A Fire Detection Scheme using Irregular Shape and Color of Flames

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Abstract

In this paper, we propose a fire detection method using irregular shapes and colors of flames in the camera image or video image for the early detection of fire. The flame is changed continuously in the form of irregular and had a particular color. In order to separate the hue components from the saturation and luminance, it uses HSV color space. In the proposed method, generate candidate flame regions by using the color of flames. It compares the new flame region and the candidate region to determine the real fire.

Keywords- Fire Detectin, Flame Color, HSV, Vision Algorithm

I. Introduction

When a fire occurs, it is accompanied with unpredictable damages of human life and property. In particular, the later we are unaware of the fire, the more damage we are experienced dramatically. Thus, the system for detecting a fire is needed to minimize damage in early. However, the conventional electrical detectors based on smoke, gas and temperature are suffered from malfunction and miscalculation due to environmental limitation (e.g. dust, condensation). One of most representative solutions for this problem is a video-based fire detection technique.

In this paper, we propose an image processing technique for detecting the flame. It uses the HSV (Hue-Saturation-Value) color space and the RGB (Red-Green-Blue) color space to extract the color of the flame, and determines the occurrence of fire by comparing and recognizing the flame zone in every frame.

II. Fire Detection

In general, although the flame shape tends to be changed irregularly, it has the color value in the specific range. In order to distinguish the color of the flame in the range, we generate the digital image which is converted into HSV color space by using the hue values except for the brightness and saturation. Then, the scheme extracts the RGB (Red, Green, Blue), H, V values of the pixels in order to configure the candidate region which is considered as real flame. For this calculation, we define expression (1) as follows.

$$F_1(\mathrm{x,y}) = \begin{cases} 1, & \begin{cases} \mathrm{RGB(x,y)} > RGB_{mean} \\ H(x,y) > H_{mean},\ H(x,y) < H_{mean} \\ V(x,y) > V_{mean} \end{cases} \\ 0, & \text{otherwise} \end{cases} \quad \cdots\cdots (1)$$

By adopting above conditional expression (1) into digital pixel, the proposed scheme generates a flame candidate binary image, called F1.

For noise reduction, firstly the scheme makes a 3x3 pixel matrix for 9 pixels. Secondly, the scheme identify whether at least 5 pixels of the matrix satisfy the expression (1) or not. If it is satisfied, it marks all the nine pixels of matrix in the binary image F1. After finishing the scan procedures of all pixels, the algorithm makes labeling for the image F1, and then it stores the coordinates of each labeled candidate block as fire area.

Fig. 1 Randomly changing shape.

It repeats to update the flame candidate binary image F1 for every flame by adopting the expression (1). The candidate shape is shown in figure 1. Due to changes in the irregular shape of the flame in a similar position and the candidate area as shown in figure 1, the labeling may be changed a little in the size and position of the pixel. Then, the scheme investigates the overlapping image blocks by comparing the saved candidate regions and a new fire image block of labeled binary image F1 of the next frame.

Whenever there is overlapping blocks between compared images, the scheme increases the count variable in the candidate region. And if there is none of overlapping blocks, it decreases the count variable. Finally, when the count variable meets a value of 0, the candidate image is removed from candidate region.

After continuously checking the fire area candidate, if the count variable is more than the threshold candidate regions (it is set to 100) and the variable is concentrated more than 3

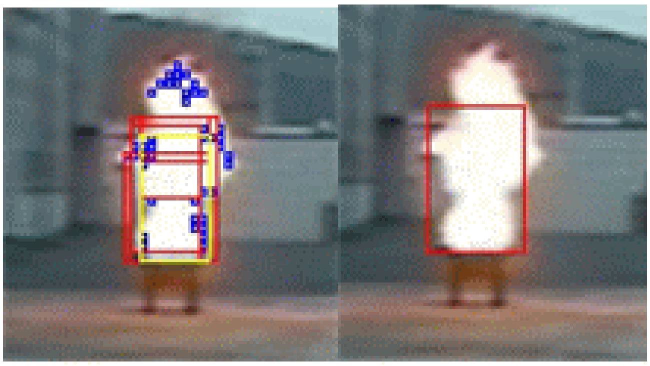

Fig. 2 Fire detection process and results.

areas, the candidate region is judged to be a real fire zone.

In figure 2, the left figure describes an image which is showing the recognition process. The blue block of the image indicates the pixel matrix satisfying the condition (1) to a 3x3 pixel matrix. The block with light blue color is labeled of blue block. The yellow block indicates fire candidate regions, and the red block denotes fire candidate region that count variable is more than predetermined value, which means a final judged area of fire. In the right image of figure 2, the scheme confirms a fire occurrence if the blocks overlaps at least 3 times, and represents the fire zone in the red block on the original image. The detailed operations and recognition algorithm of proposed scheme are summarized in figure 3.

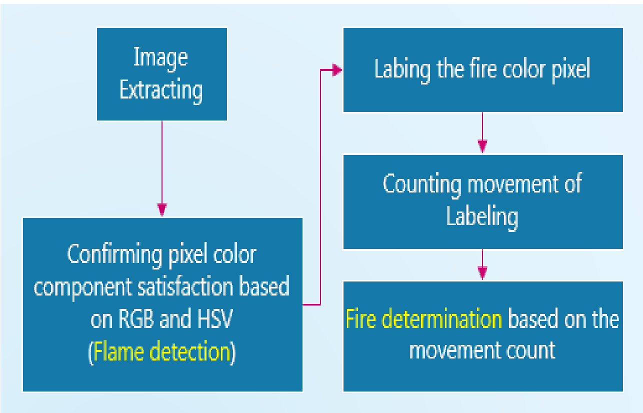

Fig. 3 Algorithm of the fire detection

IV. Performance Evaluation

In order to verify the performance of proposed algorithm, we use two kinds of vehicle driving images in tunnel spaces. The first image is for non-fire situation and the other one is fire occurrence situation to assess the accuracy of the proposed algorithm. For this, we calculate the time of fire and non-fire video. Then, we measured and compared the fire recognition rate and misrecognition rate for the fire and tunnel video. The video used for the performance evaluation is shown in figure 4. The expressions how to calculate recognition rate, misrecognition rate, recognition time ratio, misrecognition time ratio are shown below.

$$\text{Recognition rate} = \frac{\text{The number of videos recognized fire}}{\text{The total number of videos}} \; X \; 100\ (\%)$$

$$\text{Misrecognition rate} = \frac{\text{The number of videos misrecognized fire}}{\text{The total number of videos}} \; X \; 100\ (\%)$$

$$\text{Recognition time percentage} = \frac{\text{Time to recognize the fire}}{\text{The total video length}} \; \text{X} \; 100\ (\%)$$

$$\text{Misrecognition time percentage} = \frac{\text{Time to misrecognize}}{\text{The total video length}} \; \text{X} \; 100\ (\%)$$

Fig. 4 Test videos for experiments

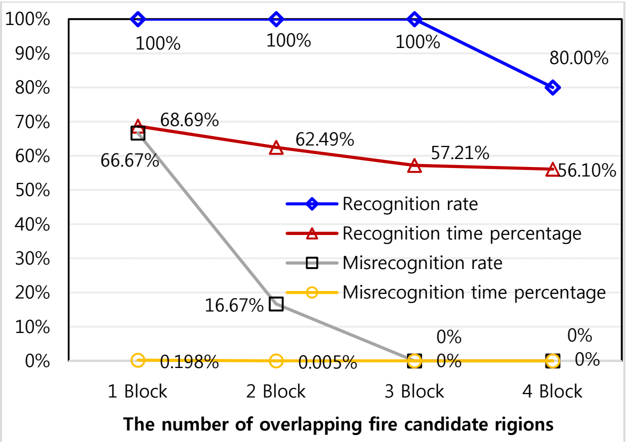

Fig. 5 Performance results of the number of overlapping fire candidate region

All performance measurements were performed via eight fire videos and nine non-fire videos as shown in figure 4. The tunnel videos are used for non-fire scenarios and their resolution are set to 640x480 (VGA) size. The total length of the fire video and non-video are 1,533 seconds and 21,751 seconds, respectively. It is important to note that most elements that may be misrecognized in the tunnel image are vehicle taillights, emergency blinking, and the surrounding light of vehicles while traffic congestion time.

Figure 5 show the results of the measurement of the recognition accuracy of the proposed algorithm based on images of figure 4. All experiments are measured while changing the number of overlapping fire candidate regions, which is the most important basis for the judgment of fire occurrence. According to the results of figure 5, it can be concluded that the most effective scenario is when the fire candidate region is overlapped at least 3 times or more.

V. Conclusion

It is very crucial to detect and make a right judgment about fire occurrence in a timely and appropriate way because the right detection provides right response to fires and other disasters before they increase the damages. In this study, we propose a noble vision algorithm which can detect the occurrence of fire by identifying the flame features in a short time. The performance of the proposed algorithm is verified according to real fire video images. It is expected to be a great help to the real-time analysis of the emergent situations. For future works, we plan to develop an extended streaming algorithm for transmitting the detected information to the remotely located areas.

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