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Fire Detection using ANN

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Abstract— "Fire detection in Video's" is more important topic for researchers to save human life and environmental loss. The proposed system is based on optical flow based feature extraction and motion segmentation. In results, it increases fire recognition rate and speed with accuracy; also requires minimum computation rate and storage memory.

Keywords— Feature Extraction, Optical flow, Background Subtraction, Supervised Classification, ANN

I. INTRODUCTION

In surveillance systems, fire detection is important component to monitor environment and buildings as a security mechanism giving alerts for staring of fire. Now-a-days fire detectors are also used in many places, using temperature, photosensitive and smoke characteristics. But these systems are failed to detect fire in harsh outdoor environment even in large spaces. It is serious problem in heavy industries, naval vessels and congested automobile traffic. Therefore, Video-based fire detection systems are more important topic for researchers. Uncontrolled fires can be detected using video-based systems at early stage before turning into disasters. These systems are widely used in military and commercial fields [1] such as portable applications [2] and traffic [3]. Video-based detection is composed of three steps: 1) Pre-processing 2) Feature Extraction 3) Supervised Classification algorithm such as neural network (NN) which is trained on a dataset of features and ground truth. The proposed system is based on optical flow based "hsi" feature extraction and motion segmentation. HSI color space is used for pixel classification. In machine vision, optical flow [4] is an important technique in motion analysis. Horn-Schunck optical flow method is used for analysis of dynamic features in the candidate region. Motion estimated pixels are send to neural network for fire like pixels. Then further with some thresholding segmentation is done as fire or no-fire. Supervised-learning machine algorithm is used to learn and classify the static of the flame.

II. SYSTEM ARCHITECTURE

Figure 1 shows the general block diagram of proposed work. The highlight of this system is the optical flow vector creation that is used to estimate the amount of motion undergone by an object while obtaining motion from one frame to second. The proposed system includes following three steps:

A. Pre-processing

Pre-processing video images involves bringing intensity of the individual particles images to normal condition and removing low-frequency background noise. Also removing reflections and masking portions of images is a part of the pre-processing. Image pre-processing is the technique of improving data images to computational processing.

Color information was used in many algorithms for fire detection [5-7]. Color transformation is involved in the pre-processing, i.e. calculating HSI features for all the frames. Firstly, it reads the input video then second it randomly selects any one of the frame. Third it will be converting that frame in to gray-scale images. These features are processing with segmentation. Classification is further continued to the next modules.

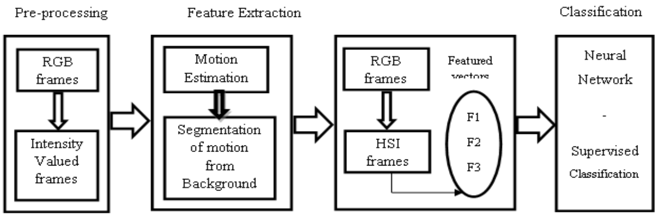


Fig. 1: Block Diagram of the Proposed System

B. Feature Extraction

In image processing, feature extraction starts from an initial set of measured data and builds derived values known as feature. When the input data to an algorithm is too large to be processed and it is supposed to be redundant, then it can be transformed into a reduced set of features. This process is called feature extraction. The extracted features may consist of relevant information from the input data, so that by using this reduced representation, the desired operations can be performed instead of using complete initial data.

C. Classification

Neural network is a useful tool for different applications. It requires extensive classification. Classification is nothing but assignment of all objects to a particular group. Feature learning is done by machine learning operations like classification. It requires raw input which is mathematically and computationally suitable to process. Classification algorithms use the computed features as input and make decision outputs regarding the target's presence. Supervised machine-learning-based classification algorithms such as Neural Network (NN) are systematically trained on data set of features and system feature.

During the testing phase, a trained feed forward neural network is being used and feature vectors are created for classification. Training the neural network is performing a non-linear regression. It separates the labelled training data into no. of classes, such as smoke, non-smoke, fire or non-fire. In the testing phase, a feature vector is supplied and the output. Feature vector is associated with a particular class. The candidate region is classified based on its feature vector F = (f1, f2, f3). T is to threshold each of the features fi based on cut-off values. Cut-off values are determined heuristically and decision is done on majority voting.

D. Workflow of the system is given below:

1. Load video
2. Extract video frame
3. Separate R G and B planes from image frame
4. Convert color image to intensity
5. Estimate optical flow
6. Apply Thresholding and Median Filtering
7. Show motion extraction
8. Segment motion pixels from original video frame
9. Pass video frame for fire detection module
10. RGB image to HSI image
11. Extract features of input image
12. Simulate image features for fire like region
13. Subtract subsequent frames to remove spurious fires
14. Apply averaging filter to eliminate and weaken spurious fire regions
15. Count fire like pixels and decide on fire present or absent

III. RESULTS

1. Neural Network Results and Graphs:

Levenberg-Marquardt algorithm is used for training purpose. To define neural network, neural object is used to store all the information in neural network toolbox software. "trainlm" is a network training function that gives weight and bias values according to optimization.

Following fig. 2 describes the neural network training window. "dividerand" function is used to divide the data and the Levenberg-Marquardt training method is used with the mean square error performance function.

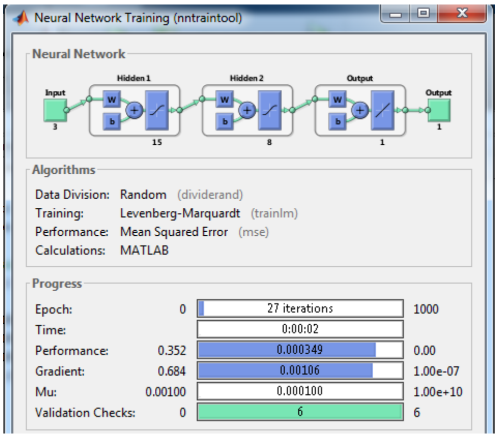
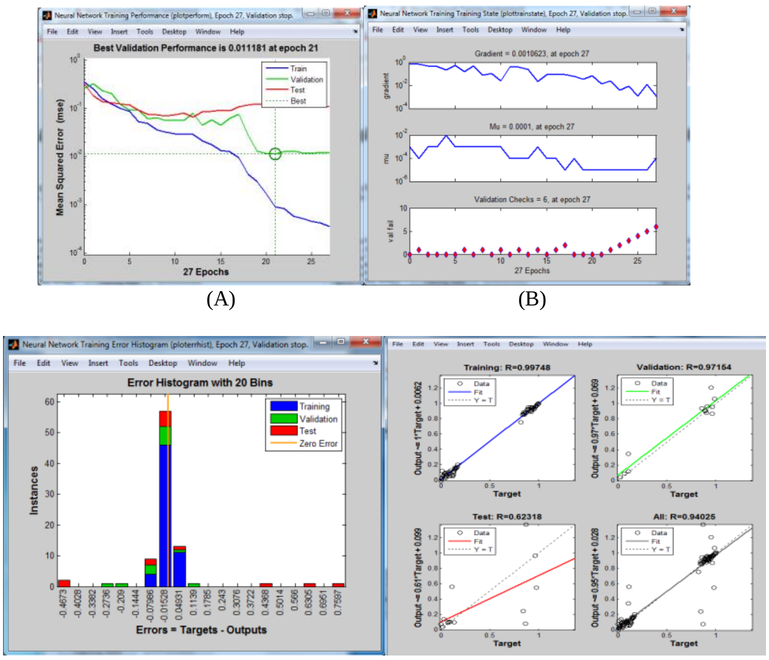


Fig. 2 Neural Network Training Window

From the training window, you can access four plots as shown in fig 3: performance, training state, error histogram, and regression.



(A) (B)

(C) (D)

Fig. 3 Graphs of Neural Network (A) Neural Network Performance Plot (B) Neural Network Training State Plot (C)Error Histogram Plot (D) Regression Plot

2. *Fire Detection Output:*

In order to evaluate performance of the system, we have selected different video's consisting different types of fire and calculates following characteristics:

1. TP (True Positive): Fire present True and algorithm detected it as fire present
2. TN (True Negative): Fire present True and algorithm detected it as fire absent
3. FP (False Positive): Fire absent and algorithm detected it as fire present
4. FN (False Negative): Fire absent and algorithm detected it as fire absent
5. FD (Fire Detection): Percentage of detected frames with fire

FD: (TP*100)/Fire frames

6. NFD (Non-Fire Detection): Percentage of detected frames with no fire those are correctly undetected

NFD: (TN*100)/Non-fire frames

7. Overall percentage of frames that are correctly detected by algorithm is:

Overall: {(TN+TP)*100}/Total frames

a. Case1 for Video1.avi:

Table 1 shows Experimental output of video1-case1. Minimum four frames are required for fire feature extraction and detection. Therefore, output didn't get for first three frames for all videos.

Fire Present in Video1 is large and consist of lot of smoke. Although this video consists of smoke, fire gets detected in all frames as it is not mixture of flame and smoke together.

No. of frames fire and non-fire frames for this video is shown in table1 as below:

TABLE NO. 1: EXPERIMENTAL OUTPUT OF VIDEO1

Video1	Algorithm o/p	Manual o/p
Total No. of frames	601	601
No. of fire frames	0	0
No. of non-fire frames	598	598

Fig. 4 shown below describes input video frame No. 28 and motion segmentation in which fire gets detected.

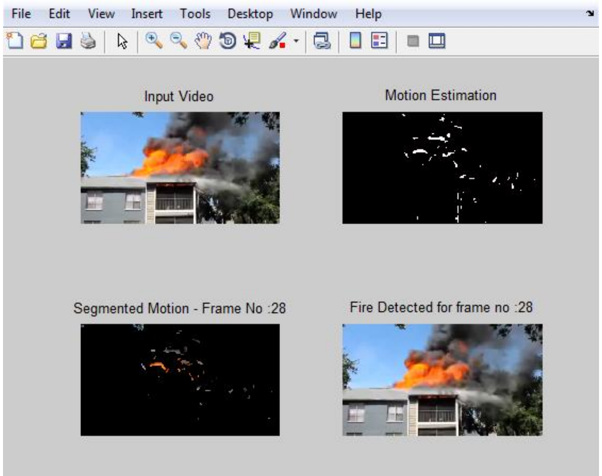


Fig. 4 Experimental output of video1 (a) Original Video files (b) Motion Estimation in video (c) Segmented motion (d) Output detection at the original video

b. Case1 for Video2.avi:

Fire Present in Video2 is large with lot of smoke (mixture of smoke and fire). Therefore, Fire is not detected in few frames where only smoke is present.

No. of frames fire and non-fire frames for this video is shown in table below:

TABLE NO. 2: EXPERIMENTAL OUTPUT OF VIDEO2

Video2	Algorithm o/p	Manual o/p
Total No. of frames	255	255
No. of fire frames	78	71
No. of non-fire frames	174	181

Fig. 5 shown below describes input video frame No. 79 and motion segmentation in which fire gets detected.

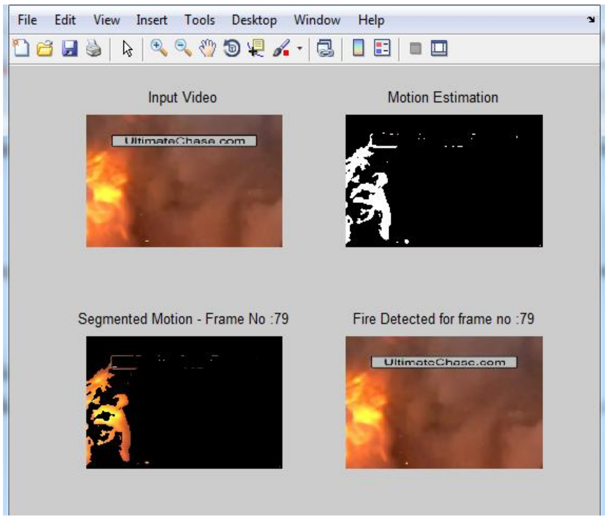


Fig. 5 Experimental output of video2-case1 (a) Original Video files (b) Motion Estimation in video
(c) Segmented motion (d) Output detection at the original video

c. Case2 for Video2.avi:

In video2; algorithm failed to detect fire for frame nos. 5, 65, 95, 116, 121, 185, 209, 210, 219, 220 though there is fire in images in the video. All these frames consist of lot of smoke.

Fig. 6 shown below describes input video frame no.5 and motion segmentation in which fire is not detected, i.e. frame with no fire.

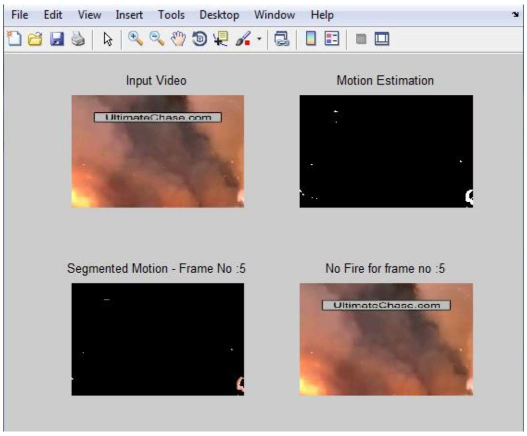


Fig. 6 Experimental output of video2-case2 (a) Original Video files (b) Motion Estimation in video
(c) Segmented motion (d) Output detection at the original video

d. Case1 for Video3.avi:

Fire Present in Video3 is large; therefore Fire gets detected in all frames as it is not mixture of flame and smoke together. Fig. 7, shown below describes input video frame No. 6 and motion segmentation in which fire gets detected.

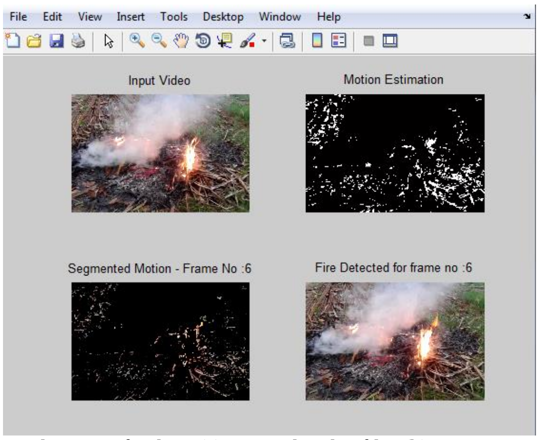


Fig. 7: Experimental output of video3 (a) Original Video files (b) Motion Estimation in video (c) Segmented motion (d) Output detection at the original video

No. of frames fire and non-fire frames for this video is shown in table below:

TABLE NO. 3: EXPERIMENTAL OUTPUT OF VIDEO3

Video3	Algorithm o/p	Manual o/p
Total No. of frames	526	526
No. of fire frames	0	0
No. of non-fire frames	523	523

Performance of the system is evaluated Fire detection and shown in table 4. It shows the percentage of fire detection and non-fire detection and also overall performance of the system for different videos.

TABLE NO. 4: EVALUATION OF FIRE DETECTION FOR VIDEO1, VIDEO2 AND VIDEO3

	Video1	Video2	Video3
TP	598	174	523
FP	0	3	0
FN	0	10	0
TN	0	77	0
FD %	100%	96.13%	100%

IV. CONCLUSIONS

The proposed system used optical flow for motion estimation. Motion estimated pixels are send to neural network for fire like pixels and color based fire detection is done using supervised machine-learning-based algorithm. The characteristic fire features are related to the flow magnitudes and directions are computed from the flow fields to discriminate between fire and non-fire motion.

V. ADVANTAGES AND DISADVANTAGES

1. **Advantages**

a. System gives better results of fire detection when tested on a large video database to demonstrate their practical usefulness.
b. A video-detection approach geared towards these scenarios where point sensors may fail.
c. Use of Neural network models gives better computational performance and stability, energetic efficiency.
d. It provides extremely high detection rates.
e. The proposed system can be used for real time video based flame detection. So it covers a large area using camera and gives accurate data of area under consideration.

2. **Disadvantages**

a. The Proposed system may fail to differentiate between fire and non-fire objects.
b. Little false detections are observed in presence of significant noise, motion of non-fire objects and rapid angle change.

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