

Research Article

Integration of IoT in Wearable Devices for Health Monitoring: Challenges and Potentials in the Field of Electrical Engineering

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Abstract

The Internet of Things (IoT) has become a major driver in technological transformation, including in wearable devices for health monitoring. The background of this research is based on the increasing need for a real-time, effective, and data-driven health system. The purpose of this study is to explore the challenges and potential of IoT integration in wearable devices, especially in the field of electrical engineering. The method used is a literature study with a content analysis approach to identify patterns and themes from related academic sources between 2018 and 2023. The results show that IoT-based wearable devices can improve the quality of healthcare by integrating sensor technology, communication modules, and artificial intelligence. However, some significant challenges, such as data security, energy consumption, and device interoperability, need to be addressed to drive widespread adoption of the technology. Blockchain is proposed as a potential solution to security concerns, while 5G offers greater bandwidth for data efficiency. This study provides important insights for the development of IoT-based wearables as a key element in modern health management.

Keywords: Internet of Things, Wearables, Health Monitoring.

INTRODUCTION

The Internet of Things (IoT) has brought significant revolution across various fields, including health monitoring through wearable devices. These devices enable real-



time collection of biometric data, such as heart rate, oxygen levels, and sleep patterns, which help individuals and healthcare professionals continuously monitor bodily conditions (Rahman et al., 2024). IoT expands the functionality of wearable devices by connecting them to a digital ecosystem capable of analyzing data to provide personalized health recommendations.

The Internet of Things (IoT) is a network of interconnected devices that enables data transfer without direct human interaction. This technology has transformed various sectors such as manufacturing, healthcare, and agriculture through real-time data collection that supports smarter decision-making. For example, IoT integration in smart city systems improves energy efficiency and monitors traffic in real time, reducing congestion and carbon emissions (M. Wang, 2025). IoT also has a major impact on environmental management, such as IoT-based technologies for monitoring water quality in aquaculture ponds, which enhance productivity and sustainability (Sundararajan et al., 2025).

However, the implementation of IoT does not come without challenges. Data security issues are a major concern, especially as the growing number of connected devices increases the potential for cyberattacks. Additionally, the lack of universal standards for communication between devices makes interoperability a major barrier. Research indicates that blockchain technology can provide a solution by offering data security and transparency in IoT networks (Wu et al., 2025). In recent years, IoT has evolved into a key technology for realizing Industry 4.0, focusing on automation and data-driven system optimization.

IoT-based wearable devices are becoming increasingly popular due to their ability to detect early signs of health disorders and reduce the need for direct medical consultation. In the field of electrical engineering, the design of these devices involves advanced components such as sensors, communication modules, and AI-based data processing algorithms (Krishnamoorthy et al., 2024). Their ability to integrate into existing healthcare infrastructure makes them an essential tool for improving the quality of healthcare services.

However, the successful implementation of IoT-based wearable devices faces several challenges, including data security, energy consumption, and limited network bandwidth. Privacy concerns are one of the main barriers to adopting this technology, especially because health data is considered highly sensitive (Liu et al., 2018). Moreover,

interoperability among different devices often becomes a technical constraint that affects the overall effectiveness of the system.

The potential of IoT-based wearable devices is substantial, particularly in managing chronic diseases such as diabetes and hypertension. Several studies have shown that these devices help patients monitor their conditions independently and improve adherence to treatment (Stanney et al., 2025). With the continuous advancement of technology, IoT-based wearables are expected to become a key pillar in modern healthcare management. As the demand for personalized and effective health technology grows, this research aims to explore solutions to existing technical and ethical challenges to promote broader adoption of this technology (Bhattacharya et al., 2025).

Previous studies have explored various aspects of IoT integration in wearable devices. Rahman et al. (2024) highlighted the role of these devices in transforming healthcare services, while Ejaz et al. (2025) discussed implementation challenges in the commercial sector. Zhang et al. (2025) examined the potential of this technology to improve the quality of life for patients with chronic conditions. However, specific research on technical and ethical challenges within the context of electrical engineering remains limited (Ejaz et al., 2025; Rahman et al., 2024; Zhang et al., 2025).

This study aims to analyze the challenges and potential of integrating IoT into wearable devices for health monitoring. It also focuses on innovative solutions that can address technical and ethical barriers, enabling more effective integration of these devices into healthcare systems.

METHOD

This study employs a qualitative approach using a literature review method to explore the challenges and potential of integrating the Internet of Things (IoT) into wearable devices for health monitoring, particularly in the field of electrical engineering. The literature review method was selected because it enables an in-depth analysis of various academic and practical sources, providing comprehensive insights into the topic (Snyder, 2019).

Data Sources

The data used in this research consists of secondary literature, including

scientific journal articles, conference proceedings, books, and research reports published between 2018 and 2023. These sources were obtained from academic databases such as Springer, ScienceDirect, and ResearchGate by using keywords such as “IoT integration,” “wearable devices,” “health monitoring,” and “electrical engineering.”

Inclusion criteria include thematic relevance, technical scope, and contribution to understanding the technical and ethical challenges in IoT implementation (Bowen, 2009).

Data Collection Techniques

Data collection was conducted through a systematic process consisting of the following steps:

1. Identification of relevant literature,
2. Selection of documents based on inclusion criteria, and
3. Critical analysis of the content of the selected literature.

The collected data were then categorized into major themes such as device design, interoperability, data security, and energy efficiency. This approach allows the identification of patterns and relationships among themes relevant to the study (Ridley, 2012).

Data Analysis Techniques

Data analysis was carried out using content analysis to extract patterns, themes, and connections across the reviewed literature. This process was complemented by thematic synthesis to integrate findings from various sources into a coherent and informative narrative.

The results of this analysis provide an overview of the technical challenges encountered in the development of IoT-based wearable devices as well as potential innovative solutions in the field of electrical engineering.

RESULT AND DISCUSSION

The following is a table of bibliographic data consisting of 10 selected articles from several relevant sources related to the research title “Factors Influencing Depression Among Adolescents in Indonesia Using an Environmental Theory Approach.” These articles provide insights into various environmental factors that affect

depression among adolescents within the Indonesian context.

Table 1. Literature Review

No	Author	Title	Research Focus
1	T. Adewale	Cloud Computing for Real-Time Health Monitoring and Wearable Devices	Integration of IoT and cloud computing for health monitoring
2	M. H. Rahman et al.	Impact of Internet of Things (IoT) on Healthcare in Transforming Patient Care	IoT-based healthcare transformation
3	U. Ejaz et al.	IoT for Hazard Detection and Worker Safety Monitoring	IoT applications in hazard detection and occupational safety monitoring
4	D. T. Phan et al.	Multi-Sensor Wearable Device with Transformer-Powered Two-Stream Fusion Model for Real-Time Monitoring	Utilization of sensors and IoT for body health monitoring
5	F. A. Mussiry et al.	Integration of IoT and Blockchain for Medical Records	Integration of IoT and blockchain for medical data security
6	D. S. Ametefe et al.	E-textiles in Healthcare: A Systematic Review	Systematic review of IoT-based wearable e-textiles
7	A. Sharma et al.	Advancements in 5G-IoT Technology-Based Healthcare	5G technology and IoT in healthcare management
8	R. Chatterjee	A Take on Smart Waste Management Using IoT	Utilization of IoT for cost efficiency and waste management
9	A. Patil et al.	Innovative Approaches in Diabetes Management Using IoT	IoT-based diabetes monitoring
10	P. Dubey et al.	The Impact of Algorithmic Technologies on Healthcare	IoT algorithm impact on healthcare

The data presented in the table above includes various studies that discuss the integration of the Internet of Things (IoT) and other technologies across different aspects of life, particularly in the fields of healthcare and resource management. The findings from each study provide valuable insights into how IoT technology can revolutionize multiple sectors, with a primary focus on efficiency, security, and

improved quality of services. Below is a detailed explanation of the research focus of each study:

The study by Adewale (2024) explores how the integration of IoT devices and cloud computing can offer solutions for real-time health monitoring. This research demonstrates that cloud computing technology can store, process, and analyze data collected from wearable devices, such as body sensors or health monitoring tools. With this support, patient conditions can be monitored more quickly and efficiently, reducing the risk of diagnostic errors and enhancing emergency response times (Adewale, 2024).

The study by Rahman et al. (2024) discusses the transformation of healthcare services enabled by IoT. This research reveals how IoT facilitates connectivity between patients, doctors, and medical devices through smart networks. This technology supports continuous patient data collection and enables faster diagnosis and more accurate decision-making, thus creating a more integrated and effective healthcare ecosystem (Rahman et al., 2024).

U. Ejaz et al. (2025) in their research titled IoT for Hazard Detection and Worker Safety Monitoring examine the implementation of IoT for hazard detection and workplace safety monitoring. These findings are highly relevant in high-risk work environments such as factories and mining sites. With IoT sensors capable of detecting environmental conditions such as temperature, hazardous gases, and vibrations, these devices can provide early warnings to prevent workplace accidents and enhance worker safety (Ejaz et al., 2025).

The study by D. T. Phan et al. (2024) titled Multi-Sensor Wearable Device with Transformer-Powered Two-Stream Fusion Model for Real-Time Monitoring highlights the use of multi-sensor wearable devices supported by a transformer-based artificial intelligence model. This technology enables the collection and analysis of more complex health data, such as heart rate patterns, body temperature, and activity levels, with high accuracy. These findings are crucial in advancing personalized, data-driven healthcare (Phan et al., 2024).

In the study by Mussiry et al. (2024), researchers examine how blockchain can be applied alongside IoT to enhance the security of medical data. Blockchain provides an additional security layer by creating encrypted and immutable medical records. This integration ensures that patient data remains protected from unauthorized access while still allowing accessibility for authorized parties, such as doctors or hospitals (Mussiry

et al., 2024).

C. Wang et al. (2024) conducted a systematic review titled *E-textiles in Healthcare: A Systematic Review*. This study discusses IoT-based e-textiles, which are smart textiles equipped with sensors to monitor health parameters such as blood pressure or oxygen levels. The research shows the significant potential of this technology for use in chronic patient management or rehabilitation (C. Wang et al., 2024).

In their study titled *Advancements in 5G-IoT Technology-Based Healthcare*, A. Sharma et al. (2024) emphasize the role of 5G technology in accelerating IoT implementation in healthcare services. The high data transmission speed offered by 5G enables IoT devices to operate more efficiently in processing real-time data. The findings indicate that 5G infrastructure will serve as a catalyst in transforming technology-driven healthcare services (Sharma et al., 2024).

The research by Dey and Chatterjee (2022) demonstrates the application of IoT in smart waste management. This study highlights how sensors and IoT devices can be used to monitor waste bin capacity levels, optimize waste collection routes, and reduce operational costs. This innovation is highly relevant in creating smart cities with efficient resource management (Dey & Chatterjee, 2022).

In their study, Patil et al. (2023) explore the use of IoT in diabetes monitoring and management. IoT devices, such as smart glucometers, allow patients to monitor their blood sugar levels in real time and provide data to healthcare providers for treatment adjustments. This facilitates a more proactive approach to diabetes management (Patil et al., 2023).

Finally, the research by Dubey et al. (2025) illustrates how IoT algorithms can transform healthcare services. Through the use of machine learning and artificial intelligence, these systems can predict health trends, provide automated diagnoses, and recommend appropriate treatments. This demonstrates how algorithmic technologies can support operational efficiency and improve healthcare outcomes (Dubey et al., 2025).

Overall, these studies illustrate the significant potential of IoT as a transformative technology across various fields, particularly in healthcare, occupational safety, and resource management. With the integration of complementary technologies such as blockchain, 5G, and AI, IoT continues to open new avenues for future innovation and efficiency.

Discussion

The use of Internet of Things (IoT)-based wearable devices has grown rapidly in recent years, especially in the health sector. These devices offer remarkable capabilities for monitoring users' health conditions in real time, such as measuring heart rate, blood oxygen levels, and physical activity. This potential enables early diagnosis and more effective management of chronic diseases. However, the integration of IoT into wearable devices is not without challenges, requiring innovative approaches to fully optimize its benefits.

One of the main challenges involves the limited power capacity of wearable devices. Since these devices are designed to be lightweight and comfortable, their batteries are often small, restricting their ability to support IoT features such as data transmission and AI-based analytics. In addition, data privacy and security issues are a major concern, given that wearable devices collect highly sensitive health information. Risks such as data breaches or misuse require robust and reliable security systems.

Interoperability issues also pose significant obstacles. Wearable devices from different manufacturers often use different communication protocols, making it difficult to create an integrated ecosystem. Moreover, limited network infrastructure—particularly in remote areas—can hinder the connectivity required to support IoT technologies. The high development costs of IoT-enabled wearable devices also contribute to reduced affordability, limiting public access to this technology.

Despite these challenges, IoT integration in wearable devices offers substantial potential. With this technology, real-time health monitoring becomes more accessible, allowing continuous collection of users' health data. This data is not only beneficial for early diagnosis but also supports personalized treatment based on individual needs. IoT integrated with artificial intelligence enables deeper analysis of health data, detecting patterns or anomalies that might go unnoticed by human observation.

Furthermore, IoT-based wearable devices support telemedicine by enabling remote communication between patients and healthcare providers with accurate, real-time health data. This can enhance the overall efficiency of healthcare services, especially in underserved areas with limited medical personnel.

To address these challenges and maximize the potential of IoT in wearable devices, several innovative solutions can be implemented. The development of energy-

efficient technologies, such as energy harvesting from body heat or motion, can extend device battery life. Additionally, the adoption of blockchain technology can enhance data security and privacy by providing encrypted and tamper-proof systems for storing and sharing medical information.

Global standardization of communication protocols is also essential to ensure interoperability among wearable devices from different manufacturers. The use of 5G networks and edge computing can accelerate connectivity and enable data processing directly on the device, reducing dependence on central servers. To increase accessibility, production costs of IoT-based wearable devices need to be reduced through innovations in materials and manufacturing processes. Public education is also important to improve understanding and acceptance of this technology.

By overcoming these challenges, the integration of IoT into wearable devices for health monitoring can be optimized. This technology holds great potential for improving the quality of healthcare services, supporting more personalized treatment, and accelerating the adoption of telemedicine in the future. With the right approach, IoT-based wearable devices can become a revolutionary solution in the global healthcare system.

CONCLUSION

This study concludes that IoT-based wearable devices hold significant potential for improving healthcare services, particularly in the management of chronic diseases and real-time health monitoring. This technology enables patients to conduct self-monitoring and supports data-driven decision-making by medical professionals. However, its implementation faces several technical and ethical challenges, including data security, device interoperability, and energy efficiency.

To address these challenges, the study proposes several strategic steps. First, the development of universal communication standards among IoT devices should be prioritized to enhance interoperability. Second, the use of blockchain technology can serve as a solution to protect patient data from security threats. Third, 5G infrastructure needs to be adopted promptly to overcome bandwidth limitations and support real-time connectivity. Additionally, it is important to educate the public and stakeholders about the benefits and risks of this technology to increase public acceptance.

The study recommends collaboration among academia, industry, and

government to create an ecosystem that supports innovation in IoT-based wearable devices. With an integrated approach, this technology can significantly contribute to creating a more efficient and personalized healthcare system in the future.

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