IoT Based Smart Home Automation and Security System Using Mobile App With Assistant Robot for Developing Countries

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***Abstract*—This paper discusses an IoT based home automation system through which home security, room air quality check, and emergency assistance can be obtained. This system can automatically provide home safety, but the user can also control the system manually if desired. The system uses the NodeMCU module as the mainboard and has a mobile application for remote monitoring. In addition to air quality detection, the system can detect CFCs used in the air conditioning system to avoid accidents. If any unwanted incident occurs, the system will immediately turn off the home's main power connection and send the house's status in the form of a notification to the user's mobile app. Also, an essential feature of the system is that the system is able to block the entry of any unwanted person in the house. There is also an assistant robot to prevent fire accidents initially.**

Keywords—IoT system, Home automation, Home security, Mobile app, NodeMCU.

I. Introduction

People now want to lead a more comfortable life; thus, automation's demand is increasing. They use automation in various fields like agriculture[1], parking[2], etc. Recently, however, the number of fire accidents has risen. The Times of India published a report of an accident on September 3, 2020, in which ten people were injured, and nine houses were damaged due to the explosion of an LPG gas cylinder. The investigation later revealed that the incident was due to a gas leak [3]. Such accidents are more common in developing and underdeveloped countries, such as Bangladesh. In February 2019, a fatal gas cylinder exploded in the Chawkbazar area, killing more than 70 people. Meanwhile, 25 people died in a fire in a mosque in Narayanganj, Bangladesh, due to a gas leak. According to the Dhaka Tribune, 150 people were injured in the AC explosion in Bangladesh during the last five years, around 30 died[4]. Home automation is significant in reducing the number of such accidents. There are also many thefts when there are no people at home, such as a lot of money and valuable gold ornaments were stolen from a house in Savar, Bangladesh [5]. Keeping the above scenario in mind, an IoT-based low-cost home automation system has been designed and later implemented. The user will be notified very quickly if LPG or CFCs gas leaks, and the main power connection of the house will be turned off as a safety measure. The system has two separate modes through which the user can automatically or manually enlist the help of his nearest fire service or selected persons in case of any bad situation. Also, if there is a fire in the house or an unwanted incident occurs, the user will know and can take help even if he is not at home. The system uses NodeMCU, which has its own internet connection so that even if there is no wi-fi at home for any reason, this system can provide information to the user about home. The whole system can be monitored remotely through the app, but if the user is not connected to the app and if there is a problem at home, then the system will go into automatic mode, and the user will be informed of the home situation via SMS. The system also uses the ESP camera module in which the user can monitor the status of his home at any time through the app if the system is connected to wi-fi. In addition to the above features, the system has an automatic ventilation process. If there is smoke in the room or the room temperature is too high, the ventilation will be done automatically. Another unique feature of the system is, it has a two-way security system for the house's door. One is fingerprint security, and the other is password security. Whenever someone comes near to the door, the system will alert the user and allow the user to see the visitor through real-time video. If the user wants, he can share the door's password with the visitor to get him inside the house. In addition to all these features, the system has an assistant robot through which a fire extinguisher ball can be automatically dropped on the house in case of fire, which will help in extinguishing the fire initially.

II. Background Study

Home security and automation is not a new research topic for the researcher. A lot of researchers introduce many methods to automate the home. These all have some uniqueness and some shortcomings. A few of these are described below. The authors of the paper [6] implemented an Arduino microcontroller-based home automation. The user can control this system through a website; besides, these

researchers introduce the metering and online billing system. However, this system did not focus on the security of the home. An IoT based home automation system is proposed by the researchers of the paper [7]. This system takes google assistant voice as an input command of the controlling of the home appliances. This feature makes this system more user-friendly than others, but in a noisy environment, google assistant cannot recognize the user properly; thus, this specialty is making this system vulnerable. Paper [8] introduces an Arduino driven home appliances control system that communicates using Bluetooth technology. A Voice commands input system was also implemented in this project. This system is very cheap, and it can easily add more appliances to the system. Since the range of Bluetooth is only 10 to 100 meters, therefore the user cannot control the device outside this limit. Researchers of paper [9] suggested a security system for home using Arduino, door lock, and GSM technology. This system also gives the user an alert message about unauthorized entry and fire hazards in the home through GSM. However, this system has only one layer of authentication on the door, and there is no control of the home appliances through the system. In Papers [10]-[12], the author has worked on door security and locker security. In these types of systems, they have provided a few layers of protection. A raspberry pi controlled IoT based home automation and security system is introduced in the paper [13]. This system uses the PIR motion sensor in front of the door to prevent the intruder from entering the home. It has also incorporated many sensors to detect the lousy gas of the house and inform the user. But this system cannot perform automatically to ameliorate the situation. Moreover, there are many existing projects where automated robots were a crucial part of the whole system. For instance, in the following paper, the authors [14] have introduced an indoor farming system using a robot assistant. Here the robot collects data from the various sensor and performs accordingly.

III. System Description

A. Workflow diagram of the system.

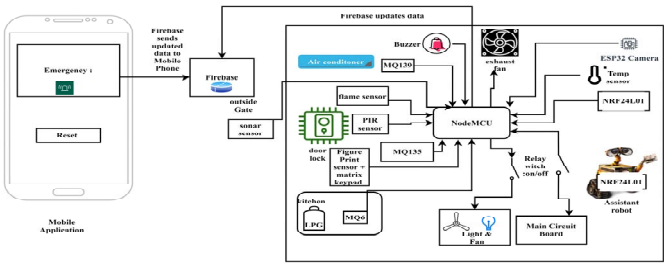
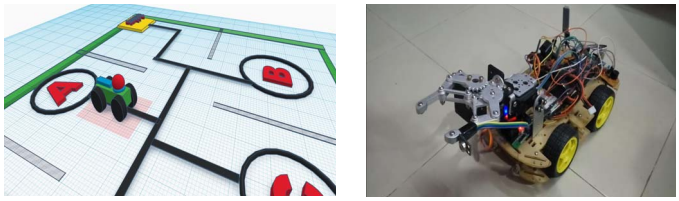


Fig. 1. System block diagram.

To ensure full functionality, the implemented system maintains a connection between the device and the mobile application, as shown in fig 1. Several sensors and ESP32 camera module have been installed in specific sites of the house to ensure effectiveness. A sonar sensor has been installed outside the door, when a visitor comes nearby the door, it gets activated and sends a signal to NodeMCU and notifies the user through the mobile application by sending a link through which users can monitor real-time video. This helps the user to take the necessary steps if the visitor is unknown and suspicious. Also, there is two-way protection in the entranceway door lock. Both figure print sensor and keypad sensor are used. The user is verified utilizing the fingerprint sensor, but if the user wants to allow someone to enter, then the user can transact the password. This password is randomly generated by the device, and only the application user has access to the password. This password will change every 24 hours to ensure extra protection. The app user can get the new password through the mobile phone interface. This password can be used in the keypad matrix to enter into the house. Besides, if anyone fails to provide the accurate password three times, then the user will also be notified via mobile app. Again, if the user has an air conditioner in their house, then s/he can equip the AC with the MQ139 sensor, which can surveil the AC for any set of potential threats concerning the AC. It will look for gas leakage and send a signal to the NodeMCU about potential threat incidents like AC explosion. If any such incident befalls, the MQ139 sensor sends a signal to the NodeMCU, which will inform the user through the application. Next, to notify the user of gas leakage in the kitchen, the MQ6 sensor must be deployed. If any LPG gas leakage is found in the air, then the user shall be notified through the mobile app regarding the issue. In addition to this, there will be flame sensors and temperature sensors (LM35) installed in potential endangered areas where there might be a chance of hazardous outbreaks like the kitchen, near the AC, near MAB. However, various precision can be taken before a serious fire outbreak if flame sensors and temperature sensors are added to understand the threat level. The sudden hike in temperature denotes a possible fire endangerment. Also, during a fire outbreak, in order to reduce smoke, Exhaust fans are set up in different rooms. These exhaust fans will be automatically triggered when there is a fire outbreak, thus assisting firefighters or those associated with similar roles. In addition to the mobile phone notification, there are buzzers associated with the system that simultaneously notify the user inside the house. Besides this, there is an assistant robot associated with the system. The robot is a line following robot (LFR), which communicates with the NodeMCU via NRF24L01 sensor. During an outbreak, the robot will detect the particular endangered area and drop a fire extinguisher ball in that area. While the mobile notification specifies the endangered area's threat and location, the buzzer notifies for any hazard. So, if the user is inside the house and not close to their mobile phone, the buzzer notifies them. On the entranceway inside the house, there is a PIR sensor that can detect people who have entered the house. This will pass the signal to the NodeMCU. The signal shall be transferred to the fan and light of the room to be activated. Initially, the fan and light must be connected with NodeMCU, and in between, there is a relay switch that originally will be turned off. So, when the PIR sensor is activated, the relay will be turned on, thus turning on the switches and lights. This PIR is also essential to serving another purpose. When a user enters the

house, the sonar sensor and its functionality are automatically turned off because the outside sonar sensor denotes a visitor. With that in mind, if the system user is already inside the house, it is pointless for the sonar sensor to be active and notifying about a visitor via the mobile application. Finally, in addition to all this work, the Main Circuit Board of the house will be turned off by the NodeMCU if there is any probable hazard because, in many cases, the MCB escalates the casualty level. Originally, the board is turned on because this supplies the power to the whole house. To restrict hazard level occurrence, this mainboard will be powered off automatically.

B. Assistant Robot.

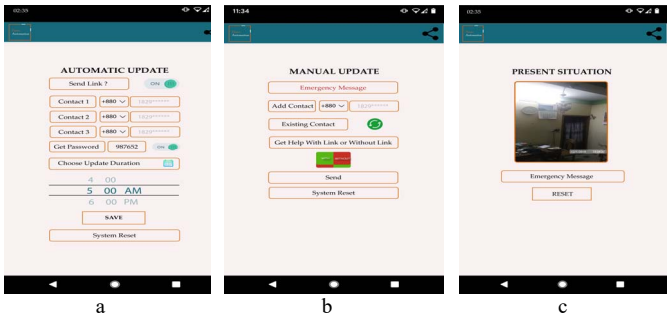


a b

Fig. 2. (a) 3D working diagram, (b) prototype of the assistant robot.

Fig 2(a) and 2(b) show the assistant robot's functional diagram and the prototype, respectively. The yellow marked area on the top left side in fig 2(a) is the stop point or rest point of the robot. Here the robot will be plugged in for charging purposes. If a fire outbreak occurs, the NodeMCU shall notify the robot via NRF24L01 sensor. After getting this trigger, the line following assistant robot shall be activated to reach its destination and search for flames in that portion of the room. After successfully detecting the flame with the help of flame sensors, the robot will drop a fire extinguishing ball with the help of a servo motor and leave the area to go back to the yellow marked point. Here the goal of the assistant robot is to work as the first line of defense against fire outbreak. The potential damage that might befall the robot is not a concern here. Here the robot tries to neutralize or minimize the casualty level before any further method is applied.

C. Application Description.

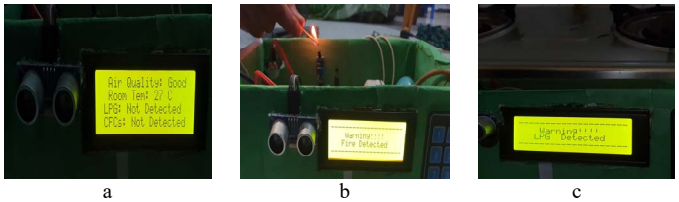


a b c

Fig. 3. App: (a) automatic mode, (b) manual mode, (c) live monitoring.

The application does not get activated until there is any sort of trigger such as house break-in, locking in, fire incident, etc. If there are any incidents like that, then signals will be sent to the firebase. Then the firebase will be notifying the remote user about a probable unwelcome incident. The application will inform the user with an alarm sound and notification about the probable cause of the notification. The system will be an online-based system where the firebase server must keep in communication with the application all the time. So, the application user must provide data access to the app all the time. There are generally two modes in the system. The first mode is for automatic update (fig 3(a)), and the second mode is a manual update (fig 3(b)). In the automatic module, the user can add some numbers and set a duration for how long the added numbers have access to getting notifications. This added contact can be a number of a nearby fire station or police station or a trusted relative. Below the adding button, there lies a switch button that wants to know if the user is willing to send the current situation of his house. To get these current situations, camera modules are implanted on various parts of the house where there might be a potential issue taking place. For example, a camera module can be set on a corner of the kitchen. So, if any fire hazard occurs, not only the app user but also the trusted contacts will be notified with a source to check out the kitchen's current scenario (an example is viewed in fig 3(c)). This will help to better understand about the required steps they have to take. Pressing the "Set Automatic" starts the countdown period of the added contacts duration of getting notified about any potential issues. Also, the system maintains an automated password generating system, which changes in every 24 hours. For getting the password, the user has to click the get pass button to get the automatically-generated password, which is applicable only for that time. Fig 3(b) shows the interface of the manual update module. The user will be notified via message and alarm about a threat, but whether the user wishes to contact trusted contacts depends upon the user. Also, a link will be generated through which real-time video of the current situation of the threatened place (example fig 3(c)) can be monitored. The user can choose to notify the trusted contacts both with and without the link. The notification will be put to a standstill when the user presses the "System Reset" button for both automated and manual mode.

IV. Results Analysis



a b c

Fig. 4. (a)Normal, (b) Fire detected, (c)LPG detected condition.

a b c

Fig. 5. (a), (b) Person entry with the fingerprint, (c) with password.

Fig 4 to 5 show the result analysis of the project. The room's normal condition and the fire detection condition are shown in 4(a) and 4(b), respectively. Figure 4(c) shows LPG

gas detection. Fig 5(a)-5(c) show the user's home entry by providing fingerprint and password, respectively.

V. The Novelty of The Work

This system is designed for considering the people of developing and underdeveloped countries. The cost was as minimum as possible while designing the system. Only necessary features that should not only facilitate home automation but also ensure a robust security system for the house. This system not only remotely notifies the user which also works perfectly even without the internet facility. For this offline mode, the system gives notification via NodeMCU. The system is designed to work on various possible case scenarios. Therefore there are both manual and automation processes of getting notified when a hazard occurs. The user can choose notification mode depending on the user's need. In addition to this, there is an assistant robot that comes as the first line of defense. During an outbreak, the robot automatically finds the affected area and takes measurements accordingly. Upon task completion, the robot returns to its stoppage are where it can charge its shelf. Also, there are cameras in various corners of the room to spectate the current situation of the affected area. The main goal of this project is to ensure not only home automation but also provide home security for the house within an affordable price range of the developed and underdeveloped countries.

VI. Future Work

The assistant robot used in the system is not very intelligent or robust. The robot can be developed to be smarter and make better decisions to deal with the threat level on a larger scale without damaging its parts. Also, the camera can be used for other purposes as well. We can add image processing to the system to recognize the trusted contracts or family members, or associated peoples of the home. Thus, the system will know when not to notify or warn if someone is near the entrance door.

VII. Conclusion

This research proposal showcases safety solutions for our house. This system warns the user concerning various segments in our house, such as warning about a probable intruder, fire safety, identifying AC gas leakage, LPG gas leakage, break-in. Moreover, the system works as home automation as well by turning on the lights fans and also ensuring two-way protection for the user to enter the house. Consequently, if there is any nature of the hazardous situation, then the user shall be notified, and the safety measures or steps were taken by the user depends upon the user because there are both automated and manual modes to take proper steps during the disastrous incident. For the automation mode, the user can set trusted contacts to send them notifications for a period of time that the user was predefined. Again, camera modules are set in different corners of the room to monitor the situation inside the house during any possible catastrophic incident. This system notifies potential hazardous incidents that will help reduce casualties not only for the house but also may become the reason that can save lives from tragic incidents.

References

[1] V. Puranik, Sharmila, A. Ranjan and A. Kumari, "Automation in Agriculture and IoT," 2019 4th International Conference on Internet of Things: Smart Innovation and Usages (IoT-SIU), Ghaziabad, India, 2019, pp. 1-6, doi: 10.1109/IoT-SIU.2019.8777619.

[2] A. Z. M. T. Kabir, N. D. Nath, F. Hasan, R. A. Utshaw and L. Saha, "Automated Parking System with Fee Management Using Arduino," 2019 10th International Conference on Computing, Communication and Networking Technologies (ICCCNT), Kanpur, India, 2019, pp. 1-6, doi: 10.1109/ICCCNT45670.2019.8944642.

[3] G. Shelke, "10 injured in Vadgaon Sheri LPG cylinder explosion: Pune News - Times of India," 03-Sep-2020. [Online]. Available: https://timesofindia.indiatimes.com/city/pune/10-injured-in-vadgaon-sheri-lpg-cylinder-explosion/articleshow/77899638.cms. [Accessed: 15-Oct-2020].

[4] "Dhaka Tribune: Latest news update from Fire Incident in Bangladesh, World." [Online]. Available: https://www.dhakatribune.com/hashtag/fire-incident. [Accessed: 16-Dec-2020].

[5] The Financial Express, "Robbers loot expat's house in Savar," The Financial Express, 16-Aug-2016. [Online]. Available: https://thefinancialexpress.com.bd/national/robbers-loot-expats-house-in-savar-1534407070. [Accessed: 15-Oct-2020].

[6] S. Mahmud, S. Ahmed and K. Shikder, "A Smart Home Automation and Metering System using Internet of Things (IoT)," 2019 International Conference on Robotics,Electrical and Signal Processing Techniques (ICREST), Dhaka, Bangladesh, 2019, pp. 451-454, doi: 10.1109/ICREST.2019.8644232

[7] S. K. Vishwakarma, P. Upadhyaya, B. Kumari and A. K. Mishra, "Smart Energy Efficient Home Automation System Using IoT," 2019 4th International Conference on Internet of Things: Smart Innovation and Usages (IoT-SIU), Ghaziabad, India, 2019, pp. 1-4, doi: 10.1109/IoT-SIU.2019.8777607.

[8] M. Mahith, D. S. B. Kumar, K. C. Prajwal and M. Dakshayini, "Bluetooth Home Automation," 2018 Second International Conference on Green Computing and Internet of Things (ICGCIoT), Bangalore, India, 2018, pp. 603-607, doi: 10.1109/ICGCIoT.2018.8753094

[9] A. Sharma and A. Goen, "Smart Home Security System," 2018 International Conference on Advanced Computation and Telecommunication (ICACAT), Bhopal, India, 2018, pp. 1-4, doi: 10.1109/ICACAT.2018.8933780.

[10] A. Z. M. Tahmidul Kabir, N. Deb Nath, U. R. Akther, F. Hasan and T. I. Alam, "Six Tier Multipurpose Security Locker System Based on Arduino," 2019 1st International Conference on Advances in Science, Engineering and Robotics Technology (ICASERT), Dhaka, Bangladesh, 2019, pp. 1-5, doi: 10.1109/ICASERT.2019.8934615.

[11] A. Z. M. Tahmidul Kabir et al., "Smart System Integration of Question Paper Security System," 2020 17th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON), Phuket, Thailand, 2020, pp. 619-623, doi: 10.1109/ECTI-CON49241.2020.9158284.

[12] M. Mathew and R. S. Divya, "Super secure door lock system for critical zones," 2017 International Conference on Networks & Advances in Computational Technologies (NetACT), Thiruvanthapuram, 2017, pp. 242-245, doi: 10.1109/NETACT.2017.8076773.

[13] S. Somani, P. Solunke, S. Oke, P. Medhi and P. P. Laturkar, "IoT Based Smart Security and Home Automation," 2018 Fourth International Conference on Computing Communication Control and Automation (ICCUBEA), Pune, India, 2018, pp. 1-4, doi: 10.1109/ICCUBEA.2018.8697610.

[14] A. Z. M. Tahmidul Kabir, A. M. Mizan, N. Debnath, A. J. Ta-sin, N. Zinnurayen and M. T. Haider, "IoT Based Low Cost Smart Indoor Farming Management System Using an Assistant Robot and Mobile App," 2020 10th Electrical Power, Electronics, Communications, Controls and Informatics Seminar (EECCIS), Malang, Indonesia, 2020, pp. 155-158, doi: 10.1109/EECCIS49483.2020.9263478.