Digital Image Processing Project 2

——Fire Detection

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Abstract

Man mastered the use of fire millions of years ago. But throughout human history, fire has been closely associated with disaster. To this day, fire takes away tens of thousands of lives from this planet every year. Not to mention the forest fires and other damage to both nature and the economy. People have long been seeking for ways to detect fire and alarm in advance. In addition to some devices based on related geometric principles or light energy, image and video processing technologies are the new trends. This report mainly discussed two traditional methods based on different principles for fire detection to deal with separate conditions.

Key words: Fire Detection, Background Method, Feature Recognition Method

Introduction

According to our daily observations as well as some basic concepts mentioned in middle school physics class, flame has got some distinct external features. For example, it shines, sometimes even with harsh light. When there is air moving, it sways heavily in the wind, forming irregular margins. Also we know that it is divided into three layers, each with different temperature levels.

Unfortunately, the features mentioned above have little help to image or video processing, as it requires quantizable ones. So we have to dig deeper at the data level. When we output the RGB channels of a fire image respectively (Fig.1), We can see that for the fire region, the intensity of channel R is the highest, channel G is the second, and channel B is the least.

Fig.1 RGB channels of a fire image

Meanwhile, for some long shots, fire tends to have a rather stable shape. Thus we can use some features like length-width ratio and degree of circularity to distinguish them.

Considering that this task involves both static and dynamic camera videos, I have adopted two different methods.

Background method

The core idea of this method is to extract the flame region by using the characteristic that other objects remain stationary in the video except the flame outline.

For each frame of the video, firstly we read it in. If it is the first frame, the the background is itself. Further calculations are meaningless. If it is not, then we generate the adaptive background by weighting the former background and the previous frame. In the program, I weighted them equally. This is because the video is actually shaking. So we need to eliminate the shaking as much as possible. Theoretically, ideal binarized difference image between the current frame and background contains only the fire region. Thus we can easily add boxes according to connected domains. Also, with some off-the-shelf code, we are able to calculate the mean intensities in gray levels to represent the threshold of binary image.

In the origin plan, as flame has no fixed shape, or to say its outline changes from frame to frame And the binarized difference image should contain the whole fire region. But it came out to be incomplete. Then I tried to locate the pixels back in the initial frame and calculate the connected domains. Unfortunately, it still worked badly. Perhaps the threshold should be re-determined.

Feature recognition method

This method mainly consists of four parts: HSV filter, length-width ratio criterion, circularity criterion, and connected domain computation. The thresholds of the first three items are based on experiences of classic fire image and certain fire in videos of this task. The parameters filter mask, bias of length-width ratio, and threshold of circularity set in the program are not typical values but a compromise of detection accuracy and false alarm ratio in the video fire1.mp4.

After reading in the current flame, we let it pass through the compound criterion mentioned above. The remainder is regarded as fire region and is outlined according to the outcome of connected domain calculation. The advantage of this approach is that we can output the result frame by frame constantly. If the computation speed is fast enough, it can even be done in near real time. However, the computation speed on personal computer is not decent at all. It took me over one hundred times of the length of the video to process.

Result Analysis

Fixed camera videos

As the result is not pretty, I haven’t output a video. Instead, some screenshots are as follows:

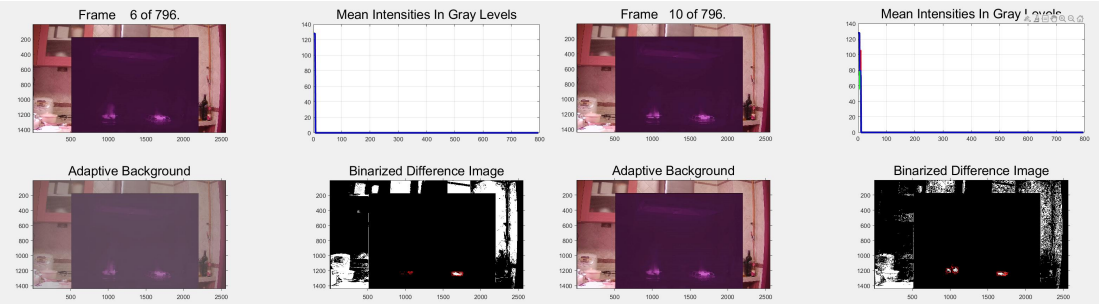

Fig.2 Screenshots of fire detection in gasstove.avi

We can easily tell that the shortcomings mainly focus on the missing of core part of fire. This is reasonable as this part tends to be stable. But not being able to outline the whole region is quite confusing. For further improvement, the weights could be optimized to achieve better background modeling.

Dynamic camera videos

Some screenshots of the outcome are as follows:

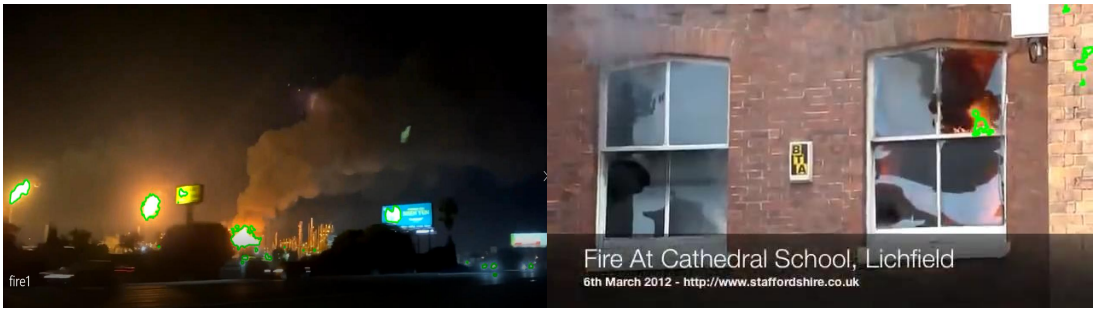

Fig.3 Screenshots of fire detection in fire1.mp4 and fire2.mp4

As we can see, the flame identification rate is good in the former video, as the criterion satisfies well with those fire regions. But many artificial luminaries are also falsely pointed out, as they cannot be filtered out by the criterion. In order to lower the false alarm rate, we may think of introducing more criteria or optimize the thresholds. But that will leads to a further increase in algorithmic complexity.

For the latter video, the heavily swinging fire is misjudged, as it is extremely irregular and doesn't fit in with the features. We may think of changing some criteria and try to find out more about its own features.

Conclusion

In this work, I have self-taught and designed two methods of fire detection, and have summarized the algorithms in my own words. It is a pity that I am not able to get better results in the limited time. Anyhow, I have formed a basic concept of background modeling in this process. Not to say that I deepened my understanding of the application of image processing. As one of the hot research topics at the moment, deep learning leads the development of fire detection. In the near future, we can expect to witness the invention of more accurate and universal criteria.

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