TPM Vol. 32, No. S3, 2025
ISSN: 1972-6325
https://www.tpmap.org/

Open Access

ELDERLY PEOPLE FALL DETECTION & ALARMING SYSTEM: A COMPARATIVE ANALYSIS AND SYSTEM OVERVIEW

HEENA MISHRA[1], C. GHANRAJ KUMAR[2], AYUSH KUMAR SHARMA[3], TUSHAR KUMAR[4]

[1,2,3,4]Department of Electrical & Electronics Engineering, Bhilai Institute of Technology, Durg, Chhattisgarh, 491001 India

Abstract: The prevalence of falls among elderly individuals poses significant challenges to healthcare systems worldwide, necessitating innovative solutions to enhance safety and prompt response. This paper focuses on the design and development of an Elderly People Fall Detection & Alarming System, aimed at detecting falls in bathroom environments and triggering timely alerts to caregivers or emergency responders. The system utilizes advanced sensing technology to detect falls, leveraging a combination of hardware components, including Arduino UNO and GSM/GPRS modules. Through integration with remote monitoring and notification systems, the system enables swift response to falls, thereby mitigating potential risks and improving overall safety for elderly individuals. The paper also explores future scope avenues, such as machine learning integration and wearable technology, to further enhance the system's capabilities and applicability in diverse settings.

Keywords: Elderly Fall Detection, Electrical Resistance / Skin Resistance, Arduino UNO, GSM/GPRS Alert System, Sensor Technology, Wireless Communication / SOS Notification

1 INTRODUCTION

At the heart of project resides a concept that merges simplicity with innovation: the utilization of the body's electrical resistance within bathroom environments to trigger a sophisticated fall detection and alert system. This ingenious approach capitalizes on the distinctive electrical signal generated when an individual interacts with the wiring infrastructure, serving as the genesis of system's response mechanism. Comprising an Arduino UNO board and a GSM module intricately intertwined, system swiftly processes this signal, initiating a cascade of actions aimed at ensuring swift assistance during emergencies. Through seamless communication with pre-programmed contacts stored within the SIM card, caregivers or emergency responders are promptly notified, while simultaneous activation of visual and auditory alerts ensures heightened situational awareness. The system's also design transcends conventional fall detection methodologies by embracing a proactive stance towards safety and security. By integrating visual cues such as indication lights and auditory signals like buzzers, we augment the effectiveness of our alerts, ensuring that individuals within proximity are promptly made aware of the unfolding emergency. This multi-sensory approach not only enhances response times but also empowers caregivers and emergency responders to intervene swiftly, potentially mitigating the severity of injuries. Through meticulous craftsmanship and a steadfast commitment to innovation, our project endeavors to redefine the standards of fall detection systems, offering a comprehensive solution that prioritizes prevention and intervention to safeguard the well-being of elderly individuals in their everyday lives.

Theory

The theory underlying our project revolves around the principle of utilizing the body's electrical resistance as a key component of fall detection and alert systems within bathroom environments. This is rooted in the understanding that when an individual makes contact with the wiring infrastructure, their body's electrical resistance combines with that of the wire, generating a distinct electrical signal. This signal, analogous to a digital fingerprint, serves as the trigger for our system's response mechanism.
Central to our theory is the integration of hardware components such as the Arduino UNO board and GSM module, which work in tandem to process and transmit the electrical signal to pre-programmed contacts stored within the SIM card. This seamless communication ensures swift notification of caregivers or emergency responders, facilitating rapid intervention during critical moments. Furthermore, this system encompasses the incorporation of visual and auditory alerts, including indication lights and buzzers, to enhance situational awareness and prompt response. By leveraging multi-sensory cues, system aims to maximize effectiveness in real-world scenarios, where every second is crucial. By harnessing the intrinsic conductivity of the human body, coupled with advanced hardware integration and sensory cues, project offers a comprehensive solution for fall detection and emergency response in bathroom environments, thereby enhancing safety and security for elderly individuals.

Working Principle

The project operates on a meticulously designed working principle that integrates hardware components and leverages the body's electrical resistance to detect falls and trigger timely alerts within bathroom environments. At the core of the system lies the utilization of the body's electrical conductivity when an individual comes into contact with the wiring infrastructure. This interaction results in the generation of a unique electrical signal, which serves as the pivotal trigger for system's response mechanism.

The working principle begins with the detection of this electrical signal by sensor network (low resistance Copper Wire infrastructure), which is strategically positioned within the bathroom environment. These intricately connected to the Arduino UNO board, are responsible for capturing variations in electrical resistance indicative of a fall event. Upon detection of the distinctive signal, the Arduino UNO board promptly initiates a series of predefined actions aimed at mitigating risks and summoning aid.

Simultaneously, the Arduino UNO board communicates with the GSM module, a critical component of our system responsible for transmitting distress signals to pre-programmed contacts stored within the SIM card. This seamless communication ensures that caregivers or emergency responders are promptly notified of the fall event, enabling swift intervention. The system incorporates visual and auditory alerts to enhance situational awareness and prompt response. Upon detection of a fall, the system activates an indication light and a buzzer, serving as tangible manifestations of urgency. These alerts not only alert individuals within proximity to the emergency but also provide crucial cues for caregivers or emergency responders.

In essence, the working principle of our project revolves around the seamless integration of hardware components, including sensors(low resistance Copper Wire), Arduino UNO board, and GSM module, to harness the body's electrical resistance and detect falls within bathroom environments. By leveraging this intrinsic conductivity and employing multi-sensory cues, our system ensures swift assistance during emergencies, thereby enhancing safety and security for elderly individuals.

Literature Setup

The development of fall detection systems has been extensively examined to elucidate prevailing trends, address challenges, and highlight advancements in the field. With the rapid evolution of smart sensors and analytical methodologies, periodic reassessment of this domain is imperative. This literature review focuses on seminal works spanning from 2014 to 2020, supplemented by earlier significant contributions, to offer a comprehensive synthesis of the landscape.

Chaudhuri et al. (2014) conducted a systematic review of fall detection devices across diverse age groups, shedding light on the prevalence of studies reliant on synthetic data. Their findings underscored the criticality of utilizing real data for ensuring reliable system performance.[1]

Zhang et al. (2015) directed their attention towards vision-based fall detection systems, categorizing them into various types, including RGB cameras, infrared cameras, and depth cameras. Notably, depth cameras, such as Microsoft Kinect, gained traction due to their cost-effectiveness and ease of installation.[2]

Cai et al. (2017) delved into benchmark datasets acquired by depth cameras like Microsoft Kinect, offering valuable insights for researchers seeking to evaluate novel methods or applications. They emphasized the significance of dataset characteristics tailored to specific applications.[3]

Chen et al. (2017a) underscored the importance of individual depth cameras and inertial sensors in vision- and non-vision-based fall detection systems, respectively. Their study highlighted the efficacy of sensor fusion techniques in bolstering system robustness.[4]

In a pioneering effort, Igual et al. (2013) identified emerging trends in leveraging smartphone-based sensors and machine learning for fall detection. Their work addressed pertinent challenges related to real-world deployment, usability, and privacy, advocating for the development of practical and non-intrusive systems.[5]

The inception of fall detection studies can be traced back to the 1990s, initially relying on accelerometers and shock sensors. Subsequent advancements witnessed the exploration of sensor fusion techniques, particularly the amalgamation of gyroscopes and accelerometers to enhance accuracy. Vision-based approaches, including surveillance and depth cameras, emerged as viable alternatives, offering superior detection capabilities. The introduction of Microsoft Kinect marked a pivotal shift towards depth cameras, revolutionizing fall detection research and catalyzing a transition from accelerometers to depth sensors.

In this project, we're engineering an innovative solution to address the pressing issue of fall detection among elderly individuals, specifically within bathroom environments. At the heart of this system is the utilization of low-resistance copper wire as sensors, strategically integrated to detect changes in human body skin resistance—a reliable indicator of a fall event. This principle, inspired by the rich body of literature on fall detection systems, offers a nuanced approach to enhancing safety and prompt response for vulnerable individuals. Upon detection of a fall, our system springs into action, swiftly transmitting distress signals via a GSM module to pre-programmed contacts. This seamless communication ensures that caregivers or emergency responders are promptly alerted, facilitating rapid intervention to mitigate potential risks.

Furthermore, system prioritizes user-centric design principles to ensure ease of installation and operation within bathroom environments. Recognizing the importance of accessibility, aim to develop a system that is not only effective but also affordable for individuals across various socio-economic backgrounds. This stands in contrast to previous systems that relied on high-end sensors and camera technology, rendering them prohibitively expensive for lower and lower-middle-income individuals, but this system uses low resistance copper wire to sense and collect data and send to the main kit (Arduino & GSM) make it more affordable for individuals across various socio-economic backgrounds. We're committed to conducting comprehensive testing and validation procedures to assess the reliability, accuracy, and effectiveness of the system in real-world scenarios. Through rigorous testing, aim to instill confidence in the system's ability to detect falls accurately and initiate prompt alerts when needed. Additionally, we're exploring avenues for future enhancement, such as integrating machine learning algorithms, to further refine system performance and adaptability. By marrying theoretical insights with practical implementation, system endeavors to redefine the standards of fall detection systems, offering a comprehensive solution that prioritizes prevention and intervention to safeguard the well-being of elderly individuals, regardless of their socio-economic status.

Experimental Setup

The experimental setup for system involves the integration of key components, namely the Arduino UNO Board and the GSM/GPRS Module Board, to realize the objectives of our fall detection and alarming system. The Arduino UNO plays a central role in collecting and converting digital signals, which are then transmitted to the GSM module board for further processing. To power the circuitry, a 12V DC Jack serves as the primary power source, ensuring parallel connectivity to both the Arduino UNO and the GSM/GPRS Board.Fig. 1 for a visual representation of Elderly People Fall Detection & Alarming System kit project.

The low-resistance copper wires are strategically positioned along bathroom walls to detect changes in electrical resistance, indicating a potential fall event. This setup was informed by a survey conducted on the electrical skin resistance of individuals across different age groups, in both dry and wet conditions. The data from this survey, stored in tabular form Table 1 & 2, guided the testing and formulation of our system to operate effectively and efficiently in real-world scenarios.For a clearer understanding of the observed trends, visual representations of the data are provided in Fig. 2 and 3. These bar graphs offer insights into the fluctuations in skin resistance across various age groups, highlighting the distinct patterns observed in both dry and wet conditions. By integrating both tabular and visual representations, this project aims to provide a comprehensive overview of the skin resistance variations among individuals of different age groups.

Upon detecting a fall, the system promptly transmits an SOS message to predefined contacts via the GSM/GPRS board. Simultaneously, visual and auditory alerts, including an indication light and a buzzer, are activated to enhance situational awareness and prompt response. This experimental setup showcases the practical implementation of our fall detection and alarming system, demonstrating its effectiveness in detecting falls and triggering timely alerts to ensure the safety and well – being of elderly individuals.

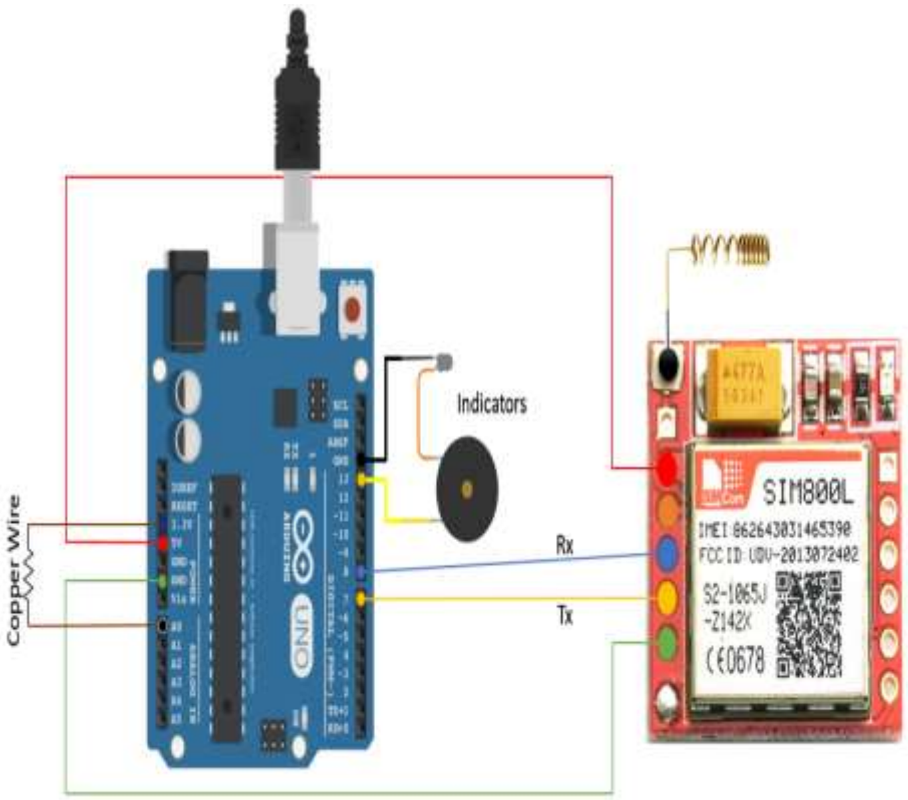

Fig. 1 – Elderly People Fall Detection & Alarming System kit

The evaluation of the fall detection system in this project entails testing its performance across varying voltage divider circuit configurations and corresponding threshold values, simulating real-world scenarios of human touch detection influenced by skin resistance. The critical threshold value, set by calibrating the potentiometer to its minimum (resulting in a resistance reading of 490 within the circuit), plays a key role in determining system sensitivity to tactile inputs. This systematic exploration underscores the importance of tailored sensitivity settings in optimizing the system's ability to detect and respond to potential fall events, ensuring enhanced user safety based on demographic-specific skin resistance profiles.

In Case 1, the system simulates its minimum sensitivity setting by adjusting the potentiometer to allow 0V through the wiring infrastructure. The threshold value is fixed at approximately 490, and the system promptly initiates its function when the detected voltage caused by a touch drops below this set threshold. This responsiveness highlights the system's immediate reaction to changes in voltage indicative of a tactile interaction with the sensor.

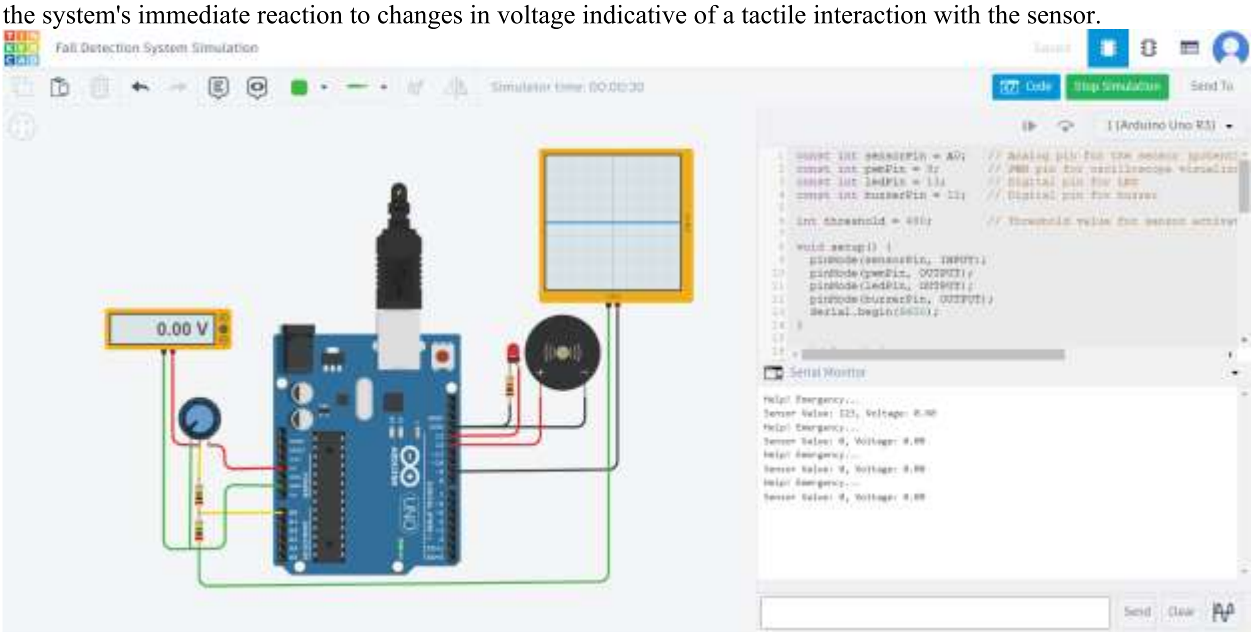

Fig.2 Setup for case 1

In Case 2, represents a scenario with a moderate sensitivity setting, corresponding to the potentiometer being set at 25%, passing approximately 1.25V through the circuit. Here, the threshold value is around 500, and upon touching the sensor, the system operates after a 10-second delay, reflecting a slightly delayed response due to the adjusted sensitivity level.

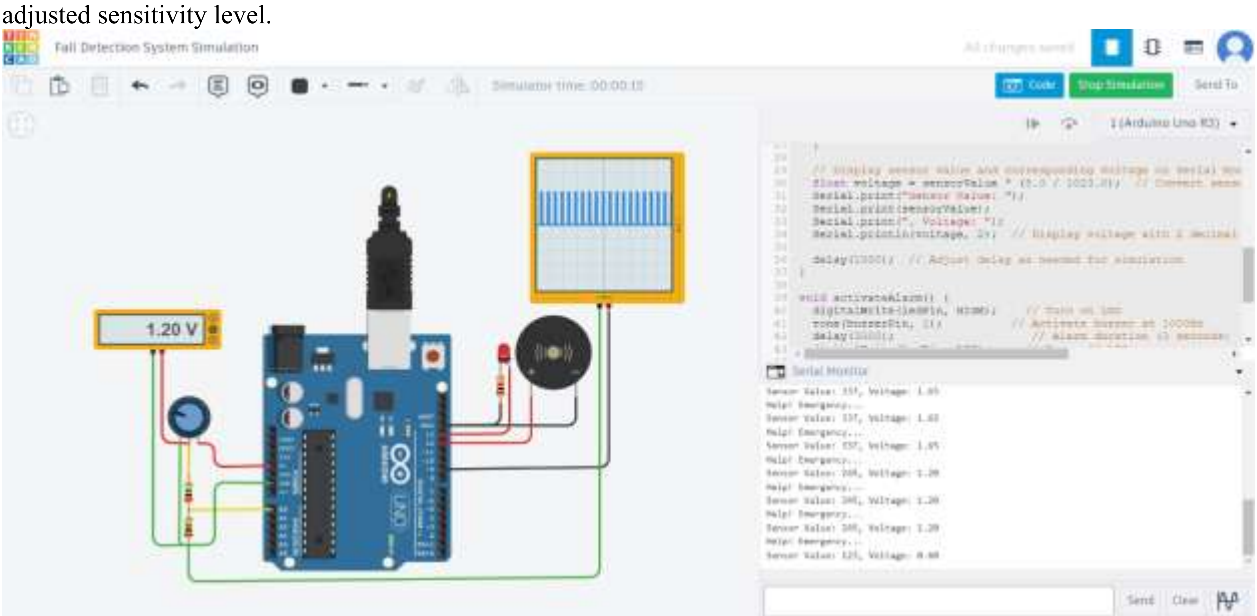

Fig.3 Setup for case 2

In Case 3, further increases the sensitivity level by setting the potentiometer at 50%, allowing around 2.40V to pass through the infrastructure. The threshold value is set at approximately 502, and the system initiates its function after a 15-second delay post-touch, demonstrating a response time commensurate with the adjusted sensitivity.In Case 3, further increases the sensitivity level by setting the potentiometer at 50%, allowing around 2.40V to pass through the infrastructure. The threshold value is set at approximately 502, and the system initiates its function after a 15-second delay post-touch, demonstrating a response time commensurate with the adjusted sensitivity.

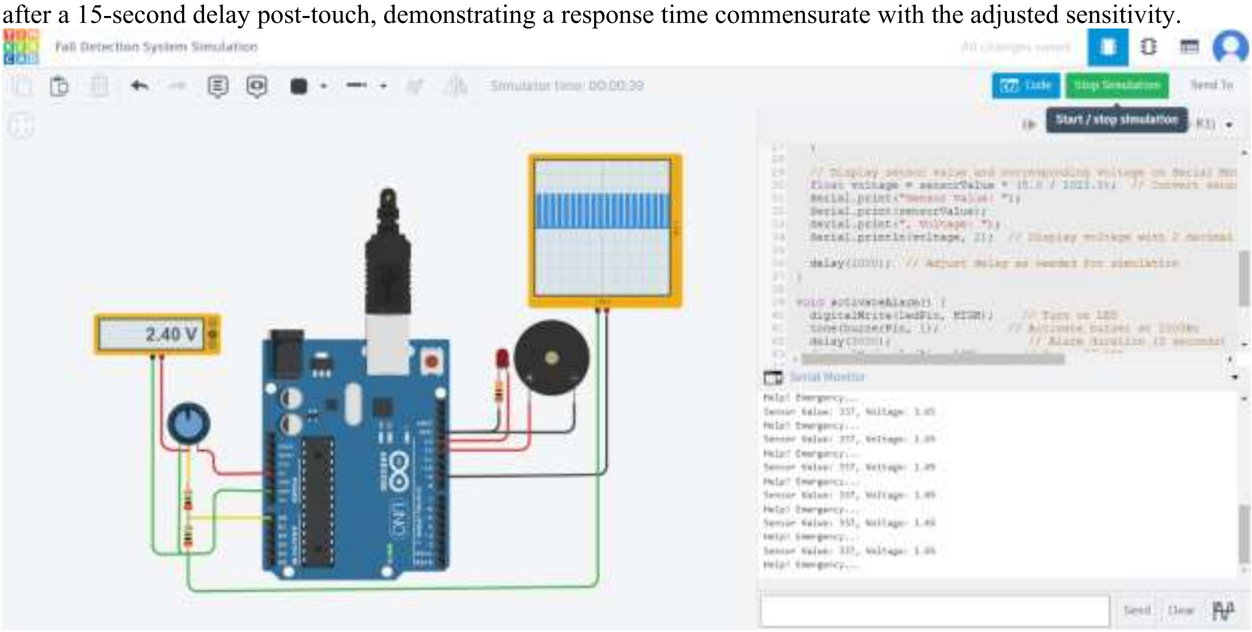

Fig.4 Setup for case 3

In Case 4, the system explores higher sensitivity by setting the potentiometer to 86%, allowing a voltage of 4V to pass through the circuit. The associated threshold value is adjusted to approximately 509. This adjustment means that when a hand touches the sensor and the detected voltage drops below 509, the system initiates its response after a delay of 20 seconds. This heightened sensitivity and delayed response time cater to scenarios where a more deliberate touch is required to trigger the system, accommodating specific user preferences or environmental conditions.

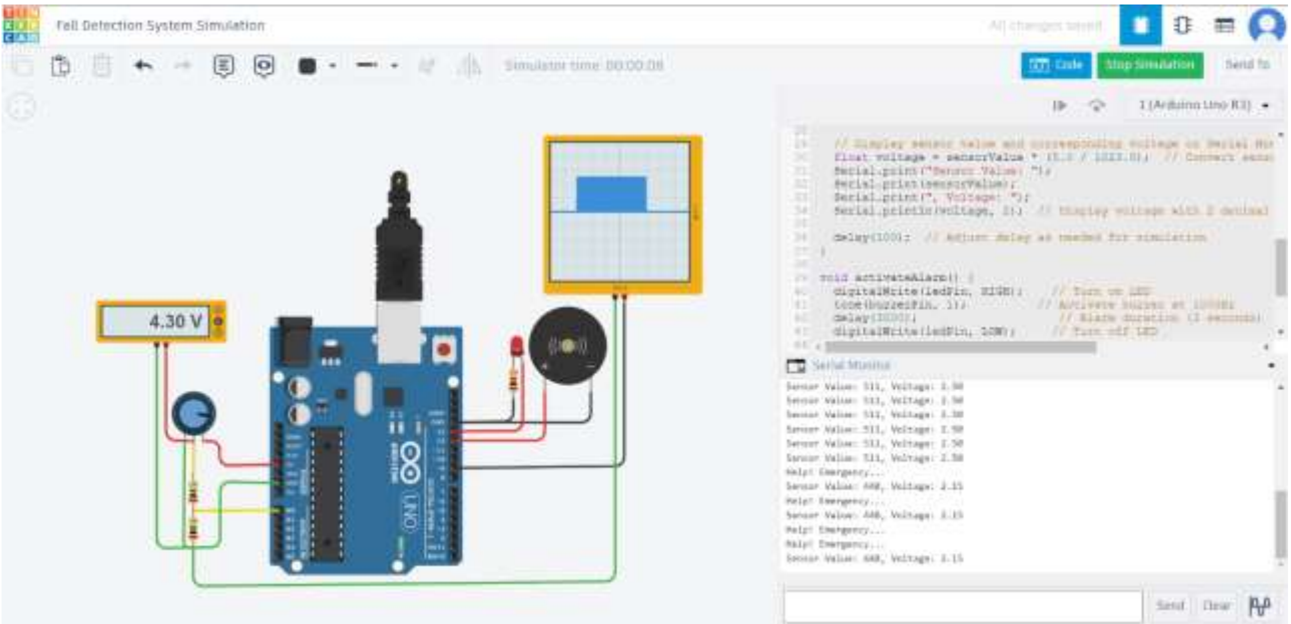

Fig.5 Setup for case 4

In Case 5, the system is configured at maximum sensitivity with the potentiometer set to 100%, allowing the full 5V supply to pass through the circuit. The threshold value is adjusted to approximately 512. Similar to Case 4, the system responds to sensor touch when the detected voltage falls below the threshold of 512, but with a consistent 20-second delay before activation. This extreme sensitivity setting ensures that even the slightest change in voltage due to a touch is detected, making the system highly responsive to subtle interactions while maintaining a brief delay to avoid false triggers.

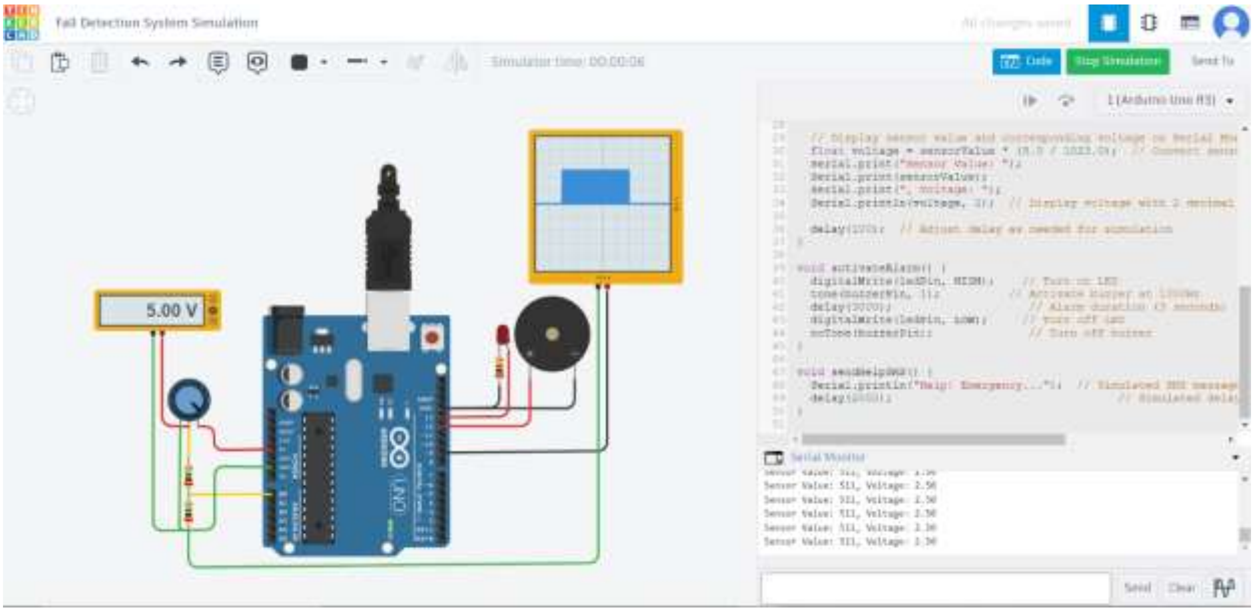

Fig.6 Setup for case 5

These test cases exemplify the system's adaptability to different levels of sensitivity based on the voltage passing through the wiring infrastructure. The set threshold values are influenced by average skin resistance typical for individuals aged between 20 to 35 years, ensuring that the system's response aligns with expected human touch behaviors under various conditions. The configurable nature of the potentiometer allows for fine-tuning the system's responsiveness to suit specific user requirements and environmental factors, facilitating optimal performance in fall detection and emergency response scenarios.

Result

The developed model of the Elderly People Fall Detection and Alarming System underwent rigorous testing to evaluate its functionality. The results of these tests are presented in Table No. 1& 2.

Table No. 1 –Human Body Skin Resistance in Dry Condition (MΩ)

Human Bode Skin Resistance (Dry Condition)						
Age Group	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60	60 - 70
Male	2.38	2.08	2.93	4.12	4.26	3.89
Female	0.57	3.65	4.99	5.20	4.22	4.17

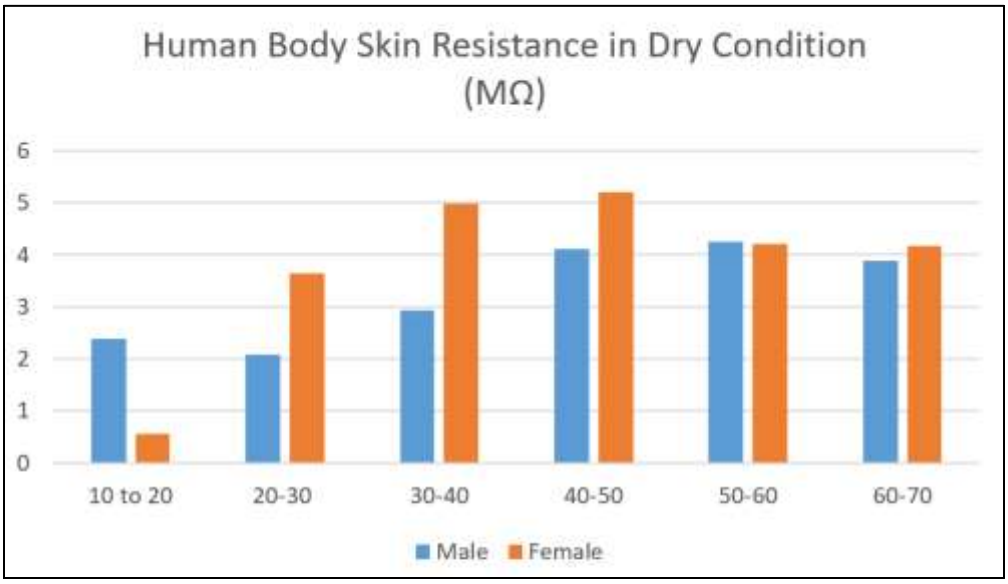

Fig. 7 – Human Body Skin Resistance in Dry Condition (MΩ)

Table No. 2 –Human Body Skin Resistance in Wet Condition (MΩ)

Human Bode Skin Resistance (Wet Condition)						
Age Group	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60	60 - 70
Male	3.75	0.61	0.73	1.09	1.44	1.47
Female	1.01	1.2	1.28	1.17	1.38	1.39

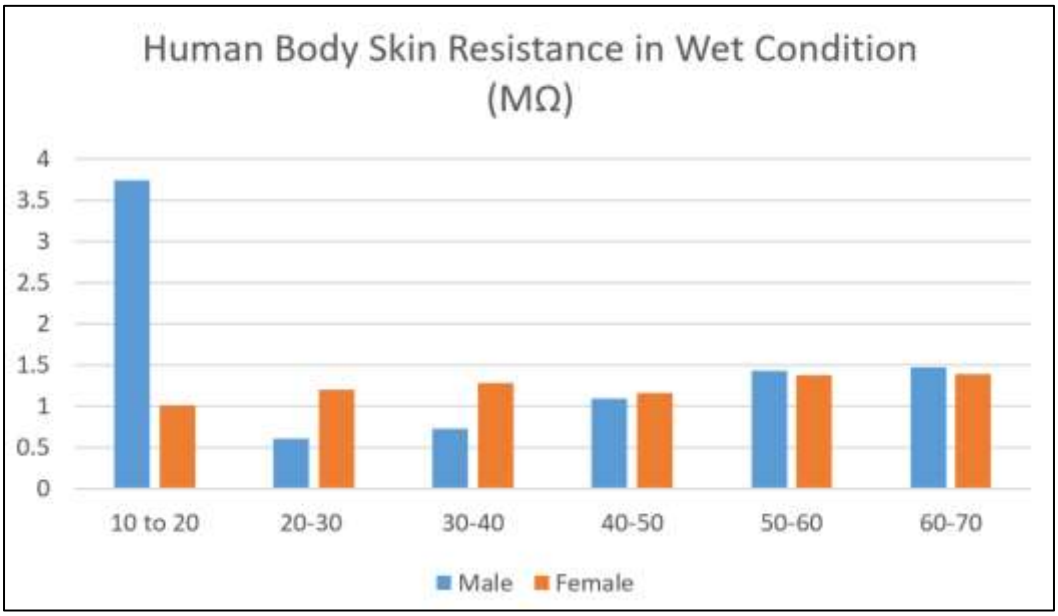

Fig. 8 – Human Body Skin Resistance in Wet Condition (MΩ)

CONCLUSION

In conclusion, the successful realization of the Elderly People Fall Detection & Alarming System marks the fulfillment of its core objectives. Through the intricate integration of software and hardware architecture, we've created a system capable of seamlessly detecting instances of falls within bathroom environments, thereby enhancing safety for vulnerable individuals. This system holds particular significance in urban settings, where the density of population and daily activities heighten the risk of accidents and emergencies. By swiftly detecting and responding to falls in washroom areas, our system plays a crucial role in safeguarding lives and mitigating the potential consequences of such incidents.

Looking ahead, there are promising avenues for further development and refinement. Future iterations of the system could benefit from advancements in sensor technology, to enhance accuracy and reliability. Integrating machine learning algorithms holds potential for refining fall detection capabilities, minimizing false alarms, and optimizing responsiveness. Additionally, the development of remote monitoring and notification systems, integration with smart home solutions, and exploration of wearable technology integration offer opportunities to further enhance safety, usability, and personalized care for elderly individuals. By embracing these future scopes, we can continue to innovate and improve upon our system, ensuring its continued relevance and effectiveness in addressing the evolving needs of elderly care.

REFERENCES

1. Karar E. Mohamed, Shehata I. Hazem, Omar Reyad, "A Survey of IoT – Based Fall Detection for Aiding Elderly Care: Sensors, Methods, Challenges and Future Trends", MDPI Open Access Journals, January 2022
2. Alamri A. Ansari W. S, Hassan M. and M., Hossain M. S., "A Survey on Snsor-Cloud: Architecture, Applications, and Approaches", International Journal of Distributed Sensor Networks, February 2013
3. Chen K. –H., Hsu Y. –W., Yang J. –J., and Jaw F. –S., "Enhanced characterization of an accelerometer-based fall detection algorithm using a repository", Instrument. Sci. Technol., October 2017
4. Bian Z. -P., Hou J., Chau L. –P., and Magnenat-Thalmann N., "Fall detection based on body parts tracking using a depth camera", IEEE J. Biomed. Health Inform., April 2014
5. Chaudhuri S., Thompson H., and Demiris G., "Fall detection devices and their use with older adults: a systematic

review", Journal of General Physical Therapy, December 2014
6. Amini A., Banitsas K., and Cosmas J., "A comparison between heuristics and machine learning techniques in fall detection using kinetic v2," in 2016 IEEE International Symposium on Medical Measurements and Applications (MeMeA) (Benevento: IEEE), May 2015
7. Auvinet E., Multon F., Saint-Arnaud A., Rousseau J., and Meunier J., "Fall Detection with multiple cameras: an occlusion-resistant method based on 3D silhouette vertical distribution," IEEE Trans. Inform. Technol. Biomed., October 2017
8. Chen K. –H., Hsu Y. –W., Yang J. –J., and Jaw F. –S., "Enhanced characterization of an accelerometer-based fall detection algorithm using a repository", Instrument. Sci. Technol., October 2013