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Entropy Functional Based Auto Adaptive Wildfire Detection Using Fuzzy Logic

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ABSTRACT: Nowadays digital camera technology and video processing techniques are increased worldwide. Due to this, the conventional fire detection methods are going to be replaced by computer vision based systems. The computer vision based systems detection has a significant role with surveillance system. Most of the algorithms used in the existing techniques propose spectral, spatial, temporal and other low level features of fire for distinguishing it from other objects in video sequences. This paper proposes a new approach to computational vision-based fire and flame detection by using a fuzzy logic edge detection and motion detection with ANN-SVM classifier as classification tool. The edge detection using fuzzy canny edge detection technique and the motion detection using motion estimation are use for fire and flame detection and ANN-SVM classifier is useful for the final classification. Finally, it decided whether the objects that have changed in that video are flame or not. Therefore, this method detects both smoke and flame effectively and obtain high accuracy by reduce false alarm rate.

KEYWORDS: Fuzzy canny edge detection, motion estimation, wildfire detection using video, SVM-ANN classifier, features extraction.

1 INTRODUCTION

Forest fires are one of the most important disasters which create great environmental problems for Nature. They are detectable but it is an unusual visual phenomenon, unlike normal object. Also it has both statical and dynamic texture. Some of the low level distinctive features of fire regions are Color, shape, motion, growth, smoke behavior, and flickering etc... Due to its frequent shape and size changes, computational vision-based systems are used for the fire and flame detection. For the vision based detection systems, the detection algorithms are depends on multi-feature-based approaches [1].

Surveillance cameras have significant role in many fields such as law enforcement, security, and protection of the environment. The computer vision based system has significant attention with the Surveillance cameras. According to the number of surveillance cameras being installed in various fields increased, conventional vision based object detection has become vital worldwide. The computer vision based detection is the method for finding a given object in a video sequence. Several signal and image processing techniques are developed for the detection of different objects from images and video sequences. The vision based object detection is used for the detection of fire, flame and smoke and is mainly a useful technique in the implementation of both indoor and outdoor fire alerts. It made more advantages over the traditional methods.

This paper presents the approach followed for fire detection by a fuzzy logic. The objective is to determine the location and the position of both potential fire and smoke and also extracting static and dynamic characteristic to reduce the number of false alarms. The paper deals mainly with both fire detection algorithms using edge detection and motion detection. Results from experiments with small controlled fires are presented. The paper is organized as follows. Section II presents the previous techniques for fire detection. Section III describes how to obtain the fire detection using the proposed technique. Section IV presents the experiments and the results obtained. The conclusions in section V complete the paper.

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2 RELATED WORKS

W. Phillips, M. Shah, and N. Lobo. [2] proposes a system that detect the fire by using motion and color information from video sequences. The technique is used to detect fire reliably under normal conditions. But it have lack of hardware implementation, high false alarm rate, distance limited and fails in Open or large spaces.

Che-Bin Liu and Narendra Ahuja [3] propose a Vision based fire detection technique. In this paper, the spectral, spatial and temporal models of fire regions in visual image sequences are presented. The spectral model was represented in terms of the color probability density of fire pixels. The spatial model detects the spatial structure within a fire region. The temporal signatures of the fire region are used as the temporal changes in the Fourier Coefficient. It has following disadvantage. Since the spatial quantization errors for small regions are likely to introduce considerable noise in the FD, we place a threshold to eliminate regions of small size. We are also excluding large but thin regions. Consequently, this algorithm does not used to detect very small or far away fire.

Toreyin, B.U., Dedeoglu, Y., Cetin, A.E., [4] was proposed a technique based on Markov models to detect flames in video. In this technique, the flame and flame colored ordinary moving objects is detected by generating a Markov model. The spatial color variations in flame had also evaluated by the same Markov models. Final decision is made by combining this information. Due to the spreading characteristics of flame depend on the strength of the wind, it was impossible to use the same location within a fixed time to model the periodic behavior of flame boundaries.

Osman Gunay et. al. [5] proposes an entropy-functional-based online adaptive decision fusion (EADF) framework for image analysis and computer vision applications. In this framework, the compound algorithm consisting of several sub-algorithms. They are: slow video moving pixel algorithm, smoke colored region detection, wavelet transform based smoothness region detection, shadow detection and elimination and covariance matrix based region detection. Each sub-algorithm had a decision associated with it and the weights are updated online according to the each decision of sub algorithms. It has the following disadvantage. It is computationally expensive and runs slow. It is not accurate to detect the exact region of input flame against the background image. Also decision algorithm produce false alarm and is time consuming.

3 PROPOSED METHODOLOGY

For the better enhancement of related works, a new approach to computational vision-based fire and flame detection by using a fuzzy logic edge detection and motion detection with ANN-SVM classifier as classification tool is proposed. The edge detection using fuzzy canny edge detection technique and the motion detection using motion estimation are use for fire and flame detection and ANN-SVM classifier is useful for the final classification. This approach is to improve the accuracy of fire and flame detection in videos and to reduce the false alarm rate to a great extent. The methodologies used:

1- 2D Preprocessing using Median Filtering
2- Edge detection using Fuzzy canny edge detection algorithm
3- Color detection using Color histogram
4- Motion detection using Adaptive rood pattern search
5- Feature classification using SVM & ANN Classifier

In this approach, first the video is converting into frames. After converting into frames, the noise is removed from the frames using median filter. Then the edge of both fire and smoke is mapped using fuzzy canny edge detection algorithm. After the edge map, the color of the edge map region is detected. Then we detect the motion of the region using motion detection. In this, motion estimation using Adaptive rood pattern search algorithm is done. In that, the first detected frame is stored and then compares with the next frame. Whether the fire or smoke is detected, then the alarm is buffered for the region. In this, feature extraction is also do ne by using SVM-ANN Classifier. Fig. 1 shows the flow diagram of proposed system

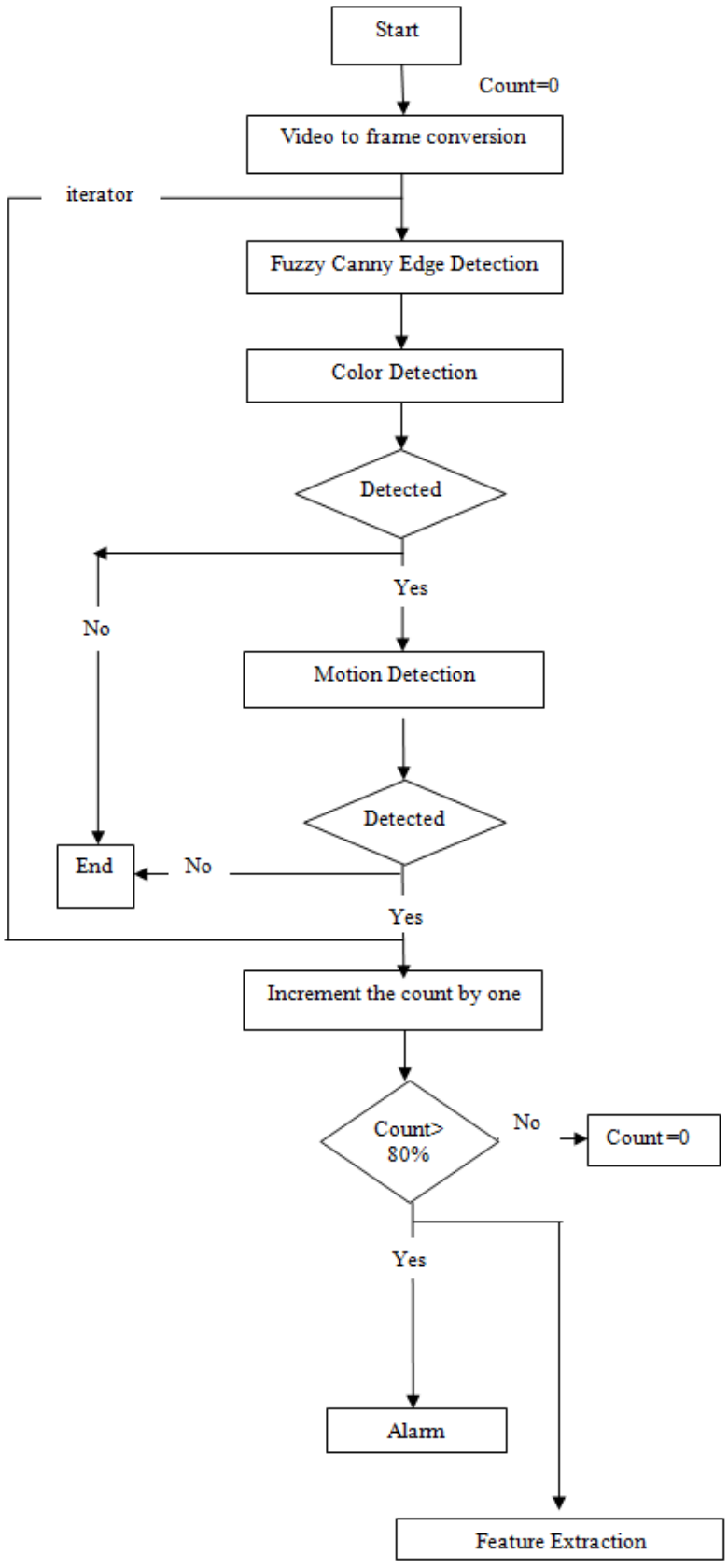

Fig. 1. Flow diagram of proposed system

3.1 PRE-PROCESSING USING MEDIAN FILTER

Once the video is obtained as input, then the video to frame conversion is done. After conversion, it is given for pre-processing to remove the noise. Mainly the video consists of salt and pepper noise. So the pre-processing is done by using median filter.

3.2 DETECTION USING FUZZY CANNY EDGE DETECTION ALGORITHM

After the pre-processing, the edge detection process is taking place to map the region where the fire and smoke obtained. The edge detection method is the recent technique to digital image for segmenting and improves the quality of the images. In this, it extracting some data with the structural properties i.e., edges in the image and discarded the unwanted data. In the recent years, so many edge detection methods have been done to improve the accuracy. Some of the previous operators used for edge detection are Prewitt, Sobel, Log filter, Robert and canny operator. These methods uses local gradient method for detection but it is not sufficient to control the noise. So the result is blurred image. Also it has some Malfunctioning at the corners, curves and the location where the gray level intensity function varies. Complex Computations, False zero crossing, and Time consuming also occurs. To eliminate the disadvantage of previous technique, we are introducing a new approach of edge detection based on fuzzy canny edge detection. This method identifies the edges of the flames correctly by removing all the noises in the flames. The proposed method identifies the continuous and clear edges of the flame/fire and produces the alarms accordingly. This process detects outlines of an object and boundaries between fire region and the background in the image.

In the fuzzy canny edge detection [6], the two basic phases of edge detection i.e. global contrast intensification and local fuzzy edge detection are first explained and is then merged with fuzzy canny operator for the better results specially for the noisy images and low contrast images. This method works on both local and global gradient information of images. Firstly, we are obtaining each pixel in the fuzzy domain. After that, the first phase that is a universal contrariety intensification operator is introduced for improves the quality of image. Due to this phase, more edginess is enhanced and discards less edginess. After this, the second phase that is local fuzzy edge detection involves edge detection with local information of images by using a fuzzy mask. After this, simple thresholding is done which is followed the canny edge detection to link the edges. The algorithm steps for the fuzzy canny edge detection are discussed below:

1) **Universal Contrast Intensification**
   a) Flame and fire image representation using fuzzy logic

2) **Edge Detection in local edges**
   a) Mask edge detector in local edges
   b) Removal of strong edges and noise
   c) Edge image thresholding

3) **Canny edge detection Algorithm**
   a) Smoothening the image with the derivation of a Gaussian
   b) Finding the gradient magnitude and gradient direction.
   c) Then taking the non-maxima suppression for the gradient magnitude image
   d) By using the two thresholds T1 > T2 :
      Then Class = {edge if magnitude > T1
      Candidate if magnitude > T2}
   e) Edge tracking is done by hysteresis

After the edge detection, color mapping is done for the detected region by marking feature points.

3.3 MOTION DETECTION USING ADAPTIVE ROOD PATTERN SEARCH

Once the color region is detected, then the motion of the region is finding by using the motion estimation. The motion estimation computes the difference between the current frame and the stored past frame that is the reference frame. The immediate fast frame is taken as the reference frame. The difference in position between the current frame and their similarity with the reference frame is defined as motion vector.

The algorithms have been implemented for the motion estimation are Exhaustive Search, Three Step Search, New Three Step Search, Simple and Efficient TSS, Four Step Search and Diamond Search. It has some following disadvantages. It has high computational cost and less PSNR value. Also they are too complex. Due to this reason, we are using adaptive rood pattern search (ARPS) algorithm [7] for the motion detection. It has less computation cost and high PSNR value. The algorithm steps used for the adaptive rood pattern search are discussed below:

a) Uses the motion vector of the macro block to its immediate left to predict its own motion vector.
b) After predicting the motion vector, checks at a rood pattern distributed points where they are at a step size of S = Max (|X|, |Y|).
c) It directly puts the search in an area where there is a high probability of finding a good matching block by using the equation (1). By using this equation , we are finding the difference between the current frame and the reference frame and then finding the proper match for detecting the motion of the fire region .

$$MAD = \frac{1}{N^2}\sum_{i=0}^{N-1}\sum_{j=0}^{N-1}|C_{ij} - R_{ij}| \quad (1)$$

Where MAD is the mean average difference, N is the size of macro block, Cij is the current block, Rij is the reference block.
d) The point that has the least weight becomes the origin for subsequent search step
e) The search pattern is obtained.
f) The procedure keeps on doing until least weighted point is found to be at the centre.

After motion detection, an alarm is buffered that showing the detection of more intensity region i.e.., fire or smoke with the motion of the region. If it is fire, then it shows a message box of fire. If it is no fire then it shows a message of no fore

3.4 FEATURE EXTRACTION USING SVM-ANN CLASSIFIER

After the detection of the fire region, we are extracting the features of that region. To obtain high accuracy in detection, the features also extracting. Some of the traditional methods used for feature extraction are kNN classifier, SVM classifier etc.., Due to the large timing of previous method, we are using SVM-ANN classifier. In this we are extracting twenty one features for studying the behaviour of the region.

4 EXPERIMENTAL RESULT

The videos of fire, smoke and no fire are recorded from video recorder. This video recorder is mounted on the device pan/tilt and it is stationary. Our input video of fire is in mp4 format with 640x360 resolutions and frame rate 30frame/second. The size of the video is 613kbs. This video is converted into number of frames. The resolution of each frame is 640x360. These image frames has file extension name to JPEG. We use 25 image frames from the input video for the experiment. Our program is implemented using MATLAB. Figure 2 shows the one of the input frame. Figure 3 gives the edge detection output of the input video. Figure 4 gives motion detection. After this, an alarm is buffered and extracts 21 features to improve the accuracy.. Figure 5 gives the graph of comparison of the proposed with existing. We are calculating the accuracy by using the equation (2). Figure 6 showing the accuracy of the fire and no fire video.

$$\text{Accuracy} = (TP+TN)/(TP+FP+TN+FN) \quad (2)$$

Where TP is the true positive, TN is the true negative, FP is the false positive and FN is the false negative.

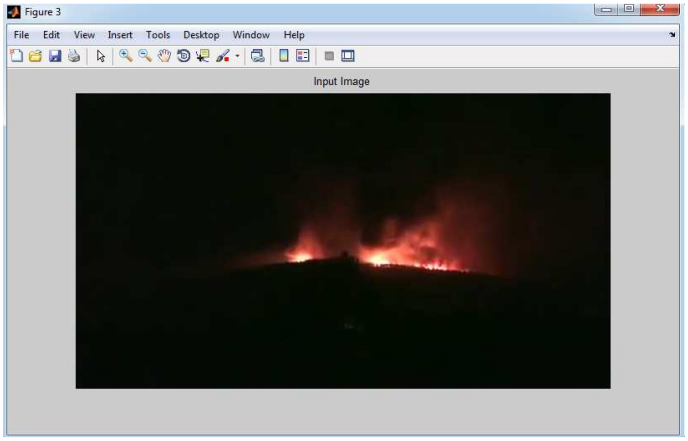

Fig. 2. One frame of the input video

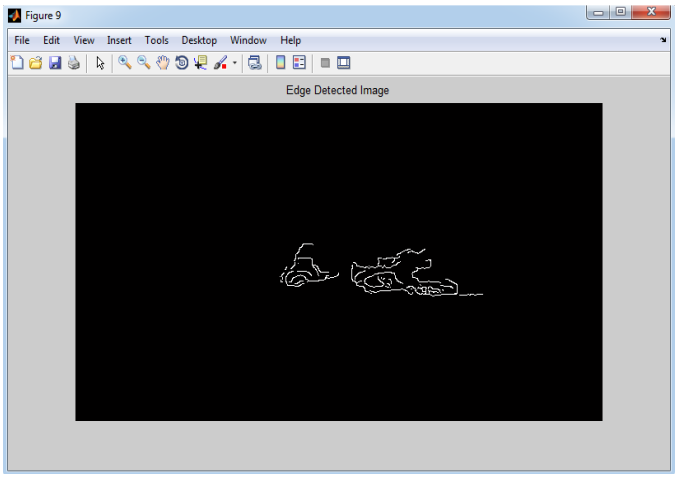

Fig. 3. Edge detection output using fuzzy canny algorithm

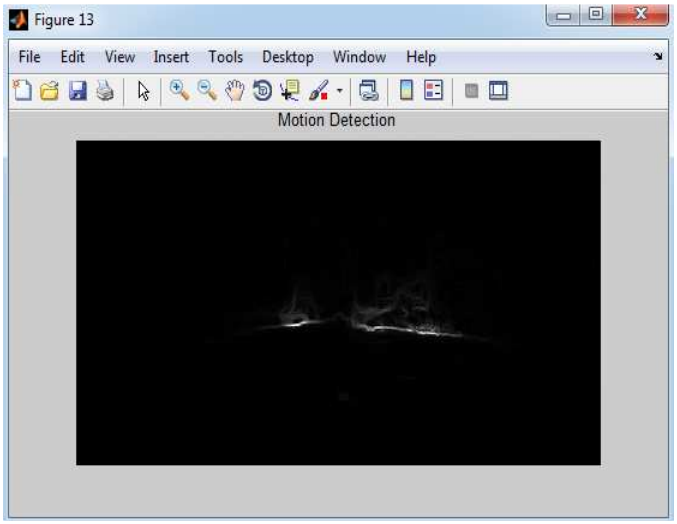

Fig. 4. Motion Detection output

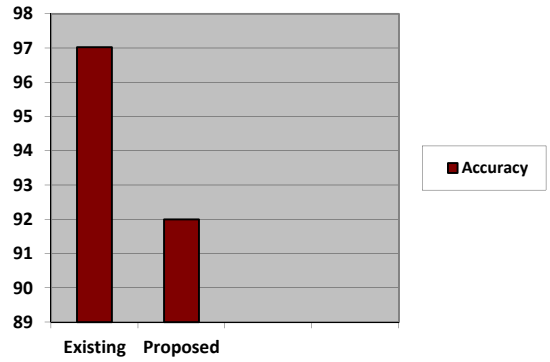

Fig.5. Graph showing the comparison of existing and proposed system

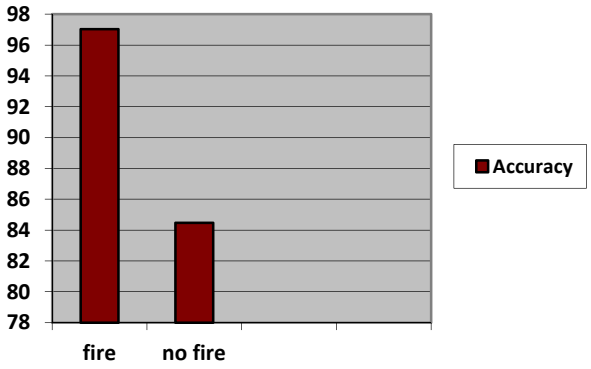

Fig. 6. Showing the accuracy of fire and non fire video

5 CONCLUSION

The vision-based detection system is used for finding the presence of fire regions in an image or video sequence. It has made significant attention in the past decade with camera surveillance systems. Most of the algorithms used in the existing techniques propose spectral, spatial, temporal and other low level features of fire for distinguishing it from other objects in video sequences. In the proposed system, a new approach to computational vision-based fire and flame detection by using a fuzzy logic edge detection and motion detection with ANN-SVM classifier as classification tool. The edge detection using fuzzy canny edge detection technique and the motion detection using motion estimation are use for fire and flame detection and ANN-SVM classifier is useful for the final classification. This technique is to improve the accuracy of fire and smoke detection in videos and to reduce the false alarm rate.

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