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Video Based Forest Fire Detection using Spatio-Temporal Flame Modeling and Dynamic Texture Analysis

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Abstract— The role of fire detection is to identify fire in a timely manner. Practically automatic forest fire detection using image processing techniques characterizes one of the significant aspects of forest fire avoidance earlier. In current fire detection systems exact location of fire, manual work such as physical inspection of fire pose a serious threat to timely detection of fire. To overcome this standard approach must be developed. Detection of fire using image and video is effective than using sensors. A computer vision based approach for detecting the presence of fire in video is presented here. The contributions for the fire detection may be an image or a video but the input as a video is quite complex process but provides good result. The fire is detected using spatio temporal flame modeling and analysis of dynamic textures. Extraction of features such as color consistency, spatial wavelet, spatio-temporal analysis, temporal analysis is by spatio temporal flame modeling. RGB color model is used for calculating color consistency and 2DWT for calculating wavelet in space. In wavelet analysis the image is divided into sub-images (LL, LH, HL, and HH). The main feature of fire, the flickering property is identified using temporal analysis. These features are combined with features of texture analysis which includes LDS and codebook is formed which are then classified using SVM classifier. This approach performs better than other fire detection system with high true positives and less true negatives.

Keywords – spatio-temporal, flame modeling, texture analysis, spatial wavelet, dynamic feature, LDS, codebook.

***Keywords*—**About four key words or phrases in alphabetical order, separated by commas.

I. INTRODUCTION

Forest fires are a notable danger to ecology and constitute a critical threat to human beings safety. Usually smoke appears before fire so it is easy to detect fire easier. People normally look for sign of smoke to detect fire in early days and took a necessary action to prevent it from spreading because when smoke get exposure to oxygen it causes fire easily. Characteristics of smoke differs in response to environment it occurred, it also differs in shape. Fire in an open environment is much difficult to handle so to avoid this different sensors such as temperature, heat sensors may be used but sensors too has many disadvantages so a standard fire detection method should be designed.

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Various image processing techniques can be used for detecting fire. In wildlife, flame will not be visible until it covers certain area so fire should be detected earlier with its exact location of its origin. So it is necessary to design a standard method to detect and extinguish fire earlier. These disadvantages are overcome by standard method of fire detection by using video. The video is converted into several frames and are used as input. The output may be video or frames detecting fire. Safety of the people can be guaranteed and required number of manual workers can be reduced by using video based forest fire detection.

In this paper section I dealt with general introduction about forest fire detection. Section II discusses about the survey on forest fire detection techniques, section III describes about the methodologyused forforest fire detection. Further section IV and V deals with results and future work. Section VI deals withconclusion.

II. LITERATURE SURVEY

Surapong Surit et.al. [8] proposed a method to detect fire from using smoke which is an early indicator of fire and supports easy identification. Static and dynamic characteristics are analyzed in this method. Four steps are composed in this method, which includes detection of change in area of fire, ROI calculation, calculation of static and dynamic characteristics, final step is identification whether it is smoke or not.

Detection of change in area of fire is done by comparing the current input frame with the background image, any change if found are captured and segmented and result is stored and used for the process and for more accuracy ROI is calculated. An algorithm named convex hull is used for ROI calculation which segments the area of change from the input. Calculation of static and dynamic characteristics is done by extracting their features. Classifiers such as SVM, NN are used to filter smoke from smoke-like objects and the originality is maintained.

P. Piccinini et.al. [2] proposed a method based on different models, variation of energy is measured and fire is detected. Energy ratio variation is measured in wavelet domain and used for smoke detection, where in color model pixel color variation is calculated (eg: pixel variation of fire and fire colored object). The results of these models are combined and classified using classifier. Bayesian classifier separates smoke and smoke like and fire and fire like objects.

Wavelet transform is used as a base to detect fire in a method proposed by R.Gonzalez. The proposed method constitutes three steps.

First step is preprocessing in which distortions are filtered out, image is resized and transformed. SWT is used for removing the high frequencies of an image, and the high frequency eliminated images are subjected to reconstruction by inverse SWT. Intensity of color image that are close to each other are grouped and histogram is plotted to observe the different levels of indexation. After histogram analysis non-smoke images are eliminated from smoke images and fire is detected by using these features.

Covariance descriptors, color models, SVM classifier are used to detect fire from video data in a method designed by Osman Gunay et.al. [4]. Videos are more advantage to image because movement of fire and fire-colored objects differs with this property we can accurately detect fire, so video data is used here. Here video data is divided into temporal blocks. Then for each block covariance matrix is built and chromatic color model is used to classify pixels of each block and fire colored pixel is rejected by SVM classifier.

Clear data alone is supported by this method and this fails for blur data.

Hamed Adab [6] proposed a method for fire detection and it is based on indexing. In addition to indexing GIS techniques and remote sensing [10] helps in detecting fire. The indexing used in this method may be structure, fire risk or hybrid fire index. In this fire detection includes the geographical condition as a main thing; according to the geographical condition indexing differs. GIS and remote sensing is used to fix the hot spot data. Indices validation should be done based on hot spot data. The fire indices are used for various purposes in fire detection, structural indices shows information that are static and this information does not change in short time. One advantage of this method is this index predicts the fire risk in advance. Fire risk index is not constant and it changes with the change in vegetation and environmental conditions. Hybrid index is a combination of features of structure and fire risk index. Combining the result of indexing is a major disadvantage.

Akshata et.al. [7] proposed a method in which Local binary Pattern and wavelet acts as a base for detecting fire. The pixel level of the input image is analyzed.

YCbCr color model is used for detecting fire. For smoke detection the method constitutes three steps, first is the segmentation of image. Local Binary Pattern is used for segmenting the image. Local Binary Pattern is nothing but an operator for texture analysis, value is computed using the pixels of an image, and mostly the center and neighbor pixel is used for calculation. Accuracy is improved by using the wavelet. Wavelet also finds an application in classification of complicated data here. In this method two images are used as input and the images are divided into sub images using 2DWT and reconstruction is by I2DWT. Two images are compared with each other for fire detection.

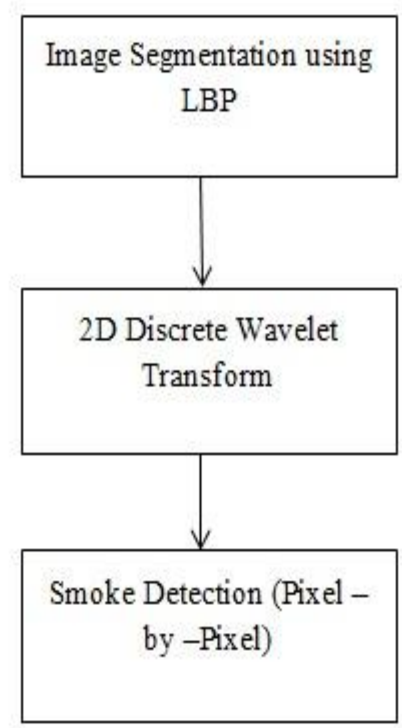
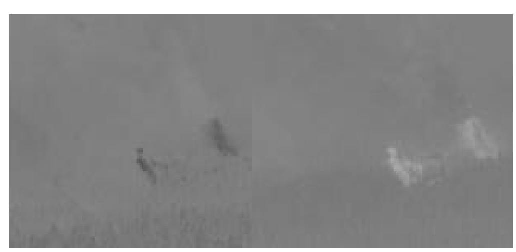


Fig.1. Fire detection process

A generic model for fire and smoke detection without the help of sensor [15] is developed by Celik (2007) [3]. YCbCr color model is used for fire detection and HSV color model is used for smoke detection. One main reason for using YCbCr is that it distinguishes luminance and chrominance. Input RGB image is transformed to YCbCr and YCbCr is separated to channels as Y, Cb, and Cr. A pixel is confirmed as fire pixel if the intensity of Y is greater than Cb and Cr.

RGB image Y channel



Cb channel Cr channel

Fig.2. Color channels

Smoke does not show the chrominance so HSV color model is used. Smoke's color varies from bluish to white at starting so in this stage itself smoke should be detected. A property named motion property helps in distinguishing smoke and smoke like object which is applied in this method.

A Neural Network based system is proposed by Cheng [5]. Detection is based on temperature, CO concentration and smoke. These features are fed as input to sensors and local decision is made. The local decisions are then sent to fusion center for producing single decision (i.e.) final decision. For fusion process RBF neural network is used.

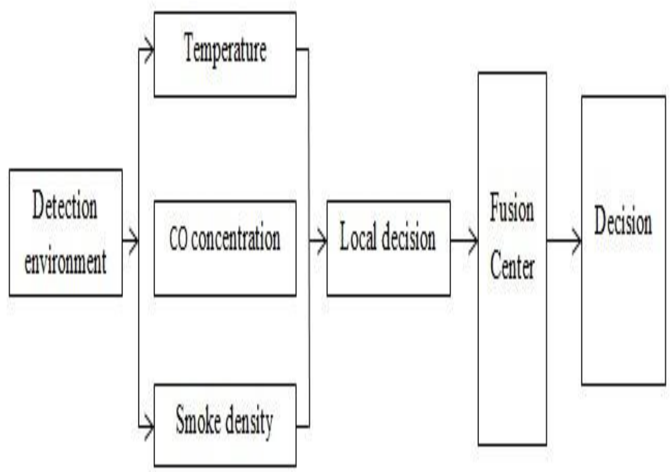


Fig.3. Decision generation process

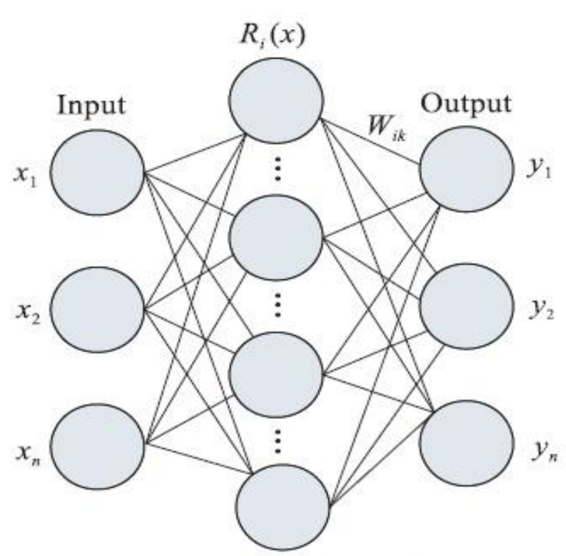


Fig.4. RBF network structure

Zhanqing (2001) [9] proposed a method for fire detection using Multi-Threshold algorithm and Neural Network also supports this method.

Neural Network generates a continuous random output in addition to classifying smoke, sky, background. Multi-Threshold algorithm is used along with Neural Network to reduce the time consumed by the Neural Network. It is not necessary to combine these two it differs depends on the area in which fire had occurred. In Neural Network the number of output neurons depends on the number of input parameters. The degree of pixel separation is specified by Euclidean Distance. Channel wise approach is used here and a reflectance is calculated for each channel, if reflectance is between 0.9 and 1.5 it is decided as smoke pixels and the remaining pixels are removed.

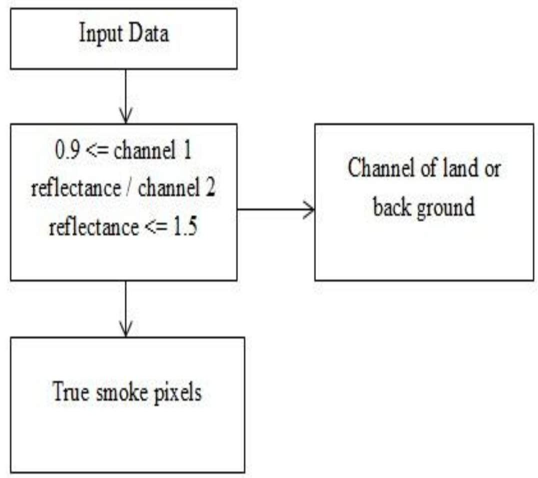


Fig.5. Multi threshold algorithm

A computer vision based approach is designed by Paulo [11]; this method is based on probability and classification. Frame-to-Frame changes are analyzed. For each frame color threshold and weighted color threshold are evaluated and mask is used. Bayes classifier is used for differentiating fire and fire-color pixel. *Apriori* is used to improve the classification result's accuracy. Centre region of frames usually locate the fire.

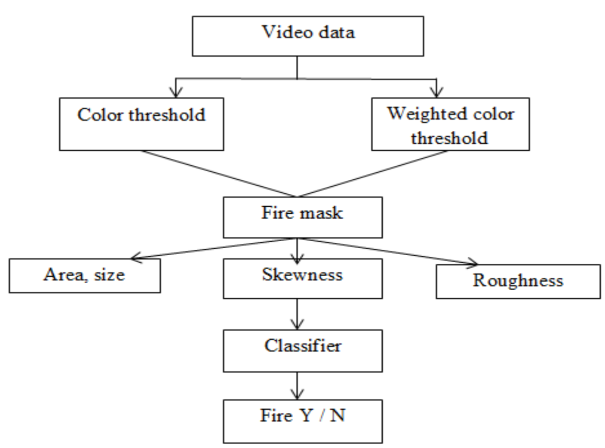


Fig.6. Fire Detection Process

To overcome the disadvantages of above methods and to increase the efficiency of these methods a standard approach should be designed. These can be achieved to some extent by using Spatio Temporal Flame Modeling and Dynamic Texture Analysis [1].

III. METHODOLOGY

A computer vision based approach for detecting fire in video is done by using spatio temporal flame modeling and dynamic texture analysis.The methodology is as follows

Candidate fire region is selected using color distribution.

Spatio temporal flame modeling - it includes extraction of various features as follows

1. Color probability – detecting fire color based on probability of each and every pixels of input.

2. Spatial wavelet analysis – behavior of fire in space is measured here, this differs for fire and fire-colored objects.

3. Spatio-temporal analysis – behavior of fire in space with respect to time is measured here. Fire shows high variations with respect to time in comparison to fire colored objects.

4. Temporal analysis – flickering property (transition from fire and non-fire region) is identified here. This property is absent for non-fire objects.

Dynamic texture analysis - fire has a spatial and time varying pattern. To increase the reliabilitywe model the temporal evolution of pixel intensities.

We apply LDS for modeling dynamic features. LDS is applied only for candidate fire region. With the extracted LDS a codebook is formed using either k-means or k-Medoids.

Classification - The formed codebook is fed into SVM for classification. The SVM classifies the fire and fire colored region.

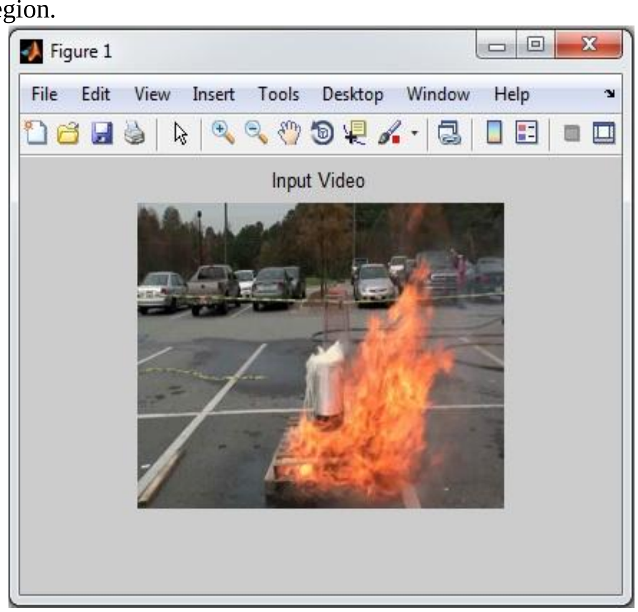


Fig.7. Input video

IV. RESULTS AND DISCUSSION

The above video is used as input. First a candidate region is detected and spatio temporal flame modeling and dynamic texture analysis is used to extract some features of the detected candidate region. mmreader and read() is used for reading the input video.

A. Detection of Candidate fire region

1. Background subtraction method is used to identify the moving objects in the video**.**

By converting the input frame into hsv frame background is separated and filter is used for noise removal.

2. Filter out non-fire colored moving region

To filter out non-fire moving pixels we compare their values with a predefined RGB color distribution that is created by nonparametric estimation from a number of real fire-samples from a variety of video sequences.

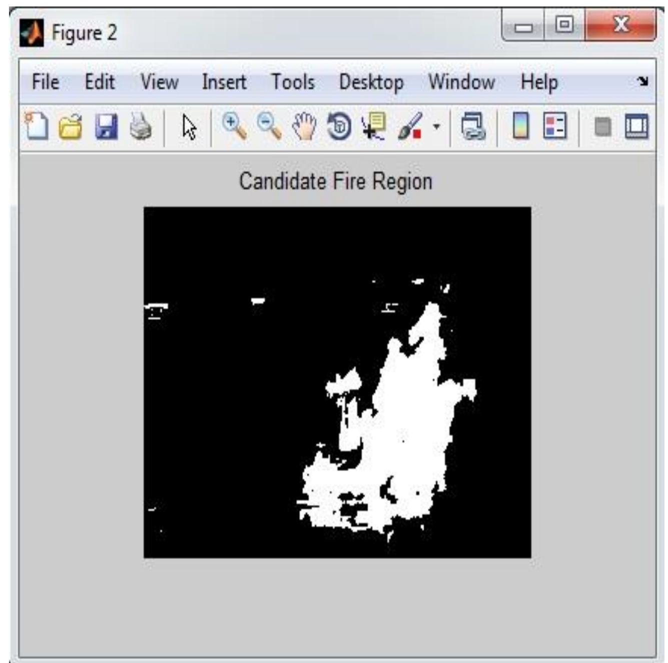


Fig.8. Candidate region

B. Spatio-temporal Flame Modeling

1. Fire color Probability

For the colour probability of each candidate block, the non-parametrically estimated probabilities of each pixel in the block are used. More specifically, the total colour probability of the candidate block is estimated as the average colour probability of each pixel.

First a RGB image is converted to HSV for this a inbuilt function rgb2hsv is used. Average need to be calculated for all rgb2hsv converted pixels,for finding average of the features (1/N)*sum(sum(hsv2)) is used.

2. Spatial Wavelet Energy

It is used to identify the spatial variations in the region. Wavelet analysis using simple filters is used to achieve higher computational efficiency, since it can be implemented without any solitary multiplication, i.e., by simple register shifts. Specifically, a 2-D wavelet filter is applied on the red channel of each frame and the spatial wavelet energy at each pixel is calculated by adding the high–low, low–high, and high–high wavelet sub images.

[LL, LH, HL, HH]=dwt2 (hsv2,'haar','d') and

E= (HL). ^2+(LH). ^2+(HH).^2 are used to find wavelet energy here. Average is found out by (1/N)*sum (sum (E)).

3. Spatio-temporal Energy

It is used to identify high-spatial energies in a single frame this feature aims to indicate the spatio-temporal variations for each block in a order of frames.

The result of wavelet is used as input here

V=(1/T)*(E-(E).^2) (V= variable indicating energy)

Average is calculated by (1/N)*sum(sum(V)).

4. Temporal analysis

Temporal analysis is applied to each candidate block to detect flickering effect. The result of above two is used for temporal analysis.

F=2. ^(c)-1 for identifying flickering property(F), hsv values of all pixels is used. Average is calculated by (1/N)*sum (sum (F)).

c. Dynamic Texture Analysis

1. Fire blocks are trained.

2. Fire colored moving objects also trained.

This training process is performed using PCA algorithm.

For modeling dynamic features LDS is used.

robustltp function is used for dynamic texture analysis.

LDS possess the property of both linear and dynamic system.

3. Clustering distance is calculated for LDS of extracted candidate blocks. For finding clustering distance in LDS k-means is used.

4. Code-book is formed using extracted LDS.

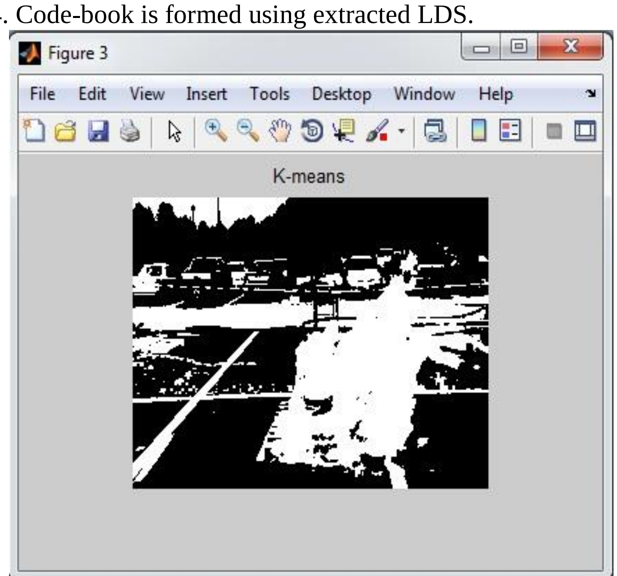


Fig.9. k-means

5. From the codebook result histogram is constructed. imhist() fuction can be used for histogram construction.

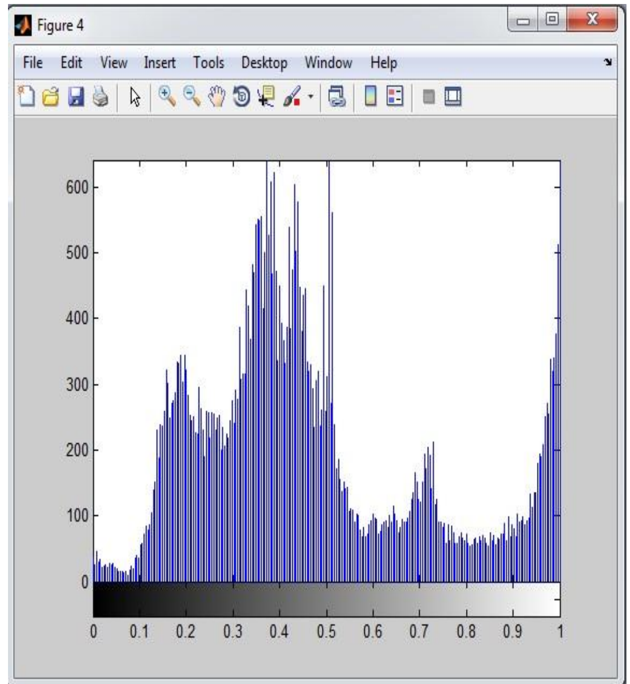


Fig.10. Histogram

With the help of features extracted a histogram is construted with k-means and imhist functions.

Spatio-Temporal consistency energy

1. Data cost considering features in the current frame

2. A smoothness cost considering the state of neighboring blocks

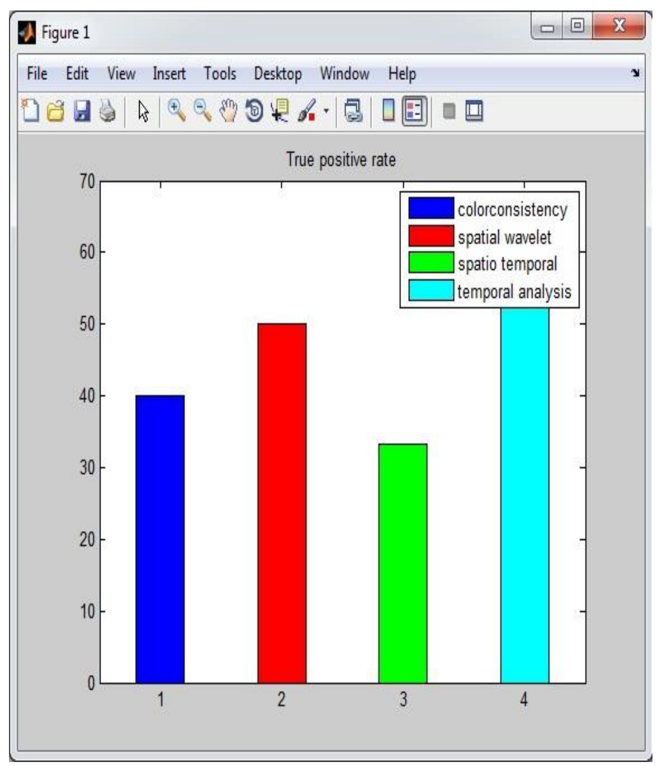


Fig.11. True positive

CLASSIFICATION (Support Vector Machine)

A feature vector consisting of six features

f = [*P*block, *E*block, *V*block, *F*block, *D*block, *Cblock*] is created.

This vector is fed as input to a two-class (fire and non-fire) SVMs classifier with a RBF kernel to classify the candidate fire regions.

After the classification process a warning dialog box appears indication the detection of fire region.

GRAPHS

True positive and false positive is calculated for the features (color consistency, spatial wavelet, spatio-temporal and temporal analysis) that are extracted from the above processes. The result obtained is as follows

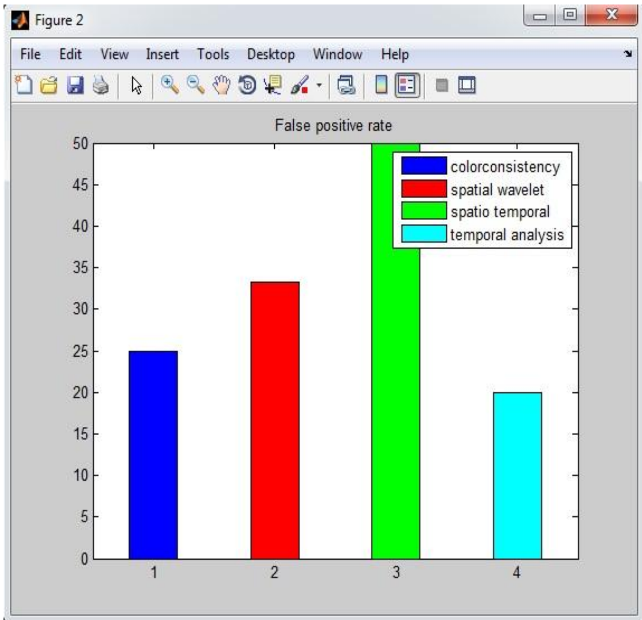


Fig.12. False positive

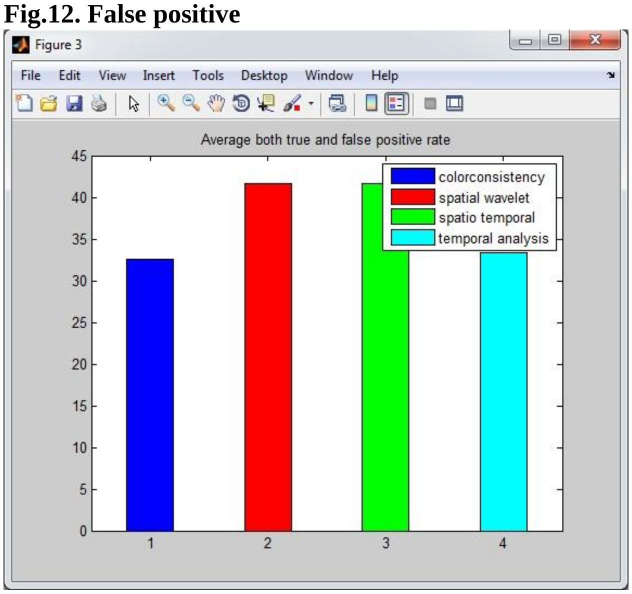


Fig.13. Average of true positive and False positive

IV. FURTHER WORK

Classifier is changed in further work. Remaining process are same.

Apart from using SVM for classifying fire and non-fire regions, Neural Network can be used for increasing the accuracy of classification.

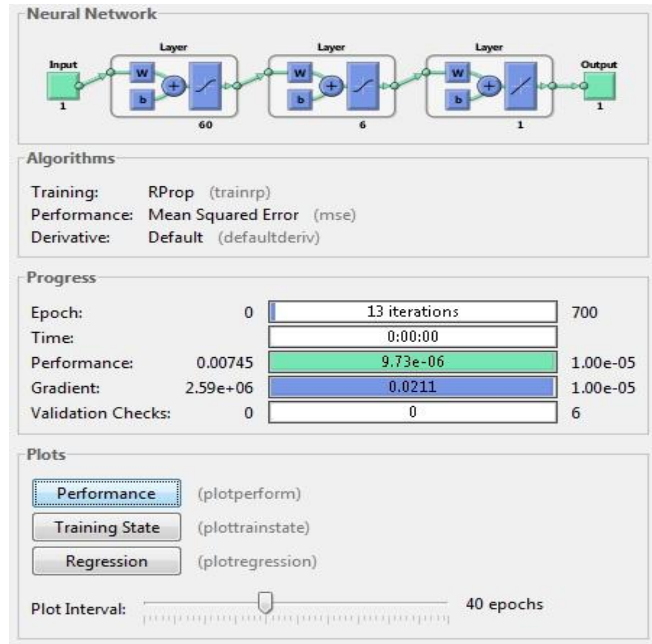


Fig.14. Sample Neural Network Training

V.CONCLUSION

Thus by modeling the behaviour of fire using various spatio temporal features along with dynamic texture analysis which improves the robustness of the processfire is detected. Further improvement can be done by using any otherclassifier. FPGA implementation is expected to provide more accurate result.

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