AN INTELLIGENT SYSTEM FOR EFFECTIVE FIRE DETECTION IN VIDEO: AN IMAGE PROCESSING APPROACH

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ABSTRACT: **In this paper, we propose a real-time fire-detector that combines foreground object information with color pixel statistics of fire. Simple adaptive background model of the scene is generated by using three Gaussian distributions, where each distribution corresponds to the pixel statistics in the respective color channel. The foreground information is extracted by using adaptive background subtraction algorithm, and then verified by the statistical fire color model to determine whether the detected foreground object is a fire candidate or not. A generic fire color model is constructed by statistical analysis of the sample images containing fire pixels. The first contribution of the paper is the application of real-time adaptive background subtraction method that aids the segmentation of the fire candidate pixels from the background. The second contribution is the use of a generic statistical model for refined fire-pixel classification. The two processes are combined to form the fire detection system and applied for the detection of fire in the consecutive frames of video sequences.**

Keywords: **Fire detection, image processing, video processing, color modeling, motion detection, image segmentation.**

1. INTRODUCTION

Fire detection systems are among the most important components in surveillance systems used to monitor buildings and the environment. Currently, almost all fire detection systems use built-in sensors that depend primarily on the reliability and the positional distribution of the sensors. It is essential that these sensors are distributed densely for a high precision fire detection system. In a sensor-based fire detection system for an outdoor environment, coverage of large areas is impractical due to the necessity of a regular distribution of sensors in close proximity.

Due to rapid developments in digital camera technology and video processing techniques, there is a major trend to replace conventional fire detection methods with computer vision based systems. Developments in content based video processing, more and more vision based fire detection systems are introduced. Vision based systems generally make use of three characteristic features of fire: colour, motion and geometry. The colour information is used as a pre-processing step in the detection of possible fire.

2. A BRIEF REVIEV OF THE WORK ALREADY DONE IN THE FIELD

With the help of some reference papers it is seen that previously the work done in this field uses the computer vision based fire detection system.

In general, computer vision-based fire detection systems employ three major stages: fire pixel classification, moving object segmentation, and analysis of the candidate regions. This analysis is usually based on two figures: the shape of the region and the temporal changes of the region. The fire detection performance depends critically on the effectiveness of the fire pixel classifier which generates seed areas that the rest of the system will exercise. The fire pixel classifier is thus required to have a very high detection rate and preferably, a low false alarm rate. There exist few algorithms which directly deal with the fire pixel classification in the literature.

The fire pixel classification can be considered both in grayscale and color video sequences. Most of the work on fire pixel classification in color video sequences is rule-based. The work of [1] used raw *R*, *G*, and *B* color information and developed a set of rules to classify the fire pixels. Instead of using the rule-based color model and others, [2] used a mixture of Gaussian models in RGB space which is obtained from a training set of fire pixels. Along with motion information and Markov field modeling of the fire flicker process [3] and [4] used background subtraction to segment changed foreground objects and three rules of RGB color components to detect fire pixels.

The overall system can result in very high false alarm rates when intensity changes are considered, and it is very sensitive to the tuning parameters employed in background subtraction. The inference [5] used normalized RGB values for a generic color model for fire. The normalized RGB is proposed in order to alleviate the effects of changing illumination. The generic model is obtained using statistical analysis carried out in *r-g, r-b,* and *g-b* color planes.

Due to the distribution of the sample fire pixels in each plane, three lines are used to specify a triangular region representing the region of interest for the fire pixels. Therefore, triangular regions in respective *r-g*, *r-b*, and *g-b* planes are used to classify a pixel.

A pixel is declared to be a fire pixel if it falls into three of the triangular regions in *r-g*, *Rb*, and *g-b* planes. The low-cost CCD cameras to detect fires in the cargo bay of long range passenger aircraft. This method uses statistical features based on grayscale video frames, which include mean pixel intensity, standard deviation, and second-order moments as well as non-image features, such as humidity and temperature to detect fire in the cargo compartment. The system is commercially used in parallel with standard smoke detectors to reduce the number of false alarms caused by the smoke detectors, and it also provides visual inspection capability which helps the aircraft crew confirm the presence or absence of fire. However, the statistical image features are not considered to be used as part of a standalone fire detection system.

Recently, proposed a generic model for fire colour [1-2]. The authors combined their model with simple moving object detection. The objects are identified by the background subtraction technique. Later on they have proposed a fuzzy logic enhanced approach which uses predominantly luminance information to replace the existing heuristic rules which are used in detection of fire-pixels. YCbCr colour space is used rather than other colour spaces because of its ability to distinguish luminance from chrominance information. The implicit fuzziness or uncertainties in the rules obtained from repeated experiments and the impreciseness of the output decision is encoded in a fuzzy representation that is expressed in linguistic terms.

The single output decision quantity is used to give a better likelihood. The fuzzy model achieves better discrimination between fire and fire like-coloured objects. Since the colour based pre-processing is essential part for all image processing based fire detection systems, an efficient colour model is needed. The fuzzy logic technique is now applied to detect fire pixels.

3. NOTEWORTHY CONTRIBUTION IN THE FIELD OF PROPOSED WORK

A detailed description of fire pixels is provided. A good color model for fire modeling and robust moving pixel segmentation are introduced. It is essential because of their critical role in computer vision-based fire detection systems. The moving pixels are detected by applying a background subtraction algorithm together with a frame differencing algorithm on the frame buffer filled with consecutive frames of input video to separate the moving pixels from non-moving pixels. The moving pixels which are also detected as a fire pixel are further analyzed in consecutive frames to raise a fire alarm.

In order to implement a colour model in an image processing, it is important to detect possible fire pixel. The rules defined for RGB colour space in order to detect possible

fire-pixel can be transformed into colour space and analysis can be performed.

The implicit fuzziness or uncertainties in the rules obtained from repeated experiments and the impreciseness of the decision variable can be encoded in a fuzzy representation. This provides a way to express the output and the framework of the thesis is established. Several algorithms have been proposed for fire detection such as:

Color Modeling for Fire Detection.
Moving Pixel Detection.

4. PROPOSED METHODOLOGY DURING THE TENURE OF THE RESEARCH WORK

Conventional fire detection systems use physical sensors to detect fire. Chemical properties of particles in the air are acquired by sensors and are used by conventional fire detection systems to raise an alarm. However, this can also cause false alarms.. In order to manage false alarms of conventional fire detection systems, a computer vision-based fire detection algorithm is proposed. Furthermore in this thesis, the fire detection is done using image processing. A new image-based real-time fire detection method was proposed which is based on computer vision techniques

6. EXPECTED OUTCOME OF THE PROPOSED RESEARCH WORK

A main contribution of this thesis is the detection of fire pixels in computer vision based fire systems. By replacing the fire sensors, image based fire detection is done which may achieve up to 99.00% correct fire detection rate with a 4.50% false alarm rate.

7. CONCLUSIONS

We have developed two models: one for fire detection and the other is for the smoke detection. For fire detection, the concepts from fuzzy logic are used to replace existing heuristic rules and make the classification more robust in effectively discriminating fire and fire like colored objects. The model achieves up to 99.00% correct fire detection rate with a 4.50% false alarm rate. For smoke detection, a statistical analysis is carried out using the idea that the smoke shows grayish color with different illumination.

The developed models can be used as pre-processing stage for fire or smoke detection systems. As a future work, region based fire and smoke recognition will be studied.

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