Fire Detection and Recognition Optimization Based on Virtual Reality Video Image

Mr. K. Mahesh

Department of Computer Science, Sri Venkateswara University, Tirupati

Abstract— *Fire detection technology based on video images can avoid many flaws in conventional methods and detect fires. To achieve this, the support vector machine (SVM) method in machine learning theory has unique advantages, while rough set (RS) theory and SVM complement each other in application. Thus, a new classifier could be created by organically combining these methods to identify fires and provide fire warnings, yielding excellent noise suppression and promotion. The RS is used as the front-end system for the SVM method, yielding improved performance than only SVM. Recognition time is reduced, and recognition efficiency is improved. Experiments show that the RS-SVM classifier model based on parameter optimization proposed in our paper mitigates deficiencies in over fitting and determining local extremum with excellent reliability and stability, and enhances the forecast accuracy of fires. The method also reduces false fire-detection alarms and uses fire feature selection in virtual reality (VR) video images and fire detection and recognition.*

I. INTRODUCTION

Accidental fire is a natural disaster that seriously threatens public safety. In recent years, accidental fire has frequently occurred in many places, including superstores, communities and forests, yielding huge losses to production and human life. After several decades of development, virtual reality technology has matured quickly and has changed people's lifestyles by being widely applied in many fields [1]. For example, VR technology has been used to manage accidental fire in industry, agriculture, hospitals, aviation, aerospace, and firefighting. Thus, virtual fire environment technology has become integral to future fire protection. Due to their detection principles or system structures, traditional fire detectors, which include temperature detectors, smog detectors and optical detectors, usually have inherent defects or application restrictions. Because flames and smog have specific colors, textures, shapes and other image features, people have begun to consider using computer visual features to improve the efficiency of fire detection (e.g., video flame detection technology based on image processing). In most fire scenes, flames and smog exist [2, 3].

1.1 Fire detection technology

Fire detection technology based on video images recognizes flames or smog in video images and then implements real-time monitoring of fire scenes. This noncontact technique requires a computer to process imagery and discriminates suspicious targets that appear in the video images by studying and extracting visual features of flames or smog [4]. A support vector machine that uses the principle of structural risk minimization can solve problems that have a small sample, a high dimensionality, and a local extremum perfectly while avoiding overfitting, over dimensionality and other problems of conventional neural networks. SVM is an effective tool for classification and recognition. Many successful applications in classification, recognition, and regression prediction are based on SVM [5] [6]. To enhance the reliability and stability of a fire detection system, SVM has been studied and developed for the field of fire detection. SVM is built upon statistical learning theory and has a strong learning ability, adaptability, and a high classification accuracy [7]. Rough set theory approximately describes uncertain and inaccurate knowledge compared to known knowledge within a database, works well in processing large amounts of data, and removes redundant information. Therefore, this study investigates an image processing technology that uses both SVM and RS, and develops a fire flame image recognition method based on the RS-SVM classifier model.

VR technology has been introduced into firefighting as a new training method. Researchers aim to describe how to prevent fire accidents quickly and effectively to safeguard human life and property, and minimize losses and damages. From this point of view, the research of fire flame image recognition is important and has marked practical value. Fire forecast based on digital image processing technology can effectively improve forecasting accuracy, reduce forecasting time, and provide more fire information. In the early stages of fire accidents, features including a larger flaming area, a wobbling fire edge, an irregular flame shape and overall flame movement tend to occur. These features make fire detection with imagery possible. Thus, many scholars have studied fire recognition methods, but fire detection can still be improved [9, 10]. In practical applications, many problems are studied due to some restrictions. The existing fire dataset is too small, and there is no large-scale video fire detection dataset. The dataset should also be continuously updated based on practical usage scenarios. Fire detection will be affected by fire-like objects (e.g., automobile taillights, streetlamps at night) and the rising and setting Sun. Different types of fires, such as a solid fire, a gas fire, and a charged fire, vary greatly in their imagery, making it more difficult to effectively extract key information in fire images [11]. Existing fire detection research based on videos detects motion regions and only excludes the disturbance of static fire-like objects, which also tends to extract the static features of fires. Thus, the dynamic features of fires are rarely considered. The above problems have made improving fire detection challenging [12, 13].

1.2 Video fire detection technology

Video fire detection technology mainly monitors the flames or smoke generated by combustion. However, flame, especially visible burning flame, is an inevitable outcome of combustion, while smoke is only a gasification phenomenon of light and heat; thus, smoke may not be generated by combustion [14]. Color information is a key factor in fire detection, and the existing mature color models include RGB and YCBCR. Flame has more significant and stable features than smoke to fire detection; thus, studies have focused mainly on how to recognize fires based on flame features [15]. Turgay, a Turkish scholar, integrated the RGB color model with the normalization method and determined the pixel counts of early flame digital images in the planes of R-B, B-G and G-R. This method can detect early fires but requires complex computations [16]. Healey and others proposed to collect videos and flame color features with high-speed cameras and extract suspicious flame regions. Yamagishi and Yamaguchi extracted the fluctuations of outward flames based on time sequences and then recognized flames using the features of the Fourier frequency domain and neural networks [17, 18]. An American scholar named Phillips proposed an image mask based on artificial learning to determine the proper threshold of a digital fire flame image in its early stage using Gaussian filter. He then analyzed this information using a Boolean detection function and then further reduced the impact of moving objects through the brightness difference and differential of digital fire images in its early stage [19]. Lin proposed an intelligent fire detection algorithm based on image processing. This algorithm comprehensively considered the dynamic and static features of accidental fires, captured moving regions, extracted features including the area and perimeter of the candidate regions, and used shape features such as irregular polygons and circles for fire detection [20]. Schultze and others proposed to obtain flame features using a spectrogram and sonogram based on the characteristic that flames flicker and move upwards, and monitored the motion direction of flame. Toreyin and others analyzed the change of the inner color of a flame using a spatial wavelet and described the dynamic state of the flame using a Markov model [21]. Habiboglu and others used a covariance matrix and SVM to recognize flame. Marbach, a Swiss scholar, analyzed a time-domain accumulated matrix and the brightness of early fire flame digital images to build a model of flame flickering in the frequency domain using wavelet analysis and Fourier transform [22]. XieRongquan used a BP neural network algorithm to calculate and detect the formation laws and signal features of fire images, including RGB color features, energy, stability and other texture features as well as the fire's perimeter, area and number of pointed corners and other shape features [23].

II. LITERATURE SURVEY

Wildland Forest Fire Smoke Detection Based on Faster R-CNN Using Synthetic Smoke Images

Q. Zhang (2018.).

In this paper, Faster R-CNN was used to detect wildland forest fire smoke to avoid the complex manually feature extraction process in additional video smoke detection methods. Synthetic smoke images are produced by inserting real smoke or simulative smoke into forest background to solve the lack of training data. The models trained by the two kinds of synthetic images respectively are tested in dataset consisting of real fire smoke images. The results show that simulative smoke is the better choice and the model is insensitive to thin smoke. It may be possible to further boost the performance by improving the synthetic process of forest fire smoke images or extending this solution to video sequences. The drawback of the system is less accuracy.

Image Fire Detection Algorithms Based on Convolutional Neural Networks

Wangda Zhao (6, Jun. 2020).

This paper demonstrated an, novel image fire detection algorithms based on the advanced object detection CNN models of Faster-RCNN, R–FCN, SSD, and YOLO v3 are proposed in this paper. A comparison of the proposed and current algorithms reveals that the accuracy of fire detection algorithms based on object detection CNNs is higher than other algorithms.

Especially, the average precision of the algorithm based on YOLO v3 reaches to 83.7%, which is higher than the other proposed algorithms. Besides, the YOLO v3 also has stronger robustness of detection performance, and its detection speed reaches 28 FPS, thereby satisfying the requirements of real-time detection. The drawback of the system is high complexity.

Simulation of Fire Detection by Infrared Imagers from Geostationary Satellites

P. Coppo (Jun 2015.).

This paper analyses, an end-to-end fire detection algorithm from geostationary satellite has been implemented. The MSG SEVIRI & MTG FCI payloads IR bands NeDT& IFOV performance have been simulated. A fire detection algorithm & the statistic of signal hidden in background have been simulated. The minimum & maximum fire temperature & area are in agreement with literature. A traceable link between instrument parameters and applications (fire detection) is established. The drawback of the system is inaccurate.

Enhancing Color Image Retrieval Performance with Feature Fusion and Non-Linear Support Vector Machine Classifier,

C. Singh (April. 2018.).

The purpose of this work is twofold: A fusion framework is proposed wherein the color histogram (CH), orthogonal combination of local binary patterns (OC-LBP), and color difference histogram (CDH) features are exploited to capture color, texture and shape information of an image, and a detailed comparative analysis of classical distance measures with non-linear support vector machine classifier (SVM) is presented. The proposed fusion is compared with individual Detailed experiments reveal that the non-linear SVM classifier with pre-computed square-chord kernel, when used with any feature, outperforms other kernels and classical measures in terms of recognition rate. Further, the proposed fused features are used CH + OC-LBP + CDH using non-linear SVM classifier with pre-computed square-chord kernel gives the best accuracy for all the aforementioned datasets. The drawback of the system is less performance.

Image Anomaly Detection for IOT Equipment Based on Deep Learning

R. Hou (Oct. 2019.).

This paper demonstrated, an anomaly detection algorithm for the monitoring environment of power IoT equipment operating environment based on deep learning from the perspective of personnel identification and fire smoke detection. The multi-stream CNN-based remote monitoring image personnel detection method and the deep convolutional neural network-based fire smoke detection method have achieved good results in personnel identification and fire smoke detection in the power equipment operating environment monitoring image, respectively. This provides a reference for monitoring image anomaly detection. The drawback of the system is low efficiency, poor stability.

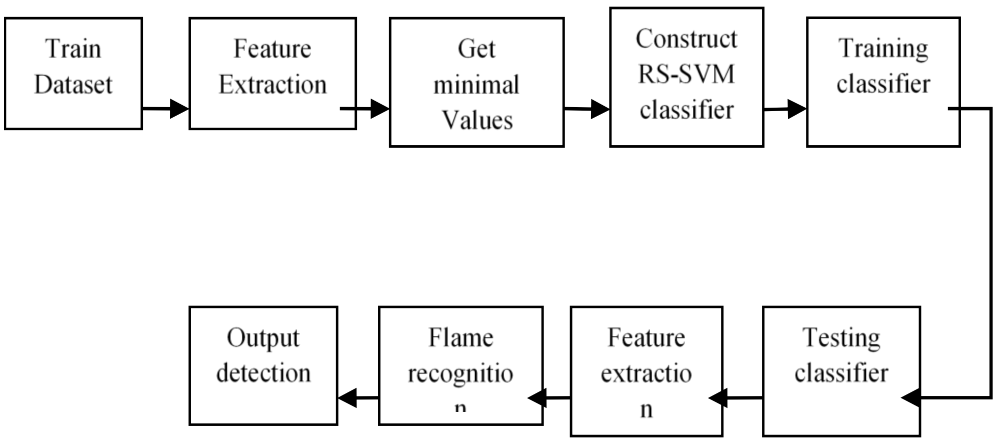
Problem Definition

Fire detection technology based on video images can avoid many flaws in conventional methods and detect fires. Accidental fire is a natural disaster that seriously threatens public safety. In recent years, accidental fire has frequently occurred in many places, including superstores, communities and forests, yielding huge losses to production and human life. After several decades of development, virtual reality technology has matured quickly and has changed people's lifestyles by being widely applied in many fields. VR technology has been used to manage accidental fire in industry, agriculture, hospitals, aviation, aerospace, and firefighting.

Fire detection technology based on video images recognizes flames or smog in video images and then implements real-time monitoring of fire scenes. This noncontact technique requires a computer to process imagery and discriminates suspicious targets that appear in the video images by studying and extracting visual features of flames or smog. A support vector machine that uses the principle of structural risk minimization can solve problems that have a small sample, a high dimensionality, and a local extremum perfectly while avoiding overfitting, over dimensionality and other problems of conventional neural networks. In this paper works analyses the SVM techniques. SVM is an effective tool for classification and recognition. Many successful applications in classification, recognition, and regression prediction are based on SVM. To enhance the reliability and stability of a fire detection system, SVM has been studied and developed for the field of fire detection. The drawback is rough set theory approximately describes uncertain and inaccurate knowledge compared to known knowledge within a database.

III. PROPOSED WORK

Accidental fire is a natural disaster that seriously threatens public safety. In recent years, accidental fire has frequently occurred in many places, including superstores, communities and forests, yielding huge losses to production and human life. After several decades of development, virtual reality technology has matured quickly and has changed people's lifestyles by being widely applied in many fields. For example, VR technology has been used to manage accidental fire in industry, agriculture, hospitals, aviation, aerospace, and firefighting. Thus, virtual fire environment technology has become integral to future fire protection. Due to their detection principles or system structures, traditional fire detectors, which include temperature detectors, smog detectors and optical detectors, usually have inherent defects or application restrictions. Because flames and smog have specific colors, textures, shapes and other image features, people have begun to consider using computer visual features to improve the efficiency of fire detection (e.g., video flame detection technology based on image processing). In most fire scenes, flames and smog exist. Fire detection technology based on video images recognizes flames or smog in video images and then implements real-time monitoring of fire scenes. Using Machine learning the Fire Detection and Recognition Optimization Based on Virtual Reality Video Image is obtained. RS is combined with SVM to create an RS-SVM classification model. Dimension reduction on the input vectors is achieved (i.e., even feature variables of the classifier with two attribute reduction algorithms), redundant information is removed, and the reduced results are input into the classifier model for classification. As the selection of kernel parameters strongly affect the classification and recognition ability of SVM, our paper investigates kernel parameter selection and analyzes the impact of the model built by kernel parameter optimization method on the flame image recognition rate. In our paper RS-SVM method is proposed.RS-SVM machine learning theory and has a strong learning ability, adaptability, and high classification accuracy is an advantage of this system.



3.1 Preprocessing

A real-world data generally contains noises, missing values, and maybe in an unusable format which cannot be directly used for machine learning models. Data preprocessing is required tasks for cleaning the data and making it suitable for a machine learning model which also increases the accuracy and efficiency of a machine learning model.

3.2 Gaussian Filter in Preprocessing

A Gaussian filter is a linear filter. It's usually used to blur the image or to reduce noise. Gaussian smoothing is also used as a pre-processing stage in computer vision algorithms in order to enhance image structures at different scales are scale space representation and scale space implementation. Gaussian blurring is commonly used when reducing the size of an image. When down sampling an image, it is common to apply a low-pass filter to the image prior to resampling. This is to ensure that spurious high-frequency information does not appear in the down sampled image (aliasing). Gaussian blurs have nice properties, such as having no sharp edges, and thus do not introduce ringing into the filtered image.

3.3 Segmentation in Fuzzy C-Mean.

Image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as image objects). The goal of segmentation is to simplify or change the representation of an image into something that is more meaningful and easier to analyze. Fuzzy c-mean clustering is one of unsupervised clustering algorithms that is widely used in image processing and computer vision because it easy to implement and clustering performance. It's used to segment an image by grouping pixels that have similar or nearly similar values into a cluster, where each group of pixel's values that belong to one cluster are similar to each other and different from pixel's values that belong to other clusters, and then these clusters represent the segments of the segmented image. Improved fuzzy c-mean algorithm offers an advantage of time consuming.

3.4 Feature Extraction in DWT and GLCM

Feature extraction is a process of dimensionality reduction by which an initial set of raw data is reduced to more manageable groups for processing.

3.4.1 DWT:

DWT means discrete wavelet transform. Feature extraction involves simplifying the amount of resources required to describe a large set of data accurately. DWT can be used for high dimensionality data analyses, such as image processing and image data analysis. The method rearranges the data giving a threshold to the wavelet coefficient using DWT and then calculates the approximate value of the raw data after applying an inverse function to the transformed data. A feature extraction of DWT coefficient is using from a neural network.

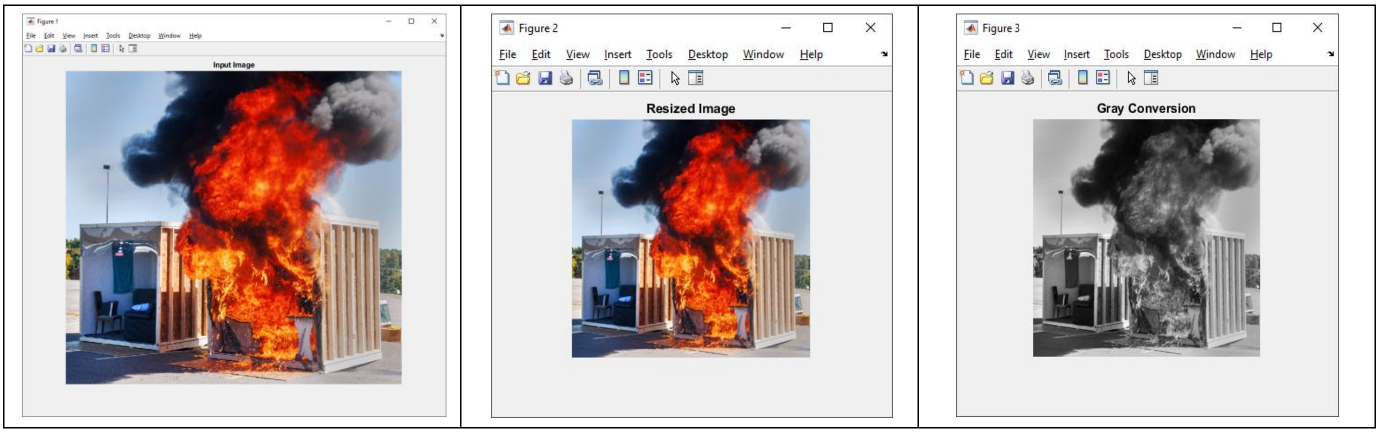
3.4.2 GLCM:

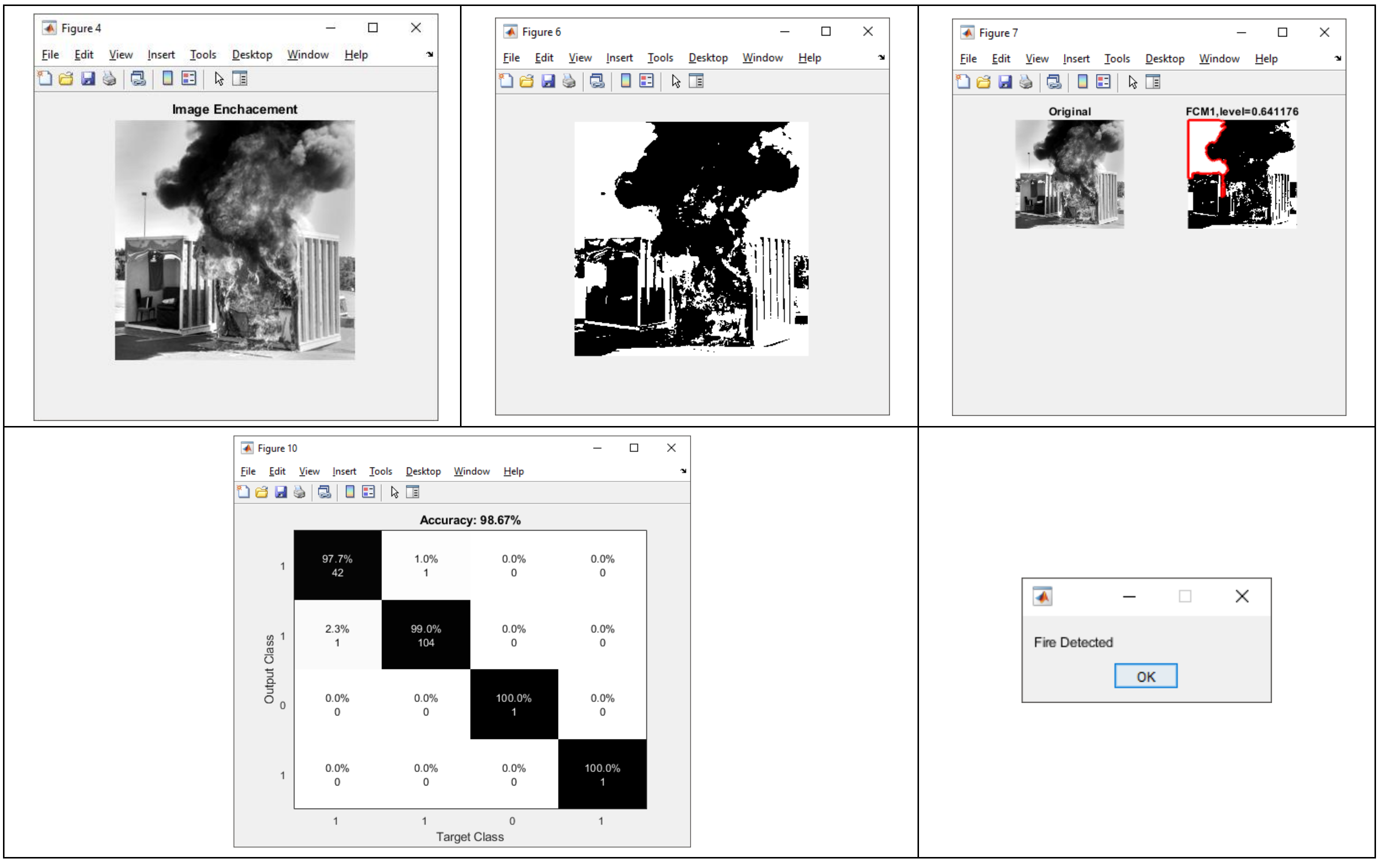
The Gray Level Cooccurrence Matrix (GLCM) method is a way of extracting second order statistical texture features. The approach has been used in a number of applications, Third and higher order textures consider the relationships among three or more pixels. The GLCM functions characterize the texture of an image by calculating how often pairs of pixels with specific values and in a specified spatial relationship occur in an image, creating a GLCM, and then extracting statistical measures from this matrix. The Gray Level Co-ocurrence Matrix (GLCM) method is used for extracting four Statistical Texture Parameters. Both method DWT and GLCM is used to extract the feature in feature extraction model.

3.5 Classification

Classification techniques is used to classify the output depending upon the feature values. SVM algorithm is used in classification problems. SVM or Support Vector Machine is a linear model for classification and regression problems. It can solve linear and non-linear problems. The idea of SVM is simple: The algorithm creates a line or a hyperplane which separates the data into classes. According to the SVM algorithm we find the points closest to the line from both the classes. These points are called support vectors. Now, we compute the distance between the line and the support vectors. This distance is called the margin. Our goal is to maximize the margin. The hyperplane for which the margin is maximum is the optimal hyperplane. For reduced computation time on high-dimensional data sets, efficiently train a binary, linear classification model, such as a linear SVM model is used to get the good performance. In our paper RS-SVM classifier is used to classify the output to obtain the better performance.

IV. IMPLEMENTATION





V. CONCLUSION

In our paper, RS-SVM fire flame recognition algorithm and designed a classifier of fire flame image recognition is implemented. In practical applications, the RS method is sensitive to noise and poor, in fault tolerance and generalization, while SVM has strong anti-noise capability and generalization performance. By building a model with SVM, the parameters of which have been successfully optimized. The experimental results show that the proposed fire flame recognition strategy yields a high recognition rate, a fast recognition speed, excellent robustness, and a wide range of application.

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