

Empowering Safety: Innovations in Disability-Specific Safety Systems

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Abstract

In today's world, technology plays an important role in enhancing the quality of life, particularly for individuals with disabilities living in dormitories or private rooms. However, the lack of a good safety system has led to accidents, highlighting the need for inclusive and effective safety applications in the room. This project addresses the safety challenges faced by disabled students at Sultan Salahuddin Abd. Aziz Shah Polytechnic focusing on those with disabilities in their room. Traditional room design and the ideas behind standard safety systems do not take into consideration the requirements of these people. A quantitative study was conducted by distributing questionnaires to seven hearing impaired students. This project has also been tested on students to ensure accuracy and effectiveness. The project features a suite of safety devices, including a vibrating bed, an automatic door, a vibrating bracelet, and a smoke detector, all controlled by Arduino UNO and Arduino NANO. Additionally, an IoT system facilitates emergency alerts via telephone communication to wardens or lecturers within a 100-meter radius. The results demonstrate that this system significantly enhances safety and mitigates the risk of accidents for hearing impaired person, proving its potential for broader application in similar settings.

Keywords: - Emergency preparedness, safety information and innovation, IoT solutions

1. Introduction

Safety is one of the basic needs of every individual. Human beings continuously seek to live in a safe environment, a variable that propels them to achieve more. However, some people, such as the differently-abled persons, may find security difficult to attain due to physical, sensory, and cognitive considerations. In the recent public discourse, stakeholders have been developing useful security systems to cater specifically to the needs of the differently abled people. The existing safety systems are not tailored to accommodate the differently abled people since they are increasingly becoming vulnerable. The study by Stefanov et al. (2004), the smart houses should be designed according to the notion of human-centeredness and should possess a high level of intelligence in their control, actions, and interactions with the users, offering them a high level of comfort and functionality. However, traditional safety measures are inaccurate since they do not support the needs of people with mobility, sensory, or cognitive impairments. Additionally, the system should offer critical insights into the importance of using the right safety system.

The advancements have been motivated by an unwavering commitment to accessibility & inclusion & will enable disabled members of society to easily realise their full safety. A study was conducted by Aziz et al. (2017), where these systems are mainly designed to assist people with disabilities and the elderly at home. Mainly used Wi-Fi technology as a connection between smartphone and a controller board. Microcontroller are used to control door lock

that is equipped with camera that can identify visitors. Servo motors are connected to Raspberry Pi controller board to make sure it can be controlled by Wi-Fi through smartphone. This project looks into the most recent developments in disability-oriented safety technologies, observing how new assistive tech and adaptive designs are changing safety practices for these individuals. These foster not just better quality of life for people with disabilities through greater independence, confidence, and emergency readiness, but also contribute more to a more inclusive and equitable society. This brings us to the context of this study, which explores assistive technology integration with user-driven customization for creating fully safe designs to suit the context they are being designed for, i.e., ensuring accessibility with a focus on user-centered safety for disabled users.

Where, a technology was developed by Yang et al. (2022), mobile terminal APP, the system effectively controls the dormitory lights, gate, water pump, curtain, fan and other equipment. While technology and design has brought us a long way, people with disabilities are still in danger inside. However, the needs of individuals with dementia are not typically put into consideration in conventional room designs and the standard safety systems; consequently, the risk of accidents, primarily of falls, and reduction of independence are exacerbated. Although different assistive technologies and adaptive design have been available, a great lack of holistic integration and user-centered customization has limited their efficiency and usability.

The issue is two-fold, safety systems and room design overlook many different disabilities, and thus an all-inclusive, universally safe/accessible surrounding is not created, and two ideological mentalities stand against one another. Second, there is a lack of data on how well these systems prevent crashes and how they improve the lives of people with disabilities. A study was conducted by Kim et al. (2017) involved a vibration alarm and SOS alert features were designed and implemented for the safety of the hearing impaired.

The technologies issues may be solved through a combination of new technologies integrated into smart homes, user-driven design approaches, and information-based decision-making. Safer, more inclusive living spaces that enable greater independence and better quality of life can be realized by designing and deploying innovative, holistic safety systems that are customized to the unique safety requirements of persons with disabilities.

The main purpose of this study is to create a solution to provide people with timely emergency alert, to awake disabled people and notify their caregivers as soon as possible. Many mutual and deaf people need to receive information about the emergency situation that cannot be known and to exit the emergency area as efficiently as possible. The last thing is proactive solutions to minimizing risks and ensuring the safety of all disabled people. Emergency Alert solution is an innovative and technological system allowing to notify the surrounding people automatically about the possible urgent situation. A good system for everyday terms is a system that offers better security for the disabled person.

Another solution which is very rapid and useful also a system but is device used by disabled people to help them perform everyday tasks. The installation and use of application are very flexible. Moreover, it can be used in various environments and conditions when people want. While a technology can communicate the presence of an emergency vehicle near a person with hearing loss by using alternative sensory channels (e.g., visual or tactile stimuli). This enables individuals to drive confidently and safely to get what they need and do what they want to do with independence, safety, and autonomy, which in turn would increase social participation (Bubar et al., 2023). At the same time, this solution should be used in various situation and places.

Another proactive solution in this study to reduce emergency accident includes the plan to prevent them from lack of security system designed that can cause incidents to disabled people. The course of action needs to develop more kinds of preventive measures and technologies help in reducing the number of injured and killed disabled people because of the incidents. Therefore, this project promises a system that allows disabled people to save themselves by using some safety devices in their rooms, such as

lighting system, watch and bed vibrator combining with IoT system.

An IoT technology, we can automatize data collection and it will be less manually intensive (Islam et al., 2015). Technological advances such as vibrating beds/bracelets are tactile alerts that can benefit not only sufferers of hearing loss but also people who have trouble responding quickly to sound cues. Another research focuses on visual disabilities and people with motor disabilities. This safety system is based on smartphones. The technological design was based on the development of a web server using an Arduino connect smartphone to the server, to send control signals for power up the household appliances UNO and a Wi-Fi shield. For further research of an advanced technology altered in the manner through a usage of vibrating beds and bracelets. Research also describes carried out an automatic door with customised smoke and fire alarm detectors to help various categories for disabled people lead lives in safety, comfort and self-reliance.

2. Methodology

This study relies on a quantitative method approach, as a research technique to conduct a whole evaluation of the efficacy of safety systems for disabled persons. This will be enabled by developed of Arduino UNO, Arduino NANO and IoT technologies in the research design, which will allow for real-time data collection and analysis.

For data collection from users, seven disabled student the participants of from Sultan Salahuddin Abd. Aziz Shah Polytechnic were selected using purposive sampling to ensure that they are a representative sample of the disabled individuals (hearing problem only). The data for this study will be collected by verifying structured surveys by administering questionnaires to the participants, which will involve assessing the baseline of the current practices and challenges of the participant.

2.1 Product Design and System

To meet the special needs of disabled persons, the safety system, including components such as a vibrating bed, automatic door, vibrating bracelet, and smoke detector was designed as an important tool in developing effective safety systems. for people with disabilities. Bringing the end users into the process of design ensures that solutions are tailored to their needs and tastes, so they'll be more likely to adopt them and get better results. The need of this safety systems that not only work, and work well, but are easy to be used by someone with sensitivity or grace. This paper adds to these works by providing a knowledge base on how to conduct user-centered design for the safety system.

This is very important in relation to the implementation of assistive technologies in this project, especially for disabled students. Studies in a

dorm setting have proven that vibrating beds, automatic doors, and even vibrating bracelets can greatly increase the safety of students with disabilities in their rooms when using monitoring technology. These tools are vital for guidance during emergencies and guarantee that students can act swiftly and appropriately, which resulted in improvements in safety and satisfaction among disabled students by installation of automatic doors and tactile alert systems in a Polytechnic dormitory.

2.2 Hardware and Software Component

The important of the system design is by creating a detailed designs and schematics that include the full range of hardware and software solutions. The materials are prepared, tools and hardware in the list, including the smoke detector MQ. 2, Arduino UNO and NANO and a DC motor (Fig. 2). The development of prototype also developed in order to test the system working properly and effectively. Fig. 1 shows the actual system of security control and IOT system for hearing impaired students who are in the dormitory room.

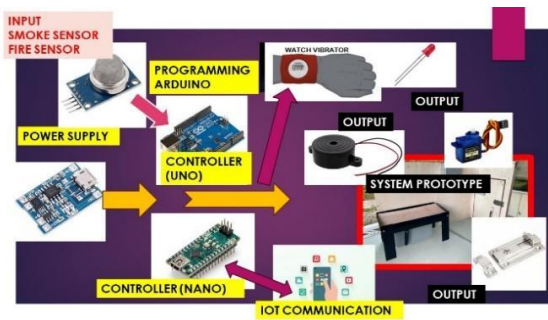


Fig. 1. The system of the project

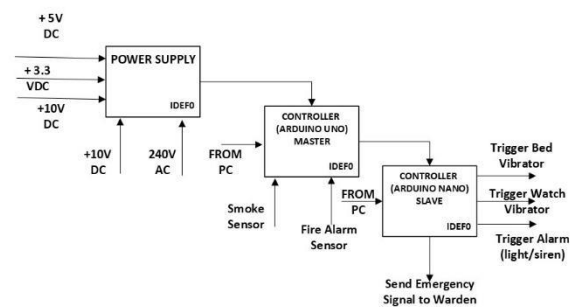


Fig. 2. The IDEF0 diagram for integrated system

2.3 Internet of Things (IoT)

The intention with this new methodology is to integrate the Internet of Things (IoT) with existing techniques in a study to purposefully collect and monitor the required data and derive automation. This Methodology section provides a structured description of the research design, participant selection, methods

of data collection, procedures of analysis, ethical considerations and any associated limitations.

An IoT communication systems will be connected for disabled students' rooms to interact information to lecturers. It is also including a bed vibrator, a bracelet vibrator, a smoke detector with emergency light, and an automatic door. The devices connect by Wi-Fi. When the smoke detector detects smoke, it sends signals for all the devices to be activated.

2.4 Full Project Integrated System

This created safety gadget system (Fig. 1) for people who have a hearing Disability, and Mute individual have a set of 4 primary system components:

- i. **Bed Shaker:** Under the mattress; shakes the bed awake in times of emergencies, for use with the elderly, heavy sleepers, including hearing impaired.
- ii. **Wearable** - A bracelet vibrator notifies the wearer in case of an emergency. Particularly valuable for those on the go and who may not be in bed.
- iii. **Sensor Smoke Detector**, merged with Emergency Light: The Dual-function device which detects smoke and lights up a powerful emergency light to as a visible alert for the user. Important for those who can't hear traditional smoke alarms.
- iv. **Automatic Door:** This involves that the doors are initially unlocked and allowed to be opened by any automated door mechanism in response to an emergency, providing a clear and safe passageway for the occupants in the buildings, especially people with reduced mobility or require emergency exit with the shortest path.

These devices are connected through a Wi-Fi protocol. Its multiple alarm mode projects a wireless Wi-Fi network to which each of the additional detectors connects in wake-up mode, and the primary unit alerts them all when smoke is sensed. They vibrate and light up, so they trust these devices in times of fear and in emergency scenarios, and this co-ordinate response ensures multiple channels of alert to warn the users and hence fasten the response time to any type of emergency user is going through. It also connects to the guard or warden to inform if there are emergency cases via Wi-Fi and hand phone. This project offers several benefits, including:

- i. **Effective Alert System:** The system uses vibration and visual triggers to ensure different disability type users receive emergency alerts.
- ii. **Integration and Automation:** Wi-Fi enables devices to communicate seamlessly with one another for a quick and coordinated response to alerts.
- iii. **Improved Safekeeping:** With the installation of an automatic door, you increase the accessibility of the building, which limits the time it takes for users to evacuate in case of an emergency.

3. Result and Discussion

This section describes the data collected, and the analysis subsequently undertaken, to answer the research questions. The data were then analysed with a simple table. The process of data analysis of the study is shown in Fig. 3(a-c). To measure the improvement and customer satisfaction, seven (7) disability students' class from the Mechanical Engineering Department were distribute a questionnaire to implement this safety system.

Through Surveys: Given to students who are in hearing impaired problem to collect quantitative information on the effectiveness of function and usability under this development. It is meant to establish or affirm the truth, verify previous work, and solve present or future problems. Our analyses of this data supplied by those test students conform to the results of our investigation.

In Table 1 to Table 3 show that all students who scored 4 and 5 agree that the system is beneficial to them. Further, the Feedback in Table 1 has an average score of 4.57, Table 2 has an average score of 4.71, while Table 3 with an average of 3.71. These results indicate that the question in Table 3 is less effective and should be combined with the question in Table 2 for improvement and effectiveness. Therefore, by combining several devices such as, a watch vibrator, bed vibrator, light alarm and IoT can create a more effective and efficient system.

Table 1. The questions asked to the students

Respondent	Question	Result	Comment
	Ask	Range 1 - 5	
Student 1	Is the safety system able to wake you up during emergency	5	Good system
Student 2		4	Help me a lot
Student 3		5	Good
Student 4		4	Can improve
Student 5		4	Can implement
Student 6		5	Good project
Student 7		5	Real Implement
		<i>1- Very Bad, 2- Bad, 3- Fair, 4- Good, 5- Excellence</i>	

Table 2. The questions asked to the students

Respondent	Question	Result	Comment
	Ask	Range 1 - 5	
Student 1	Did you feel the vibration of the watch vibrator & bed vibrator	5	Good system
Student 2		5	Help me a lot
Student 3		5	Good
Student 4		4	Can improve
Student 5		4	Can implement
Student 6		5	Good project
Student 7		5	Real Implement
		<i>1- Very Bad, 2- Bad, 3- Fair, 4- Good, 5- Excellence</i>	

Table 3. The questions asked to the students

Respondent	Question	Result	Comment
	Ask	Range 1 - 5	
Student 1	This light alarm system helps me out from room	4	Good system
Student 2		4	Help me a lot
Student 3		4	Good
Student 4		4	Can improve
Student 5		3	Can implement
Student 6		3	Good project
Student 7		4	Real Implement
		<i>1- Very Bad, 2- Bad, 3- Fair, 4- Good, 5- Excellence</i>	

While Table 2 shows the data collected on 7 students with hearing disabilities using watch vibrator device. The wake-up times were recorded three times, and the data shown is the average of these three trials. The data shown is an average of 3 times. The wake-up times, which range from 5 to 10 seconds, and it is clearly shows that the device used is effectively and they can survive from fire accidents.

Furthermore, the data collected for the light equipment used to wake-up students (Table 3). The recorded wake-up times in range of 15 to 30 seconds, indicating that, this device system less effective compared to watch vibrator. Therefore, by combining both devices will gain a good result and a more effective system.

Table 2. Data analysis on wake-up time (watch vibrator)

Respondent	Type of Device Used	Time Taken to Wake-Up (second)	Signal (IoT) Signal Sent to Warden
Student 1	Watch Vibrator	5	Received
Student 2	Watch Vibrator	7	Received
Student 3	Watch Vibrator	6	Received
Student 4	Watch Vibrator	10	Received
Student 5	Watch Vibrator	9	Received
Student 6	Watch Vibrator	6	Received
Student 7	Watch Vibrator	7	Received

Table 3. Data analysis on wake-up time (light alarm)

Respondent	Type of Device Used	Time Taken to Wake-Up (second)	Signal (IoT) Signal Sent to Warden
Student 1	Light Alarm	15	Received
Student 2	Light Alarm	18	Received
Student 3	Light Alarm	20	Received
Student 4	Light Alarm	17	Received
Student 5	Light Alarm	25	Received
Student 6	Light Alarm	30	Received
Student 7	Light Alarm	17	Received

4. Conclusion

This project aims to achieve its objectives of the research by developing a prototype safety specifically designed for disabled students. The prototype has been successfully developed as planned and is functioning effectively. It meets its objectives by aiding disabled individuals during emergencies. This prototype gets to give a clear view on how the system supposed to works on disabled person especially stay in their room.

Hopefully, in future the number involved in accidents can be reduce among disabled persons. Based on the whole process of discussion and product creation, this innovation project can be used as an example as a solution in the future. Furthermore, the results of this project are very promising and can be marketed commercially.

The improvements to product designs should be implemented as soon as testing begins to compare the data collected during the proceeding test. This should be done to analyse the data that has been acquired and to assess how successful the product is after adjustment.

As a recommendation and suggestions for improvement, several things should be considered such as:

- i. Use ESP32 as motherboard to our system as it is much easier to conduct.

- ii. Use the correct programming for the system to make sure it's working according to the circuit flow.
- iii. Use more components to make it able to use as many systems as possible and not only for disabled person, even for old persons that have problems with their hearing.

It is better to have a good knowledge on related technology such as IoT and hardware technology.

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References

- Aziz, A., Abd Wahab, M. H., Mustapha, A., & Mohsin, M. F. M. (2017). Design and development of smart home security system for disabled and elderly people. *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, 9(3-7), 135-138.
- Bubar, A., Eckstein, B., Ell, A., Hilt, E., Martin, S., Powell, T., ... & Rios Rincon, A. (2023). Emergency siren detection technology and hearing impairment: a systematized literature review. *Disability and Rehabilitation: Assistive Technology*, 18(3), 295-303. <https://doi.org/10.1080/17483107.2020.1849430>.
- Islam, S. R., Kwak, D., Kabir, M. H., Hossain, M., & Kwak, K. S. (2015). The internet of things for health care: a comprehensive survey. *IEEE access*, 3, 678-708. <https://doi.org/10.1109/ACCESS.2015.2437951>.
- Kim, C., Kim, D., Lee, H., Park, H., Kwon, G., Park, E., & Lim, H. (2017). Design and implementation of application for the hearing impaired people. In *MATEC Web of Conferences* (Vol. 125, p. 04007). EDP Sciences.
- Stefanov, D. H., Bien, Z., & Bang, W. C. (2004). The smart house for older persons and persons with physical disabilities: structure, technology arrangements, and perspectives. *IEEE transactions on neural systems and rehabilitation engineering*, 12(2), 228-250. <https://doi.org/10.1109/TNSRE.2004.828423>.
- Yang, Y., Lin, L., & Lin, Y. (2021, October). The Design of Campus Dormitory Intelligent Control System Based on Cloud Platform. In *Proceedings*

*of the 2021 5th International Conference on
Electronic Information Technology and Computer*

Engineering (pp. 1682-1686).
<https://doi.org/10.1145/3501409.3501546>.