Optik 126 (2015) 5011–5018

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.de/ijleo

Fire detection and identification method based on visual attention mechanism

Hai-jun Zhang*, Nan Zhang, Nan-feng Xiao

School of Computer Science and Engineering, South China University of Technology, Guangzhou 510006, China

ARTICLE INFO

Article history:
Received 18 October 2014
Accepted 9 September 2015

Keywords:
Visual attention mechanism
Video image
Fire detection
Support vector machine
Suspected region extraction

ABSTRACT

The method of traditional fire detection has many deficiencies. Not only being susceptible to been interference by environmental factors, but also not to find a lot of information timely and effectively from the fire inspection information. At the same time also not to record the specific details when the fire breaks out. These make it difficult for subsequent fire cause investigation. Therefore, this paper puts forward a new method for fire detection and identification by using visual attention mechanism. That is, through simulation of the human visual system, visual attention mechanism can help us from a lot of complex images to quickly find the information "been worth noting" of the image to find critical information, and to eliminate a lot of useless information. The method can significantly speed up image processing and improve the accuracy of image recognition. Several experiments have been designed to verify the effectiveness of the method by using SVM learning and training. The experimental results denote that the novel algorithms based on visual attention mechanism and been mixed linear function nuclear and radial basis function nuclear improve the accuracy and speed of recognition, significantly reduces the false negative rate of fire recognition and improves the accuracy of fire detection.

1. Introduction

Fire is a kind of uncontrolled combustion phenomenon, it causes harm is very big. Due to the occurrence causes of fire are complex, and the accident probability is very high, so it is difficult to predict in advance. Therefore, in the early days of the fire to accurately identify and alarm are extremely important. At present, most of the fire detection systems still use sensors depending on sampling the concentration of the particles in the air, temperature and so on physical phenomena for fire detection. These traditional ways of fire detection are vulnerable to the impact of the surrounding environment. Compared to the traditional fire detection and identification methods, the fire detection and recognition method based on video images due to the use of the more abundant scenes of fire information, which has obvious advantages. In this paper, the method embedded visual attention mechanism for fire detection and recognition can quickly finds the "worth noting" part – fire suspected area from a large number of complex fire images information, so as to improve the accuracy and speed of fire recognition and significantly reduce the problem such as non-response rates of fire recognition.

The remainder of this paper is organized as follows. Section 2 presents the existing research of domestic and foreign. Visual attention mechanism and Itti model are introduced in Section 3. Section 4 analyzes extraction of interested fire image region. Section 5 analyzes extraction of suspected area of flame. The choice of flame feature is introduced in Section 6. Extraction of smoke suspected area and feature selection are introduced in Section 7. Experimental results and analysis are evaluated in Section 8. The paper is concluded with a summary and discussion of possible future work in Section 9.

2. The existing research of domestic and foreign

At present, in the academia of domestic and foreign the methods research based on video images for fire detection and recognition mainly are divided into two directions: one is to detect whether there are flames in the video images or not; the other is to detect whether there is smoke phenomenon caused by fire in video images or not. On this basis, according to different detection methods and means, the further can be divided into detection methods based on video and video images. For example Krull etc. realized the aircraft cabin fire detection system using the method based on grayscale

* Corresponding author. Tel.: +86 13750557069.
E-mail address: nihaoba_456@163.com (H.-j. Zhang).

http://dx.doi.org/10.1016/j.ijleo.2015.09.167
0030-4026/

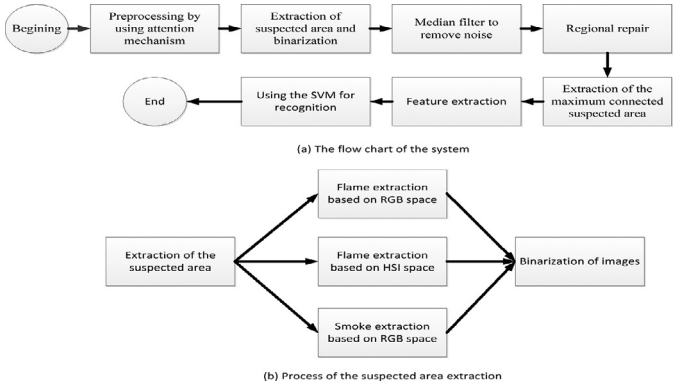

Fig. 1. Fire detection and recognition based on visual attention mechanism model.

of images [16]; Chen and Toreyin etc. analyzed and statistics RGB color information of the fire images [14], adopted the method of color threshold to make images segmented and extracted the fire suspected area. Unlike them Hong etc. used the HSI color threshold information of the fire images to make images segmented [16].

In addition, some scholars putted forward the method used visual attention mechanism for fire detection and recognition. However, computing cost of the algorithm based on a large number of consecutive video frames using attention mechanism was too big, which would reduce the fir recognition speed. In addition, the research theory of visual attention mechanism on video images is not enough deep and there are not mature methods for the significant degree analysis combining the exercise and change aims now. Therefore, based on the above reasons, this paper puts forward a kind of method for fire detection and recognition based on visual attention mechanism, its work process is shown in Fig. 1.

Namely the video images are preprocessed based on attention mechanism at first, eliminate most irrelevant content from the original images, and then fire suspected area is extracted using image segmentation technology, finally, to extract feature and use support vector machine (SVM) for fire recognition. We use the flame extraction based on RGB space, the flame extraction based on HSI space and the smoke extraction based on RGB space when fire suspected area is segmented. When the feature is selected, based on physical and mathematical characteristics of flame and smoke, we use color histogram, edge color moment and texture as features for extracting.

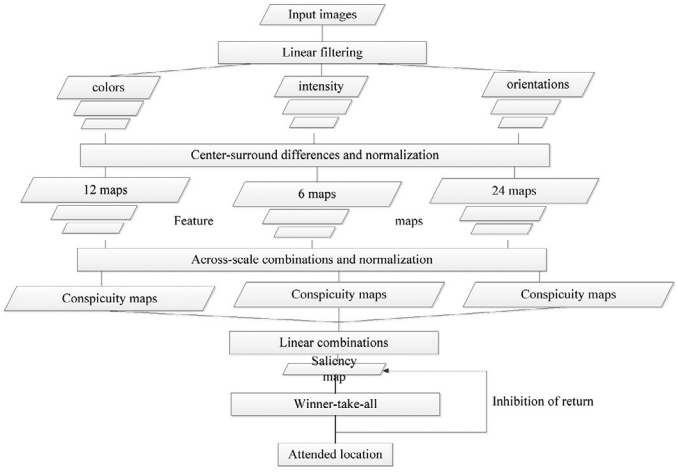

Fig. 2. Itti visual attention model.

3. Visual attention mechanism and Itti model

Visual attention mechanism, in simple terms, when we is observing and processing visual information, we will always pay priority attention for and prioritize enough significant things and information, and ignore not significant things and information. In this paper, visual attention mechanism adopted by the method is based on the Itti visual model [1] in the fire images preprocessing, as shown in Fig. 2. First the input images are made Gaussian decomposition, get multiresolution samplings of the original images; then we calculate characteristics graphs of brightness, color and front according to the samplings, incorporate these characteristics graphs again and can get the attention graphs of three characteristics; From the merger of the three attention graphs to generate a remarkable graph; Finally, we get the focus of attention and interest areas by the winner-takes-all (WAT) neural network.

4. Extraction of interested fire image region

4.1. Gaussian pyramid

In the receptive field theory of human visual system, the mechanism of central excitement and peripheral control conforms to Gaussian distribution, in the visual attention mechanism using Gaussian pyramid decomposition just based on this theory. Gaussian pyramid is a kind of multi-scale visual analysis method – simulate people to observe an object from different distance get visual information of different resolution, so as to get some essential characteristics about the object, it uses Gaussian function continuously for convolution operation and filtering of images and gets different scales of images. Simply put, is to use type (1) to make convolution algorithm for the ith layer of the pyramid to generate the $(i+1)$th layer.

$$G_{I+1}(k,j) = Down(G_i) = \sum_{m=-2}^{2}\sum_{n=-2}^{2} h(m,n)G_i(2k+m, 2j+n) \tag{1}$$

The Gaussian kernel is used by the above processing, as shown in type (2).

$$h = \begin{vmatrix} \frac{1}{256} & \frac{1}{64} & \frac{3}{128} & \frac{1}{64} & \frac{1}{256} \\ \frac{1}{64} & \frac{1}{16} & \frac{3}{32} & \frac{1}{16} & \frac{1}{64} \\ \frac{3}{128} & \frac{3}{32} & \frac{9}{64} & \frac{3}{32} & \frac{3}{128} \\ \frac{1}{64} & \frac{1}{16} & \frac{3}{32} & \frac{1}{16} & \frac{1}{64} \\ \frac{1}{256} & \frac{1}{64} & \frac{3}{128} & \frac{1}{64} & \frac{1}{256} \end{vmatrix} \tag{2}$$

From the type (1) as you can see, compared with general convolution, the arithmetic of Gaussian pyramid makes the size of images down to 1/4.

4.2. Extraction of brightness feature

In the visual attention mechanism, brightness is one of the best sensitive visual characteristics of human eyes. So the conversion from RGB model to HSI model, this section uses formula (3) to get the brightness features of fire images, as shown in Fig. 3.

$$I = \frac{1}{3}(R+G+B) \tag{3}$$

And then use the type (1) to make multi-scale analysis of image shown in Fig. 3(b) build Gaussian pyramid, for eight consecutive drop sampling operations, a set of different scales brightness images are available, as shown in Fig. 4.