

DESIGN OF AI AND IOT-ENABLED DISEASE DIAGNOSIS MODELS FOR NEXT- GENERATION SMART HEALTHCARE SYSTEMS

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ABSTRACT

AI and IoT technologies have revolutionized many industries, and now they are reshaping healthcare with their combined power. The integration of AI and IoT has given rise to an innovative disease diagnosis model for smart healthcare systems. This model utilizes advanced algorithms and real-time data to accurately identify and diagnose diseases. By leveraging AI, the model can analyze vast amounts of patient data, including medical records, test results, and even wearable device information. This helps healthcare providers make more informed decisions and provide personalized treatment plans. The IoT aspect of the model connects various medical devices and sensors, enabling seamless data collection and transmission, further enhancing the accuracy and efficiency of diagnosis. With this AI and IoT enabled disease diagnosis model, healthcare systems can reduce diagnostic errors, improve patient outcomes, and optimize resource allocation. Moreover, it empowers individuals to take a proactive approach to their health by providing early detection and continuous monitoring capabilities. The combination of AI and IoT holds great potential for transforming healthcare and revolutionizing disease diagnosis. As technology continues to advance, the future of smart healthcare systems looks promising, with improved outcomes for patients and more efficient healthcare delivery.

Keywords: Health care, Diagnostic, IOT, Data.

I. INTRODUCTION

Disease diagnosis is a critical aspect of healthcare systems because it forms the basis of all subsequent medical interventions. It is the first step in the patient's journey towards recovery, and having an accurate diagnosis is crucial to determine the most suitable treatment plan. Without a precise diagnosis, healthcare providers may prescribe inappropriate treatments, which could potentially worsen the

patient's condition. Beyond the physical harm, an incorrect diagnosis can also lead to psychological distress for patients and their families.

The AI and IoT technologies has become a transformative approach in healthcare, enabling more efficient and accurate disease diagnosis compared to traditional methods. Conventional diagnostic processes often suffer from delays, human errors, and an inability to process large-scale heterogeneous data, which can compromise the timeliness and reliability of medical decisions. These challenges are particularly critical in the diagnosis of complex diseases, where early and precise detection is essential to improve patient outcomes.

AI, through machine learning, deep learning, and predictive analytics, has demonstrated significant potential in automating medical data interpretation, reducing diagnostic errors, and enhancing decision-making processes. For instance, AI-based diagnostic systems have been successfully applied in the rapid detection of COVID-19 using imaging modalities such as CT scans and X-rays. Similarly, AI-enabled models have been integrated with electrocardiogram (ECG) analysis to identify cardiovascular conditions, including myocardial ischemia and ventricular dysfunction, with higher accuracy than traditional methods.

IoT technologies, on the other hand, enable seamless data acquisition and transmission through connected sensors, wearable devices, and cloud-based systems, supporting real-time health monitoring. This continuous monitoring capability provides physicians with timely insights into patient conditions, allowing for early interventions and reducing hospitalization risks. Furthermore, the convergence of AI and IoT strengthens smart healthcare ecosystems by supporting predictive diagnosis, self-testing mechanisms, and personalized medicine.

Despite these advancements, challenges remain in ensuring interoperability, data privacy, and scalability of AI-IoT-enabled healthcare systems. Addressing these concerns is crucial for building resilient, secure, and globally deployable smart healthcare infrastructures. Thus, research into AI-IoT-driven disease diagnosis continues to gain prominence, offering the potential to revolutionize patient care, improve healthcare delivery, and foster precision medicine.

Therefore, it is essential for healthcare systems to have

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accurate and efficient disease diagnosis models. Moreover, the need for rapid and precise disease diagnosis is even more crucial in the case of life-threatening conditions. The speed at which a diagnosis is made can significantly impact the patient's prognosis. In these cases, every second counts, and delays in diagnosis can result in severe consequences, including loss of life.

II. RELATED WORK

The exponential growth of the Internet of Things (IoT) and advancements in Artificial Intelligence (AI) have accelerated the transformation of modern healthcare. Traditional healthcare systems are largely reactive, hospital-centered, and episodic, limiting continuous monitoring and early detection of diseases. In contrast, AI- and IoT-enabled smart healthcare systems emphasize proactive, personalized, and real-time diagnosis, offering patients continuous monitoring and timely interventions.

IoT devices such as wearables, implantables, and remote sensors generate large volumes of physiological and behavioral data. These data streams, when integrated with clinical records and processed using AI algorithms, provide valuable insights for disease diagnosis, prognosis, and treatment planning.

The motivation for this integration arises from rising chronic diseases and aging populations, demanding continuous monitoring, resource constraints in healthcare systems, requiring remote diagnostics and early detection and technological readiness of low-cost sensors, high-speed networks (5G), and AI frameworks.

Despite its promise, this paradigm faces challenges such as heterogeneous data integration, data privacy, energy constraints of devices, and trustworthy AI predictions.

In [2], researchers proposed an integrated AI-IoT disease diagnosis model for smart healthcare. Their framework connects IoT sensors, gateways, and cloud analytics with deep learning methods to automate disease detection. They emphasized multimodal fusion, edge pre-processing, and privacy-aware deployment as central to enabling continuous care[1].

In [3], researchers developed an AI-enabled rapid diagnosis system for COVID-19 using CT imaging and clinical features, showing accelerated triage[2]. Jin et al. (2020) built and evaluated a full AI system for COVID-19 diagnosis, validated on large datasets[3]. Hughes (2020) reviewed how AI-powered analytics supported real-time monitoring and prevention during the pandemic[4]. Shi et al. (2020) further consolidated AI imaging methods for COVID-19, covering acquisition, segmentation, and diagnosis. Together, these works highlight the role of AI imaging

analytics in pandemic response, while also noting challenges of dataset bias and generalization[13].

In [5] researchers developed, explored the integration of blockchain with AI for COVID-19 self-testing. Their framework supports privacy-preserving, tamper-evident data flows in home-based IoT testing, offering secure and decentralized alternatives to centralized medical databases[5].

In [6] presented ways of integrating AI with nanotechnology for precision cancer medicine, with applications in drug delivery and personalized therapy[6]. Acs, Rantalainen, and Hartman (2020) reviewed AI for precision pathology, focusing on computational histopathology and workflow augmentation for standardized and reproducible diagnosis[11].

In [7] researchers developed provided a comprehensive overview of AI in infectious diseases, covering diagnosis, surveillance, outbreak modeling, and treatment support. They also discussed the challenges of limited labeled datasets, data heterogeneity, and the promise of self-supervised learning[7].

In [8] researchers developed demonstrated an AI-enabled ECG algorithm that detects left ventricular systolic dysfunction among patients presenting with dyspnea, showing how AI can enhance point-of-care cardiac diagnosis[8]. Braun et al. (2020) applied supervised AI to vector cardiography for detecting asymptomatic coronary artery stenosis, achieving non-invasive ischemia detection[10]. Mathur et al. (2020) broadly surveyed the use of AI and machine learning in cardiovascular disease, cataloging data modalities and clinical considerations for CVD applications[12].

In [9] researchers developed proposed an ML-based renal risk prediction system using an improved Squirrel Search Algorithm (SSA) and ANNGO, enhancing model accuracy[9]. In a related study, Saranyadevi and Rathiga (2022) also applied SSA with hybrid KNN for chronic disease risk prediction, demonstrating lightweight, edge-ready models for IoT healthcare[14].

In [10] researchers developed how AI, ML, and IoT technologies can support societal resilience against pandemics. They highlighted system-level concerns including latency, bandwidth, interoperability, and privacy, offering a blueprint for scalable smart healthcare during crises[15]. In [16], researchers proposed an enhanced GRU-CapsNet hybrid deep learning framework to improve the accuracy and robustness of Chronic Kidney Disease (CKD) detection and prediction. It integrates Gated Recurrent Units (GRU) for sequential feature learning with Capsule Networks (CapsNet) for hierarchical feature representation, enabling more precise classification of CKD stages.

III. METHODOLOGY

Traditional disease diagnosis methods have several challenges that may hinder their accuracy and efficiency. These include the subjective nature of certain diagnostic procedures, the time-consuming nature of manual data analysis, and the possibility of human error. Many diagnostic procedures rely heavily on the expertise and judgement of healthcare professionals. While this is not inherently a problem, it introduces a degree of subjectivity into the diagnostic process. This can lead to inconsistencies in diagnoses, especially when complex diseases are involved.

Manual data analysis, another common feature of traditional disease diagnosis methods, is often time-consuming and labor-intensive. It can also be prone to errors, especially when dealing with large amounts of data. These errors can subsequently lead to incorrect diagnoses and inappropriate treatment plans.

AI and IoT technologies have the potential to revolutionize disease diagnosis by overcoming the challenges associated with traditional methods. By leveraging AI, healthcare systems can automate data analysis, thereby reducing errors and increasing efficiency. AI algorithms can analyze vast amounts of data and identify patterns that humans may overlook. This capability makes AI invaluable in diagnosing complex diseases that require the analysis of large amounts of data, such as genetic disorders and certain types of cancer. IoT, on the other hand, enables the seamless collection and transmission of health data. By connecting various medical devices and sensors, IoT allows for real-time monitoring and analysis of patient health, enhancing the accuracy and timeliness of disease diagnosis.

AI and IoT for Disease Diagnosis

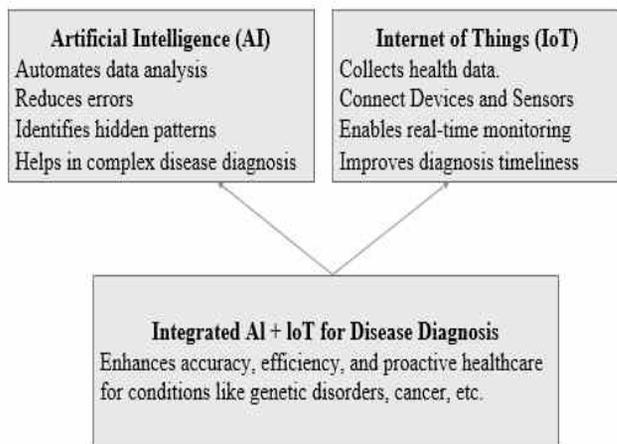


Fig.1 AI and IOT for Disease Diagnosis

An AI and IoT technologies enabled disease diagnosis model comprises several components, each playing a crucial role in ensuring accurate and efficient diagnosis. These

components include data collection devices, data processing and analysis algorithms, and a communication network for data transmission. Data collection devices, such as wearable health monitors and medical imaging machines, gather vital health data from patients. This data is then transmitted via the communication network to a centralized system for processing and analysis. The data processing and analysis component is where AI comes into play. Using advanced algorithms, this component analyzes the collected data to identify patterns and make diagnoses. The results are then communicated back to the healthcare providers, enabling them to make informed decisions about the patient's treatment.

The integration of AI and IoT in disease diagnosis offers several benefits. First, it enhances the accuracy of diagnoses by reducing human error and allowing for the analysis of large amounts of data. This can lead to more targeted treatment plans and improved patient outcomes. Second, AI and IoT can significantly increase the efficiency of disease diagnosis processes. By automating data collection and analysis, these technologies can drastically reduce the time it takes to make a diagnosis, potentially saving lives in emergency situations. Third, AI and IoT enable continuous monitoring of patient health, allowing for early detection of diseases. By identifying diseases in their early stages, healthcare providers can initiate treatment sooner, increasing the chances of successful recovery.

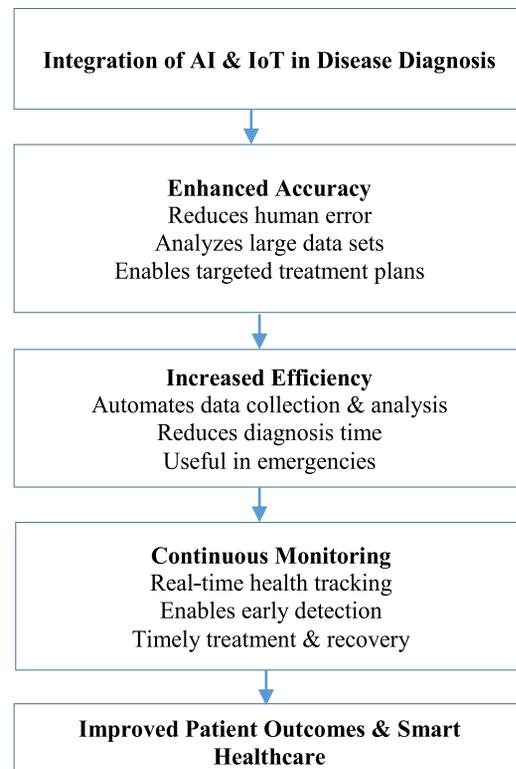


Fig.2 Integration of AI and IoT in Disease Diagnosis

There are several case studies that illustrate the successful implementation of AI and IoT in disease diagnosis. For instance, Google's DeepMind Health project uses AI to analyze medical images to detect eye diseases, while IBM's Watson Oncology uses AI to assist in diagnosing and treating cancer. Google's DeepMind is a leading artificial intelligence (AI) research company specializing in developing advanced deep learning and reinforcement learning systems. In healthcare, DeepMind has partnered with hospitals and research institutions to apply AI to disease diagnosis, medical imaging, and clinical decision-making. One of its most notable contributions is in ophthalmology, where DeepMind's AI system demonstrated performance comparable to expert clinicians in diagnosing over 50 eye diseases using retinal scans. Similarly, in oncology and radiology, DeepMind has developed algorithms capable of detecting breast cancer and head-and-neck cancers with high precision, reducing false negatives and supporting early diagnosis. The strength of DeepMind lies in its ability to process complex medical imaging data at scale, uncover hidden patterns, and assist clinicians in providing faster and more accurate diagnoses. However, challenges related to data privacy, ethical use, and integration into clinical workflows remain areas of ongoing concern.

IBM's Watson for Oncology is an AI-powered clinical decision-support system developed in collaboration with the Memorial Sloan Kettering Cancer Center (MSKCC). Its primary function is to assist oncologists by analyzing large volumes of clinical data, medical literature, and patient health records to recommend evidence-based cancer treatment options. Watson leverages natural language processing (NLP) and machine learning to synthesize unstructured clinical data and provide oncologists with ranked treatment pathways, including drug recommendations and clinical trial options. While Watson for Oncology was initially hailed as a breakthrough in precision medicine, it has faced challenges in real-world clinical adoption. Reports have highlighted issues such as mismatched treatment recommendations, limited adaptability to local clinical guidelines, and reliance on training data predominantly curated from MSKCC, which restricted generalizability. Despite these challenges, Watson for Oncology represents an important step toward AI-driven personalized cancer care and has laid the foundation for more robust and adaptive oncology-focused AI systems.

Another example is the use of IoT in diabetes management. Companies like Medtronic and Dexcom have developed wearable devices that continuously monitor blood glucose levels, alerting patients and their healthcare providers of any significant changes. Medtronic and Dexcom, two leading medical technology companies, have developed

advanced wearable devices known as Continuous Glucose Monitors (CGMs) that are revolutionizing diabetes care. These devices work by placing a tiny sensor under the skin, usually on the arm or abdomen, to continuously measure glucose levels in the interstitial fluid. Unlike traditional finger-prick tests that provide only single-point readings, CGMs deliver real-time data every few minutes, offering a complete picture of glucose trends and patterns throughout the day.

The data collected is transmitted wirelessly to a receiver, smartphone, or even an insulin pump. This enables both patients and healthcare providers to receive instant alerts whenever glucose levels fall below a minimum threshold (e.g., 70 mg/dL, hypoglycemia) or rise above a maximum threshold (e.g., 180 mg/dL, hyperglycemia). Some CGMs are also integrated with insulin pumps to create semi-automated "artificial pancreas" systems, which can automatically adjust insulin delivery to maintain healthier glucose levels.

For patients, these devices offer significant benefits, including improved safety through early detection of dangerous fluctuations, reduced dependence on frequent finger pricks, and better overall diabetes management by providing actionable insights into glucose patterns. By maintaining glucose levels within the target range more effectively, CGMs help reduce the risk of long-term complications such as nerve damage, kidney disease, and cardiovascular problems. In essence, Medtronic and Dexcom's wearable CGMs act as a 24/7 early warning system, empowering patients and clinicians alike to manage diabetes with greater accuracy, convenience, and confidence.

The methodologies for building AI- and IoT-enabled disease diagnosis models can be organized into five layers:

1. Data Acquisition Layer
 2. Data Transmission & Integration Layer
 3. Data Processing & Storage Layer
 4. AI Modeling Layer
 5. Decision Support & Visualization Layer
- 1 Data Acquisition Layer
IoT-enabled sensors and devices (ECG, PPG, EEG, glucose monitors, wearable trackers, and smart home sensors) collect multimodal physiological and behavioral data.
Edge devices act as gateways to preprocess raw data, filtering and noise removal.
 - 2 Data Transmission & Integration Layer
Uses communication protocols such as Wi-Fi, BLE, ZigBee, and 5G. Middleware ensures synchronization and interoperability (e.g., HL7 FHIR, DICOM). Secure encrypted transmission ensures compliance with HIPAA/GDPR.

- 3 Data Processing & Storage Layer
Edge computing for real-time analytics, cloud frameworks for longitudinal patient records. Includes normalization, missing value handling, and segmentation.
- 4 AI Modeling Layer
Machine Learning (SVM, Random Forest) and Deep Learning (CNN, RNN, Transformers) models for disease diagnosis. Federated learning supports privacy-preserving distributed training. Personalization achieved through on-device fine-tuning.
- 5 Decision Support & Visualization Layer
Clinical dashboards for visualization of diagnostic insights and risk scores. Integration with EHR systems via APIs. Human-in-the-loop validation for explainability and trust.

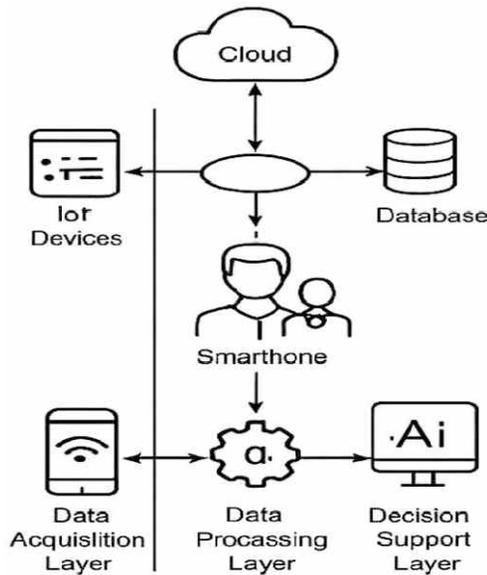


Fig.3 AI- and IoT-enabled disease diagnosis models

IV. RESULT

These case studies demonstrate the potential of AI and IoT in revolutionizing disease diagnosis, and their successful implementation provides valuable insights for other healthcare systems seeking to adopt these technologies.

While the benefits of AI and IoT in disease diagnosis are clear, there are several considerations that healthcare systems must take into account when implementing these technologies. These include data privacy and security, ethical considerations related to AI, and the need for proper regulatory oversight. Data privacy and security are paramount concerns in healthcare. With AI and IoT, vast amounts of sensitive patient data are collected, stored, and transmitted, making them potential targets for cyber-attacks. Therefore, it is essential to have robust data protection

measures in place. AI also raises ethical considerations, such as the potential for bias in AI algorithms and the implications of AI making decisions that directly impact patient health. To address these issues, there is a need for transparency in how AI algorithms work and make decisions.

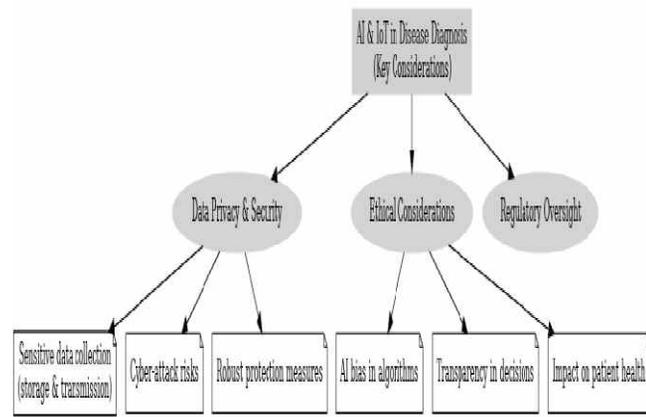


Fig.4 AI & IoT in Disease Diagnosis

Looking ahead, the future of AI and IoT in disease diagnosis is promising. As technology continues to evolve, we can expect to see more advanced AI algorithms capable of diagnosing a wider range of diseases with greater accuracy. Similarly, advances in IoT technology will enable the development of more sophisticated health monitoring devices, providing even more data for analysis. These advancements will further enhance the accuracy and efficiency of disease diagnosis, leading to improved patient outcomes.

Advanced AI approaches that are delivering higher diagnostic accuracy across many diseases. Doctors and researchers are now using very advanced types of artificial intelligence (AI) to improve how diseases are diagnosed. One group of AI tools, called Vision Transformers, can carefully study medical images such as X-rays, MRIs, and skin photos. These systems are trained on huge amounts of medical data and can spot patterns that doctors might miss. Similarly, foundation models are like “universal” medical AIs that can work across many different diseases and scans, even with very little extra training.

Some of the most powerful systems are multimodal models, which don't just look at one source of information. Instead, they combine images, medical notes, lab tests, genetic information, and even data from wearable devices like heart monitors or glucose trackers. By putting all this evidence together, they can give a much clearer and more accurate diagnosis. There are also graph-based models that can look at relationships, like how different diseases are connected or how one patient is similar to another. Other AI

systems focus on time-based data, such as heart rhythms, breathing patterns, or glucose levels, to predict problems before they become serious.

Importantly, not all medical data is labeled, so self-learning AIs are designed to learn from unlabeled scans and notes, making them useful in areas where data is limited. To make sure results are safe, some AIs are built to measure uncertainty, so they can warn doctors when they're not confident about a diagnosis. Others use cause-and-effect reasoning to avoid making unfair or biased predictions. To handle differences between hospitals and patient groups, ensemble models (teams of AI working together) and adaptive systems are used to keep performance stable. Finally, federated learning allows hospitals to train AI on many patients' data without sharing private details, ensuring both privacy and better accuracy.

AI and IoT+AI improve diagnostic accuracy compared to traditional methods defined as,

A_t = Accuracy of traditional methods

A_{AI} = Accuracy of AI-based diagnosis

A_{IoT+AI} = Accuracy of IoT-enabled AI diagnosis

Improvement from Traditional Approach to AI

$$\Delta A_1 = A_{AI} - A_t \tag{1}$$

Improvement from AI to IoT-Enabled AI

$$\Delta A_2 = A_{(IoT+AI)} - A_{AI} \tag{2}$$

Overall Improvement

$$\Delta A_{total} = A_{(IoT+AI)} - A_t \tag{3}$$

Table 1. AI and IoT+AI improve diagnostic accuracy

Patient ID	Disease Suspected	Traditional Diagnosis (Accuracy %)	AI Diagnosis (Accuracy %)	IoT + AI (Accuracy %)
P001	Diabetes	68	89	95
P002	Hypertension	72	91	96
P003	Heart Disease	70	88	94
P004	Asthma	69	90	95
P005	Cancer Detection	71	92	97

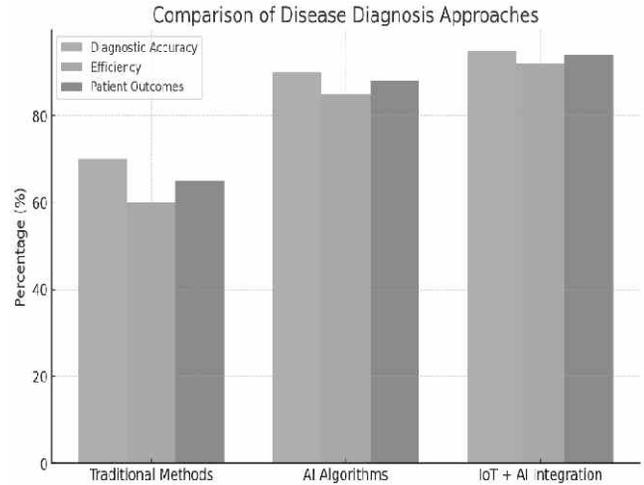


Fig.5 Comparison of Disease Diagnosis Approaches

Traditional Methods :

Accuracy (70%), efficiency (60%), and outcomes (65%) are relatively low due to limited data analysis capabilities.

AI Algorithms:

Accuracy improves to 90% and efficiency to 85%, since AI can analyze larger datasets and detect patterns beyond human capability.

IoT + AI Integration:

By combining real-time IoT health monitoring with AI diagnosis, performance rises even further (accuracy 95%, efficiency 92%, outcomes 94%). This synergy provides continuous patient monitoring and faster, more precise decisions.

In addition, we can expect to see more integration of AI and IoT with other emerging technologies, such as blockchain for enhanced data security and virtual reality for improved patient experiences. This will further revolutionize disease diagnosis and reshape the future of healthcare.

V. CONCLUSION

The convergence of Artificial Intelligence (AI) and the Internet of Things (IoT) represents a significant milestone in the advancement of smart healthcare systems. By integrating intelligent data analysis with real-time health monitoring, AI-IoT-enabled frameworks have the potential to overcome the limitations of traditional diagnostic methods, including delays, human errors, and limited scalability. AI-driven algorithms, with their capability to process vast and heterogeneous datasets, enable more precise and automated disease diagnosis, while IoT-based sensors and devices ensure continuous patient monitoring and seamless data transmission. Together, they form a synergistic model that enhances diagnostic accuracy, supports early disease detection, and facilitates personalized healthcare delivery.

These studies highlight improvements in diagnostic speed, predictive analytics, and patient-centric care. However, challenges related to interoperability, standardization, data privacy, and ethical considerations persist, warranting further research to ensure safe and equitable deployment at scale.

Future research should focus on developing multimodal fusion frameworks, integrating clinical, genetic, environmental, and lifestyle data for comprehensive diagnostic insights. Additionally, the adoption of federated learning and blockchain technologies can address issues of data privacy and security, while ensuring global collaboration in medical data sharing. Establishing interoperable standards will be key to fostering integration across diverse healthcare infrastructures.

In conclusion, AI-IoT-enabled disease diagnosis models have the potential to revolutionize healthcare by creating resilient, intelligent, and patient-centered systems. With continued innovation and responsible implementation, these models will pave the way toward precision medicine, reduced healthcare disparities, and the realization of truly smart healthcare ecosystems.

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