FireFighterDrone

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Abstract: In a world where fire accidents are increasingly common and the brave first responders always risk their lives to save the lives of others. Unfortunately, history tells that these brave first responders do not survive most of the time. To save as many lives as possible, it is important to leave dangerous tasks to machines. One such device is a drone; it provides great maneuverability and doesn't risk any personnel. Drones can also gather information at greater speed, reliability and are also able to drop items. Thus, the solution mentioned below will help us solve this problem along with the functionalities mentioned below.

Keywords: Unmanned aerial vehicle(UAV), Machine Learning, Fire Fighting, Object Detection, Flammable Gases, Temperature sensor, Flight Controller, Internet of Things, Panorama, Area Map.

1 Introduction

Fire related accidents are becoming increasingly common. [1] According to the NCRB, a total of 18,450 cases of fire accidents were reported in India in 2015, with 1,193 people injured and 17,700 killed. In the last 6 months, Mumbai has seen 12 major fires which resulted in the death of 22 people. Reading articles like *"Fire outbreaks is the third biggest risk to business continuity and operations, according to India Risk Survey(IRS) 2018. In IRS 2016, fire outbreaks were ranked eighth biggest risk to business"* only make the statement more valid. Along with it having casualties of firemen like *"2 firemen who died in well tragedy were feted for work-TOI"* makes us question the system to the core. Hence in this project we aim to reduce the burden of firemen by making a drone, the actual first responder instead of firemen and hence potentially saving actual human lives. This is an IOT based drone system that will provide valuable insights of the situation with the help of cameras and sensors. The proposed system will help the firemen to monitor the situation like checking if there is a human trapped inside or are there any explosives in the area near the fire, check for harmful gases if any and devise a plan of action accordingly. The vast increase in the number of fire-related accidents makes it a serious issue. The drone will help to improve response to the tragedy and hence help in saving lives. The functionality of dropping a fire Extinguisher Ball to control the fire will also help the firemen.

2 Existing Solutions

1. Robofire

● RoboFire is the latest asset of our fire department. It was recently used in a major fire outbreak in MTNL building, Bandra, Mumbai [6].

● Robofire is among 14 fire tenders that were used by the department to control level-4 fire.

● It is a remote control instrument. Trained individuals are required to guide this bot. It can travel only on land and is able to capture images at the spot of an accident.

● The bot is also able to carry the water pipe to the spots where it is difficult for a fireman to reach.

● Hence, to carry out such functionalities it is a quite big, heavy and space occupying robot. Also, it costs ₹1 crore.

2. Fire Tender

● 'Fire Tender', 'Fire truck', 'Fire engine' and 'Fire appliance' are used interchangeably.

● The primary purposes of a fire engine include transporting firefighters to an accident spot, providing water required to fight a fire, and carrying other tools to provide hazardous materials mitigation and technical rescue.

● A typical modern fire engine will carry a wide range of tools required for firefighting tasks, with common equipment including a pump, a water tank, hoses, ground ladders, hand tools, self-contained breathing apparatuses, basic life support equipment, and first aid kits.

● They are usually fitted with sirens, as well as communication equipment such as two-way radios and mobile computer technology.
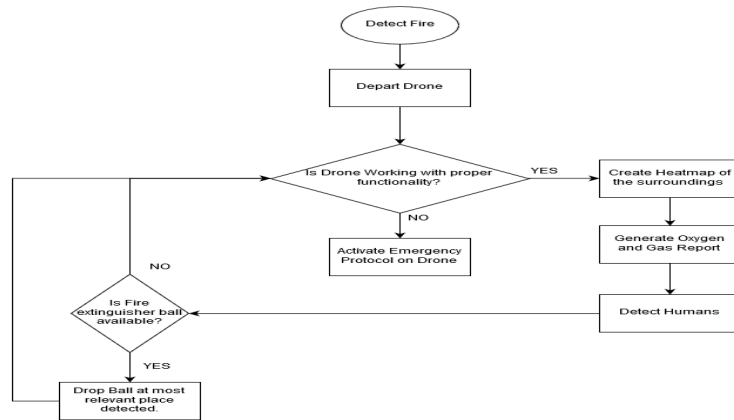
3 Functionalities

Fig. 1. Block Diagram

1. Construction of UAV

UAV or unmanned aerial vehicle was constructed in phases: 1. First part involved construction of an actual drone which includes assembling a quadcopter frame. On top of that frame various components for the drone are added which are:

a. Motor: Motors which are added must be at least 1000kv so as to have sufficient power for it to fly.

b. ESC: ESC or electronic speed controller must be attached to the drone equal to the number of motors on drones on drone as every motor requires an Esc. Hence in case of a quadcopter 4 Esc's must be added.

c. Propeller: Carbon fiber propellers are used to have sufficient strength and longevity in life span for propellers.

d. Battery: Battery can be chosen from 2200 mah to 5400 mah depending on the need and time to flight which is required.

2. Object detection using camera module

The drone is equipped with 2 cameras: the normal camera and the thermal camera. Object Detection is done using the normal camera. The camera gives live feed to us on a screen on which we run the object detection program. A machine learning model is trained and used for this purpose. The model is trained to detect humans, pets and certain types of objects that we normally have in our house and can explode in the presence of fire. The list of objects that the model is trained to detect are:-

1. Humans
2. Air Conditioner
3. Laptop
4. Dogs
5. Cats
6. Gas cylinder
7. Electric Board
8. Fire Extinguisher
9. Birds
10. Cell phone
11. Television
12. Microwave
13. Refrigerator
14. Geyser
15. Fire hydrant

3. 2D Panorama area model using image stitching in Python

During moments of emergency firemen enter a space of unknowns and deal with surrounding which is not familiar to them. So there's a significant amount of time which is dedicated to gaging the environment/surroundings instead of directly moving to rescue operation. To bridge this gap 2d panorama model is necessary to be created so as to help firemen gage the situation quickly. [2] This is achieved with the help of image stitching in python using invariant features. The video is captured from a Raspberry Pi camera and multiple frames are captured from that video. The captured frames are then stitched into a single panoramic image using feature and image matching[7][8].

4. Toxicity report generation using MQ-sensors

[3] MQ gas sensors help us detect the hazardous gases in the surrounding. Integrating this sensor to our drone will help us detect the harmful gases around the accident spot and take necessary precautions for the same. With the help of the output received from this sensor, we can also classify the fire into one of the four levels of fire, thus helping the firemen take required precautions and equipment for themselves as well as during the rescue operations.

5. Integration of sensors, camera and drone

There are mainly two hardware boards which are used simultaneously for the drone which are NodeMCU and Raspberry Pi.

1. Raspberry Pi This board is equipped with functionalities of creating 3d Area Map of the surrounding and other mapping functionalities. This is achieved with the help of the onboard Raspberry Pi Camera module.

2. NodeMCU This board is responsible for very important functionalities like having ultrasonic sensors on it for collision prevention while traversing the surrounding. It is also equipped with a Gyro sensor to measure the angle of rotation and adjust the speed motors. To control the speed of motors it is also connected with the Escs as Esc is mainly responsible for speed control of motors.

4 Hardware And Software

● **Hardware**

1. Quadcopter Frame
2. Propellers
3. Motors
4. ESC
5. Battery
6. Normal Camera
7. Thermal Camera
8. Smoke and Gas Sensor
9. Gyro and Accelerometer
10. Arduino Uno Board
11. Node MCU
12. Raspberry Pi
13. Speaker
14. Microphone
15. Temperature and Humidity Sensor
16. Fire Extinguisher Ball
17. Robotic Arm Gripper

● **Software**
1. Python
2. MySQL/Firebase/ Postgres
3. Android Studio
4. Flask
5. Arduino IDE

5 Results

● **Object Detection:** The object detection model that we have used will take the live video feed from the Raspberry Pi camera and detect 13 classes of objects like humans, cats,dogs, laptops, refrigerators etc. This will be done by reading every frame from the video and the model will try to detect the objects in each frame.

Fig. 2. Object (human) detection

● **2D Panorama area model:** Panorama Area Generation takes Video recording as an input and performs operation on it to generate panorama as the final result as shown in fig. 3. This result is obtained with the code executing in two sections. First capture of frames takes place from video. These frames must not be redundant so to avoid it max correlation number is set and above which frames are discarded. Frames which are captured are then distant frames and these frames are then fed to generate panorama.

Fig. 3. Panorama Generation

● **Gas sensor module:** MQ9 gas sensor helps us detect concentration of flammable gases like CO, CH4, LPG, etc in the surrounding to produce the toxicity report. Inbuilt resistors help us determine gas concentration. When the gas concentration is high, resistance is low and vice versa. 'RS' is the resistance in gas concentration and 'R0' is resistance of sensor in clean air. RS/R0 ratio gives us the desired result.
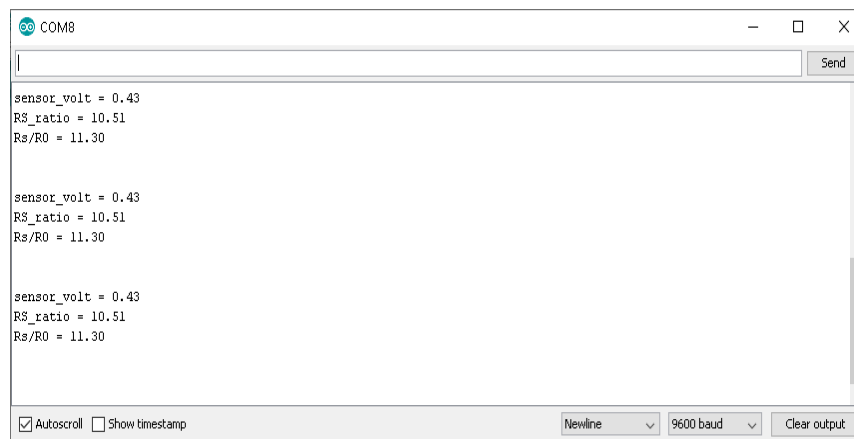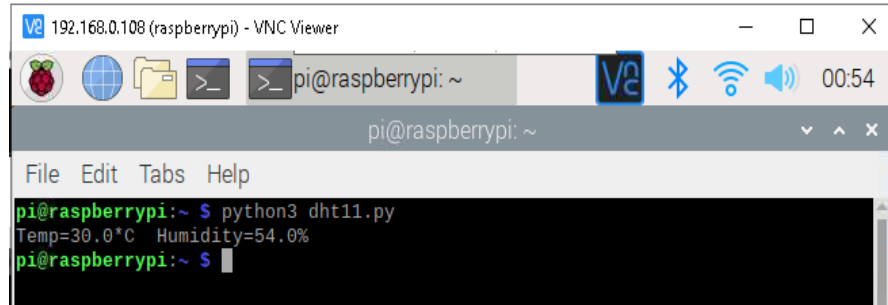

Fig. 4. MQ9 gas concentration output

DHT sensor: DHT11(Temperature and Humidity Sensor) is used to detect real time temperature calibrated to output digital signal.Four pin single packaged DHT11 is small in size(12*15.5*5.5) and consumes low power typically 3-5.5V.Polymer resistor is used as a sensing element.Range of sensing temperature lies between 0-50 Celsius with an error rate of +-2.0 Celsius. Humidity detection range lies from 20-90%RH with an error rate of +-1%.

Fig. 5. DHT Sensor Result

6   Future Scope

● **Fire Extinguisher ball drop using Robotic Arm:** [4] Fire Extinguisher Ball is used as fire extinguisher by firemen as it releases Carbon-dioxide when it burns. Due to this feature it can then be loaded on to drone and released. This loading and releasing is achieved with the help of Robotic ARM. This robotic arm is actually a robotic gripper which runs on a standard servo motor which can be controlled on multiple boards like NodeMCU and arduino.

● **Heat map generation using Thermal Camera:** Usually the firemen are not aware about the intensity of fire at the accident spot, also the safe entry and exit points are unknown. To aid them in the rescue process, heat map of the accident spot can be generated with the help of a thermal camera. [5] Infrared thermal images can help plot a 3D heat map of the spot using image-based modelling. With the help of this map, firemen can strategize the rescue process and also know where fire extinguisher ball is to be dropped at the earliest. A thermal camera can also help detect stranded humans in fire during the rescue process.

Besides the fire department, the scope of the project is widespread. The features mentioned above can be incorporated with some additional functionalities to benefit other sectors of the society as well, namely-

● **Video Surveillance:** Using the camera module on raspberry pi, the drone can be used as a surveillance tool to monitor a specific area or any location.

● **Soil and field analysis:** Drones prove to be influential at the beginning of the crop cycle. It can produce precise 3-D maps for early soil analysis that can be used in planning seed planting patterns. After planting, the drone provides soil analysis information that provides data for irrigation and nitrogen-level management.

● **Irrigation:** Drones can identify which parts of a field are dry or need improvements with the help of thermal sensors. Along with this, drones also allow the calculation of the vegetation index, which describes the health and relative density of the crop, and show the heat signature, the amount of energy or heat the crop emits.

● **Road Maintenance:** The frequent detection of different types of road damage like cracks and potholes is a critical task in road maintenance. Manual visual inspection is not only

tedious, time- consuming and costly, but also dangerous for the personnel. With the help of drones equipped with ultrasonic sensors and cameras, the damaged areas will be easier to spot and the data would be much more reliable and cost efficient

7   Conclusion

The idea of firefighter drone will help to improve the response and reduce the time required to monitor an area and help a distressed civilian. The use of thermal and normal cameras for creation of 3D area and heat model will provide valuable insights that would help the firemen to devise an appropriate plan of action that would otherwise be difficult. Human and explosives detection using cameras can help the firemen find distressed civilians. Speaker and microphone provide additional communication functionality. Using Fire Extinguisher Ball, fire in a particular area can be reduced and an entry or exit route can be created. The toxicity reports generated by the gas sensors can also help the firemen protect themselves. The cameras, sensors and other hardware used to make the drone are cost effective so that the drone would be affordable for the Fire-Fighter Department.

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