diagnosis and treatment recommendations over time by learning from patient data. Watson Machine Learning is a potent tool that makes it possible to train and use machine learning models. The system can spot patterns and connections in patient data that might not be obvious to human doctors right away. By continuously learning from patient data, the system is able to provide more accurate diagnoses and treatment recommendations. To increase their precision and efficiency, the machine learning models can be continuously taught and updated. This makes it possible for the system to keep up with the most recent advancements in medical research and to enhance its performance over time.

v. Integration with Electronic Medical Records (EMRs):

The system would need to be connected with electronic medical record systems to assure that patient data is securely stored and accessible to healthcare practitioners.

Integration with systems for electronic medical records is necessary to guarantee that patient data is safely stored and accessible to healthcare professionals. In order to make knowledgeable decisions about patient care, doctors can now obtain the patient data they require. It must be made sure that the system complies with all pertinent data in order to be able to interact with electronic medical record systems.

vi. Deployment and maintenance:

After the system is created, it must be installed in a secure setting and its accuracy and performance must be checked. To keep the system current with the most recent medical research and best practices, regular upgrades and maintenance would be necessary.

The performance and efficacy of a medical diagnosis and treatment recommendation system based on artificial intelligence must be enhanced by integrating elements. Here are some strategies for adding features to the system:

vii. Incorporating Natural Language Processing (NLP) Technology:

The system can enhance its capacity to comprehend and process human language, which is essential in the healthcare industry, by integrating NLP technology. NLP can help the system detect symptoms, diseases, and possible treatments from unstructured data, such as doctor's notes, patient reviews, and social media posts. The system may be better able to provide recommendations that are more accurate and pertinent if it can comprehend the context and intent of the patient's inquiries and requests. For example, the system may employ NLP technology to distinguish between "I have a headache" and "I have a migraine," and then suggest more appropriate therapies.(Mirbabaie, Stieglitz and Frick, 2021)

viii. Integration with Wearable Devices:

A vast amount of real-time patient data can be obtained by integrating wearable technology, like fitness trackers and smartwatches, to improve the system's recommendations for diagnosis and therapy. The system can use the information gathered by these sensors, such as heart rate, blood pressure, and activity levels, to analyse potential health issues, track progress, and provide the necessary advice. The use of wearable technology for medication adherence monitoring can give clinicians important data for modifying treatment programs as necessary.

ix. Incorporating Image Analysis:

The proposed system uses image analysis technology to examine medical pictures including X-rays, MRIs, and CT scans to find abnormalities and identify diseases. In order to make earlier and more accurate diagnoses, image analysis can assist the system in spotting small changes in images that human doctors might overlook. By giving clinicians thorough knowledge of the patient's anatomy and health, it can also help with the planning and execution of medical operations, such as surgeries. In order to help clinicians, make better choices regarding patient care, image analysis can also be used to track the development of diseases and assess the efficacy of therapies over time.

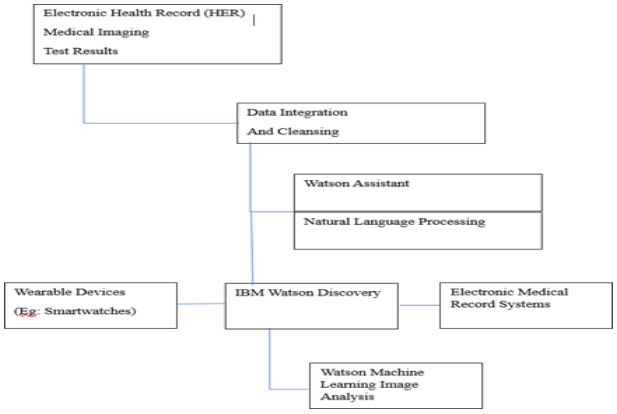

Figure 1. System architecture of the proposed system

Source: Author

The system architecture in this design is broken down into four key parts: data collection and integration, William's assistant, williams discovery, and William's machine learning with image analysis. Electronic health records, medical imaging, and wearable technology are just a few of the sources from which the data collection and integration component gathers and integrates essential patient data. Using natural language processing technology, the Watson Assistant component enables interaction between medical personnel and the system. The Watson Discovery component analyses massive amounts of patient data for patterns and insights to generate more accurate diagnoses and treatment recommendations. Last but not least, Watson Machine Learning with Image Analysis employs machine learning models to learn from patient data and analyse medical images in order to discover irregularities, diagnose diseases, and track the evolution of diseases.

Overall, the elements and parts that make up a medical diagnosis and treatment recommendation system based on artificial cognition are high-level discussed in this system architectural diagram.

IV. DISCUSSION

This section consists of an overall description and a summary of the points that have been discussed in the literature review section. The aim, findings, technology and the limitations of the research work discussed above.

Table 1: Summary of the Literature Review

Paper	Aim	Findings	Technology	Limitations
(Chen *et al.*, 2018)	To develop and evaluate a smart healthcare system that leverages edge computing and cognitive computing technologies to improve the quality and efficiency of healthcare services.	* System was effective in improving the accuracy and speed of medical diagnosis. * Reducing the workload of medical staff. * Improving patient outcomes.	*Edge computing for real-time data processing. *Cognitive computing for medical diagnosis and decision-making.	* Highly complex *Technical expertise required *Cost-effectiveness not measured. *Privacy concerns related to medical data storage.
(Behera , Bala and Dhir, 2019)	To provide an overview of the current state of the art and to highlight the potential of cognitive computing technologies for improving healthcare services.	*Cognitive computing can improve healthcare by enhancing decision-making, diagnosis, and treatment. *Challenges in data privacy and implementation remain.	*Natural language processing, machine learning, expert systems, and data analytics, for improving decision-making, diagnosis, and treatment processes.	*Lack of empirical studies on the effectiveness of cognitive computing in healthcare *The potential biases in the selected literature.
(Ahmed *et al.*, 2017)	To explore the potential impact of cognitive computing on the healthcare industry and to discuss the challenges and opportunities associated with its implementation.	*Cognitive computing has the potential to revolutionize healthcare by improving diagnosis, treatment, and patient outcomes. challenges include data privacy, regulation, and ethical considerations, according to the article.	*Cognitive computing, which utilizes artificial intelligence and machine learning algorithms.	*One-sided view of cognitive computing's impact on healthcare and does not fully address potential ethical or social implications of its implementation.
(Wan, Gu and Ni, 2020)	To investigate the use of cognitive computing and wireless communications to enhance healthcare services provided by robots	*The combination of cognitive computing and wireless communication can improve the efficiency and effectiveness of healthcare service robots.	*The combination of cognitive computing and wireless communication for healthcare service robots.	*Focused on the potential benefits of the technology and does not discuss potential ethical or social implications.
(Laxmi Lydia *et al.*, 2021)	New approach for COVID-19 detection using cognitive computing and edge computing technology in an IoT environment, to improve the speed and accuracy of diagnosis.	*The proposed approach using cognitive computing and edge computing can effectively detect COVID-19 infections with high accuracy.	*The combination of cognitive computing and edge computing for COVID-19 detection in an IoT environment.	*The proposed approach has not been tested in a real-world setting and may face challenges related to data privacy and regulatory compliance.
(Abie, 2019)	To explore the use of cognitive computing for cybersecurity in healthcare systems enabled by cyber-physical systems and IoT.	*The article finds that the use of cognitive computing can improve cybersecurity in healthcare systems enabled by cyber-physical systems and IoT.	*Use of cognitive computing for cybersecurity in healthcare systems enabled by cyber-physical systems and IoT.	*Focused on the potential benefits of the technology and does not discuss potential ethical or social implications.
(Amin *et al.*, 2019)	to develop a cognitive computing-based system for detecting and monitoring pathological conditions in healthcare.	*The proposed cognitive computing-based system can effectively detect and monitor pathological conditions in healthcare.	*The development of a cognitive computing-based system for pathology detection and	*The proposed system has not been tested extensively in a real- world setting and may

The review investigates various approaches to improving medical diagnosis and treatment recommendations that make use of cognitive computing, artificial intelligence, and machine learning. The review focuses on such systems' potential benefits and drawbacks, such as their ability to process large amounts of medical data, improve accuracy, and reduce errors in medical decision-making. However, it does highlight several limitations, including the need for high-quality data, the risk of bias, and the need for human oversight. Overall, the review concludes that cognition-based medical diagnosis and treatment recommendation systems have a high potential to improve healthcare outcomes, but more research is required to overcome current limitations and ensure their efficacy and safety.

V. CONCLUSION

In conclusion, the development of Artificial Cognition based Medical Diagnosis and Treatment Recommendation Systems is a promising field that has the potential to revolutionize the way medical diagnosis and treatment recommendations are made. These systems are designed to mimic the cognitive abilities of human doctors and can process large amounts of medical data to make accurate diagnoses and treatment recommendations. The review of existing literature indicates that such systems have shown significant success in various medical domains, including radiology, pathology, and cardiology, among others. Moreover, the use of Artificial Cognition based Medical Diagnosis and Treatment Recommendation Systems can result in faster and more accurate diagnoses, reducing the risk of misdiagnosis, and thereby leading to better patient outcomes.

Despite the benefits of this system, there are still some limitations and challenges to be addressed, including the need for large amounts of high-quality data, the ethical concerns related to the use of such systems, and the

potential for errors or biases in the algorithms used. However, these challenges can be overcome with careful consideration and appropriate measures to ensure that the systems are reliable and safe to use. Overall, Artificial Cognition based Medical Diagnosis and Treatment Recommendation Systems have enormous potential to revolutionize the healthcare industry, and further research and development in this field are crucial to realize the full benefits of these systems.

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