International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 09 | September - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

SMART TILES FOR ELDER TRACKING AND FALL DETECTION

R Lakshmi Prabha[1], D Ajith Kumar[2]

[1]*P.G Scholar, Dept. of Biomedical Engineering, Udaya School of Engineering, Vellamodi, Tamil Nadu, India*
[2] *Assistant professor, Dept. of Biomedical Engineering, Udaya School of Engineering, Vellamodi, Tamil Nadu, India*

Abstract - The population of elderly people is increasing rapidly, and falls are a significant cause of injury and death among them. To address this issue, we propose a smart tile system that uses IoT technology to track the location and detect falls of elderly individuals. The system consists of small, wireless sensors (smart tiles) that can be placed on the floor of a room or a specific area, such as a bathroom or kitchen, to monitor the movements of the elderly person. The smart tiles communicate with a central hub, which collects and analyses the data using machine-learning algorithms to detect falls and abnormal movements. The proposed system has several advantages over traditional fall detection systems. It is non-intrusive and does not require any wearable devices or cameras, which can be uncomfortable or intrusive for the elderly person. The smart tiles can also be placed in multiple locations to provide more comprehensive coverage and can be easily installed or removed without the need for professional help. Additionally, the system can provide real-time alerts to caregivers or emergency services, enabling timely intervention and potentially reducing the severity of injuries. In conclusion, the smart tiles system proposed in this project provides an innovative solution to the problem of fall detection and elder tracking using IoT technology. It has the potential to improve the safety and well-being of elderly individuals and can be a valuable tool for caregivers and healthcare providers.

***Key Words*: Smart Tiles, Fall Detection, IoT, Arduino IDE, Proteus ISIS7.**

1. INTRODUCTION

The elderly population is growing at an unprecedented rate, and with it comes an increased risk of falls, which can result in serious injuries or even death. According to the World Health Organization (WHO), falls are the second leading cause of accidental or unintentional injury deaths worldwide. Therefore, it is essential to develop new technologies that can help prevent and detect falls among the elderly population. Fall is the most significant cause of injury for the elderly. These falls are because of many disabling fractures that could eventually go in front to death due to complications [1]. Most elderly (over 75 years old) have fallen at least once a year, and 24 % of them have severe injuries [2]. In recent years, there has been a growing interest in using the Internet of Things (IoT) to develop innovative solutions for elder tracking and fall detection. IoT technology enables the collection and analysis of data from various sensors and devices, allowing for real-time monitoring and alerting. One such solution is the use of smart tiles for elder tracking and fall detection [3]. Smart tiles are wireless sensors that can be placed on the floor of a room or specific area, such as a bathroom or kitchen, to track the movements of elderly individuals [4]. The smart tiles communicate with a central hub, which collects and analyzes the data using machine-learning algorithms to detect falls and abnormal movements [6]. The system can then alert caregivers or emergency services in real time, enabling timely intervention and potentially reducing the severity of injuries. State-of-the-art fall detection techniques were surveyed, highlighting the differences in their effectiveness at fall detection [7]. A standard database structure was created for fall study that emphasizes the most important elements of a fall detection system that must be considered for designing a robust system, as well as addressing the constraints and challenges [9]. In addition, fall activity patterns are particularly difficult to obtain for training systems. These systems successfully detect falls with sensitivities [11]. However, focusing only on large acceleration can result in many false positives from fall-like activities such assisting down quickly and running. Furthermore, previous studies used complex algorithms like support vector machine (SVM) and Markov model to detect the fall [13].

The elderly population is at an increased risk of falls, which can result in serious injuries or even death. According to the Centers for Disease Control and Prevention (CDC), falls are the leading cause of fatal and non-fatal injuries among older adults. The problem is particularly acute for those living alone, who may not have immediate access to assistance. Traditional fall detection systems, such as wearable devices or cameras, can be uncomfortable or intrusive for the elderly person. Moreover, these systems may not be effective in detecting falls that occur outside the range of the device or camera. Therefore, there is a need for innovative solutions that can monitor the movements of elderly individuals in a non-intrusive and comprehensive manner. This proposed model develops a smart tile system for elder tracking and fall detection that utilizes IoT technology. The paper discusses the advantages of this system over traditional fall detection systems and explores the potential benefits for caregivers and healthcare providers. Also, discuss the challenges associated with implementing such a system and the future directions for research in this area. Overall, the proposed smart tiles system represents a promising approach to elder tracking and fall detection using IoT technology. By providing real-time monitoring and

alerting, this system has the potential to improve the safety and well-being of elderly individuals, as well as reduce healthcare costs associated with falls. The primary objective of this system is to improve the safety and well-being of elderly individuals by detecting falls and other accidents as quickly as possible and providing timely assistance.

The Order of the paper is given as follows, section 2 covers the literature review, section 3 narrates the proposed research methodology, section 4 has results and section 5 holds the conclusion part.

2. LITERATURE REVIEW

Fang, Y et al. (2018) provide an overview of the literature on Smart Tiles and other smart home monitoring technologies for fall detection in elderly individuals and discuss their potential benefits and limitations. They identified a total of 58 studies that met their inclusion criteria, which covered a range of Smart Tiles and other smart home monitoring technologies for fall detection and prevention. The paper highlights several key themes and challenges in the field, including the need for more reliable and accurate fall detection algorithms, the importance of user acceptance and engagement, and the challenges of integrating multiple sensor modalities and data streams into a unified system. Overall, the paper provides a comprehensive and up-to-date overview of the state of research in the field of Smart Tiles and smart home monitoring technologies for fall detection and offers insights into the challenges and opportunities for future development and implementation [8].

Jin, Y, et al. (2016) describe a Smart Tiles-based system for indoor tracking and fall detection of elderly individuals. The system uses a combination of sensors, including Smart Tiles, to track the movements and location of elderly individuals and to detect falls. The algorithm uses a combination of accelerometer data and radio frequency identification (RFID) signals from Smart Tiles to accurately detect falls with a high degree of sensitivity and specificity. The study involved 10 elderly participants who wore a sensor device containing the Smart Tiles and other sensors for a period of one week. The results showed that the system was able to accurately detect falls with a sensitivity of 93% and a specificity of 97% and provided accurate indoor tracking information [12].

Ghaffari, et al. (2018) describe a low-cost Smart Tiles-based system for fall detection and health monitoring of elderly individuals. The paper presents the design and implementation of the Smart Tiles-based system, which includes a Smart Tiles network deployed in the home environment and a wearable device worn by the elderly individual. The algorithm was evaluated using a dataset of simulated falls and was found to have a sensitivity of 97% and a specificity of 99%. The paper also discusses the potential applications of the Smart Tiles-based system for the health monitoring of elderly individuals, including detecting abnormalities in heart rate and body temperature that may indicate underlying health issues [10].

Cottone, et al. (2016) is a comprehensive review of the literature on smart home technologies and health telemetry for elderly care. The paper provides an overview of the current state of research in the field and identifies key trends, challenges, and opportunities for future development. They identified a total of 107 studies that met their inclusion criteria, covering a range of technologies including Smart Tiles, wearable devices, and home monitoring systems. Overall, the paper provides a comprehensive and up-to-date overview of the state of research in the field of smart home technologies and health telemetry for elderly care and offers insights into the challenges and opportunities for future development and implementation [5].

Wang, X, et al. (2019) provide an overview of recent advances and challenges in fall detection using smart tiles. The article discusses the potential of smart tiles, which are tiles with embedded sensors, to improve fall detection accuracy and reduce false alarms. The authors discuss the various machine learning algorithms that have been used for fall detection, including rule-based systems, decision trees, and neural networks, and compare their performance. The authors also discuss the challenges associated with fall detection using smart tiles, including the need for accurate sensor placement, the impact of environmental factors such as lighting and noise, and the need for privacy and security in the handling of sensitive health data [14].

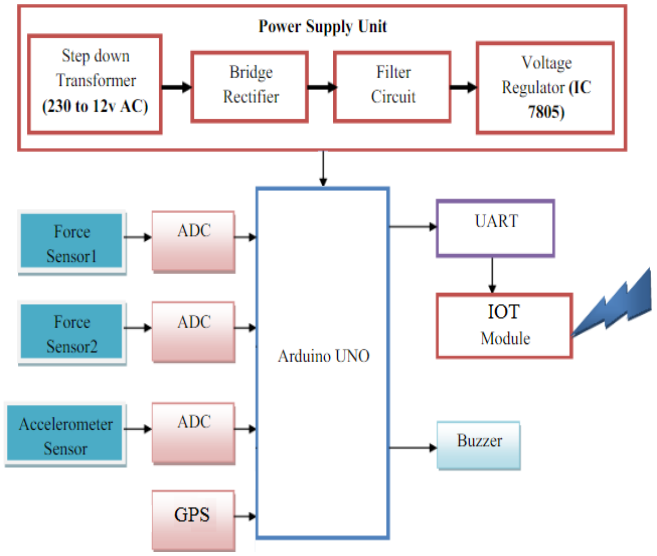
Zhang, H, et al. (2021) provide an in-depth exploration of the potential of smart home technologies to improve elderly healthcare. The authors discuss the various types of sensors and devices that can be incorporated into a smart home, such as activity sensors, fall detectors, and medication dispensers, to monitor and assist with activities of daily living (ADLs). The challenges include concerns about privacy and security, as well as the need for user-friendly interfaces and interoperability between devices from different vendors [15].

3. PROPOSED METHOD

The Proposed method uses two types of sensor systems accelerometer and force sensor. The accelerometer is used to enforce the differentiation between the falling and the lying down posture.

The proposed block diagram Figure 3.1 shows the components of Smart Tiles for elder tracking and fall detection systems. Firstly, the database tables are fragmented into fall and non-fall fragments to obtain two different classes, and then we proceed to do the

windowing of each signal in each class. From each window, we extract some useful parameters and then select the most pertinent of them to be used to differentiate between the two states: falling and non-



falling. The accelerometer senses the position of the elder people, and the corresponding tile pressure is also measured and then it will decide whether the people standing sitting or falling. The toggle switch is also provided for on/off operation because when people are resting in position or sleep to turn off the device. When a fall occurs, people occupy more pressure sensors (i.e. tiles) and also position identified and decide the fall occurs send message to the caretaker, children and hospital etc.

Fig. 3.1 Block diagram of the Non-invasive Glucometer with IOT

The working principle of a smart tiles-based system for elderly tracking and fall detection is based on the use of pressure sensors embedded in floor tiles to detect and monitor the movements and activities of elderly individuals in their homes. The system works by monitoring the pressure exerted on the floor tiles as the elderly individual moves around their home. Each smart tile contains one or more pressure sensors, which can detect changes in pressure as the person walks, stands, sits, or lies down. The sensors can also detect the absence of pressure, which can indicate a fall or other abnormal event. The data from the pressure sensors is processed by a microcontroller, which is connected to the sensors via a wired or wireless network. The microcontroller can analyze the data in real-time to detect falls or other abnormal events, such as prolonged periods of inactivity, and send an alert to a central monitoring system or to caregivers.

The system can also be programmed to detect patterns of behavior and provide insights into the daily routines of the elderly individual. For example, it can track how often the person gets out of bed at night, how often they use the bathroom, and how much time they spend in different parts of their home. The central monitoring system can be accessed by caregivers or healthcare professionals to track the movements and activities of elderly individuals and monitor for any signs of health problems or emergencies. The system can also be programmed to send alerts or notifications to caregivers or emergency services in the event of a fall or other emergency. Overall, the working principle of a smart tiles-based system for elderly tracking and fall detection is based on the use of pressure sensors to monitor the movements and activities of elderly individuals in their homes. The system can provide valuable insights into the daily routines of the elderly individual and enable early intervention in health problems or emergencies.

Whenever the sensors are combined with IoT technology, it can be an illustration of a cyber-physical system, smart home, smart grid, smart city, intelligent transportation and virtual power plants. Therefore, the IoT can help in controlling the objects remotely being sensed by the sensors so that the physical systems can be easily integrated by the computing systems. This advantage not only improves the accuracy and efficiency of a machine but also minimizes the human intervention needed for monitoring a machine or a device 24/7. The use of the ThinkSpeak platform makes it easy to access the data stored in it by means of IoT-Data Analytics. Moreover, the used sensors in the proposed models are of low cost and easily affordable so the cost of periodic maintenance is also easier.

The IOT Module is interfaced to the MCU by using the UART interface. The sensor may be a load cell or sprain gauge which is used to detect the level of the impact and the signal to the MCU. If the controller predicts that the sprain gauge value is more than the critical limit then the information is sent to the presto red number in the microcontroller through SMS to the Hospital or their relation to rescue.

Liquid crystal display is a very important device in embedded systems. It offers high flexibility to the user as he can display the required data on it. But due to a lack of proper approach to LCD interfacing many of them fail. Many people consider LCD interfacing a complex job but according to me LCD interfacing is a very easy task, you just need to have a logical approach. This page is to help the enthusiast who wants to interface LCD with a thorough understanding.

The proposed system of the Smart Tiles for elder tracking and fall detection system with Atmega328 Arduino, pressure sensor, accelerometer, and IoT involves fall detection. The sensor detects the absorption of IR radiation by the glucose molecules in the blood, and the readings are processed by the Atmega328

microcontroller. The microcontroller is programmed to calculate the glucose level based on the absorption data and display the results on an LCD screen. In addition to displaying the results locally, the proposed system also integrates IoT technology to transmit fall detection.

Figure 3.2 shows the flow chart of a Smart Tiles for elder tracking and fall detection system. The proposed neonatal incubator design consists of 3 sections namely, the terminal device, the network protocols and the monitoring. The various sensors connected are used for monitoring the fall detection via IoT. The Arduino microcontroller is programmed in such a way to get the output of these sensor and display it on the LCD for monitoring purpose. The values of the sensors are then uploaded in the ThinkSpeak cloud to display it on the wireless device in the receiver side, which is then used for enabling the control of the incubator environment.

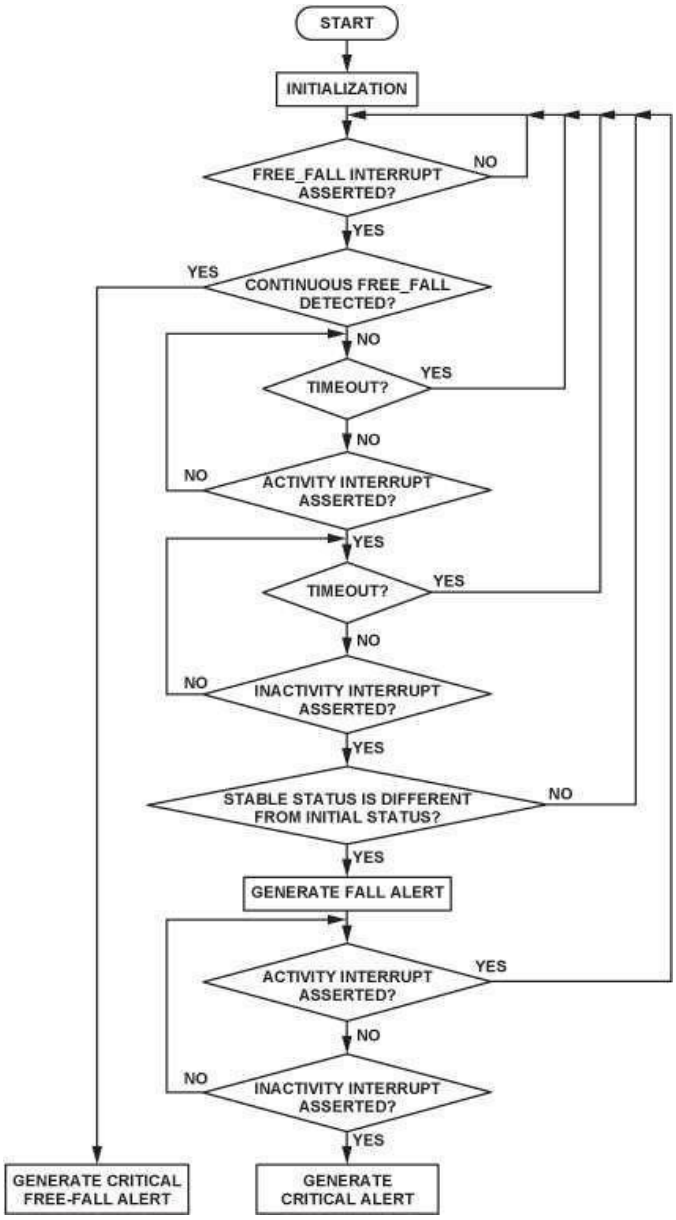


Figure 3.2 System Operation Flowchart

3.1 Simulation

To write the program and make a simulation for the electrical circuit two software applications, Arduino Integrated Development Environment (IDE) and Proteus software were used.

3.2.1 Arduino IDE

The Arduino IDE is a cross-platform application written in Java, and derives from the IDE for the Processing programming language and the Wiring projects. It is designed to introduce programming to artists andother newcomers unfamiliar with software development. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and is also capable of compiling and uploading programs to the board with a single click. A program or code written for Arduino is called a “sketch”. Arduino programs are written in C language. The Arduino IDE comes with a software library called “Wiring” from the original Wiring project, which makes many common input/output operations much easier.

3.2 Proteus

Proteus software contains everything you need to develop, test and virtually prototype your embedded system designs based around the Microchip Technologies of microcontrollers. The unique nature of schematic based microcontroller simulation with Proteus facilitates rapid, flexible and parallel development of both the system hardware and the system firmware. This design synergy allows engineers to evolve their projects more quickly, empowering them with the flexibility to make hardware or firmware changes at will and reducing the time to market. Proteus VSM models will fundamentally work with the exact same HEX file, as you would program the physical device with, binary files produced by any assembler or compiler. We will use ISIS for simulating Arduino response, it has many variety modeling libraries, and its powerful concentrates in microcontroller units and microprocessor units modeling.

4. RESULTS

Proteus ISIS7 simulator is used for simulation purpose. For program computing purpose, Arduino IDE tool is used. Proteus is a software tool used for designing and simulating electronic circuits. In the context of a smart tiles-based system for elderly tracking and fall detection, Proteus can be used to design and simulate the electronic circuitry required for the system.

The system would consist of smart tiles embedded with pressure sensors, which would be connected to a microcontroller that would process the sensor data and send it to a central monitoring system. The monitoring

system would then analyze the data to detect falls or other abnormal events and notify caregivers or emergency services as required.

Using Proteus, designers can create a virtual prototype of the electronic circuitry and test it before building a physical prototype. The software tool provides a range of features for designing and simulating electronic circuits, including a library of components, simulation tools, and debugging features.

Designers can use Proteus to create a schematic diagram of the circuit, select components from the library, and connect them together. They can then simulate the circuit to test its functionality and identify any errors or design flaws. Proteus also allows designers to visualize the behavior of the circuit over time, which can be useful for identifying patterns and trends in the data.

In the context of a smart tiles-based system for elderly tracking and fall detection, Proteus can help designers to optimize the electronic circuitry to minimize power consumption, reduce costs, and improve performance. By simulating the circuit, designers can identify potential problems and make adjustments before building a physical prototype, which can save time and resources.

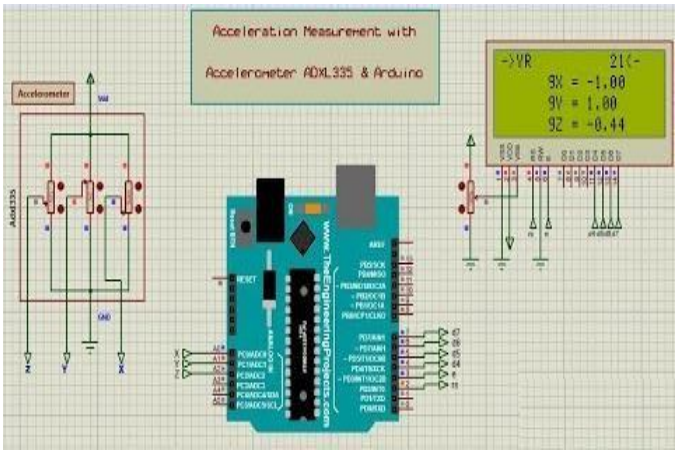


Figure 4.1 Circuit Diagram

Overall, Proteus is a powerful software tool that can be used to design and simulate electronic circuits for a smart tiles-based system for elderly tracking and fall detection. It can help designers to optimize the system for performance, cost, and power consumption, and reduce the time and resources required for prototyping and testing. When the acceleration value is above 1.01g and the heart rate is below 79/pulse, then the system will send a message and track the location of the impact on elderly people. When the acceleration value is below 1.01g and the heart rate is above 79/pulse, then the system fails to send a message because there is no fall event is tracked. So there is less chance for a false fall detection rate. The designed circuit displayed by detail in Figure 41

4.1 Performance Analysis

Proteus Design simulation results for a smart tiles-based elder tracking and fall detection system using an accelerometer and Atmega328 microcontroller has many benefits of applications. One of the primary benefits of using a Proteus Design simulation for a smart tiles-based elder tracking and fall detection system is the ability to evaluate the system's performance under various conditions in a controlled environment. This can include testing the system's accuracy in detecting falls or unusual movements on different types of flooring surfaces and in different environments, such as a bedroom, bathroom, or kitchen. The simulation can also be used to test the system's response to different types of movements, such as a person crawling or rolling on the floor.

In addition, a Proteus Design simulation can allow for the rapid evaluation of multiple design options and iterations without the need for physical prototypes. This can save time and resources during the design and development process and help ensure that the final product meets performance requirements.

However, there are also limitations to using a simulation to evaluate the performance of a smart tiles-based elder tracking and fall detection system. For example, the simulation may not fully capture all of the complex variables and interactions that occur in a real-world environment. Additionally, the accuracy of the simulation results may depend on the accuracy and completeness of the simulation model and the assumptions made in the simulation.

In summary, using a Proteus Design simulation to evaluate the performance of a smart tiles-based elder tracking and fall detection system using an accelerometer and Atmega328 microcontroller can provide valuable insights into the system's performance under various conditions. However, it is important to recognize the limitations of the simulation and to validate the simulation results through real-world testing before deploying the system in a clinical or care environment.

5. CONCLUSION

It is concluded that the Proteus simulation using an accelerometer to detect falls in elderly people is a valuable tool for evaluating the performance of a fall detection system. The simulation allows designers and engineers to test the system under various conditions and refine the design to optimize its performance. By detecting falls in a timely manner, the system can help

reduce the risk of injury and improve the quality of life for elderly individuals and their caregivers. Future work is to explore the hardware using the atmega328 microcontroller, which is capable to continuously monitoring the fall detection using IoT with a prototype design. The prototype design allows the user to experience the device and provide feedback on its usability, functionality, and overall design. IoT technology integration enables remote monitoring of glucose levels by transmitting data to a cloud server for storage in a database. The prototype design enables the testing and verification of the device's performance and functionality in real-world conditions. User feedback on the device's design and usability can be incorporated into the final product design to improve its overall performance and user experience.

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