Forest Fire Detection Using UAV Images and Videos

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Declaration of Authorship

This is to certify that the work presented in this thesis is the outcome of the analysis and experiments carried out by Imam Mosharaf and Md. Akhlaq Rifat Rahman under the supervision of A. B. M. Ashikur Rahman, Assistant Professor, Department of Computer Science and Engineering, Islamic University of Technology (IUT), Dhaka, Bangladesh. It is also declared that neither of this thesis nor any part of this thesis has been submitted anywhere else for any degree or diploma. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

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Dedicated to our Parents and Teachers

Abstract

Forest is considered as one of the most important and indispensable part of a country. At least 25 of the total land area of a country should be forest in order to maintain the perfect ecological balance. Because of the climatic condition of that part of the world, this is a very common scenario in those countries and a constant threat. This happens randomly throughout the whole year. Still no one has invented any method to detect or predict forest fire before its occurrence. So we can't stop it from happening when it occurs due natural causes. But if early detection can be made, we can save a lot of wild lives as well as we can get rid of mass destruction. Our main target there is to detect the fire at a very early stage to take proper measures to stop it from spreading. In this paper we used videos of fire regions. But the detection method is image based. We segmented the video into images and detected fire from those images based on some definite experimental rules. Finally the decision is made based on the threshold values of fire pixels. We went through several filter threshold values in order to minimize the false alarm rate and provide the best possible outcome.

Acknowledgement

It is an auspicious moment for us to submit our thesis work by which are eventually going to end our Bachelor of Science study. At the very beginning, we want to express our heartfelt gratitude to Almighty Allah for his blessings bestowed upon us which made it possible to complete this thesis research successfully. Without the mercy of Allah, we would not be where we are right now.

We would like to express our grateful appreciation to A.B.M Ashikur Rahman, Assistant Professor, Department of Computer Science and Engineering, Islamic University of Technology for being our adviser and mentor. His motivation, suggestions and insights for this thesis have been invaluable. Without his support and proper guidance, this thesis would not see the path of proper itinerary of the research world. His valuable opinion, time and input provided throughout the thesis work, from the first phase of thesis topics introduction, research area selection, proposition of algorithm, modification and implementation helped us to do our thesis work in proper way. We are grateful to him for his constant and energetic guidance and valuable advice.

We would like to extend our vote of thanks to all the respected jury members of our thesis committee for their insightful comments and constructive criticism of our research work. Surely they have helped us to improve this research work.

Last but not the least, we would like to express our sincere gratitude to all the faculty members of the Computer Science and Engineering department of Islamic University of Technology. They helped make our working environment a pleasant one by providing a helpful set of eyes and ears when problems arose.

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Chapter 1

Introduction

In this chapter, we first present an overview of our thesis that includes the signification of the problem and the problem statement in detail. Research challenges to be faced in the whole scenario is also discussed based on the problem statement. Thesis objectives, motivations and our contribution are noted in sections. The end of this chapter has the description of the organization of the thesis.

1.1 Overview

Forest is considered as one of the most important and indispensable part of a country. At least 25 of the total land area of a country should be forest in order to maintain the perfect ecological balance. In Bangladesh about 17.5 forest is prevalent which is not sufficient enough. In the western areas the portion of the forest is large but they have a serious problem of wildfire or Forest fire. Because of the climatic condition of that part of the world, this is a very common scenario in those countries and a constant threat. This happens randomly throughout the whole year. Still no one has invented any method to detect or predict forest fire before its occurrence. So we can't stop it from happening when it occurs due natural causes. But if early detection can be made, we can save a lot of wild lives as well as we can get rid of mass destruction. The main problem here is that once the forest fire has started then it spreads so fast by wind and lots of dead leaves or trees resting in the forest. Even fire fighters can't reach there due to extreme heat of the fire created. Again in remote areas of the forest, it can never be reached with newly invented more effective firefighting technologies. So usually we have to use helicopters or fire fighter planes or drones to reach the fire zone. This costs a lot of time and money. There is no reliable method to detect it at an early period correctly to stop it from spreading. So our main target there is to detect the fire at a very early stage to take proper measures to stop it from spreading.

1.2 Motivation

As we have given the topic digital image processing for research purpose and there are many sectors of it but we wanted to work on environment related topics. We have seen that this topic has been explored least than any other environment related topics using computer vision. Moreover, wildfire has become one of the trending issue to be noticed in recent years. The largest wildfire caused in May 9, 2012 in Catron County burned through a total of 297,845 acres of the Gila National Forest. It took more than 1,200 firefighters to get rid of this fire. Later on, after analysis it was seen that the blaze started from two separate fires caused by lightning strikes, and finally they joined to form the massive blaze. Had they been able to detect the fire earlier, this damage would have never occurred. In 2016, in New Zealand, the alarming pace of destruction was 51 percent higher than the prior year with a loss of 73.4 million acres. Deadly blazes in Brazil and Indonesia were among those contributing to the loss. If we add up the total acreage from 2013 through 2018 we get 5,395,088 acres only in California. These reasons mainly drove us to work on this field to find a reliable proposal.

1.3 Problem Statement

Our main target is here to detect fires at a beginning stage with most possible accuracy and reduced false alarms. So at the beginning we researched on the image processing for detecting fires. But then some new possibilities of false alarms came. So we considered to process on videos too. But our main project was on image processing. So we segmented the videos into several images. Then processed on these images to detect fire in a forest. Based on the recent literature we derived that processing on images rather than videos gives better results.

The primary goal of our thesis is "Determining the presence of fire based on the images we derived from the videos through UAVs". There are a lot of existing methods to detect fire from images as well as videos. Here we focused on determining the fire from images which is found from segmenting the videos.

And we skipped using Deep Learning Method due to insufficient data-set, resources and complexity. We implemented the algorithm using some experimental threshold values. And it provided us the final output.

1.4 Research Challenges

The developed methodologies should satisfy the following criteria:

1. Work on frames of videos rather than still images. Most of the implementations are based on fire detection from image. We focused on determining the fire from videos that will make our claim more rigid.

2. Figuring out the fire detection rules on a single pixel from different experiments with highest success rate. Fluctuation of fire pixels is a very common characteristics of fire. We considered this criteria.

3. Work on Different color models in detecting fire pixels. It helped filtering at different layers.

4. Threshold maintaining for optimized result in another concern.

5. Clear and enriched dataset is another very important concern.

6. Error optimization must be taken into consideration.

1.5 Contributions

In this thesis, we presented a new implementation for detecting fire from a video, if exists. Here we followed a set of rules collected from several papers and merged them altogether along with our own set of rules. A brief overview of the contributions of this thesis is as follows:

1. We combined the rules those give most optimum result, given in several research papers on fire detection in order to optimizing the detection from a still image. We had to merge different rules provided by different implementations.

2. We took consideration of videos as because processing on just still images gives false alarms on similar images like fire-like images and caution signs of fire or a big tree with fire colored leaves.

3. We segmented the videos into image frames upon which the further processing was implemented to detect the fire pixels.

4. Old feature representations methods like mean and standard deviation have been rejuvenated to be combined and used with our feature representations.

5. We figured out the threshold values for the fire pixel detection from the seven rules provided in the implementation of Vipin V et al. Then we determined the threshold value for standard deviation of intensity which provided us the second layer checking of fire pixels. We had to determine one final threshold value of the fire pixel ratio in the complete image for final decision making.

6. Created our own data-set with positive and negative videos of fires.

7. It provides us more robust output than the existing implementations. Moreover, the computational complexity is also less and it requires very basic resources with no extra facilities.

1.6 Thesis Organization

On the following section, we provide a literature review on forest fire detection. It focuses on the background studies of our concerned area and describes the pros and cons of the existing papers.
On the next section to literature review, we described our proposed methodologies. Here all the implementation details are discussed step by step along with necessary figures and descriptions.
After the implementation details, we showed our experimental analysis and comparison between our implementation and others. The confusion matrix was shown here.

Finally, the conclusion is provided with along with our limitations as well as future works.

Chapter 2

Literature Review

Fire detection has been a recently emerging issue in our recent world. Different implementation ideas have been proposed till now. Despite this, there is no reliable method to detect forest fire at an early period correctly to stop it from spreading. So our main target there is to detect the fire at a very early stage to take proper measures to stop it from spreading. We have focused on detecting mainly fire, flame and smoke by Digital Image Processing. The input provided in the process is Video from which frames are separated for further manipulation. We have summarized the proposals provided those have been done mainly without deep neural network. Lastly we conclude out discussion with our proposed methods and implementations and future works that will work as a reliable method for early fire detection based on Image Processing.

2.1 Background

2.1.1 Basic Studies

While implementing this paper, we had to deal with different image formats; namely RGB, HSI, YCbCr. So, let's have a brief discussion on each of these formats:

RGB

An RGB image, sometimes referred to as a truecolor image, is stored in MATLAB as an m-by-n-by-3 data array that defines red, green, and blue color components for each individual pixel. For further knowledge, we are referring to the appendix part.

HSI

The HSI (hue, saturation, intensity) color model, decouples the intensity component from the color-carrying information(hue and saturation) in a color image. For further knowledge, we are referring to the appendix part.

YCbCr

One of two primary color spaces used to represent digital component video (the other is RGB). The difference between YCbCr and RGB is that YCbCr represents color as brightness and two color difference signals, while RGB represents color as red, green and blue. For further knowledge, we are referring to the appendix part.

2.1.2 Related Studies

According to the experts, forest fire will halve the world forest stand by the year 2030. Even the Amazon, the world's most bio-diverse rainforest, was burning at a rate not seen in almost a decade. It was decried as a global tragedy. Lit by farmers, the fires raged through villages, destroyed ecosystems and pumped climate-warming pollution into the atmosphere. It has been a real huge loss for the whole manking as the whole world. It has become one the recent concerning issues in the current world.

Traditional fire protection methods that exist use mechanical devices or humans in order to monitor the surroundings. And another existing method is the use of sensors in order to detect the fire. And the parameters to trigger these sensors are fire and smoke detection techniques namely sampling, temperature sampling, and air transparency testing. An alarm is not raised unless the particles reach the sensors and activate them.

Some of the methods are mentioned below:-

Wireless Sensor Networks is one of the mentionable existing application. In a wireless sensor-based fire detection system, large area forest coverage is impractical due to the requirement of regular distribution of sensors in close prox-

imity. Also battery charge is a another big concern.
Fire Watch Towers are made to observe the location of fire through human guards. However, accurate human observation is greatly limited by operator fatigue, time of day, time of year, and geographic location.
Satellite and Aerial Monitoring is another major mentionable existing application to detect fire. Satellites based system can monitor a large area, but the resolution is low. Moreover the view from satellite can easily be hampered by cloud and large bodies covering the upper top of the affected regions. These systems are very expensive too. Weather condition will seriously decrease the accuracy.
Rapid growth of the electronics is another reason behind the motivation for an image processing based approach. Most of the cameras can be directly connected to the computer and store the captured images to the computer. Computer-vision-based systems can be utilized here.

2.2 Overview on Forest Fire Detection Methods

There are many related works on this topic. we have read papers on three basic topics on our research field. We have separated the whole research into 3 sections, namely:
• Fire detection
• Flame detection
• Smoke detection
Our main purpose here is to detect fire from the videos and images we got. For fire detection by using computer vision, at first the image frames are separated from the corresponding videos. Then the fire pixels in the frame are to be detected. So our first task here is to detect fire pixels. Different proposals have been proposed on fire pixel classification Using different methods. They have used different chrominance models to manipulate the images for required detection Like RGB, YCbCr, CIY. This section presents a brief overview of these methods.

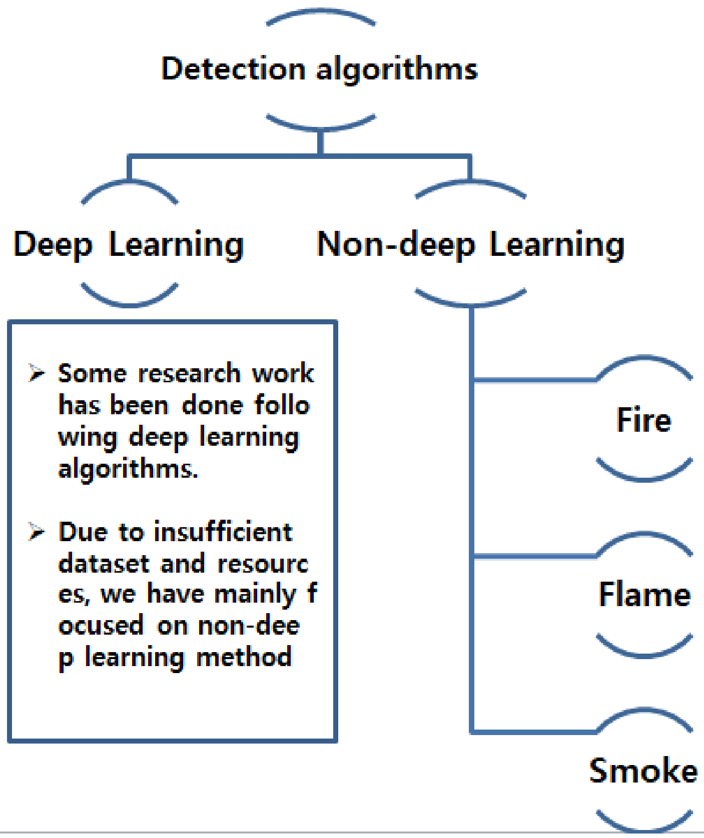

Figure 1: Existing Algorithms on Fire Detection

2.2.1 Fire Detection Methods

Here, we went through some papers on different writers which implemented in various different ways.
Vipin V et al. proposed rule based color model for fire pixel classification. It is our master paper hence we used the proposed seven rules for fire detection from an image.The proposed algorithm uses RGB and YCbCr color spac. They tested the performance of the proposed algorithm on two sets of images, one of which contains fire; the other contains fire-like regions. It is mentionable that the algorithm is cheap in computation and it can be used for real time forest fire detection. As per their proposal the proposed model achieves 99% flame detection rate and 14% false alarm rate. Kumarguru Poobalan et al. proposed a fire detection algorithm based on image processing techniques which is compatible to UAVs. The algorithm uses RGB colour model to detect the colour of the fire which is mainly comprehended by the intensity of the component R which is red colour. They showed an accuracy of 80.64%. Priyadarshini et al.

proposed an Image processing based forest fire detection using YCbCr color model. The method separates fire flame pixels as well as high temperature fire center pixels. They claimed that it achieved a 99.4% fire detection rate and 12% false alarm rate. Yusuf Hakan Habiboglu et al. used a a video based fire detection system that has been shown which uses color, spatial and temporal information. They claimed that their system is able to classify all video files containing fire, with a reasonable false alarm ratio in videos without fire.

2.2.2 Flame Detection Methods

Here we have discussed some papers that implemented the flame detection methods from videos and images which we used in our further implementation.

Ugur Toreyin et al. proposed a method where the procedure is maintained through video processing. They analyzed the video in wavelet domain. Temporal wavelet transform was used to detect quasi-periodic behavior in flame. Spatial wavelet transform was used to detect color variations in flame. They claimed that though there were a lot of clips with moving fire-like objects, it gave no false alarms in any of these sequences. They also tested with video clips containing 61 sequences containing a total of 83,745 frames. out of 61 sequences, 19 contained fire. And in this case the fire detection rate was 0.999 and false alarm rate was .001. Zhen Zhong et al. proposed an algortihm basing on Convolutional Neural Network (CNN). They used ordinary camera to capture video and further processed the video based on some CNN algorithms. Emphasis could be given to realizing the fire location and detection further which will increase the reliability.

2.2.3 Smoke Detection Methods

Jayavardhana Gubbi et al. proposed a smoke detection method using Wavelets and SVM. For testing purpose, they used Forest Fire, Tunnel Fire and News Channel Videos. Their The KNN classifier showed accuracies of 68.88% and 76.16% whereas the SVM classifier resulted in 63.21% and 88.75% accuracies with DCT and Wavelet features respectively. Qi-xing ZHANG et al. proposed a forest fire smoke detection using R-CNN. They focused on the effectiveness of using the smoke images to train CNNs. Since they used R-CNN to detect smoke, they didn't need to extract features manually. The processing speed is faster.

Now, from the aforesaid discussion, it is clear that Smoke and Flame detection methods are not very much reliable and produce ambiguous output. In case of deteriorated climatic conditions, fog can be classified as smoke as they seem alike if the particles are not examined. Flame also can't provide us rigid output like fire. Due to these limitations, we have focused on Fire Detection methods only. After analysing all these detailed algorithms on these three criteria, we have decided to work on fire detection.

Chapter 3

Proposed Methodologies

This chapter presents our proposed method to detect fire. We provided the implementation details in this section.

3.1 Overview

Here the following parts are divided into two major parts. In the first part we showed the implementation details of fire pixel classification from a single image frame from the video segments. In the second part we showed the final fire image detection with multiple step checking on different threshold values. The flow chart of our whole implementation is shown here.

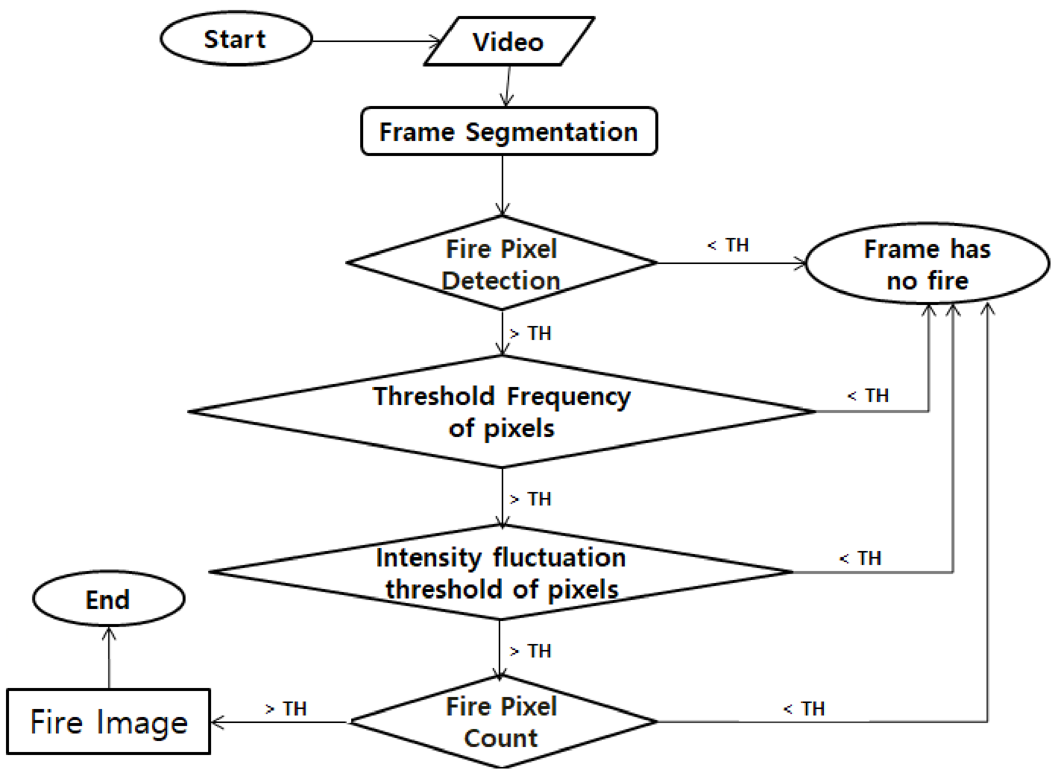

Figure 2: Flow Chart

3.2 Fire Pixel Detection from an Image Frame

In this level, we followed 2 steps:

3.2.1 Frame segmentation from video

At first we collected our sample dataset from different web sites containing wild fire and forest fire videos. We also collected videos from some reliable sites provided in papers. We included our own custom video that contains both positive and negative videos.

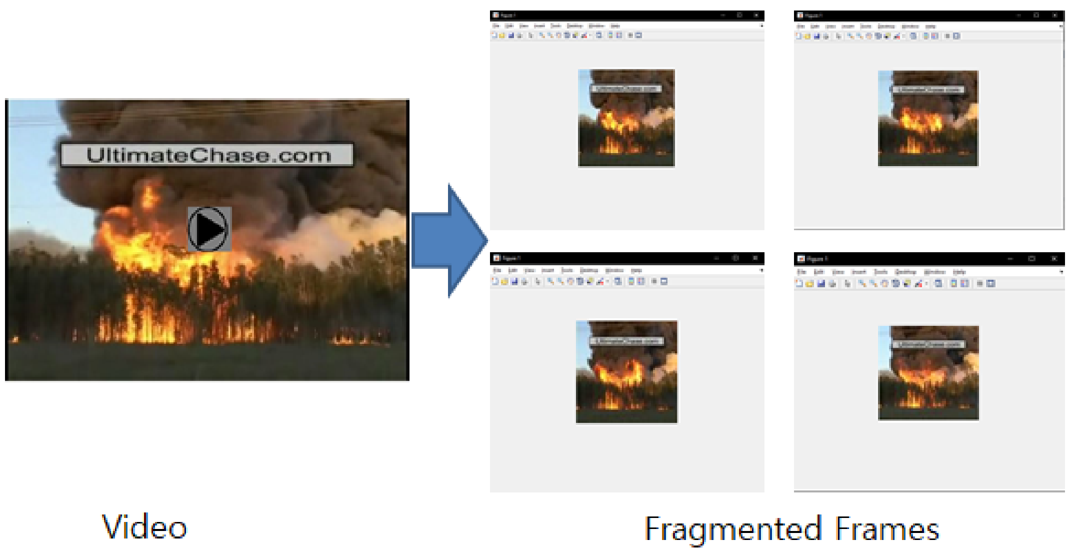

Figure 3: Image Segmentation from Video

After that we had to choose any definite video for processing. It may be positive or negative. Then we segmented the whole video into image frames. The segmentation provides us around 1500 frames for a 2 min video.

3.2.2 Fire Pixel Detection on Each Corresponding Frames

This step is one of the most important part of our algorithm. Here as input we took one image frame at a time. We iterated the whole image frame set and processed each image individually. After processing each image we saved the

output image for further processing.
The detailed explanation of the step is described briefly:

At first we checked the first two rules for all pixels. If any definite pixel passes these two rules, it'll be checked for rest five rules.

First two rules are applied on RGB image.

A. Rule I

From experimental value it is seen that for the fire regions, R channel has higher intensity values than the G channel, and B channel has the lowest intensity value among the three.
So the value of R component is the greatest followed by G and B values.

$$R_1(x,y) = \begin{cases} 1, \text{if } R(x,y) > G(x,y) > B(x,y) \\ 0, \text{otherwise} \end{cases} \quad \text{------- (1)}$$

Figure 4: Rule 01

B. Rule II

From the histogram analysis of the fire location, Vipin's paper suggested that there had to be some threshold values for the pixels to be fire. It holds for all the three components R,G and B.

$$R_2(x,y) = \begin{cases} 1, \text{if } (R(x,y) > 190) \cap (G(x,y) > 100) \cap (B(x,y) < 140 \\ 0, \text{otherwise} \end{cases}$$

$$\text{------- (2)}$$

Figure 5: Rule 02

The histogram analysis provides the proper outlook of this rule.
Combining the first and second rules, we get the following output.

Now the RGB image is changed to YCbCr format.Remaining five rules are applied on this image format.

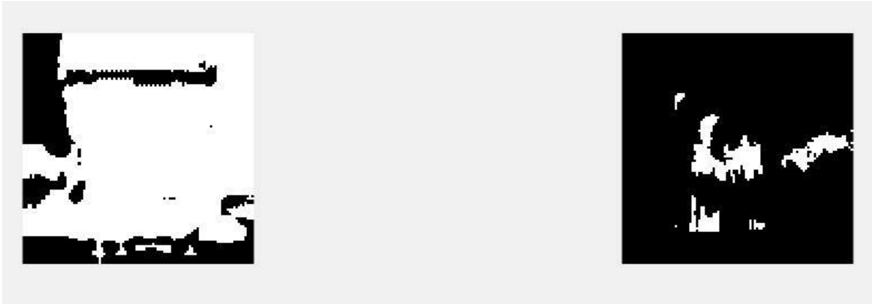

Figure 6: Combining rules 01 and 02

C. Rule III

Observing a large data set, it was figured out that the Y component of a fire image contains larger value or equal value than the Cb component.

If this criteria meets we assign the value to be 1. Else it'll be Zero.

$$R_3(x,y) = \begin{cases} 1, \text{if } Y(x,y) \geq Cb(x,y) \\ 0, \text{otherwise} \end{cases} \quad \text{-----} \ (3)$$

Figure 7: Rule 03

The output of rule 03 is provided in the following figure.

Figure 8: Rule 03 output

D. Rule IV

And it was also detected that the Cr component is greater than or equal to that of Cb component.

If this criteria meets we assign the value to be 1. Else it'll be Zero.

$$R_4(x,y) = \begin{cases} 1, \text{if } Cr(x,y) \geq Cb(x,y) \\ 0, \text{otherwise} \end{cases} \qquad \text{------ (4)}$$

Figure 9: Rule 04

E. Rule V

For the flame region the value of the Y component is bigger than the mean Y component of the overall image as proposed by Vipin. While the value of Cb component is in general smaller than that of the mean Cb value of the overall image.

Furthermore, the Cr component of the flame region is bigger than the mean Cr component. So, it leads us to this formula

$$R_5(x,y) = \begin{cases} 1, \text{if } (Y(x,y) \geq Y_{mean}(x,y)) \cap (Cb(x,y) \leq Cb_{mean}(x,y)) \\ \quad \cap (Cr(x,y) \geq Cr_{mean}(x,y)) \\ 0, \text{otherwise} \end{cases} \qquad \text{-------------- (5)}$$

Figure 10: Rule 05

F. Rule VI

For the fire pixel the Cb component is predominantly “black” (lower intensity) while the Cr component, on the other hand, is predominantly “white” (higher intensity); as explained by the paper by Vipin. Here, the value of Th is accurately determined according to a Receiver Operating Characteristics (ROC) Curve. It was shown that the detection rate is over 95% and false alarm rate is less than 30% (point c) which corresponds to Th = 70.

The combined output of rule 04, 05 and 06 is provided in the following figure.

$$R_6(x,y) = \begin{cases} 1, \text{if } |Cb(x,y) - Cr(x,y)| \geq Th \\ 0, \text{otherwise} \end{cases} \quad \text{---- (6)}$$

Figure 11: Rule 06

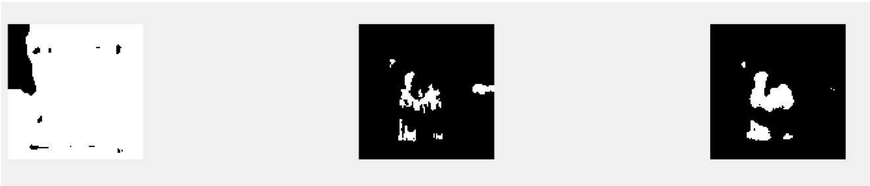

Figure 12: Rule 04, 05 and 06 output

G. Rule VII

The paper by Vipin V figured out the threshold values for Cb and Cr region for fire pixels. If both these conditions are met they are assigned as value 1. Else it will be zero. The output after applying rule 07 is provided in the following

$$R_7(x,y) = \begin{cases} 1, \text{if } (Cb(x,y) \leq 120) \cap (Cr(x,y) \geq 150) \\ 0, \text{otherwise} \end{cases} \quad \text{--- (7)}$$

Figure 13: Rule 07

figure.

Some output of images after applying all these rules is provided.

3.3 Presence of Fire in the Video

In this level, we followed 5 steps:

3.3.1 Frequency of pixels having fire

We counted the frequency of each pixels for all the image frames. Here if a definite pixel of a frame has been detected as fire pixel it will be assigned the value. Else it will be zero.

So, we summed up the corresponding pixel values of each frame altogether.

Figure 14: Rule 07 output

Figure 15: Combined output

Let (x,y) be a definite pixel. After calculating the frequency if the value of (x,y) is m; it means that definite pixel has been detected as fire pixel in m frames out of all the frames.

Here a grey scale image found after plotting the frequency of each pixel is provided. The region having dark color indicates the fire containing region. And the variation in intensity defines the variation in their respective values.

Figure 16: Image from frequency matrix

3.3.2 Determining Frequency Threshold Value

Here the threshold of the frequency value for the fire pixel detection is determined. Here we calculated the percentage of total number of times a pixel is detected as fire pixel from the predetermined frequency value.
Here, percentage_value = (freq(x,y)/nmbr_of_frames)*100
After some experimental analysis the threshold value we took is 20.

3.3.3 Intensity fluctuation of fire pixels

It is one of the most important steps. Here we traced back to the original image frames.
At first, we collected the positions of all the passed image pixels from the threshold checking done at the previous step. Later on, we converted all the image frames into HSI format as we'll deal with the Intensity value.

Now we plot the curve for each pixel which denotes the fluctuation of pixel

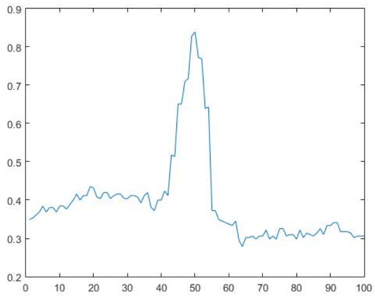

Figure 17: Pixel 5 curve plot

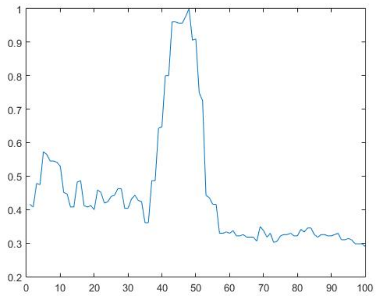

Figure 18: Pixel 12 curve plot

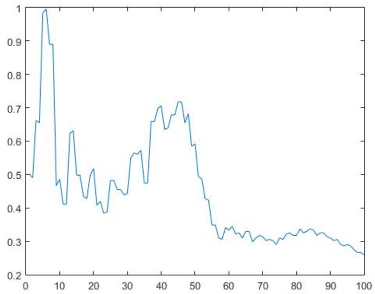

Figure 19: Pixel 14 curve plot.

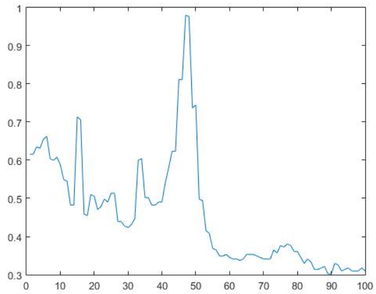

Figure 20: Pixel 26 curve plot.

intensities over the images with the flow of time. This fluctuation defines that the pixel values differ in their intensities as it is the natural property of fire to glow with different intensities all the time.

3.3.4 Finding Intensity threshold based on standard deviation (0-.25)

Here we figured out the Standard Deviation of the curve found from previous step of each pixel for all the frames.

The max standard deviation of intensity = (1-0)/4 = 0.25

So, the values will range from 0 to 0.25. Now the question is why we do need this standard deviation and it's threshold! The answer is that the fluctuation found at previous step doesn't provide us the perfect detection of fire pixels. As the pixels detected could be fire like regions which could fluctuate in intensity due to various reasons. So it won't provide us the best possible outcome. So, if the detected pixel becomes equal or exceeds the threshold value of standard deviation, it will be finally defined as fire pixel.

The Threshold value here, we found from experimental values is 0.1.

3.3.5 Final count of fire pixels

In this phase, we determined the final ratio of fire pixels as compared to the whole image. And from this ratio we define the presence of fire in the corresponding video.

Here, it is clearly visible that we need another threshold value of the fire pixel ratio in the complete image. And if the corresponding images of the video become equal or exceeds the threshold value, it will be finally classified as fire containing video.

Now our final main concern is to determine this threshold value. In order to detect this threshold value, we used ROC curve. And this curve provided us with the value of 10%.

Chapter 4

Experimental Analysis

In this chapter, we discuss about the experimental setup, comparison, dataset, result analysis based on different criteria.

4.1 Experimental Setup

The experiment was conducted on a personal computer having:

- Processor: AMD Ryzen 7 1700
  - 8 core
  - 16 CPUs
  - 3.0Ghz
- Cache Size:
  - L2 Cache: 4MB
  - L3 Cache: 16MB
- Ram: 16GB

4.2 Evaluation Methodologies

These evaluation methodologies were used to compare our proposed methodologies with previous literature:

4.2.1 Confusion matrix Analysis

A confusion matrix is a technique for summarizing the performance of a classification algorithm.
Classification accuracy alone can be misleading if we have an unequal number of observations in each class or if you have more than two classes in your dataset.

Calculating a confusion matrix can give you a better idea of what your classification model is getting right and what types of errors it is making.

Predicted / Actual	Fire	Not fire
Fire	9	2
Not Fire	1	12

Figure 21: image from frequency matrix

Here, the total number of positive videos = 11
the total number of negative videos = 13
Accuracy = (9/(9+2))*100 = 82.88%

4.2.2 Execution Time

Execution time is the time during which a program is running. In our case, it is the time taken for a program to execute for each and every phase while processing the image frames from video. The time taken considerably while processing are video segmenting and processing individually.

4.2.3 Accuracy

Accuracy is the quality or state of being correct or precise. It is the degree to which the result of a measurement, calculation, or specification conforms to the correct value or a standard. In our case, accuracy can be defined as the percentage of False Alarms.
The accuracy of the algorithm specify the ability of the algorithm in detecting the ROI.

Accuracy = TP/ (TP+TN)*100%

The efficiency test is given as Efficiency = (TN+TP/TN+TP+FN+FP)*100%

4.3 Dataset

To evaluate the effectiveness of the proposed method, and efficiency of our algorithm, we took into consideration both positive and negative videos.

Positive videos contain real fire.

Whereas, negative videos contain non-fire element and fire like regions.

We collected a total of 13 positive videos and 11 negative videos. And the accuracy and testing was done based on these videos.

4.4 Result Analysis: Comparison with Existing Solutions

Here we have figured out all the analytical data from the confusion matrix. They are discussed below.

4.4.1 False Negative (Actually there is fire but not detected)

- This is the most dangerous case
- This can dismiss all the intention of this project to zero.
- In our system it happened in case of videos which is less than 18%
- We have achieved less in this than most of the other research papers.
- We have used 3 different color models so that we can minimize the rate of false alarm
- The reinforcement techniques we used are the combinations of different papers proposed processes.

4.4.2 False Positive (Actually there is no fire but detected as fire)

- This is a case where efficiency is lost.
- Creates confusion and chaos and for false alarm it causes loss of effort and money.

- In our system it happened in case of videos which is less than %
- Other methods causes too many false alarms
- Most of them has more than % error in this case
- We used 3 step verification to detect a fire pixel.
- We took consideration of still images of fire and considered flames and flickering. That's why in most of the cases only real Fires can trigger our alarm.

Chapter 5

Conclusion

5.1 Summary

From the comparative analysis provided earlier, it is seen that our proposed algorithm provides a very robust output through which we can alert the respective authorities and lessen the destruction caused by it. We have already minimized the false alarm rate by a huge amount. We will try to minimize the false alarm rate and optimize the solution for over the existing solutions. At last the whole research has been done for a greater good for humanity and wild life. If we can detect the fire accurately before the spread of fire then it will contribute a lot to the whole western side of the world who suffers most. It will also decrease fact of global warming.

5.2 Future Work

This report initially elaborates on the major concerns of forest fire. We have focused on detecting mainly fire, flame and smoke by Digital Image Processing. The input provided in the process is Video from which frames are separated for further manipulation. We have summarized the proposals provided those have been done mainly without deep neural network.

- Rules with more accuracy from different papers
- Reduce the rate of false alarm
- Take consideration of smoke detection
- Threshold maintaining for optimized result
- Clear and enriched dataset
- Error optimization

Lastly we conclude with our proposed methods and future works that will work as a reliable method for early fire detection based on Image Processing.

Chapter 6

Appendix

RGB

RGB images do not use a palette. The color of each pixel is determined by the combination of the red, green, and blue intensities stored in each color plane at the pixel's location. Graphics file formats store RGB images as 24-bit images, where the red, green, and blue components are 8 bits each. This yields a potential of 16 million colors. The precision with which a real-life image can be replicated has led to the commonly used term truecolor image.

RGB is a device-dependent color model: different devices detect or reproduce a given RGB value differently, since the color elements (such as phosphors or dyes) and their response to the individual R, G, and B levels vary from manufacturer to manufacturer, or even in the same device over time. Thus an RGB value does not define the same color across devices without some kind of color management.

Typical RGB input devices are color TV and video cameras, image scanners, and digital cameras. Typical RGB output devices are TV sets of various technologies (CRT, LCD, plasma, OLED, quantum dots, etc.), computer and mobile phone displays, video projectors, multicolor LED displays and large screens such as Jumbotron. Color printers, on the other hand are not RGB devices, but subtractive color devices (typically CMYK color model).

HSI

The HSI color space is very important and attractive color model for image processing applications because it represents color s similarly how the human eye senses colors.

The HSI color model represents every color with three components: hue (H), saturation (S), intensity (I).The HSI model is an ideal tool for developing

image processing algorithms based on color descriptions that are natural and intuitive to humans.
The Hue component describes the color in the form of an angle between [0,360] degrees. The Saturation component describes how much the color is diluted with white light. The range of the S varies between [0,1]. The Intensity range is between [0,1] and 0 means black, 1 means white.

YCbCr

YCbCr color spaces are defined by a mathematical coordinate transformation from an associated RGB color space. If the underlying RGB color space is absolute, the YCbCr color space is an absolute color space as well; conversely, if the RGB space is ill-defined, so is YCbCr.
YCbCr is sometimes abbreviated to YCC. YCbCr is often called YPbPr when used for analog component video, although the term YCbCr is commonly used for both systems, with or without the prime.

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