

Forest Fire Detection using IoT Enabled Drone

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Abstract—Fire outbreak has been a common issue in forests and large buildings. In this research we are using a drone to detect forest and building fires which uses the techniques of image processing and video processing. Our research can be divided into three main modules. The first module focuses on the cloud service ThingSpeak to perform data analysis. The Data collected by the drone, with the help of flame sensor attached to Arduino, is transferred to ThingSpeak. This is achieved through the esp8266-01 wifi module attached to Arduino. The second module is based on image processing. With the help of inbuilt camera module, the drone captures real time images and image processing is done on that image using google API. The algorithm uses content based image retrieval and detects whether fire is caught inside the image or not, along with its intensity. The algorithm also detects the objects present nearby the fire. Hence if people are present or trapped nearby the fire we can detect them and prioritize the areas which needs immediate attention. The third module focuses on video processing. The algorithm detects fire based on the color of the pixels captured. All the three modules are together integrated in this research to boost up the accuracy of fire detection by the drone. Uniqueness of this research is that it comprises of 3 different modules each having different but inter-related functions. All three modules boost up the fire detection accuracy and can thus help in saving lives.

Index Terms— ThingSpeak, Arduino Uno, Flame sensor, Esp8266-01, Drone, Camera module, Image processing, Video processing, Google API, Content based image retrieval.

I. INTRODUCTION

In the modern era, drone technology is becoming very popular and is proving to be very effective in almost every field. Cases of forests and buildings catching fire are running rampant throughout the country. Many times they remain undetected or untimely detected due to area isolation or any other reason. Sometimes more than one place catches fire and the need arises to decide which area to prioritize. People caught inside buildings are not detected because they may have passed out or are not visible to the naked eye. Hence a problem may arise that the area which has no citizens trapped inside it is given the first priority. This may result in civilian casualties. With the help of our proposed system those lives can be saved. The live images and videos captured by the drone undergo image processing [2] [3] using google API. The analysis tells us whether there are people present nearby the fire [5] [4]. Hence that area can be given higher priority. Flame sensors attached to Arduino Uno which is attached to the drone, first detects the fire and send the data to ThingSpeak [7] using Esp8266-01 [1]. There the data is analyzed and graph is plotted. The accuracy of the sensor is increased using image and video processing [2] with the help of the inbuilt camera module and google API.

II. RELATED WORKS

A. Unmanned Aircraft Systems (ICUAS), 2017, IEEE Xplore, IEEE

ICUAS focused on very challenging and timely topic of network unmanned systems. Challenges to be faced and overcome include, robust and fault-tolerant systems, see-and-avoid systems, flight control systems, payloads, communications, level of autonomy, manned and unmanned swarms, and network controlled swarms. Unmanned aerial vehicle (UAV) based on computer vision is becoming more and more prominent for forest fire detection. Image processing algorithms like histogram-based segmentation and optical flow approach for fire pixels detection are one of the few used for fire detection. This is becoming more popular worldwide in order to preserve natural resources and protect human safety and property. Data science for decision aiding is also being incorporated in the drone technology in order to make it pilot free. Through this the drone can detect obstacles and itself avoid those obstacles.

B. Parallel, Distributed and Network-Based Processing, 2007. PDP'07. 15th EUROMICRO international conference, IEEE Xplore, IEEE

Illegal migration as well as wildfires constitute commonplace situations in southern European countries, where the mountainous terrain and thick forests make the surveillance and location of these incidents a tall task. This territory could benefit from Unmanned Aerial Vehicles (UAVs) with optical and thermal sensors in conjunction with sophisticated image processing and

computer vision algorithms, in order to detect suspicious activity or prevent the spreading of a fire. Taking into account that the flight height is about two kilometers, human and fire detection algorithms are mainly based on blob detection. For both processes thermal imaging is used in order to improve the accuracy of the algorithms, while in the case of human recognition information like movement patterns as well as shadow size and shape are also considered. For fire detection a blob detector is utilized in conjunction with a color based descriptor, applied to thermal and optical images, respectively. Unlike fire, human detection is a more demanding process resulting in a more sophisticated and complex algorithm. The main difficulty of human detection originates from the high flight altitude. In images taken from high altitude where the ground sample distance is not small enough, people appear as small blobs occupying few pixels, leading corresponding research works to be based on blob detectors to detect humans. Their shadows as well as motion detection and object tracking can then be used to determine whether these regions of interest do depict humans.

III. PROPOSED WORK

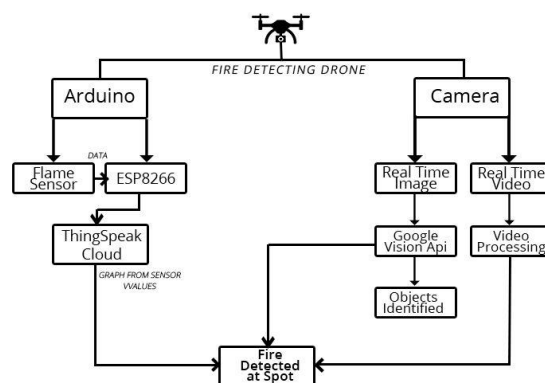


Fig 1 : Architecture

Hardware Details

A. Arduino UNO

Arduino Uno is truly outstanding and easily programmable microcontroller board [8]. It has fourteen digital input/output pins, a sixteen megahertz ceramic resonator, half -dozen analog inputs, an ICSP header, a USB connection, a power jack, and a reset button. It is programed using a USB cable connected to a computer. After programming it can also be used without the USB with the help of a battery. The Uno uses Atmega16U2 which is programmed as a USB-to-serial converter. Its operating voltage is 5V.

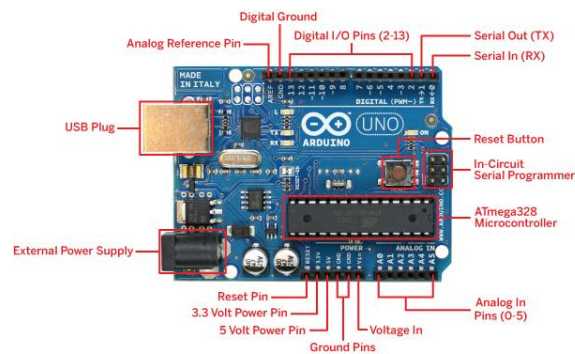


Fig 2 : Arduino Uno

B. Flame Sensor

The flame sensor detects IR (Infrared) light wavelength between 760nm – 1100nm [9]. Most of the flame sensors comes with YG1006 sensor which is a high speed and high sensitive NPN silicon photo transistor. There are two types of flame sensors. One with three pins and the other with four pins. In our research we have used the one with three pins.

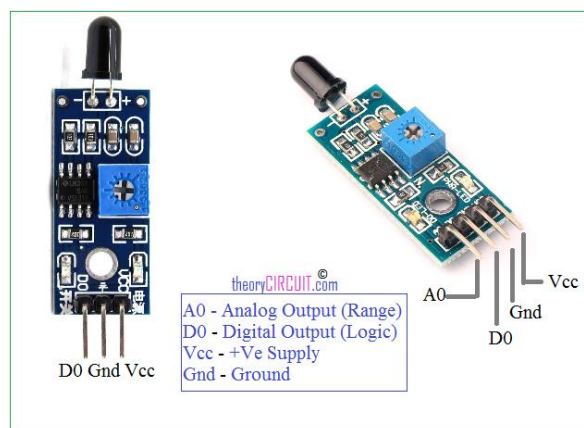


Fig 3 : Flame sensor

C. ESP8266-01

ESP8266-01 is a very low cost WIFI enabled chip. It is the smallest ESP8266 module and has only 8 pins. Out of these 8 pins, 4 are for I/O and the other 4 are needed for the operation of the module.

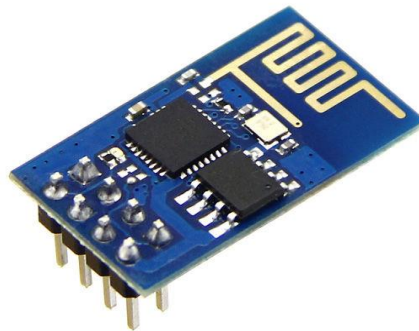


Fig 4 : ESP8266-01

Implementation

The flame sensor and the ESP8266-01 module is connected to the Arduino microcontroller for recording sensor data and sending it to ThingSpeak [1]. The Arduino is then attached to the body of the drone. The drone on coming near to a fire senses it with the help of the flame sensor and sends the data via the WIFI module [1]. Image processing and video processing comprise the other two modules.

A. Module 1

The flame sensor is first connected to Arduino Uno. After this the esp8266-01 WIFI module is connected to the microcontroller. The entire setup is then attached to the drone. During its flight, initially the flame sensor records no data. As soon as the drone comes in the vicinity of a fire the flame sensor immediately catches the infrared radiations of the flames and records the intensity of the flames according to the distance of the drone from the fire [11]. The recorded data is then sent to a cloud platform called ThingSpeak [7] via the Esp8266-01 WIFI module [1]. On things speak the data is analyzed in a user friendly environment. The data is represented in the form of flame intensity vs time graph. This informs us that the drone has detected a fire and we can view its intensity.

B. Module 2

Module 2 comprises of image processing [2] [3] using google API. There is an inbuilt camera module present in the drone. On capturing the image of the area under fire, the drone sends the image for image processing. Content based image processing is performed [2] [3] using google API. Through the algorithm the intensity of the flame is produced as output along with the nearby objects present. With the help of this system we can identify whether people are trapped inside the building or the forest fire. This will help us to prioritize the area for rescue and prevent civilian casualties. This is the main purpose of this module.

C. Module 3

The main purpose of module 3 is to further improve the accuracy and the efficiency of the other two modules. Module 3 comprises of the video recording feature of the drone and its processing [1] [4] [5] using Opencv library of Python. In the algorithm we are processing the video frame by frame, where the noises from each frame are removed by smoothing each frame [13]. RGB color model is used for the detection of red color information in image [4] [5] [1]. In fire color detection, R should be

more stressed than the other components. Hence R becomes the dominating color channel in an RGB image for fire. R should be over some predefined threshold value. RTH and R should be greater than B as well as G [4] [1]. Then the result is converted to HSI color model where H represent hue, S represent saturation and I represents intensity [5] [1]. We have then applied Sobel edge detection technique [12] [13] to find the edge as well as the growth of the fire. In the final step we segment fire from the non-fire background by applying a distance formula which if less than a particular threshold value is added to the fire region [13]. The algorithm is explained in the flowchart below:

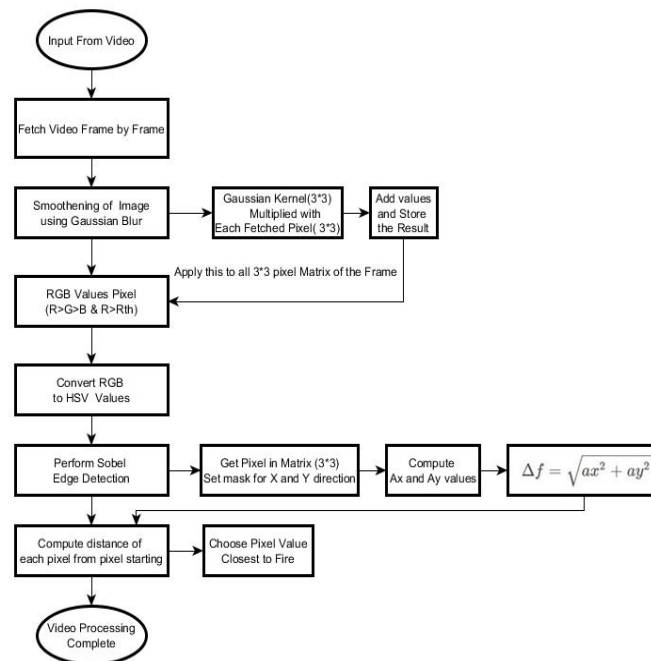


Fig 5 : A flowchart of the video processing algorithm.

In the above mentioned algorithm, $Ax = (Z_7 + 2*Z_8 + Z_9) - (Z_1 + 2*Z_2 + Z_3)$ and $Ay = (Z_3 + 2*Z_6 + Z_9) - (Z_1 + 2*Z_4 + Z_7)$, where Z is the element of the 3x3 pixel matrix.

IV. RESULT ANALYSIS

Various outputs in the form of graphs and photos are incorporated in this research. The graphs are generated using ThingSpeak. The photos incorporated here are captured from the drone on a sample fire which we ignited. Results from video processing and image processing are also mentioned.

Fig 6 was obtained from ThingSpeak. The flame sensor sends its readings to ThingSpeak. The values range from 0 to 1024. If the value is 1024 then it means that there is no fire. As the sensor comes near the fire or the flame intensity increases, the reading values decreases.

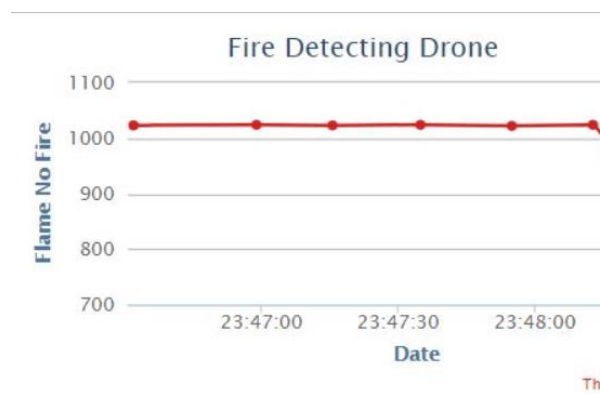


Fig 6 : graph depicting no fire, obtained from ThingSpeak.

Fig 7 was also obtained from ThingSpeak. It shows that there is a fire nearby the drone. The value of the graph initially decreases which shows that the sensor is close to the fire, i.e, the intensity of the fire is high. After this the value increases and then decreases. This shows that the intensity is decreasing and increasing depending upon the distance of the flame sensor from the fire.

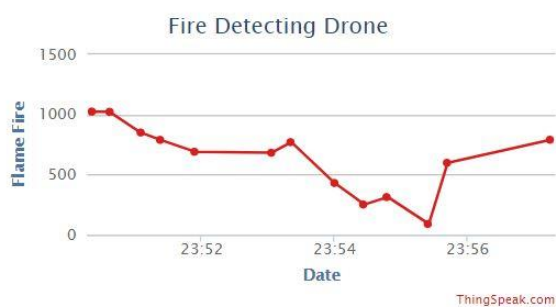


Fig 7 : Graph depicting fire and its changing intensities, obtained from ThingSpeak.

Fig 8 was obtained as a result of the video processing [4] [5] algorithm in module 3 which was used to further improve the efficiency of module one and two. The algorithm blackens all the pixels other than the flame pixels. This helps in distinguishing the fire from other objects and analyzing the spread of the fire properly.

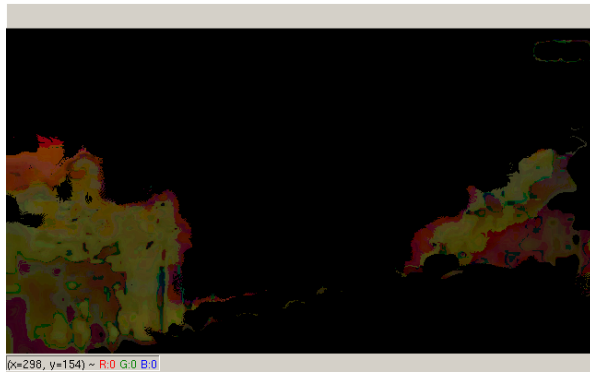


Fig 8 : Spread of the fire

The figure was obtained as a result of the video processing algorithm [4] [5] of the live video fed to it by the drone. The visible pixels (orange, red, yellow) [5] are the flame pixels which distinguish the fire from other objects which have not yet caught fire.

Fig 9 was obtained as a result of image processing [2] [3] done on the image caught by the drone. The output of the algorithm is displayed in the terminal. The result shows 88.53% flame intensity. This is the average intensity of the entire fire. in the next line, 94.89% is the maximum intensity of the fire recorded by the drone.

```

akay@akay-PC:~/Desktop/vision$ python vi.py
FIRE DETECTED IN THE IMAGE
Description is >> fire >> Value of Intensity of fire in Image >> 88.53%
94.89%
akay@akay-PC:~/Desktop/vision$

```

Fig 9 : Output of the image processing algorithm displayed in terminal.

Fig 10 and Fig 11 are the image and the screenshot taken from the video caught by the drone. They were fed to the image processing and the video processing algorithms.



Fig 10 : Image caught by the drone



Fig 11 : Screenshot of an instance of the video captured by the drone.

V. CONCLUSION

Internet of Things provides various benefits to the society and incorporating other features with it results in good quality of results. The ThingSpeak cloud service proved to be a very efficient tool for data analysis part of internet of things. It is an easy accessible platform. Esp8266-01 Wi-Fi module which was used to send data to ThingSpeak proved to be the most basic and cheaply available Wi-Fi module. Through our research we were able to obtain successful results as the fire which we lit was perfectly recognized by the image and video processing algorithms. The video processing algorithm also distinguished the fire from the other nearby objects. Hence this technique can be incorporated over a wider scale by using more powerful drones. This will help in saving lives of the people who are trapped in fire inside buildings or any other areas.

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