DEVELOPING AN INTELLIGENT FIRE ALARMING, MONITORING AND RESCUING SYSTEM USING UAV

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ABSTRACT:

Fire alarm methods become increasingly complicated and functionally more competent and responsible in recent years. All are intended to fulfill the conditions: protection of property and assets and protection of life. Audio and visual signs are sent to notify people about concerning fire or CO concentration in range zone along with UAV this all is part of fire alarm assembly. Fire sirens and sensors are usually set in fire alarm operations for more effective safety for nearby formations. The advanced fire alarm sign comprises using either a sound or a flash and some additional features such as sending a message or a phone call or e-mail and it will also help us know about the smoke level and temperature of the fire. Its important part is that it will have the priority to save the life of people as well as prevent the infrastructure from the fire so to do the job simultaneously the advanced features are utilized this also includes using IoT to use it wirelessly with UAV and CCTV which will help in audio and visuals for the accident site along with that it will also send message to people living near the accident location so that they can help people by rescuing them.

1. INTRODUCTION

Fire incidences need the incentive of alarm or prevention of buzzing any alarm whenever it cannot be confirmed. Sensing of fire and the subsequent communications require wireless means to avoid cabling faults. It was understood that two types of messages are required to be started in case of fire, one warns the people entrapped on the site of the fire, with leading exit map specific to the location secondly, connection with the people located near the accident site so that they can work as rescuer. Commonly, people use the wired system for detection of fire and these systems which can be changed with the wireless system as wired systems focus on basics such as temperature, amount of CO, smoke concentration(Wu et al. 2018), etc. but this will be not much effective as its range is too low and if CCTV based practice is used it will not cover some limited areas which will decrease its effectiveness. Thus, there is a need for developing a fire detection system (including sensors and cameras) capable of wirelessly communicating fire information (from inside the building/infrastructure) to the control station. Monitoring the site from proximity. 3D map of the infrastructure under fire along with the position and extent of fire will help the determination of escape routes(Zhang et al. 2018)for inmates in real-time, which will be communicated to entrapped people. Thus, presenting it as creative fire detecting, monitoring, and rescuing mode.

2. BACKGROUND

General fire alarm systems face numerous challenges, e.g. not appropriate and no information, no time-effective information on the level of risk due to fire, etc. These weaknesses can cope up with the development of an advanced alarm system that works wireless and provide with UAV and CCTV for proper time monitoring data. M. Yang and C. Zhang tried the Alarm System with the smoke sensor in 2006 to improve the quality of the fire alarm system(Presence 2014). Chen, D. in 2013 introduced an effective routing method where UAV recorded this information from the accident position to investigate it for judgment planning. Y. Guo, X. Hu, B. Hu, J.Cheng, M. Zhou, and R. Y. Kwok worked on cyber-physical systems(Wu et al. 2018) related to current challenges and future networking applications which is useful in this system. Ueyama, J. et al. in 2014 practiced a UAV based approach to establish a broadcast sensor system for monitoring. Seo, S. H., Choi, J., Song J. (2017) practiced Safe Utilization of Lights and UAVs in Emergency Response Systems for Formulating a Fire Hazard. Aedo, I. et al. (2012) worked on personalized building notification with evacuation routes in a smartphone. Liu, J.W.S. et al. (2016) suggested a related method for departure, which can transmit a piece of simple navigational data. This practice position guides inside the construction furthermore environmental conditions inside to discover personalized specific step evacuation maps.

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3. DEVELOPING INTELLIGENT FIRE ALARM SYSTEM

Commercial fire alarm systems are important for saving life and property, but because they have various components and features, they can be a bit complicated. This can lead to problems like a false alarm, inappropriate message, insufficient information, no real-time information on the spread of the fire, etc. All the above-mentioned limitations are worked to be overcome with the development of IoT (Internet of Things) based smart fire alarming system running wirelessly and requiring Unmanned Aerial Vehicle (UAV) that broadcasts the live video. An intelligent Fire alarm System with UAV includes UAV(Unmanned Aerial Vehicle)(Seo, Choi, and Song 2017), IFD (Intelligent Fire Detector), SM(security manager), CCTV, CSD(Central Server Database), and user.

IFD and CCTV help to give relevant information and message regarding a fire. They send signals wirelessly on the IoT platform. In case of fire or any emergency, SM and the user are informed wirelessly by the server to take further action. IFD (Intelligent Fire Detector) is programmed to check the fire in the

vicinity of detectors by sensing carbon monoxide(co) and smoke concentration, increasing temperature, and flame. When there is any unusual condition or any sign of fire is detected all data are recorded at the central server database, and UAV rests on charging stand comes into play. CCTV and UAV footage are used to monitor any potential fire risks. These footages are stored on the server and can be monitored by SM and the user. They can observe the fire at any moment. The final decision is made after UAV and CCTV footage and manual examination of the fireplace.

In the case of fire commonly smoke, heat, infrared radiation, or many harmful gases are released. Many electrochemical sensors are designed to sense one or more of these phenomena. We used flame-detector, Smoke (MQ2), temperature sensor (LM35), and carbon monoxide (MQ7) to observe changes in our device. When an unusual situation detected by detectors, the central server database sends a message to UAV-Quadcopter to reach the fireplace. When UAV-Quadcopter reaches the fireplace, it sends the real-time video footage to the Central server. The security manager can recognize the fire using live video footage. This can cause great panic and confusion among the people in the building in case of the false alarm, UAV-Quadcopter rests back to the charging stand. No further action will be taken and everything returns to the normal state. If the fire is recognized by Security Manager based on CCTV, UAV footage. The alarms and nozzle water sprayer system become active-Quadcopter helps people present inside the building during the fire to get out of it(Aedo et al. 2012). All footages and locations of fire are sent to the firefighting team to help them in rescue. The neighbor fire station and ambulance are informed.

The primary element of UAV based Intelligent Fire Alarm System is an Intelligent Fire Detector. The Intelligent Fire Detector is an assembly of intelligent detecting sensors that consist of carbon monoxide, smoke, flame, and temperature sensors. Intelligent Fire Detector interacts with the central server wirelessly transferring sensors value. The central server knows the location of fire detectors and is made to overcome the problems faced by the commercial fire alarm. The commercial fire alarm also requires huge wiring which increases the project cost. These problems can be resolved by using a wireless fire alarm system. In a conventional alarm system, it is very difficult to control the buzzing of false alarm at midnight due to haze or any damage in the wiring(Aedo et al. 2012). This can cause great panic and confusion among the people in the building. The solution to these problems is to make an intelligent fire alarm system (IFAS) managed by mobile apps (Wan et al. 2020). Users can also switch off the false alarm with the help of the mobile app. And can check the CCTV footage of any room or balcony in the building. By simply registering on the mobile app with their Name, Mobile Number, and email id. In the case of fire users Mobile Application also has the feature to warn Security Manager (SM) and other users in the building to make them out of the building before spreading fire.

The conventional fire detecting system has some limitations as mentioned below:

- The possibility of false alarm is quite high, for example, any damage in the wireline can cause a false alarm.
- The wired alarm also needs a manual inspection of the fireplace which is a very time-consuming process.
- The source of the fire cannot be identified and may require special investigation thus adding to the damages.
- What to do when there is fire, how to exit? And How to avoid panic among users and what will the smallest route to get people out of the building.
- Battery life, the condition of the sensors cannot be explained.
- An officer for monitoring live data is needed in conventional systems.
- The sensors in Intelligent Fire Detector (Figure 3) helps in reducing false alarm cases. Like when both carbon monoxide and smoke sensor give high concentration then flame and temperature sensors are cross-checked for confirming fire. All IFD's are assigned a location in the building.

The Raspberry Pi is one of the commonly used technology in the IoT platform. Raspberry Pi when connected with the MQ2 sensor for detecting smoke this will help us in getting digital data when it detects smoke. Raspberry pi can easily correlate to the internet and help in processing power. MQ 2 sensor is taken because it detects smoke, LPG, CO, H2, CH4, alcohol, and Propane. The sensor works on the principle of the heating coil. The sensor gets warm by using heat and the time is taken to heat it up is known as "burn time". The sensor board has four pins to connect to a raspberry pi. These are power, ground, analog output, and digital output. MQ2 sensor has the sensation characteristics for numerous gas for detecting such as CO2, CH4, etc. LPG gas is the most sensible to detect and smoke is likely to be normal sensitive, and propane gas is the least sensitive. To send the information of detected fire, Firebase Cloud Messaging is used for our system it provides us alert messages and notification on the android app at no cost. Initially individual has to register himself for firebase console and then it will add to firebase after which we can further monitor and modify settings of the firebase. This will also notify others who have log in to the firebase console. The Firebase is depended on the cloud for real-time and which is monitored and connected with each client. After we have developed an android app utilizing iOS and JavaScript SDKs and which will further connected to clients for getting automatic real-time updated data and for alert messages and emails. Initially, we have designed an android app utilizing an android studio and after it, we have registered on firebase and got linked to the device in real-time and then all the registered data will be displayed on-time data page after which the linked gadgets will get an alert notification.

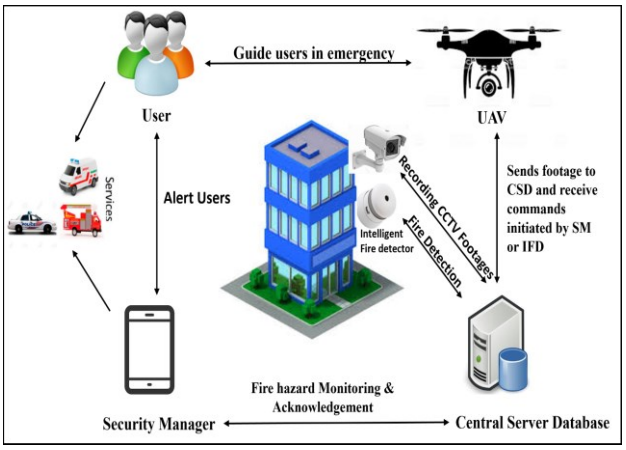

Figure 1. UAV based fire alarm system

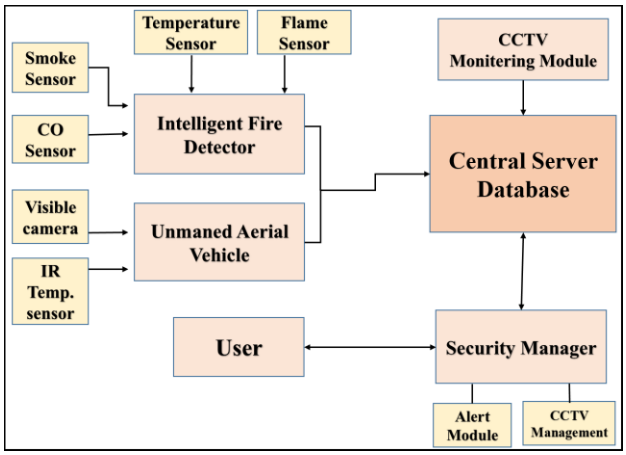

Figure 2. CSD connected wirelessly with detectors IFD, CCTV, UAV and SM in IFAS

Figure 2 represents the detailed stepwise working of model wirelessly in this CSD (Central Service Database) which plays a major role in transferring information or send an alert to further intelligent fire detector, security manager, and UAV. This will give notification to firefighting services which will further take action to rescue the people. Different sensors sense the gases and fire and will alert. After IFD sensing the signal of fire than CSD based upon security managers decision decide about the fire at the place or not.

The mind map is shown in (figure 3) the connection between different sensors such as LM 35, MQ2, MQ7, etc. these sensors sense the different gases such CO and detect fire and then pass the alert to further devices so that fire can be prevented these all sensors are integrated to Arduino UNO which helps us to integrate the data and send it further.

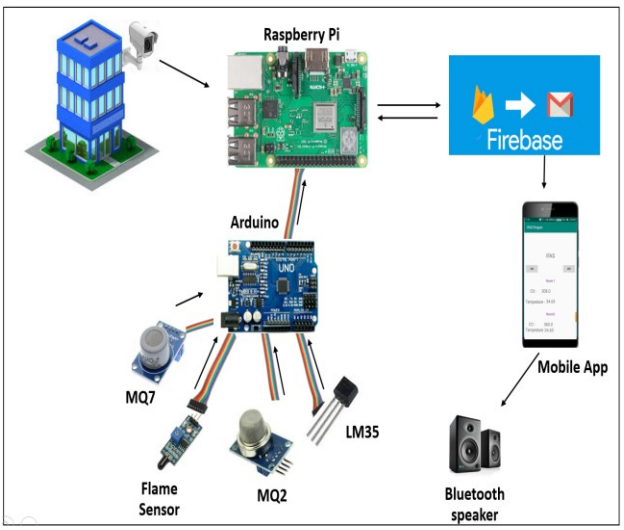

Figure 3. IFD connected with different sensors

Following are the components of IFAS:

- Microcontroller and IoT module
- Raspberry Pi 3
- Arduino UNO
- Bluetooth Speaker Sensors

1. **Ionization CO Sensor (MQ7):** It is the advance sensor used for detecting carbon monoxide (CO) and the layer of it is composed of SnO2 which helps it maintain stability such that it can be used for 5 years without any problem.
   Features: 1) High sensitivity to carbon monoxide
   2) Stable and long life
2. **Ionization Smoke Sensor(MQ2):** It is a very effective and useful gas sensor known as MQ2 or Chemiresistors as it is used to detect the concentration of gas and it works on the principle that it will detect upon a change of resistance of the sensing material when the Gas comes in contact with the material.
3. **Temperature sensor (LM35):** LM35 is the temperature sensing sensor that works on the principle of voltage is directly proportional to temperature it has the benefit that it can take the reading of temperature on both centigrade and Fahrenheit so it will very efficient as compared to other sensors.
4. **Flame Sensor**: It is a type of sensor intended to identify as well as counter the appearance of a flame or fire which leads fire detection easily and efficiently.

SOFTWARE:

1. **Arduino IDE**: It provides the platform to write codes in different programming languages and upload them to the Arduino board which provided an integrated environment for different practical purposes.

2. **Android Studio:** Android studio is a tool used for building developing useful and advanced applications for android stand and plays a crucial role in testing and working of different sensors and it is also very useful in creating new and practical uses of IoT without having exact Android tools.

Libraries used in Raspberry Pi:

- Espeak and Pyaudio
- Firebase
- SMTP

The Intelligent Fire Detector works in four steps:

(1) 'Green': shows that alarm is working perfectly;
(2) 'White': shows that sensors detected something
(3) 'Yellow': shows that sensors detected fire;
(4) 'Red'. shows that sensor is not working properly.

- Green: When Intelligent Fire Detector is running perfectly or if it shows no more fire, it sends the message to the central server about the active state of IFD.

- White: When Intelligent Fire Detector is not working properly due to some fault in sensors, low battery, or others, it sends the message to the central server about the inactive state of IFD.

- Yellow: If Intelligent Fire Detector senses an unusual situation, it is shown the message unsafe(Wang et al. 2018). The security manager gets abnormal condition data from detectors. CSD sends UAV for Realtime monitoring of the fireplace.

- Red: When the security manager or CSD classifier confirms the fire. The alarm system starts buzzing by providing the proper direction to get out of the building with speakers installed in the building and UAV. And sprinklers will active. Every user is informed on the mobile app about the fire.

4. RESULTS AND DISCUSSION

On testing the Intelligent Fire Alarm System prototype (IFAS), we can see that the system functioned properly with smoke, carbon monoxide, temperature, flame sensor and can live monitor with UAV and CCTV. The Intelligent Fire Detector will keep on monitoring the several rooms and halls of RGIPT campus and CCTV footage also gives live videos. CCTV monitoring of halls helps to cover all places. When fire like conditions or fire is detected, all sensors send the signal to the central server database wirelessly on IoT platform (Figure 5). From there the message is transferred to the control room, where the security manager keeps on monitoring, and in case of any emergency. If the emergency has been received on CSD, it is sent to the control room, Security manager (SM) keep on monitoring co, smoke, and temperature level. Security Manager (SM) looks at all false alarm situations by comparing them with the rate of temperature increase and other parameters. SM also confirm the fire with the live CCTV footage. The system will be deactivated when there is a false alarm, no further data are shared with CSD and dangerous situation SM inform to nearby services.

The connection between raspberry pi, Arduino, temperature, and gas sensor (Figure 4) and passing the alert message and create buzzing sound so that the services can be reached to cure fire. This further sends a message to the central server database which will further deliver it and which can be monitored easily. To send the information to the design, Firebase Cloud Messaging is used for our system it provides us alert messages and notification on the android app at no cost. Initially individual has to register himself for firebase console and then it will add to firebase after which we can further monitor and modify settings of the firebase. This will also notify others who have log in to the firebase console.

CCTV will be most efficient when the feature of image processing will be best and when image processing combined along with camera inspection the image or video recorded will be effective in detecting fire and also help in monitoring fire. IoT is connected with the series of data which are alert notification send after the image processed which is captured by camera. This can be sent to the server by using the internet and after it will send alert notification to android.

CCTV and UAV provide numerous benefits over common detection methods such as it are cheaper and its implementation is simple compared to common techniques and their response time is less and it does not require anything to get triggered and able to capture larger areas which makes it more unique and advanced technology. The system manager is capable of producing an alert warning for fire detection. The system manager allows monitoring of locations via CCTV and UAV and displays maps of the area which is firebase real-time management. Then in case of fire, these maps will help the people to rescue and prevent fire by monitoring and fighting fire. This data is very important for efficient fire management by fire fighting forces.

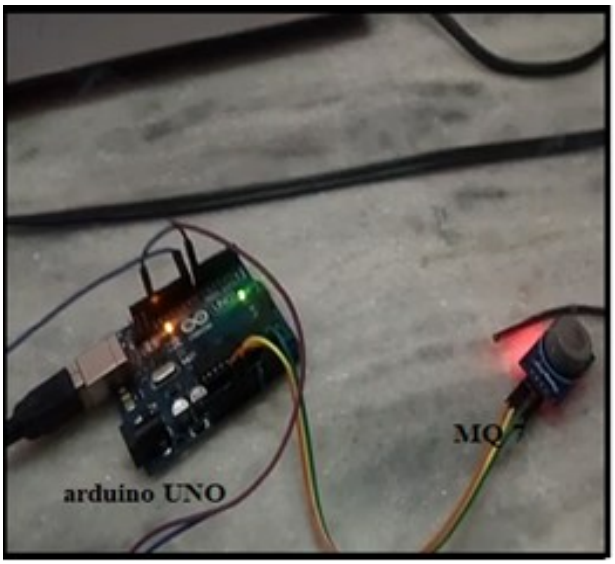

Figure 4. Intelligent fire detector prototype

Figure 5. Testing of Unmanned Aerial Vehicle at Fire Location

UAV-quadcopter with an attached camera facilitates the streaming of live videos of the fireplace to all the connected users. The use of UAV-quadcopter here helps get detailed Realtime photographs and videos of the fireplace at close range from outside. In an example, fire at an academic block of RGIPT, IFD sends information to a central server database with initiate the UAV resting on the charging stand from the control room in auto navigation mode in Figure 5. Then the UAV reaches the fireplace on autopilot mode after adjusting the co-ordinates of each detector in the room. The UAV also has an

ultrasonic sensor to avoid it from striking the walls of the building.

Intelligent Fire Detector (IFD) sends data to the Central Server Database in Figure 6 so that the Security Manager (SM) can take further decisions in case of fire. In the case of fire, Intelligent Fire Detector detects fire Security Manager (SM) confirms the fire by live CCTV footage Figure 7. Once SM confirmed the fire, the server sent the message regarding fire to all the registered users connected with the fire spot and its vicinity. Then, the location of the fireplace is shared with them and UAV, placed at the control room is programmed to reach fire location on autopilot navigation mode. The visible camera attached with UAV capture the Realtime information of the fire location and send it to the server. With real-time footage UAV is also attached with an IR Temperature sensor to detect the temperature of the room. An ultrasonic sensor on UAV protects it from striking the building wall or any obstacle in its path.

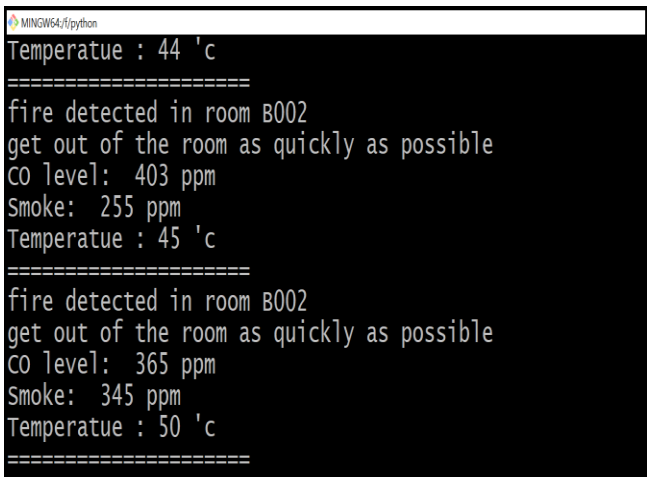

Figure 6. IFD transferring real-time data to the central server in case of fire

Figure 7. CCTV for Fire Detection at RGIPT

With UAV footage Security Manager and User monitor the real-time video and temperature (infrared temperature sensor) by Unmanned Aerial Vehicle- Quadcopter Figure 7.and take necessary decisions. Figure 8. This wireless service allows the different Users at a time to monitoring the building from any corner of the world by simply registering on the mobile application. Mobile users will get information about the fire, smoke, CO, and temperature of the spot of fire, along with its video of CCTV and UAV to know the real-time status of the fire in Figure 8.

Figure 8. Live information on fire status in mobile with a particular address of room and building.

Android application is linked to firebase and plays a crucial role in real-time data management for giving realistic data of concentration of smoke and temperature of the fire and helps us in detecting, monitoring, and fighting from fire then it also uses the image as a confirmation. This app is connected to the cloud which further notifies the clients who have signed up on the cloud and also informs fire fighting services via alert notification. The app is an advanced feature for fire prevention which is very effective, time-efficient, and high range. The security manager will also send an email and alert notification to the client, fire fighting services after surety of the fire which makes it different and unique. It has the principle that when the sensor senses the heat and if the temperature crosses the threshold value then it will notify the system management than they will send alert notification to the client signed in cloud data.

5. CONCLUSION

An intelligent Fire Detector prototype is made with smoke, co, temperature, and flame sensor. IFD and CCTV data are transferred wirelessly to the central server unit. Upon confirmation of fire within the building are registered users are informed. Further, messages from the central server database help to navigate the UAV. Unmanned Aerial Vehicle (UAV) attached with a visible camera and IR temperature sensor, enables the streaming of live videos to all the registered users. UAV helps in getting close shots of fire sites and temperature from outside. Consequently, it gives a complete video or photograph of the fireplace in real-time, unlike the indoor CCTV footage. Information on IoT based detection with UAV monitoring of fire along with guiding rescuing operation in real-

time has great potential for saving lives and reduce property damage.

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