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FIRE DETECTION USING INFRARED IMAGES FOR UAV-BASED FOREST FIRE SURVEILLANCE

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Abstract: The paper presents an unmanned aircraft system, consisting of several aerial vehicles and a central station, for forest fire monitoring. Fire monitoring is defined as the computation in real-time of the evolution of the fire front shape and potentially other parameters related to the fire propagation, and are very important for forest fire fighting. The paper shows how an UAS can automatically obtain this information by means of on-board infrared or visual cameras. This project uses a simple fire detection Matlab algorithm based on thresholding to detect forest fire. The system is designed in a way that in future complicated detection algorithms can easily be integrated with the system. Moreover, it is shown how multiple aerial vehicles can collaborate in this application, allowing to cover bigger areas or to obtain complementary views of a fire. The paper presents results obtained in experiments considering actual controlled forest fires in quasi-operational conditions, involving a fleet of three vehicles, two autonomous helicopters and one blimp.

Index Terms: **Fire Detection, Infrared & Visual Cameras, Internet of Things, Neural Networks**

INTRODUCTION

Forest fires are an immense burden to the environment, infrastructure, economy, and most importantly, human life around the world. In 2012, the United States spent an excess of $1.2 billion dollars trying to suppress fires that claimed over 9.3 million acres of land, 2,216 residences, 1,961 outbuildings, and 67 commercial structures. Early detection of forest fire can drastically reduce the loss. . The integral part of the ecological role of the forest fires is formed by the controlling factors like the plant community development, soil nutrient availability and biological diversity. Fires are considered as a significant environmental issue because they cause prominent economic and ecological damage. This project is an effort to build an automated real time early warning system as a measure to prevent forest fires, through detecting early signs of fire. Since this project is more focused on building a fully functional demo of the system that could use any fire detection algorithms rather than focusing on just building a fire detecting algorithm as done in the past, a simple thresholding technique is being applied to the imagery data from the camera to detect fire in the scene within a second. Finally, an automated warning alert is sent out.

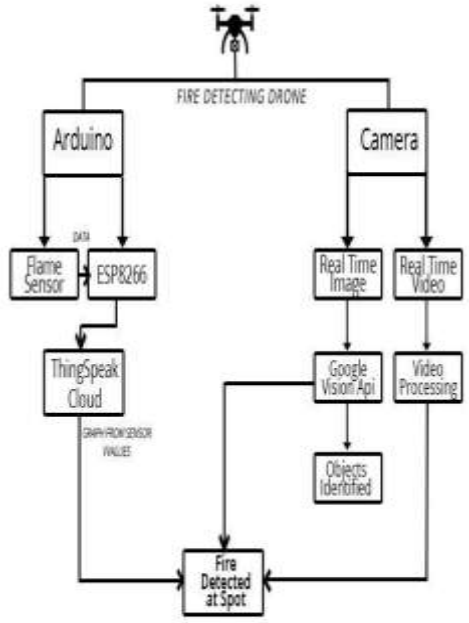

Fig 1: Working of Fire Detecting Drone

PROBLEM STATEMENT

As we know fire spreads very vastly in forests due to this it causes a very large destruction and ultimately there is a huge loss to rescue. In order to eliminate this kind of situation we have designed drones as they will reduce manpower and time and will save our forests in lesser time is will also reduce our cost. These drones work upon the mechanism of fire detection Matlab algorithm based on thresholding to detect forest fire in this multiple aerial vehicles can collaborate in this application, allowing to cover bigger areas and to obtain complementary views of a fire.

RELATED WORK

There are a large number of approaches that has been developed to detect forest fire.

They are as follows-

Pablo Chamoso *et al*., proposed that UAVs can be used in fire control due to their ability to man over rapidly and their wide range of operation. Its main use is incombatting fire. Special emphasis is placed on fire detection techniques using computer and infrared computer techniques, as well as the hardware systems that drones must incorporate to perform this task.

Chi Yuan *et al*., (2016) proposed that earlier forest fire alarm systems were critical in making prompt response in the event of unexpected hazards. Then Cost-effective cameras, improvements in memory, and enhanced computation power have all enabled the design and real-time application of fire detecting algorithms using light and small-size embedded surveillance systems. Both color and motion features of fire are adopted for the design of the studied forest fire detection strategies.

Vladimir Sherstjuk *et al*., (2018) have worked upon tactical forest fire-fighting operations based on a team of unmanned aerial vehicles, remote sensing, and image processing. Functions and missions of the system, as well as its architecture have been taken into account. The image processing and remote sensing algorithms are presented, a way for data integration into a real-time DSS is proposed.

RESULT AND ANALYSIS PROCESS FOR FIRE DETECTION

In our proposed Fire Detection System, we detect the fire based on the various parameters and condition as shown in Fig. 2. Flowchart. Firstly, our system extracts videos of the environment on a real-time basis, in every 2 seconds. These video then go through the detection techniques of : Area detection, Color detection, Motion detection and Smoke detection.

For detection purpose two consecutive frames are considered at a time, to make corresponding comparison and analysis. The captured video first go through Area detection, where the area under fire is detected in by converting RGB into HSV color space. After area detection we go further for Color detection. In Color detection the RGB components of the captured image are separated and also it is converted from RGB to YCbCr color space. Then based on various comparisons in RGB and YCbCr color space and also, using thresholds which we have decided by experimental evaluations, color detection is done. Then we go for motion detection, where we convert the 2 frames from RGB into gray and after comparison we check for the mean motion threshold, which is decided after experimental evaluation and motion detection is done. For Smoke detection, we keep the extracted images in RGB color space and based on the decided smoke threshold and evaluated mean threshold the frames are processed and smoke detection is done.

On the start of monitoring, after going through the mentioned detection techniques, the condition is checked to give final discretion that fire is detected or not, depending on which the alert alarm is turned ON.

This algorithm is based in the fact that visual color images of fire have high absolute values in the red component of the RGB coordinates. This property permits simple threshold-based criteria on the red component of the color images to segment fire images in natural scenarios. However, not only fire gives high values in the red component. Another characteristic of fire is the ratio between the red component and the blue and green components. An image is loaded into color detection system. Color detection system applies the specific property of RGB pixels and gives the output result as an image with a selected area of color detection. Rule based color model approach has been followed due to its simplicity and effectiveness. For that, color space RGB and YCbCr is chosen. For classification of a pixel to be fire we have identified seven rules. If a pixel satisfies these seven rules, we say that pixel belong to fire class.

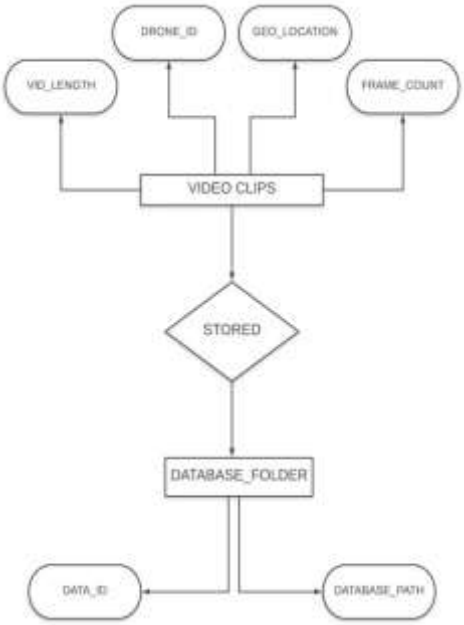

Fig-2 data flow diagram

Steps:

Convert frames into JPG images from video file

Convert JPG to RGB modeling

Convert RGB to HSV image

Combine results from Step III and Step VI

Apply segmentation and GOTO step VIII

Apply Sobel Edge Detection on images comes out from step II

GOTO Step IV

Store result into database for current working image

Repeat Steps II to Step VIII for at least 50 images

Detect fire in motion in all processed image data

Results

Algorithm:-

Sobel Edge Detection:-

Introduction: -Edge Detection is when we use matrix math to calculate areas of different intensities of an video. Areas where there are extreme differences in the intensities of the pixel usually indicate an edge of an object. After finding all of the large differences in intensities in a picture, we have discovered all of the edges in the picture. Sobel Edge detection is a widely used algorithm of edge detection in video processing. Along with Canny and Sobel is one of the most popular edge detection algorithms used in today's technology [1].

The Math behind the Algorithm

When using Sobel Edge Detection, the video is processed in the X and Y directions separate first, and then combined together to form a new video which represents the sum of the X and Y edges of the video. However, these images can be processed separately.

When using a Sobel Edge Detector, it is first convert the image from an RGB scale to a Grayscale image. Then from there, we will use what is called kernel convolution. A kernel is a 3 x 3 matrix consisting of differently (or symmetrically) weighted indexes. This will represent the filter that we will be implementing for an edge detection process.

When we want to scan across the X direction of an image for example, we will want to use the following X Direction Kernel to scan for large changes in the gradient. Similarly, when we want to scan across the Y direction of an image, we could also use the following Y Direction Kernel to scan for large gradients as well.

Fig-6 is the original image that was used in this project[1] Fig:7 Use Sobel Edge Detection[1]

In the fig we use the first step to using Sobel Edge Detection is to convert the image to grayscale. While it is possible to use the algorithm in standard RGB scale, it is easier to implement in a grayscale. Below is the grayscale image.

Fig-12 Edge Detection

3.3 Program outputs:

Here, we have shown the actual snapshots of our program output for each evaluating Parameter and for all conditions together.

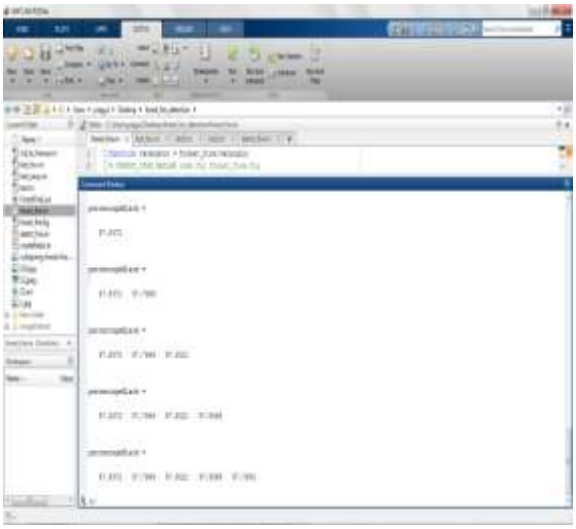

Fig 14 for different value present in program

In this fig 14 we find the different value of video we enter the program and then we find the many of images form of this video. And we detected the fire on that area.

Detected Fire with step wise process:-

Fig 17 Original image

This fig 17 is actual image we process them on this image with the help of RGB color we see next pic.

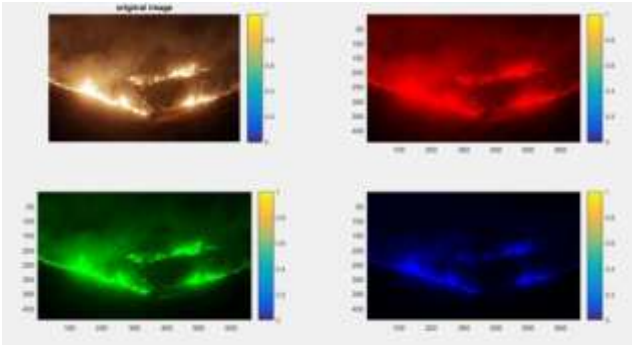

Fig 18 RGB Color

This fig 18 define the R (red) G(green) B(blue) color that define the color of fire on that area.

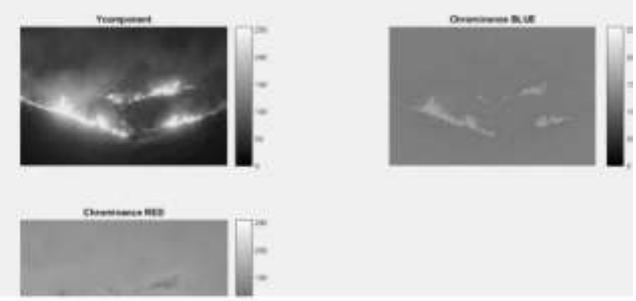

Fig 19 filtered image

This fig 19 that is filtered image proceed by the RGB color process.

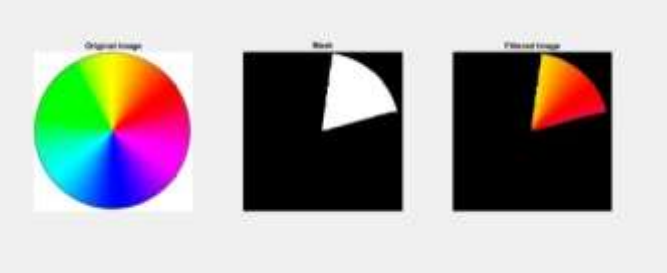

Fig 20 code to find original image

This fig 20 see the picture that is color of wheel to find the actual code we find the fired image of particular images that we proceed on the function.

4. FACTS AND FIGURES

There have been a lot of destruction done by fire all around the world. It is a cause of a natural disaster. When the forest catches fire somewhere, it is not easy to locate it initially. But, as it moves through the forest taking most of the forest cover area under fire, it, then, takes a huge form and this leads to a lot of destruction to flora and fauna life of the forest. Homes to many animals are destroyed and these animals comes in the city or village area which then disturbs the social life of humans. So, to save ourselves from various kinds of discomfort, it is very necessary that the fire should be detected at very initial stages and should be controlled as soon as possible.

In this paper, we are representing few figures and data that show how intense and furious is the effect of fire when it moves heavily through the forests:

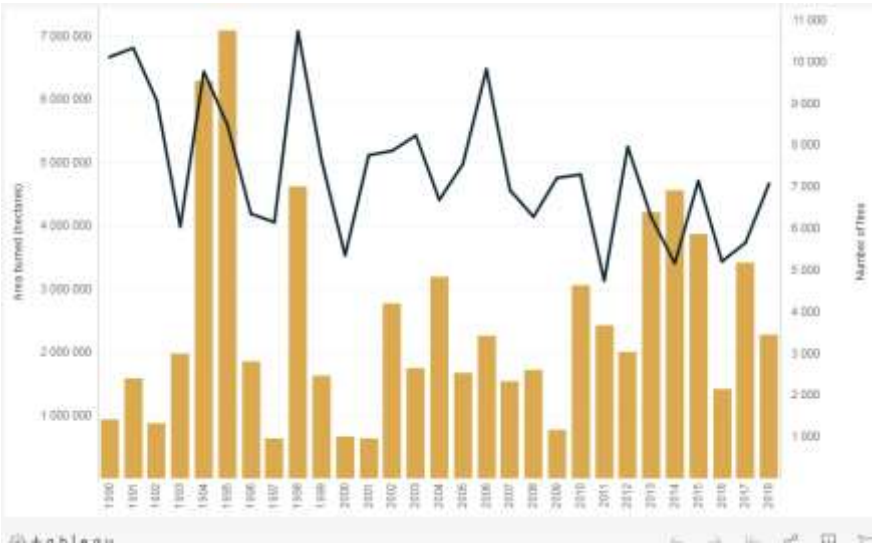

Fig. 21 – Area burnt by fire during various years

The above figure tells about the area that gets destroyed due to forest fires.

Number of fires by user specified groupings

Jurisdiction	Cause	Response category	Protection zone	1990	1991	1992	1993	1994	1995	1996	1997	1998	199
Alberta	Forest industry	Full	Intensive	22	14	12	11	13	14	8	29	10	2
			Limited										
		Modified	Intensive										
			Limited										
		None	Intensive										
			Limited										
	Incendiary	Full	Intensive	32	73	56	38	40	56	10	16	42	2
			Limited										
		Modified	Intensive										
			Limited										
		None	Intensive										
			Limited										
	Lightning	Full	Intensive	914	466	626	517	499	357	217	242	1 192	89
			Limited										

Fig. 22 – Number of fires under various categories

4. CONCLUSIONS & FUTURE WORK

This project, Fire Detection System has been developed using Image Processing and Matlab software. This system has the ability to apply image processing techniques to detect fire. This system can be used to monitor fire and has achieved 90% accuracy for single webcam. The system works on real time, as it extracts frames in every 2 seconds, it provides continuous monitoring. This system has high efficiency as it has incorporated techniques of Area detection, Color detection, Motion detection, and Smoke detection as well as Humidity and Temperature detection. For better performance outcomes use of RGB, HSV and YCbCr color space is made in the detection techniques, as per their suitability, efficiency and properties. The different parameters like threshold value, blind spots will be handled properly in our future research. Thus application of proposed fire detection system gives us a better system performance in term of fewer false alarms and thus a higher system performance is achieved.

For further accuracy use of Neural Networks for decision making can be made and GSM module can also be implemented for sending SMS to nearby fire station in case of severe fire. Water sprinklers can also be incorporated. By research and analysis, the efficiency of the proposed Fire detection system can be increased. The margin of false alarms can be reduced even further by developing algorithms to eliminate the detection of red colored cloth as fire. By proper analysis, suitable location height and length for camera installment can be decided, in order to remove blind-spot areas.

6. REFERENCES

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