STM JOURNALS

Journal of
Microcontroller Engineering and Applications

ISSN: 2455-197X
Volume 11, Issue 3, 2024
September—December
DOI (Journal): 10.37591/JoMEA

https://journals.stmjournals.com/jomea

Research JoMEA

IoT-based Patient Fall Detection and Alerting System for Patient Safety

Sruthi S. Madhavan[1,*], Hamsavarthan[2], Ragul V.[2], Thangavel M.[2]

Abstract

This paper presents an Internet of Things (IoT) based patient fall detection and alerting system designed to enhance patient safety in healthcare settings. Falls among patients, especially in hospitals or care facilities, can lead to severe injuries and complications. The proposed system utilizes wearable sensors integrated with IoT technology to continuously monitor the movements and activities of patients. Machine learning algorithms are employed to analyze sensor data in real time, enabling the system to accurately detect fall events. Upon detection of a fall, the system triggers immediate alerts to healthcare providers or caregivers, facilitating prompt intervention and reducing response time. Through its proactive approach, the IoT-based system aims to mitigate the risks associated with patient falls, thereby enhancing overall patient safety and well-being in healthcare environments. Since deep learning and machine learning tend to be used interchangeably, it is worth noting the nuances between the two. Machine learning, deep learning, and neural networks are all sub-fields of artificial intelligence. However, neural networks are a sub-field of machine learning, and deep learning is a sub-field of neural networks.

Keywords: IoT, patient safety, fall detection, wearable sensors, healthcare, machine learning, real-time monitoring, alerting system, caregiver intervention

INTRODUCTION

Patient safety is of paramount concern in healthcare facilities worldwide, with continuous efforts to minimize risks and enhance the quality of care provided. Among various safety concerns, patient falls stand out as a significant challenge, particularly in hospitals, nursing homes, and other care settings. Falls not only result in physical injuries, but also contribute to prolonged hospital stays, increased healthcare costs, and diminished quality of life for patients. In this context, the development of robust fall detection and alert systems has emerged as a critical endeavor to address this pressing issue. Traditional fall prevention measures often rely on manual observation by healthcare staff, which can be resource-intensive and prone to human error. Recognizing the limitations of conventional methods, there has been growing interest in leveraging technological advancements, particularly in the realm of the Internet of Things (IoT), to enhance patient safety. IoT-based systems offer the potential to continuously monitor patient movements and activities using a network of interconnected sensors, thereby enabling real-time detection and response to fall events. This paper presented an IoT-based patient fall detection and alerting system designed to proactively identify and mitigate the risks associated with falls in healthcare environments. By integrating wearable sensors with

***Author for Correspondence**
Sruthi S. Madhavan
E-mail: nietsruthimadhavan@nehrucolleges.com

[1]Assistant Professor, Department of Artificial Intelligence and Data Science, Nehru Institute of Engineering and Technology, Anna University, Coimbatore, India
[2]Student, Department of Artificial Intelligence and Data Science, Nehru Institute of Engineering and Technology, Anna University, Coimbatore, India

Received Date: July 01, 2024
Accepted Date: September 23, 2024
Published Date: October 15, 2024

Citation: Sruthi S. Madhavan, Hamsavarthan, Ragul V., Thangavel M. IoT-based Patient Fall Detection and Alerting System for Patient Safety. Journal of Microcontroller Engineering and Applications. 2024; 11(3): 9–14p.

IoT technology, the system aims to provide continuous monitoring of patient movements, allowing for early detection of fall incidents. By leveraging machine learning algorithms, the system analyzes sensor data in real time to distinguish between normal activities and fall events with high accuracy. Real-time monitoring is a technique that involves continuous collection, analysis, and visualization of data to understand the current state of a system or process.

MATERIALS AND METHODS

The development of an IoT-based patient fall detection and alert system is integral to its functionality and effectiveness. Wearable sensors, including accelerometers and gyroscopes, are utilized to capture patients' movements and orientations discreetly and comfortably. Such sensors are typically integrated into wrist-worn or body-worn patches. Data collected by these sensors are transmitted to a cloud-based IoT platform through reliable protocols, such as message queuing telemetry transport (MQTT) or HTTP, ensuring secure and seamless communication. Preprocessing techniques including noise filtering and feature extraction were then applied to the sensor data. Supervised machine learning algorithms, such as Support Vector Machines or Artificial Neural Networks, are trained using labeled datasets to accurately detect fall events. In real time, these algorithms analyze incoming sensor data streams to identify patterns indicative of falls, triggering alerts through various communication channels, such as SMS or email. A predefined response protocol guides healthcare providers or caregivers to respond promptly and appropriately to fall alerts. System performance is evaluated using real-world scenarios and metrics, such as sensitivity and specificity, while ethical considerations ensure patient privacy and data security throughout the system's development and deployment.

Additionally, the IoT platform serves as a central repository for storing and managing sensor data and facilitating real-time monitoring and analysis. Data preprocessing techniques play a crucial role in cleaning and preparing incoming data streams for analysis, thereby ensuring the accuracy and reliability of fall detection algorithms. These techniques may involve removing noise, normalizing sensor readings, and extracting relevant features to capture the unique patterns associated with fall events. By preprocessing the data before feeding them into the machine learning algorithms, the system can effectively distinguish between normal activities and fall incidents, minimize false positives, and enhance the overall detection performance.

The deployment of machine learning algorithms for fall detection entails training models on labeled datasets containing examples of both normal activities and fall events. This supervised learning approach enables algorithms to learn and recognize patterns indicative of falls, thereby improving their accuracy and generalization capabilities. The trained models were then deployed in real time to analyze incoming sensor data streams and detect fall events with high precision. Continuous monitoring and feedback mechanisms may be employed to fine-tune the algorithms' performance over time, ensuring adaptability to evolving patient behaviors and environmental conditions. Fall detection (also called automatic fall detection) uses sensors such as accelerometers, which detect motion, to identify when you fall and then send an alert to the medical alert company's monitoring center that you need help with.

Furthermore, the alerting mechanism plays a critical role in ensuring timely intervention and response to falls. Upon detecting a fall, the system generates alerts and notifies designated healthcare providers or caregivers through customizable communication channels. These alerts are accompanied by relevant information such as the patient's location and activity status to facilitate quick assessment and decision-making. By streamlining the alert process and providing actionable information, the system enables healthcare providers to respond promptly and effectively, thereby minimizing the potential consequences of patient falls and improving overall patient safety and well-being.

LITERATURE REVIEW

Majumder et al. presented an IoT-based smart home system designed for remote monitoring and healthcare, focusing on elderly patients. The system integrates various sensors to monitor activities,

detect falls, and send alerts to caregivers and healthcare providers. It emphasizes the use of real-time data analytics to ensure timely intervention and enhance patient safety [1].

Abdulmalek et al. introduced a fall detection system that leveraged machine learning algorithms and wearable sensors to accurately identify falls. The system processes data from accelerometers and gyroscopes to distinguish between falls and other activities, thereby significantly reducing false alarms. It aims to improve the reliability and effectiveness of fall detection in elderly care [2].

Saguna et al. discussed various IoT-based fall detection technologies, highlighting advancements in sensor accuracy, data processing algorithms, and communication protocols. It explores the challenges in implementing these systems, such as their energy efficiency and data privacy, and provides insights into future trends and potential improvements [3].

Zouka et al. presented a fall detection system that utilizes IoT and cloud computing to provide real-time monitoring and alerting. The system employs a network of sensors to detect falls and immediately notify caregivers through cloud-based platforms. It emphasizes scalability and the ability to handle large volumes of data efficiently [4].

Karar et al. explored the development of an IoT-enabled fall detection system tailored to elderly care. It integrates wearable devices with ambient sensors to enhance detection accuracy and provide continuous monitoring. The system includes features for real-time alerts and detailed reporting aimed at improving response times and patient outcomes. To create AI algorithms and techniques for fall detection systems (FDS) on the IoT environment, Karar et al. evaluated recent research [5].

Hercog et al. provided a case study of an affordable home automated system based on wireless, custom-developed Wi-Fi-based hardware, and open-source home automation software as well as a review of relevant works in this research field [6].

The goal of Behera et al. was to make users' lives easier and smarter by using wearable technology with home automation and healthcare. The three primary functions of Smart Wear are the integration of these two features: health monitoring and home automation. By automating their environment and monitoring a healthy lifestyle, patients become more comfortable [7].

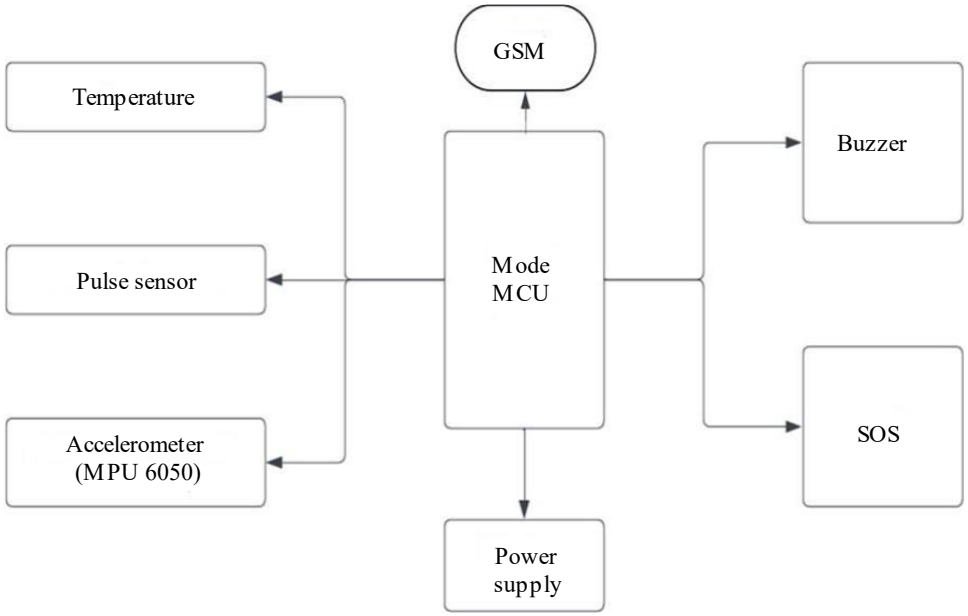


Figure 1. Block diagram of the fall detection system.

A machine-learning-based technique for evaluating the quality of activities in smart homes was presented by Javed et al. We measured the activity quality of 179 volunteer participants who completed a challenging and intricate set of tasks in our smart home flat to validate our methodology [8].

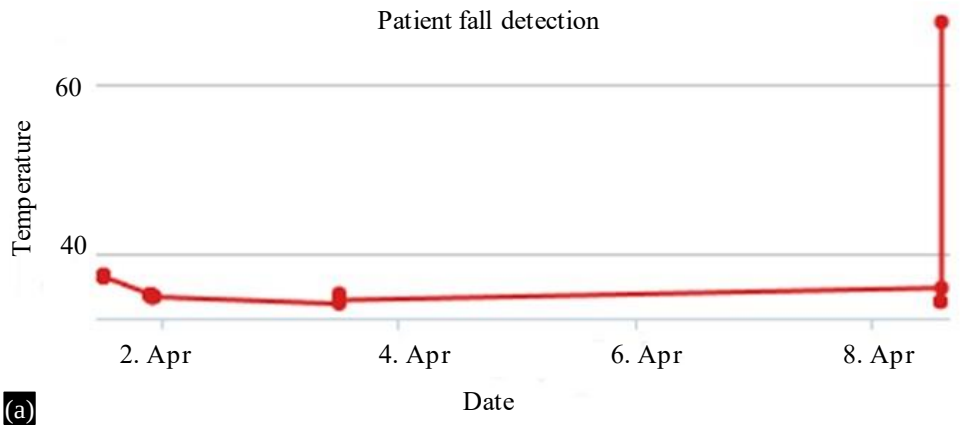
A dependable and lightweight remote authentication method was suggested by Ashraf et al. for the upcoming wave of the Internet of Things-based smart homes. The automated validation of Internet security-sensitive protocols and applications (AVISPA) technique is utilized for both formal and informal security assessments to test the resilience of the suggested plan [9]. Rajaei suggested an active detection system that detects falls in a patient's surroundings using IoT. It immediately notifies caregivers and sends crucial data for therapy [10].

The acceleration data of elderly patients are continually collected using a wearable sensor and saved on a cloud server using an IoT board. Gupta et al. proposed a system for falling detection. An Android application was developed to allow medical experts to study senior patients' falls and provide the necessary support, if needed, by accessing the saved data [11]. Mahesh et al. found that IoT-based fall detection and warning system has become an essential resource for elderly carers. This cutting-edge gadget uses gyroscope and accelerometer sensors to track a person's movements over time [12]. Before Edeib et al. gathered an autumn dataset from accelerometer sensors, they used machine learning to assess whether it was a falling season [13].

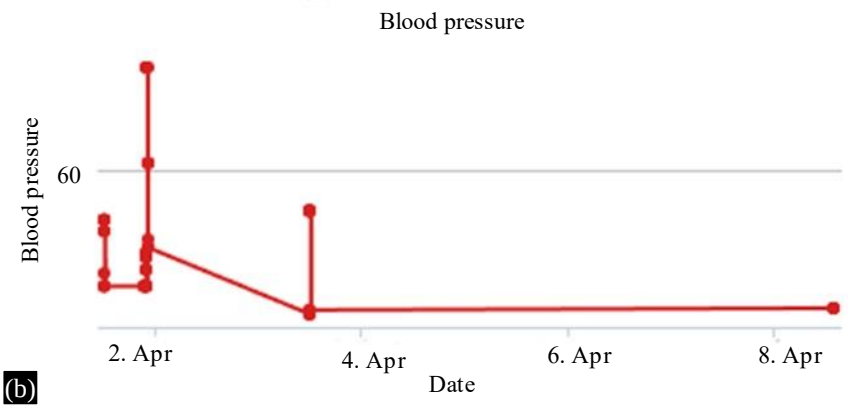
The IoT-based patient fall detection and alerting system integrates multiple components to ensure patient safety through continuous monitoring and a rapid response, as shown in Figure 1. The GSM module sends alerts to caregivers and emergency contacts when a fall is detected. Temperature and pulse sensors monitor the patient's health by measuring the body temperature and heart rate. The accelerometer detects falls by sensing sudden changes in movement and orientation. The system is powered by a reliable power supply and controlled by a microcontroller unit (MCU) that processes data from all sensors. Additionally, a buzzer provides audible alerts, and an SOS button allows patients to manually call for help, ensuring comprehensive safety and quick responses during emergencies.

RESULTS

The IoT-based patient fall detection and alerting system provides comprehensive health monitoring by integrating temperature and blood pressure data with fall detection, as shown in Figure 2. When a fall is detected by an accelerometer, the system records the patient's body temperature and blood pressure readings simultaneously. These vital signs are crucial for assessing a patient's overall condition after a fall. The temperature sensor measures and logs the patient's body temperature, whereas the blood pressure monitor records the systolic and diastolic pressures. These data, along with the date and time of the fall, were sent to caregivers and healthcare providers via the GSM module, ensuring timely intervention and detailed health monitoring.



(a)



(b)

Figure 2. Output of the proposed system.

DISCUSSION

IoT-based patient fall detection and alerting systems have emerged as promising solutions to mitigate the risks associated with patient falls in healthcare settings. By leveraging wearable sensors, real-time data analysis, and proactive alerting mechanisms, these systems can promptly detect fall events and trigger timely interventions from healthcare providers or caregivers. Studies have demonstrated the effectiveness of these systems in accurately identifying falls, while minimizing false alarms, thereby improving patient safety, and reducing the severity of fall-related injuries. However, the deployment of IoT-based FDS presents challenges, including sensor accuracy, data privacy concerns, interoperability issues, and user acceptance. Addressing these challenges is crucial to ensure the effective implementation of these systems in clinical practice.

Ethical considerations play a significant role in the development and deployment of IoT-based fall detection and alert systems for patients. Protecting patient privacy, autonomy, and informed consent is paramount, especially for the collection and transmission of sensitive health data. Moreover, ensuring the reliability and accuracy of fall detection algorithms is essential to avoid unnecessary interventions and to maintain patient trust in the system. In addition, the potential implications of false alarms and overreliance on technology must be carefully considered to prevent unintended consequences and ensure patient safety.

Future research and innovation in IoT-based patient fall detection and alerting systems are poised to address current challenges and unlock new opportunities for improving patient care. Integration with additional sensor modalities, such as video cameras or environmental sensors, can provide valuable context for fall detection algorithms, enhancing their accuracy and reliability. Furthermore, the adoption of artificial intelligence techniques such as machine learning and predictive analytics may enable proactive risk assessment and personalized interventions tailored to individual patient needs. Moreover, ensuring the scalability, sustainability, and interoperability of these systems is critical for their widespread adoption and integration into the existing healthcare infrastructure and practices.

CONCLUSION

In conclusion, IoT-based patient fall detection, and alerting systems represent significant advancements in healthcare technology, offering the potential to enhance patient safety and reduce the severity of fall-related injuries. These systems leverage wearable sensors, real-time data analysis, and proactive alert mechanisms to promptly detect fall events and trigger timely interventions, ultimately improving patient outcomes. However, challenges such as sensor accuracy, data privacy concerns, and user acceptance must be addressed to ensure the effective implementation of these systems in clinical practice. By addressing these challenges and embracing future research and innovation, IoT-based FDS have the potential to revolutionize patient care and contribute to a safer and more efficient healthcare environment. As we continue to refine and optimize these systems, it is essential to prioritize patient

privacy, autonomy, and informed consent, ensuring that patient safety remains at the forefront of our efforts to leverage technology to improve healthcare delivery.

REFERENCES

1. Majumder S, Aghayi E, Noferesti M, Memarzadeh-Tehran H, Mondal T, Pang Z, et al. Smart homes for elderly healthcare-recent advances and research challenges. Sensors (Basel). 2017;17(11):2496. DOI: 10.3390/s17112496. PubMed: 29088123.
2. Abdulmalek S, Nasir A, Jabbar WA, Almuhaya MAM, Bairagi AK, Khan MAM, et al. IoT-based healthcare-monitoring system towards improving quality of life: A review. Healthcare (Basel). 2022;10(10):1993. DOI: 10.3390/healthcare10101993. PubMed: 36292441. PubMed Central: PMC9601552.
3. Saguna S, Åhlund C, Larsson A. Experiences and challenges of providing IoT-based care for elderly in real-life smart home environments. Handbook of Integration of Cloud Computing, Cyber Physical Systems and Internet of Things. 2020;255–71.
4. El Zouka HA, Hosni MM. Secure IoT communications for smart healthcare monitoring system. Internet of Things. 2021 Mar 1;13:100036.
5. Karar ME, Shehata HI, Reyad O. A survey of IoT-based fall detection for aiding elderly care: Sensors, methods, challenges and future trends. Appl Sci (Basel). 2022;12(7):3276. DOI: 10.3390/app12073276.
6. Hercog D, Sedonja D, Recek B, Truntič M, Gergič B. Smart home solutions using Wi-Fi-based hardware. Tehnički Vjesnik. 2020;27:1351–8.
7. Behera SK, Saisudha G, Vasundhara L, Nasreen J. Wear-an integrated watch for patients. In: 2022 International Conference on Power, Energy, Control and Transmission Systems (ICPECTS). IEEE; 2022. p. 1–4.
8. Javed AR, Fahad LG, Farhan AA, Abbas S, Srivastava G, Parizi RM, et al. Automated cognitive health assessment in smart homes using machine learning. Sustain Cities Soc. 2021;65:102572. DOI: 10.1016/j.scs.2020.102572.
9. Ashraf Z, Sohail A, Hameed A, Farhan M, Alotaibi FA, Alnfiai MM. Robust and lightweight remote user authentication mechanism for next-generation IoT-based smart home. IEEE Access. 2023;11:137899–910. DOI: 10.1109/ACCESS.2023.3336763.
10. Rajaei H. An IoT-based smart monitoring system detecting patient falls. In: Annual Modeling and Simulation Conference (ANNSIM). IEEE; 2022. p. 839–50. DOI: 10.23919/ANNSIM55834.2022.9859346.
11. Gupta A, Srivastava R, Gupta H, Kumar B. IoT-based fall detection monitoring and alarm system for elderly. IEEE 7th Uttar Pradesh Section International Conference on Electrical, Electronics and Computer Engineering (UPCON). Prayagraj, India: IEEE; 2020. p. 1–5. DOI: 10.1109/UPCON50219.2020.9376569.
12. Mahesh G, Kalidas M. A real-time IoT-based fall detection and alert system for elderly. Int Conf Adv Comput. 2023;327–31. DOI: 10.1109/ICAICCIT60255.2023.10465914.
13. Edeib SRM, Dziyauddin RA, Amir NIM. Fall detection and monitoring using machine learning: A comparative study. Int J Adv Comput Sci Appl. 2023;14. DOI: 10.14569/IJACSA.2023.0140284.

