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Image-based Assistance to Fire Extinguishing System with Mote

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Abstract

This paper studies a computer vision based fire scene analysis method that can be applied to a sensor network based system which can assist fire extinguishing activities. We proposed an image based sensor network system with mote. To deal with heavy images, we introduced computer vision algorithm to address the low bandwidth of sensor network. Our vision algorithm can detect fire, smoke and the global direction of smoke from a variety of color fire images that provides clear understanding of the fire caught place.

1. Introduction

Fire results in immeasurable sufferings to man and mankind. Fire fighters all over the world are constantly seeking the benefits of early warning of potential fires. Hence to assist the fire extinguishing activities, we propose an image-based sensor network system with mote to notice the fire fighters about the location of fire, smoke situation, propagation direction of smoke, wounded person's situation of a fire caught place apart from the fireman. There are some existing methods to detect fire with sensor networks. The method in [1] describes the design of a system for wildfire monitoring incorporating wireless sensors, but provides no visual information of fire and smoke. Two previous vision-based methods that are presented in [2] and [3] seem to be promising. However, both of these can detect only fires in ideal conditions and do not address the detection of smoke. Hence we propose a system to detect fire and smoke and its propagation path, and to transmit the visual information to the fire fighters with sensor network for their better understanding of the situation of the fire caught place.

2. Proposed Approach

Our proposed method targets the use of an ad hoc sensor network based on color video sequences taken by camera of the sensor nodes as shown in figure 1. Because even if part of the network is destroyed, the ad hoc network can survive. For clear understanding of the fire caught place, video sequence should be sent to the fire fighters. But the band width of sensor networks such as ad hoc network with Mote is too narrow to directly send the video fire sequences. Hence as compression method of the video sequences, computer vision technologies are used in our proposed system. The use of computer vision technology is not only for compression but also for more advanced analysis of video sequences of fire.

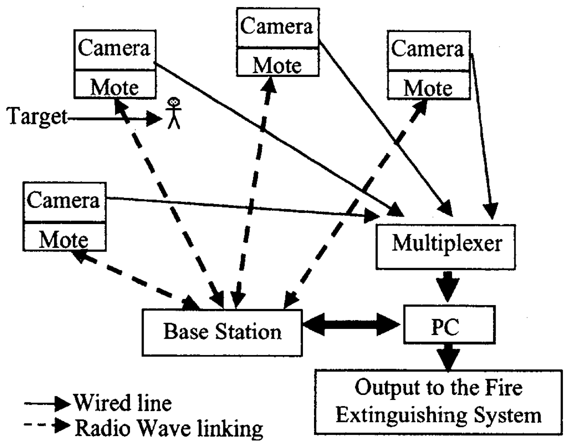

Figure 1: Proposed method with mote and image processing unit.

Therefore our proposed method consists of two main parts: (a) sensor network with mote and (b) image processing unit. The purpose of the sensor network is to transmit local information around its node to the fire fighters. The image processing unit provides the visual understanding of the fire caught place.

3. Algorithm for Image-based Fire and Smoke Detection

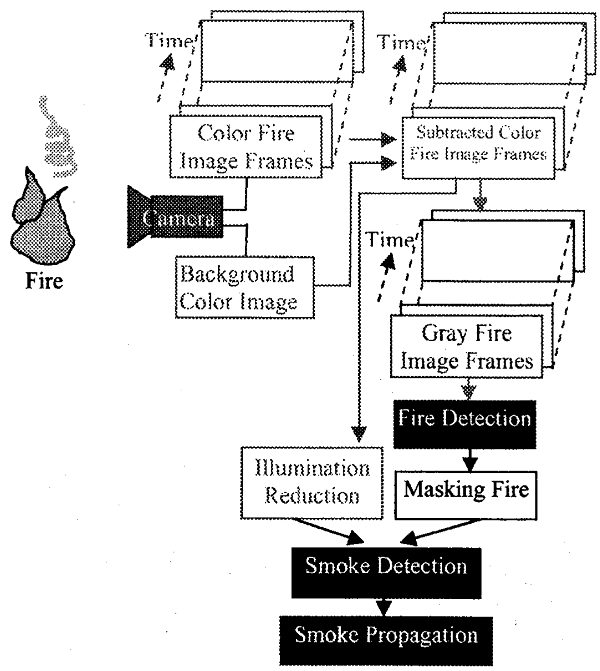

Figure 2: Block diagram of the proposed algorithm.

As shown in figure 2, the proposed method consists of three main modules (filled with black in the diagram) such as (i) fire detection, (ii) smoke detection, and (iii) global direction of smoke detection. For the detection of fire, a camera takes the color video sequences of fire and the background image which is subtracted form color video sequences. The color subtracted images of fire are then converted to its gray level image. A threshold is applied to that gray level image to detect fire. To ignore the effect of other objects present in the scene, noise reduction is done on the thresholded fire images.

For our case, the fire periphery and the strong reflection caused by the fire create noise in the detection of smoke. We created fire mask after detecting the fire that suppresses the effect of fire and some noises created by fire. But the illumination created by fire around its vicinity also has a strong influence in the detection of smoke. Hence to ignore the effect of illumination, we did illumination reduction by comparing the red channel values with green and blue channel values of the background subtracted image. Then we applied the fire mask and did illumination reduction to detect smoke without noise. A threshold is then applied that detects the smoke.

The detected smoke region is then subblocked and threshold is applied on each subblock to get the significant smoke candidate. Then by comparing the edges of successive images and applying DP matching to the contours of the corresponding smoke regions in the successive frames the global direction of smoke is detected.

4. Experimentals, Results and Discussions

The image frames used in our experiments were experimentally taken in a fire laboratory. They include different types of fires and smokes such as at the beginning of a fire, traversed after some time and fully covered with smoke after the suppression of fire. The color video sequences consist of 13,000 frames in BMP. The size of each frame was 720x480. The camera was positioned about 10 feet far from the fire spot. The real fire had been generated in a room by burning small pieces of woods with some burning chemicals. The size of the room was about 25x25 square feet.

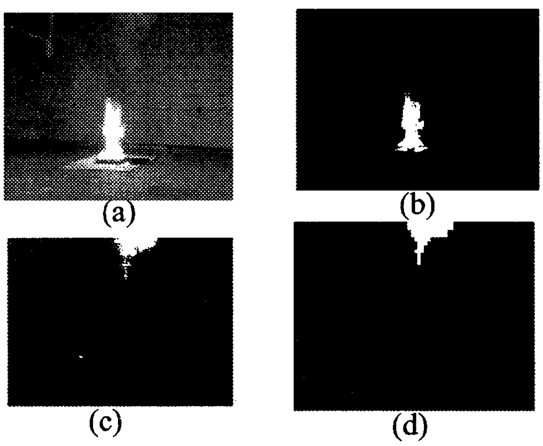

Figure 3: (a) Color fire image, (b) Detected fire, (c) Detected smoke, (d) Subblocked smoke image.

From the figure 3(b) and 3(c), it is observed that fire and smoke has been detected successfully without any noise. It is seen that we could ignore the effect of fire periphery and the illumination caused by fire with fire mask and illumination reduction. We detected the global direction of smoke by considering the orientation of maximum displacement vectors of two successive subblocked smoke image frames i and i+1 as shown in figure 4(a) and 4(b) which was calculated by DP matching. Then by histogram analysis of the displacement vectors, we counted its peak with respect to orientation. From figure 4(c), it is seen that the peak of the histogram is in 0 to 45 degree; therefore the global direction of smoke is 0-45 degree for these two successive frames.

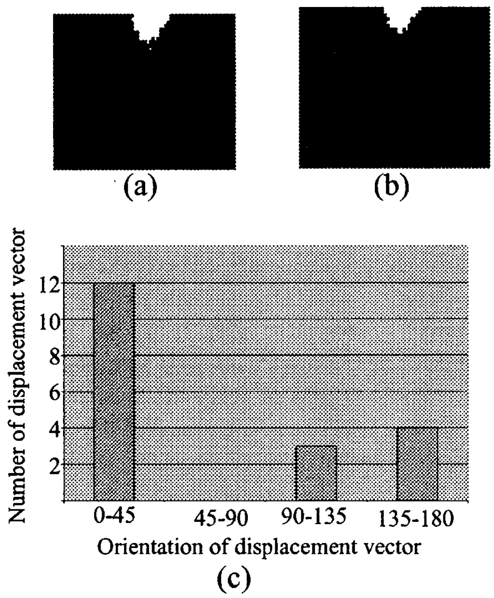

Figure 4: (a) Subblocked smoke image frame i (b) Subblocked smoke image frame i+1, (c) Histogram analysis for smoke tracking

5. Conclusion

The fire caught place needs to initiate quick rescue process to save the damages of properties. Hence the implementation of our proposed method would greatly enhance initiating the quick fire extinguishing activities with the visual information of fire and smoke; and using the global direction of smoke fire fighters can assume from which direction smoke is coming and initiate their activities thereby.

References

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