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An IoT based Automated Door Accessing System for Visually Impaired People

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***Abstract*— Nowadays IoT plays an integral role to ease the lives of general people and visually impaired people are not an exception. Amongst the many, automated door management system is a primary concern to enhance the home security. Though there is a number of research conducted on automated door access system, a very few of them focuses on integrating all the required features to assist visually impaired people. Therefore, the objective of this research is to develop an automated door accessing system for visually impaired people. In order to attain the objective, this research *firstly* proposed a conceptual framework to develop an automated door access system. *Secondly*, a prototype for the proposed system was developed integrating features like visitor authentication using face recognition, voice command, suspicious activity detection using audio alert and recognize harmful objects visitors may carry using object and metal detection. *Finally*, a light-weighted evaluation study was conducted in a laboratory environment to assess the functional accuracy (effectiveness) of the proposed system. This paper also highlighted the practical and future implications of the proposed system.**

***Keywords*—IoT, automated door access, face recognition, assistive tool, visually impaired.**

I. Introduction

A report by World Health Organization(WHO) and International Agency for Prevention of Blindness (IAPB) stated that there are approximately 285 million people around the world who are visually impaired. Visually impaired people faces limitations to carry out movements and their daily activities without assistance. Moreover, almost 90% of them have to depend on others to ensure their safety. Thus special considerations are required to make the systems utilizable for them.

A significant number of research and development has been carried out focusing on ICT and visually impaired people that assist them with their movements [1], entertainment [2], recognizing images [3] and the like. A very few systems have been developed for easier and greater security door access control in their homes, though a cost effective and reliable security system is important for visually impaired people to control the access of their door [4]. Automated door accessing system mostly considers the audio alert features, use of authentication with security cards, pattern or password to open and close the door automatically. These features are primarily focused on general users or aged people. Thus, considering the limitations of visually impaired people still more features are required such as object detection to determine presence of weapons with visitors, voice command control, metal detection for enhancing security and the like.

Therefore, the objective of this research is to design and develop a prototype model based on IoT that includes the revealed features for automated door accessing system to aid and assist visually impaired people. In order to attain the objective, the existing literature has been reviewed to understand the required features that should be included for developing such a system for visually impaired people and developed a prototypical system based on IoT that includes the required features.

The remaining sections of this article are organized as follows: Section II presents the related works in this field along with their limitations. Section III discusses the conceptual framework for the proposed system. Details of development and implementation of the prototype has been presented in section IV. The results of the light weighted evaluation of the developed prototype is given in section V. Section VI concludes the research.

II. Related Works

This section briefly discusses the works related to the development of automated door access system focusing to the general users as well as the visually impaired users.

A limited number of systems exist that deals with automated face recognition system for door access control. Yugashini et al. [5] proposes a system that carries out face detection on the outsider and runs facial recognition. The door automatically opens if the face matches with database image, otherwise an SMS is sent to alert the user. A sensor based home automation and door access control system with an interface to monitor the system using internet is proposed in [6]. It supports automatic door lock and unlock from a remote location via internet and any security breach is notified by sending the user an email. Ibrahim and Zin [7] conducts a study for accessing door lock system using facial recognition in an office environment, giving focus on making the face recognition mechanism as accurate as possible for better security purpose. Zuo and With [8] proposed a cost-effective system for controlling door access at natural user environment. Hwang and Baek [9] proposes a door lock system that can be controlled by a pass code and the door can be locked and unlocked from a remote location using the internet. However, none of these systems

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explicitly focuses on visually impaired people. Since, these existing systems lack audio alert feature, rather implements SMS alert, email alert or display alert. These systems also missed to detect potential threats (such as visitor carrying unsafe objects) or force entry into the room.

Again, an emergency system is developed in [10] to warn users during adverse conditions to enhance home security. Few other home automation systems allow control of the home appliances from home or anywhere around the globe [11]–[13]. Home automation systems exist that often integrates smart voice recognition [14] to ease the control of home appliances by aged and disabled people.

The literature review showed that a limited number of studies were conducted focusing on smart home automation and assistive systems for visually impaired users, while a few research related to the automated door access systems were conducted with an explicit focus on the visually impaired people. The existing literature also highlighted some key features that are required for visually impaired people such as face recognition and voice command control. Though, the existing systems have their merits and demerits of their own, but these systems did not consider all the required featured that are needed for visually impaired users. Thus, this research is focused on developing an automated door access system integrating all the required features considering the limitations of visually impaired users.

III. Conceptual Framework

A conceptual framework is proposed for developing an automated door accessing system for the visually impaired people. The proposed conceptual framework is depicted in Figure 1. This proposed system will be attached to the door to detect visitors through face recognition and inform users whether the guest is known or unknown while users can open the door automatically by voice command using a desktop application. This device will detect any kind of suspicious activities such as a person roaming around in front of the door for a long time and it will also generate an audio alert in any kind of dangerous situation.

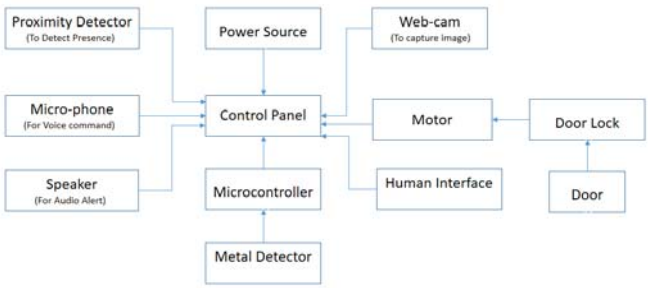

Fig. 1: Conceptual framework of the proposed system

This system will include the following features to enhance the safety, security and privacy of the visually impaired people.

(i) *Recognizing human presence* - System will identify the presence of any human, if he/she arrives in front of the door.
(ii) *Face detection* - The system will capture the visitor's face and then send the image of the visitor to the system database to carry out facial recognition.
(iii) *Object detection* - Object detection will be conducted on the captured picture to identify whether the person is carrying any dangerous weapon.
(iv) *Automated door control through voice command* - If the visitor is a known person (face matches with database), then an audio speech will be generated by the sound system to inform the owner about the person outside and the system will ask for permission from the owner whether or not to open the door. The owner can grant permission to open the door through voice command using a microphone and the door will automatically open.
(v) *Audio alert* - If the visitor is an unknown person an audio alert will be generated with a warning that the person outside is unknown.
(vi) *SMS system for help* - If any intruder wants to break in, an automated message will be sent to the relatives of the user.

For the software part of the prototype, a desktop system will be developed to provide control of the entire system.

IV. System Development

A prototype system was developed grounded on the proposed conceptual framework that combines a hardware part and a desktop application for automatically controlling the door by voice command. The components required for the hardware implementation are Raspberry pi, Arduino, Sonar sensor, Webcam, Speaker etc and the software part was programmed by python and OpenCv. Figure 2 shows how the proposed system performs to access the door automatically by the visually impaired people.

Raspberry Pi 3 B+ is used as main processing unit. Three ultrasonic sensors are used for the purpose of detecting person outside the door, door's position and triggers; echo of ultrasonic sensors are connected to GPIO pin of Raspberry Pi 3 B+ along with three 1K resistors. Arduino Uno 3 B+ is used for metal detection. It activates after getting signal from the raspberry pi.

Outside the door a sonar is placed which keeps running at all times so that, if a person comes within a certain range outside the door it can detect the presence. To further enhance the level of security measurement for emergencies. If someone tries to break in through the door, the system will send a text message to the nearest security authority for the users' home, alerting that someone is trying to break into the house and the user needs help. Speaker is used to give voice alert which is connected to raspberry pi USB port. After presence detection the camera will turn on, it captures the photo of the person standing in front of the door and is then turned off. Webcam is used to detect face. The

face portion is cropped out of it to match it with the images that is saved in the database. The output on whether person outside is known or an unknown is then generated as sound format considering the visually impaired people. If the person is carrying any metal object with him/her the system uses a metal detector circuit that is built with Arduino to detect risky metal instruments. From the photo that was captured previously, the system tries to detect harmful objects that may be carried by the person outside the door.

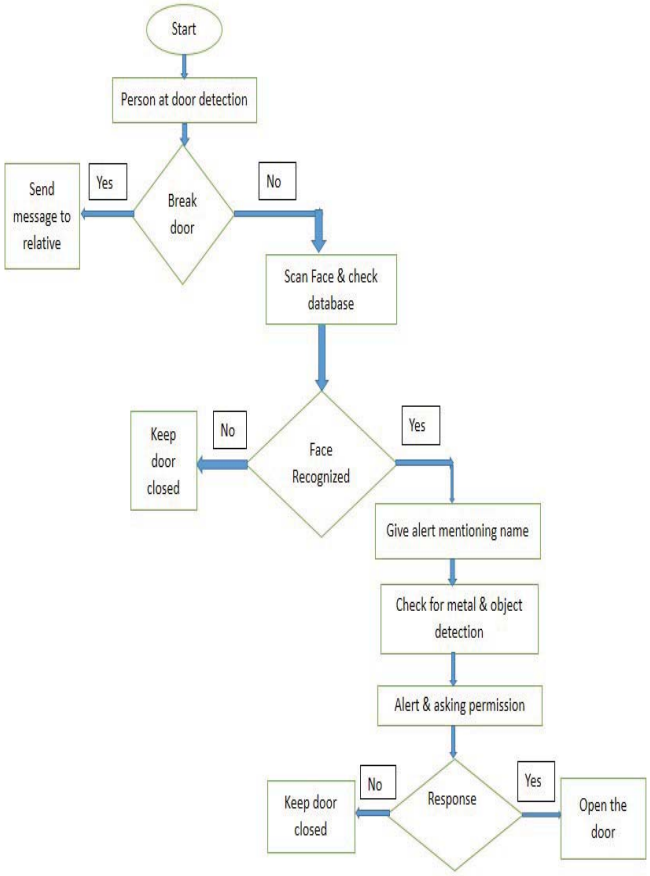

Fig. 2: Work flow of the proposed system

If it is a known person standing outside then after object detection the system asks the user if she/he wants to open the door. On the other side, if it is an unknown person, the system still asks for the permission because some person who are known to the user residing in the house may not be known to the system. So he can still enter the house upon the users' permission. After the system asks for user's permission, it waits 30 seconds for the user's decision. Sound Card is used to take voice permission as input. If the user is unable to give decision in that time, the system asks for permission again and this goes around till the user gives one of the decisions. If the user denies permission, the system returns to the presence detection phase. When the user grants permission, the door lock is opened using a motor and the outsider is allowed to come inside through the door and then the door will close automatically. DC 12V Solenoid Electric Door Lock is used as lock of the door, operated by a 12V battery and 1 channel 5V relay module. Relay module is connected to the raspberry pi. When raspberry sends a signal the door is unlocked. After the door is closed the system goes back to the presence detection phase and the next steps keep getting executed as mentioned.

The software interface developed for this proposed system is shown in Figure 3. The application needs to be installed and faces of the known people has to be listed in database. This is a dynamic process. Anytime the list can be edited from the settings option. By tapping the 'Start' button, the system will run according to the coded instructions. Haar Cascade is a classifier that is used for detecting human face. When webcam captures an image this classifier detects if there is a human face in it or not. OpenCV and Tensorflow are used together for detecting an object. Google speech recognizer is used for speech recognition. Pyaudio is used for sound output. For better understanding of the system, clients can learn how to use the software by tapping the 'Tutorial' button. Terms, conditions and policies are provided in the 'About Us' section.

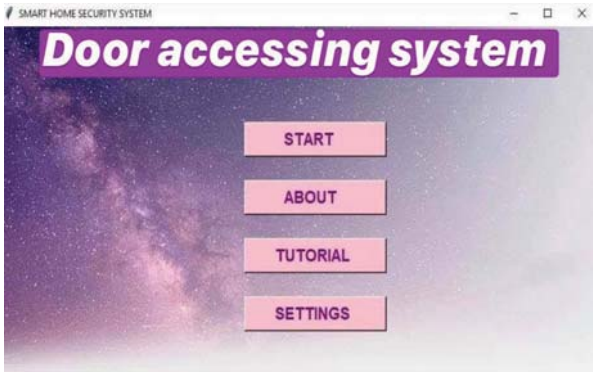

Fig. 3: Homepage of the proposed system

The prototypical version of the proposed system is showed in Figure 4.

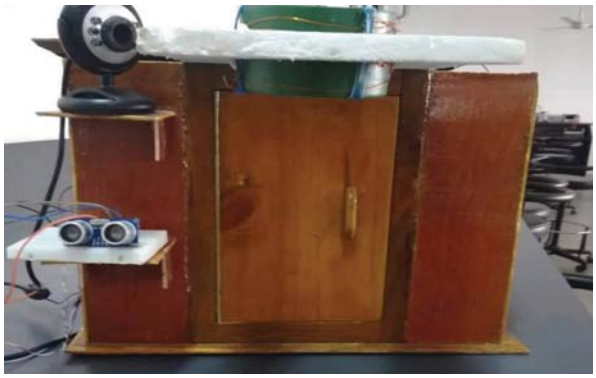

Fig. 4: Prototype of the proposed system

V. EVALUATING THE PROTOTYPE

The prototypical system was evaluated at the software engineering lab at authors' institute. For evaluating the system each of the features of this application were tested individually and the result of the test is summarized in Table I. The system was evaluated with five participants including three faculty members and two final year students. At the beginning of the evaluation, a brief about the objective of this evaluation was given and demonstrated the system for three to five minutes. They were asked to perform each task as stated in Table I. During the task completion by the participant, the data of how many trials were required till successful performance was recorded along with the observations attained from failed attempts.

The result showed that maximum number of participants completed the maximum number of features within the first trial. As for example, object detection task was completed by 80% within their first trial. However, according to the mean value, face detection had more failures because of low light intensity and standing position of the participant in front of the door. Again, face detection works comparatively better than other features, though sometimes it fails due to lack of proper light.

TABLE I: Evaluation Table

Features	**Mean and SD of the no of trails**	**Observation**
Recognizing Human Presence	1±0	Sonar sensor can successfully detect human presence in every attempt.
Face Detection	1.4±0.49	Failure at detecting facial structure properly due to low light intensity or person not standing in right position in front of the webcam.
Object Detection	1.2±0.40	Due to low light intensity the image captured for object detection lacked proper resolution which caused error.
Automated Door control through voice command	1.2±0.40	Because of outside noise sometimes speaker failed to receive voice command which caused error.
Audio Alert	1.4±0.49	An error occurred when system failed to recognize the person.
SMS System for help	1.2±0.40	An error was faced first time for invalid phone number.

VI. DISCUSSION AND CONCLUSIONS

This system includes features like recognizing human presence, face detection, object detection, automated door control through voice command, audio alert and sending SMS system. The result of the evaluation study showed that the functionalities of the proposed system performs well and more work are required to reduce the detection delay and the problem associated with the light intensity. This research has some limitations that needs to be addressed, such as the system needs to be installed by taking assistance from another person before being used by a visually impaired user. Moreover, the prototype of the proposed system was implemented on a mini door version.

This proposed system will reduce the dependency of a visually impaired person and give them a sense of self sufficiency while strengthening security at home. It will also create a moral development within users with the use of this technology. The future plan is to implement the concrete system by reducing detection delay and overcoming the other limitations of this system. The system will be tested with real end-users in a real-environment. Apart from this, a mobile application of the proposed system will be developed for users to get more control of the system.

REFERENCES

[1] N. S. Khan, S. Kundu, S. Al Ahsan, M. Sarker, and M. N. Islam, "An assistive system of walking for visually impaired," in *2018 International Conference on Computer, Communication, Chemical, Material and Electronic Engineering (IC4ME2)*. IEEE, 2018, pp. 1–4.

[2] M. N. Islam, T. T. Inan, N. T. Promi, S. Z. Diya, and A. K. M. N. Islam, "Design, implementation and evaluation of a mobile game for blind people: Towards making mobile fun accessible to everyone," in *Information and Communication Technologies for Humanitarian Services*. The IET, 2020.

[3] R. Chincha and Y. Tian, "Finding objects for blind people based on surf features," in *2011 IEEE International Conference on Bioinformatics and Biomedicine Workshops (BIBMW)*. IEEE, 2011, pp. 526–527.

[4] D. R. N. R. Manjunatha, "Home security system and door access control based on face recognition," in *International Research Journal of Engineering and Technology (IRJET)*, vol. 4. IRJET, 2017, pp. 437–442.

[5] I. Yugashini, S. Vidhyasri, and K. G. Devi, "Design and implementation of automated door accessing system with face recognition," *International Journal of Science and Modern Engineering (IJISME)*, vol. 1, no. 12, 2013.

[6] M. H. Assaf, R. Mootoo, S. R. Das, E. M. Petriu, V. Groza, and S. Biswas, "Sensor based home automation and security system," in *2012 IEEE International Instrumentation and Measurement Technology Conference Proceedings*. IEEE, 2012, pp. 722–727.

[7] R. Ibrahim and Z. M. Zin, "Study of automated face recognition system for office door access control application," in *2011 IEEE 3rd International Conference on Communication Software and Networks*. IEEE, 2011, pp. 132–136.

[8] F. Zuo and P. de With, "Real-time embedded face recognition for smart home," *IEEE transactions on consumer Electronics*, vol. 51, no. 1, pp. 183–190, 2005.

[9] I.-K. Hwang and J.-W. Baek, "Wireless access monitoring and control system based on digital door lock," *IEEE Transactions on Consumer Electronics*, vol. 53, no. 4, pp. 1724–1730, 2007.

[10] D. Javale, M. Mohsin, S. Nandanwar, and M. Shingate, "Home automation and security system using android adk," *International journal of electronics communication and computer technology (IJECCT)*, vol. 3, no. 2, pp. 382–385, 2013.

[11] Y. Erol, H. H. Balik, S. Inal, and D. Karabulut, "Safe and secure pic based remote control application for intelligent home," *IJCSNS*, vol. 7, no. 5, p. 179, 2007.

[12] K. Y. Lee and J. W. Choi, "Remote-controlled home automation system via bluetooth home network," in *SICE 2003 Annual Conference (IEEE Cat. No. 03TH8734)*, vol. 3. IEEE, 2003, pp. 2824–2829.

[13] A.-R. Al-Ali and M. Al-Rousan, "Java-based home automation system," *IEEE Transactions on Consumer Electronics*, vol. 50, no. 2, pp. 498–504, 2004.

[14] A. Ravi, R. Brindha, S. Janani, S. Meenatchi, and V. Prathiba, "Smart voice recognition based home automation system for aging and disabled people," *International Journal of Advanced Scientific Research & Development (IJASRD)*, vol. 5, no. 1, pp. 11–18, 2018.