EMERGING METHODS FOR EARLY DETECTION OF FOREST FIRE

project Report

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ABSTRACT:

As part of the early warning system, forest fire detection has a critical role in detecting fire in a forest area to prevent damage to forest ecosystems. In this case, the speed of the detection process is the most critical factor to support a fast response by the authorities. Thus, this article proposes a new framework for fire detection based on combining color-motion-shape features with machine learning technology. The characteristics of the fire are not only red but also from their irregular shape and movement that tends to be constant at specific locations. These characteristics are represented by color probabilities in the segmentation stage, color histograms in the classification stage, and image moments in the verification stage. A frame-based evaluation and an intersection over union (IoU) ratio was applied to evaluate the proposed framework. Frame-based evaluation measures the performance in detecting fires. In contrast, the IoU ratio measures the performance in localizing the fires. The experiment found that the proposed framework produced 89.97% and 10.03% in the true-positive rate and the false-negative rate, respectively, using the VisiFire dataset. Meanwhile, the proposed method can obtain an average of 21.70 FPS in processing time. These results proved that the proposed method is fast in the detection process and can maintain performance accuracy. Thus, the proposed method is suitable and reliable for integrating into the early warning system.

1.Introduction:

The government has taken many strategies to reduce the occurrence of forest fires, especially early fire detection. However, these strategies have not fully utilized artificial intelligence to the best of our knowledge. Therefore, an early warning system based on artificial intelligence is needed to detect fire in a forest area.

Fire detection is one of the essential modules in an early warning system, which is used to identify abnormal events in a monitoring area. Fire detectors are used to provide the earliest possible warning of a fire. Conventional fire detectors currently use smoke and temperature sensors. If the sensor is placed in an open and wide area such as a forest, densely populated settlements, and roads, it will be less effective and cost a significant amount of money. In addition, conventional fire detectors have problems regarding delays and alarm sound errors. In other words, the utilization of camera monitoring is currently increasing to ensure citizens' safety. Therefore, it is possible for Closed Circuit Television (CCTV) cameras to detect fires using digital image processing and computer vision technology, referred to as image-based fire detection. The advantages of image-based fire detection compared to conventional fire detectors can be placed in an open and wide area so that the costs incurred can be cheaper.

Image-based fire detection is strongly influenced by the features used to distinguish fire from other objects. Two types of features are often used to detect fire: handcrafted features and non-handcrafted features. Handcrafted features are designed with predetermined rules. Examples of these features are motion, shape, color, and texture. Meanwhile, non-handcrafted features are obtained directly from the neural network layers.

Our goal was to integrate the fire detection module into a CCTV-based early warning system (EWS). In the EWS, the speed of the process is crucial in responding quickly to any detected abnormal events. Because of this requirement, the integrated fire detection module must run in real-time but still maintain performance. Therefore, this study proposed a real-time fire detection based on a combination of novel color-motion features and machine learning to achieve real-time processing and high accuracy in performance. Overall, the main contributions of the work are summarized as follows:

- Introducing the use of a color probability model based on the Gaussian Mixture Model for segmenting the fire region, which can handle any illumination condition.
- Proposing simple motion feature analysis of fire detection, which reduces the false-positive rate.

- Integrating classification-based fire verification to make decision steps more effective and efficient in localizing the fire region.
- Introducing the new evaluation protocol and annotation for fire detection evaluation based on the intersection over union (IoU) rate.

2.TrainingData Acquisition:

In this research, two training datasets were used: the dataset for fire segmentation and fire classification. The dataset for segmentation consisted of 30 images of fire regions in various conditions with the size of 100 × 100 pixels. The features were extracted on this dataset based on the RGB colour model for representing the variation in fire colours in the colour probability model. The selected samples of fire colour images used for the segmentation stage. On the other hand, the fire classification stage utilized a dataset consisting of 1124 fire images and 1301 non-fire images]. It was produced by capturing photographs of fire and non-fire objects in challenging situations, such as the fire image in the forest and non-fire images with fire-like objects in the background. The dataset was then divided into 80% and 20% for training and testing.

Fig1:Train set Forest with fire Fig2: Train set Forest without fire

3.Proposed Framework:

The fire detection system starts by forming a color probability model for the segmenting fire region using the Artifical intelligence and Deep learning methods. Then, the model is trained based on a dataset containing varying fire colours. This model would find the fire region candidates in the video frames extracted from the video input.

4. Results and Discussion:

Experimental Setting and Protocol Evaluation :

The proposed method was tested on several public datasets. The proposed method was implemented using the Python programming language on a Core i3 CPU and 8GB RAM. In the experiment, the true-positive rate (TPR), the true-negative rate (TNR), the false-positive rate (FPR), the false-negative rate (FNR), the intersection over union (IoU) rate, as well as the processing time were evaluated. The TPR is the ratio between the number of correctly detected fire frames and the number of ground truth fire frames.
Nevertheless, the proposed method still has limitations. For example, the system may fail to detect potential fire or invisible fire caused by a significant amount of smoke or haze in the forest due to the proposed method

depending on the visual appearance of fire. Therefore, utilizing additional sensors (e.g., thermal camera, temperature sensor, humidity sensor, etc.) could be one of the solutions to overcome this problem. Additionally, the proposed method still produces false positives, affecting fire detection handling. Therefore, further research is needed to reduce these false positives. Examples of successful and failed fire detection using the proposed method.

CONCLUSION:

A real-time and reliable fire detection method for an early warning system is required so that an immediate response to an incident can be made effective. In this study, methods based on color probabilities and motion features were successfully implemented to achieve this goal. The proposed method exploits the characteristics of the color of fire by developing a probability model using a multiple Gaussian. On the other hand, other fire characteristics, namely, dynamic fire movement modeled with motion features based on moment invariants, were also applied. The experiment found that the processing time required on average reached 21.70 FPS with a relatively high true positive rate of 89.92%. These results indicate that the proposed method is suitable for a real-time early warning system. Nonetheless, one of the greatest challenges in implementing the module is physically installing the camera, which may be very difficult. Therefore, it will remain a challenge for our further research.