# Vision based Fire Detection and Robot Maneuvering Algorithm

Md. Zainal Abedin
Computer Science and Engineering
USTC, Chittagong
Bangladesh

Md. Sajjatul Islam
Computer Science and Engineering
EDU, Chittagong
Bangladesh

## ABSTRACT
Vision based fire detection is potentially a useful technique. With the increase in the number of surveillance cameras being installed, a vision based fire detection capability can be incorporated in existing surveillance systems at relatively low additional cost. Vision based fire detection offers advantages over the traditional methods. It will thus complement the existing devices. Conventional fire detection systems use physical sensors to detect fire. Chemical properties of particles in the air are acquired by sensors and are used by conventional fire detection systems to raise an alarm. However, this can also cause false alarms; for example, a person smoking in a room may trigger a typical fire alarm system. In order to manage false alarms of conventional fire detection systems, a computer vision-based fire detection algorithm is proposed in this paper. The proposed system consists of two main parts: fire color modeling and robot navigation. The algorithm can be used in parallel with conventional fire detection systems to reduce false alarms in order to rescue indoor appliances. It can also be deployed as a stand-alone system to detect fire by using video frames acquired through a video acquisition device. A fire color model is developed in RGB color space to identify fire pixels. The proposed fire color model is tested with video sequences captured in different illumination condition in indoor ambience. The experimental results are quite encouraging in terms of correctly classifying fire pixels according to color information only. In addition; the navigation of the robot is tested through a simulated environment.

## General Terms
Image processing, Computer Vision, Algorithm

## Keywords
False alarm, RGB fire color model, robot navigation

## 1. INTRODUCTION
Visual fire detection can be very useful where conventional fire detectors cannon be used. Fire has diverse, multispectral signatures, several of which have been utilized to devise different methods for its detection. Most of the methods can be categorized into smoke, heat, or radiation detection. A detailed survey can be found in [1].Particle and temperature sampling, and air transparency testing are simple methods that are frequently used for fire detection [2, 3]. These methods require close proximity to the fire and gives false alarm in case of smoke. In [2], color and motion are used to classify regions as fire or non-fire and statistical method is use to detect fire in [3]. But these methods only work on ideal condition. In [4] thermal sensor are used which changes intensity based on temperature. In [5] and [6], two vision based methods are presented, but both of them rely on the ideal conditions. Ref [7] gives general information about the progress in the application of image processing algorithms in fire detection. In the research of [8] and [9], flame area is extracted using statistical HSV color space. In [10] a real time fire detector is used that combines foreground object information with statistical fire color model.

The majority of vision based fire detection system employs some type of hybrid model combining color, geometry and motion features. In this work we used the color feature to classify the fire region. A human has five sensory organs namely sight, hearing, taste, smell and touch. A human has a tendency to rely on his eyes more than any other sensory organ. Sight helps a human to determine the size, shape and color of an object. A human can easily see and determine fire from a long distance. Thus, in our work, we are focusing on the vision sensory abilities in our robot to determine fire. In this work, an intelligent fire fighting and detection system is proposed which uses a machine vision to locate the fire flame positions and to control a mobile robot to approach the fire source.

The organization of the rest of paper is as follows. In section 2, the proposed fire detection algorithm is explained along with flowchart of the algorithm. Then the navigation algorithm of the fire extinguisher robot is presented in section 3, followed by our simulation results in section 4 and in section 5 with a discussion of limitations and future steps of this research as conclusion is represented.

## 2. FIRE DETECTION ALGORITHM
All vision based systems generally make use of three characteristic features of fire: color, motion and geometry. In this work we used color information of the fire to locate the fire region.

At first, the frames are captured from the image acquisition devices- camera. The frame size is divided into three regions namely Left (L), Middle (M) and Right(R) which is illustrated in figure1. We then enhanced the contrast of the image by increasing its Gamma value five times. Then the image is complemented to obtain the blue border surrounding the fire flame. This blue borders was used in order to determine the region of interest – fire region. The blue border should have an intensity satisfying the threshold values, I= ((R>150 & R<180) & (G>210 & G<231) & (B>215 & B<245)). The image is thus converted into a binary Image with the white area indicating the fire region. After this, the region properties of the fire flame are calculated and centroid of the fire (Left or

Middle or Right) is determined. The complete flowchart of fire detection algorithm is presented in Figure 2


**Fig 1: Division of image into three regions - named LEFT, MIDDLE and RIGHT**

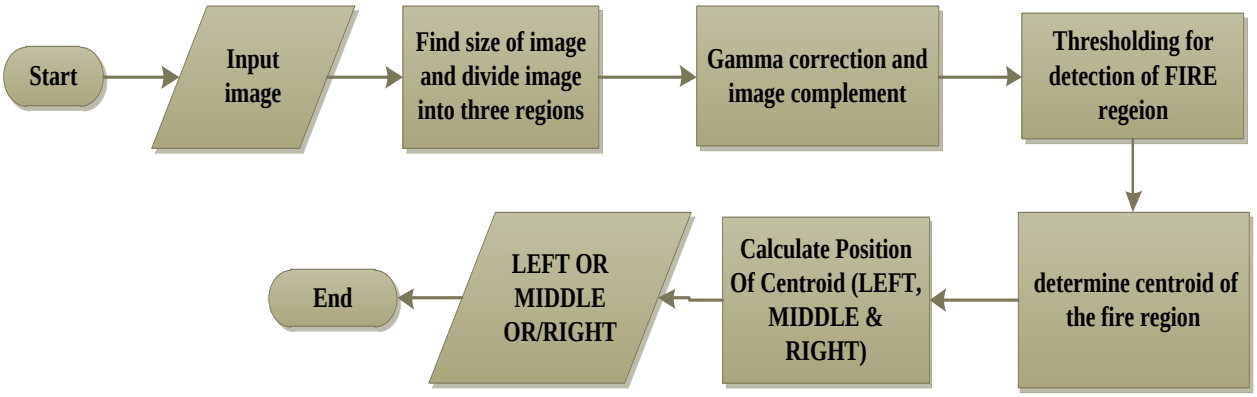


**Fig 2: Fire Detection Algorithm**

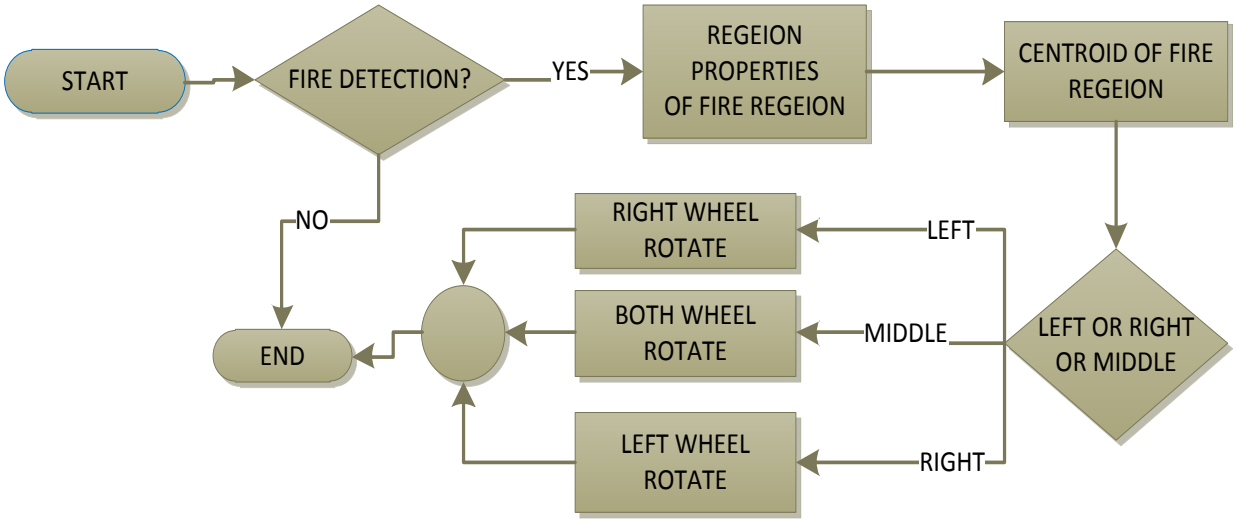


**Fig 3: Robot Maneuvering Algorithm**

## 3. ROBOT MANEUVERING ALGORITHM

After detecting the fire, the vision based robot determines the centroid of the flame by using the region properties . The position may be left,middle and right. Then the offset value of these positions is used in order to be alligned towards the centre of the flame. The robot turns left or right according to the offset value of location of fire regein until it gets the centroid is in the middle regeion. When the location is returned middle, then the robot approaches to the fire regeion in order to extinguish the fire flame. The complete flowchart of proposed algorithm is depicted in figure 3.

## 4. SIMULATION RESULT

To simulate the proposed fire detection system, we tested it on some frame sequences .The system was prototyped using MATLAB R2012 with the Intel Core Dual Processor at 2 GHz processor 2 GB RAM. The resolution of the frame was 320 by 240 and the frame rate was 30 FPS. The data sets consisted of indoor, day, and night video sequences with a variety of lighting conditions and distances to the fire in the video.

The fire robot was simulated in an attempt to detect the fire and move to fire region. When turned on, the frames are captured using on board image acquisition device. Then fire detection algorithm is executed to determine whether there is fire or not. If fire is detected, then it starts to determine the position of the fire flame and an attempt is initiated to approach toward the fire by aligning itself in the direction of fire. The robot stops itself if there is no fire in the surrounding.

Some simulation results are presented here in Fig.4 to Fig.6 in these cases the fire was detected successfully, the centroid of the fire was found Middle, Right and Left respectfully. In the case of Fig.4 the robot turned to approach to the direction of fire flame to extinguish. In figure 5, the robot turned left until the centroid is middle and in figure 6 the fire robot responded according to our proposed algorithm. The proposed algorithm classified fire pixels correctly in the image captured indoor under different illumination conditions, such as day and night, presence of different light source. But, when tested on images captured in outdoor under the sunlight, it failed to detect the fire flame correctly.

**Fig 4.1: Input Image 1**

**Fig 4.2: gamma increased image of input image 1**

**Fig 4.3: complement of gamma increased image**

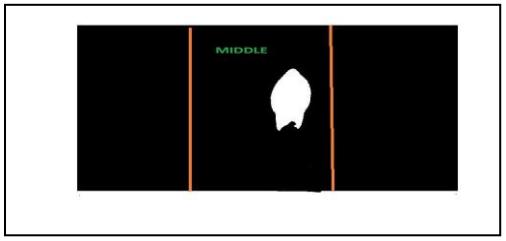


**Fig 4.4: threshold image**

**Fig 5.1: Input Image 2**

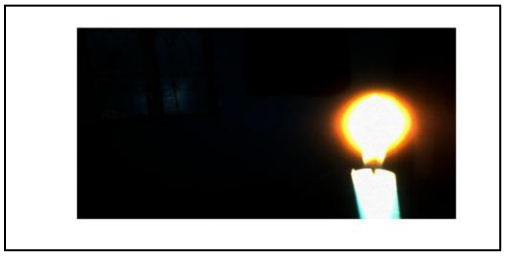

**Fig 5.2: gamma increased image of input image 2**

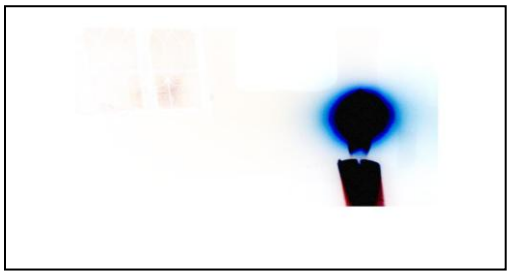

**Fig 5.3: complement of gamma increased image**

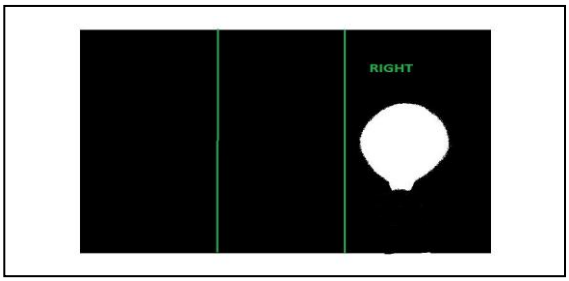


**Fig 5.4: threshold image**

**Fig 6.1: Input Image 3**

**Fig 6.2: gamma increased image of input image 1**

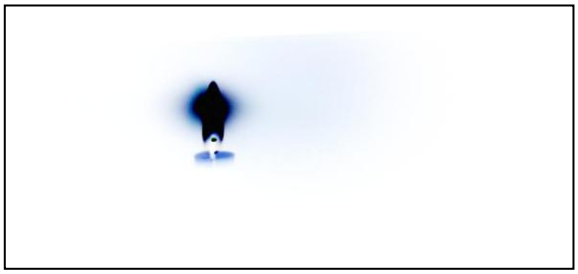

**Fig 6.3: complement of gamma increased image**

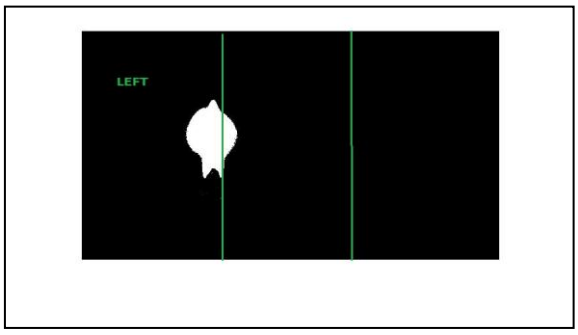


**Fig 6.4: threshold image**

## 5. CONCLUSION

In this paper, a simple algorithm for fire detection and maneuvering fire robot based on vision capability was proposed where a fire color model was developed in RGB color space to identify fire pixels and for extinguishing fire, a navigation procedure was designed. The fire detection algorithms classify the fire region by Gamma correction, image complement and thresholding in order. After detecting the fire, the robot aligns itself according to the position of centre of fire region through determination of centroid of the fire.

Though the results were quite encouraging in the scenario of when the image was captured in indoor environment at different illumination condition, the proposed algorithm failed to detect fire in the images while simulation in the outdoor under the direct sunlight. Further work will extend our algorithm to be more robust, efficient and real time.

## 6. REFERENCES

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