MASTERS OF SCIENCE COMPUTER SCIENCE AND ENGINEERING

SMOKE DETECTION USING IMAGE PROCESSING

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Smoke Detection using Image Processing

A project submitted in partial fulfillment of the requirements for the degree of Masters of Science in Computer Science and Engineering.

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DECLARATION

We, hereby declare that this thesis is based on the results found by ourselves. Materials of work found by other researcher are mentioned by reference. This Thesis, neither in whole or in part, has been previously submitted for any degree.

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Abstract

In this report, we have proposed a smoke detection method from image. The Smoke Detection using Image Processing (SDIP) is based on four steps. First, Smoke image acquisition and pretreatment is performed. Second, Preprocessing of collected images. Which include converting RGB to HSV, Binarization, Thresholding, Third, Selecting smokes principals. Fourth, Smoke detection based on principals considering Saturation, Intensity and Area of the smoke. The Smoke Detection using Image Processing (SDIP) System is implemented by the MATLAB simulation. We use 46 images for calculating threshold value and 87 images for the identifying smoke. We use some statistical equations to calculate threshold value. We compare our result by trial and error process. We use some graphs to show the result. We also compare some recommended algorithm with our proposed algorithm.

Acknowledgements

I would like to take this opportunity to express my gratitude to those people whom had given me the support and help throughout this implementation. At first, I want to admit my gratefulness to almighty God who enabled me to complete this implementation successfully. Then I would like to give thanks to my project supervisor Dr. Jia Uddin, Assistant Professor, Department of Computer Science & Engineering, BRAC University for his continuous guidance, spontaneous support, relentless encouragement, helpful suggestion, constructive advice, constructive criticism and endless patience to take the project and give me direction to complete a thesis paper implementation. The successful completion of project would not been possible without his persistent motivation and guidance. I must also convey my special thanks and gratitude to Dr. Amitabha Chakrabarty, Assistant Professor, department of Computer Science & Engineering for his constant guidance. I would like to thanks to all of my friends for their valuable suggestions and assistance for completing the implementation.

CHAPTER 1

INTRODUCTION

1.1 Motivations

Smoke detection methods are a vital commodity in every occupied building in the world. Smoke detection method help to detect and indicate a threat to nearby inhabitants in the event of a fire. Smoke detectors allow people to become aware of their surroundings and alert them to seek safety. In the recent time a lots of fire accident happened in Bangladesh. September 11, 2016 the fire at a food and cigarette packaging factory in Bangladesh that killed at least 26 people has been extinguished, but heavy smoke and the risk of the building collapsing further were hampering the search of the premises. September 10, 2016 a fire broke out in a garment packaging factory just outside the Bangladeshi capital on Saturday, killing at least 12 people, police and witnesses said. February 1, 2015 at least 13 people including two women were killed when a fire swept through a plastics factory in Bangladesh's capital Dhaka on Saturday, police said. There are a lots of example can be found. Studies have shown that in the United States the use of early warning fire and smoke detection systems has resulted in a significant reduction overall in fire deaths. Smoke detectors play an important role in saving lives and are the first defense in helping to identifying a fire. Though a lots of smoke detectors projects are available today’s world but Smoke detection from image is very limited. Some researchers have already designed a smoke detection method from captured video but smoke detection from still picture is a challenging thing which can be very helpful to increase the efficiency to the smoke detector.

1.2 Thesis orientation

Our thesis paper on smoke detection using image processing system (SDIPS) is organized into five chapters. These are:

Chapter-1 Introduction: In this chapter we have already discussed about motivation and prospects of smoke detection using image processing system (SDIPS). Actually it is the preliminary chapter which describes the primary description about the implementation.

Chapter-2 Literature Review: It contains the sufficient description about previous work done on smoke detection and their limitations.

Chapter-3 Proposed Model: This chapter includes the description of our proposed model and implementation process of SDIPS. This chapter contains step by step details of our proposed model.

Chapter-4 Experimental Results and Discussion: This chapter contains the experimental set up and some experimental results that have been done during implementation of SDIP system. We try to represent the implementation results with proper figure and output format analysis here.

Chapter-5 Conclusion and Recommendations: This chapter concludes our thesis works mentioning the goal that we are achieved in by completing our work. We also mention the correctness and accuracy of our methodology by which we have done the work. Moreover, the limitations are mentioned in this chapter.

CHAPTER 2

BACKGROUND INFORMATION

2.1 Literature Review

A lot of work has been done in this field and there is a lot to improve. Before starting implementation of main task we go through similar paper to know about the whole system such as what are the things we need to consider in order to detecting the smoke, what are the algorithms other people used to face recognition and what is their accuracy level. Turgay Çelik, Hüseyin Özkaramanl, and Hasan Demirel has proposed "Fire and Smoke Detection Without Sensor: Image Processing Based Approach" [1]. The models use different col- our models for both fire and smoke. The colour models are extracted using a statistical analysis of samples extracted from different type of video sequences and images. For smoke detection they used Saturation value ($S\ (x, y) <= 0.1$) which is not enough to detect smoke. DongKeun Kim and Yuan-Fang Wang has proposed a model "Smoke Detection in Video" [2]. They proposed a method for smoke detection in outdoor video sequences. They used background image as reference image. But problem is that they used the technique for captured video But it will not be useful for captured image from difference place. Their method will work only for the selected place. E.Haber, Kolesov, P.Karasev, A.Tannenbaum has proposed a method "Fire and Smoke Detection in Video With Optimal Mass Transport Based Optical Flow and Neural Network"[3]. , we propose the use of *optimal mass transport* (OMT) optical flow as a low-dimensional descriptor of these complex processes. The detection process is posed as a supervised Bayesian classification problem with spatiotemporal neighborhoods of pixels; feature vectors are composed of OMT velocities and R,G,B color channels. The classifier is implemented as a single-hidden-layer neural net- work. Sample results show probability of pixels belonging to fire or smoke. In particular, the classifier successfully distinguishes between smoke and similarly colored white wall, as well as fire from a similarly colored background. But they did it for video not for the captured image. Pietro Morerio, Lucio Marcenaro, Carlo S. Regazzoni have proposed a method "*Early Fire and Smoke Detection Based on Colour Features and Motion Analysis*" [4].

Detection of fire and smoke pixels is at first achieved by means of a motion detection algorithm. In addition, separation of smoke and fire pixels using color information (within appropriate spaces, specifically chosen in order to enhance specific chromatic features) is performed. In parallel, a pixel selection based on the dynamics of the area is carried out in order to reduce false detection. The outputs of the three parallel algorithms are eventually fused by means of a MLP. But problem is they work for video not for captured image. In the captured image it is hard to detect motion actually there is no chance. Yu Chunyu, Fang Jun, Wang Jinjun and Zhang Yongming have proposed a model "Video Fire Smoke Detection Using Motion and Color Features" [5]. Again they did it from a video sequence and they used motion.

CHAPTER 3

PROPOSED METHODOLOGY

3.1 Overview

Figure-3.1 shows a bird's eye view of Smoke Detection using Image Processing System (SDIPS).

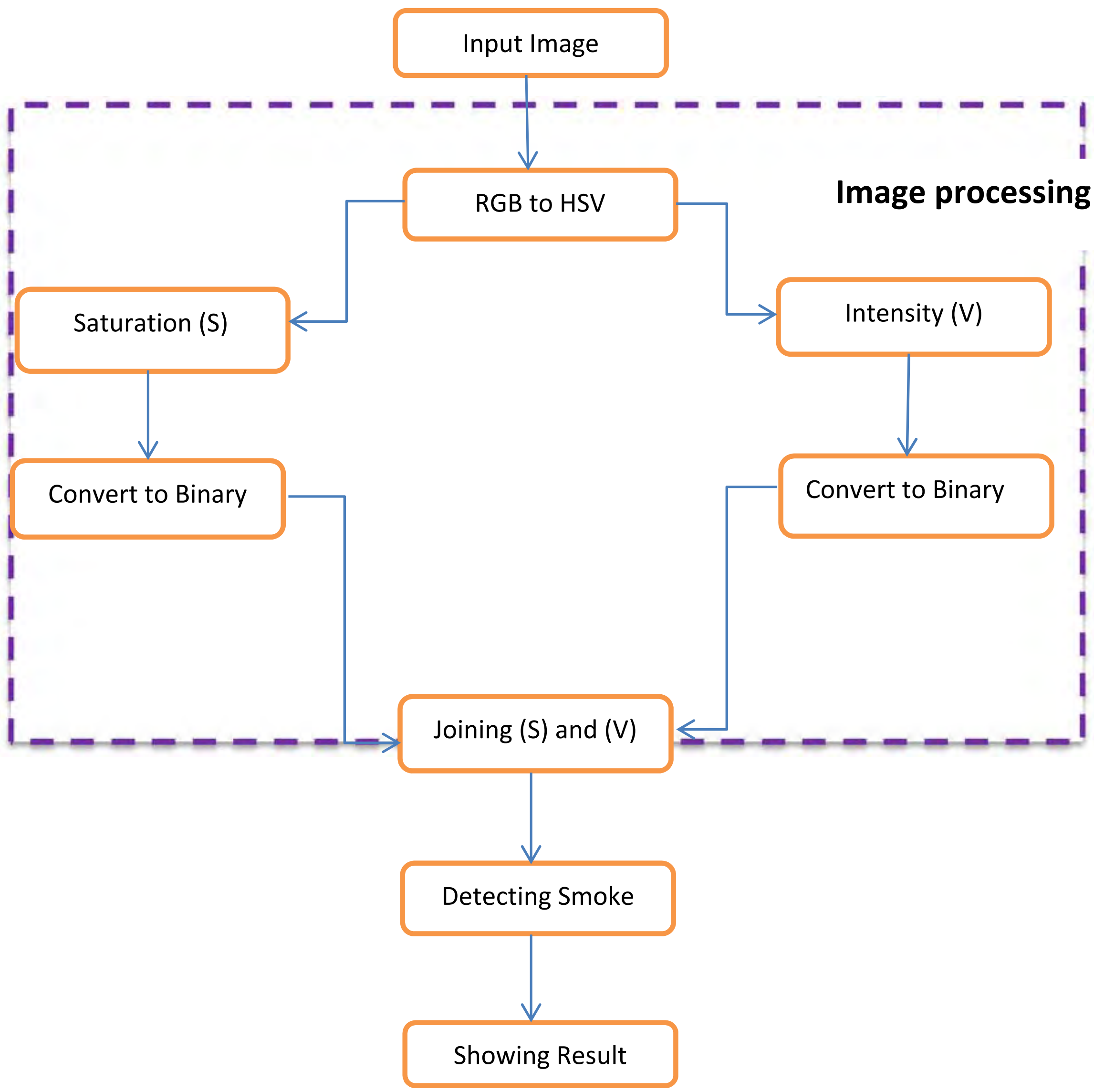

Figure 3.1 Flowcharts of SDIPS

Our proposed model can be described in the following steps. This includes:

- Input Image
- Color Space Conversion
- Detecting Smoke using Image Processing

In the following we will have a details look about each of the steps. From this chapter we will able to learn about the dataset is used and we can understand the Smoke Detecting using Image Processing System (SDIPS) properly.

3.1.1 Input Image

Our ability of vividly describing the content of images is a clear demonstration of the power of human visual system. We can only recognize smoke in images. But visual perception is not limited to the recognition and description of objects. Our aim is to recognize the smoke from the image. We first select some characteristics of smoke by analyzing the smoke picture. We try to find the smoke image from the goggle and other site but we want to make sure the quality of the image, because without the image of good quality we will not able to select the characteristics of the smoke from the image. Our dataset consists of 87 pictures for identifying the smoke and 46 images for thresholding smoke. This 46 image is used to calculate the mean, variance, standard deviation and finally the threshold value.

3.1.2 Color Space Conversion

Color space conversion has some small parts also they are:

- RGB to HSV
- Calculate saturation and intensity
- Binarization on the basis of threshold value.

(a) RGB to HSV conversion

Most televisions, computer displays, and projectors produce colors by combining red, green, and blue light in varying intensities—the so-called RGB additive primary colors. The resulting mixtures in RGB color space can reproduce a wide variety of colors (called a gamut); however, the relationship between the constituent amounts of red, green, and blue light and the resulting color is unintuitive, especially for inexperienced users, and for users familiar with subtractive color mixing of paints or traditional artists' models based on tints and shades . Furthermore, neither additive nor subtractive color models define color relationships the same way the human eye does.

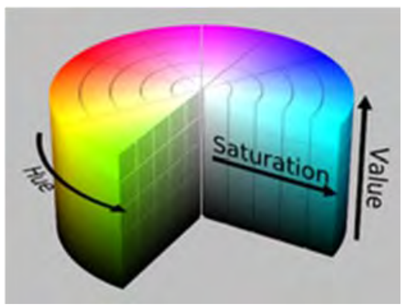

Figure 3(2): HSV color model

HSV is cylindrical geometries (fig. 3(2)), with hue, their angular dimension, starting at the red primary at 0°, passing through the green primary at 120° and the blue primary at 240°, and then wrapping back to red at 360°. The central vertical axis comprises the neutral, achromatic, or gray colors, ranging from black at lightness 0 or value 0, the bottom, to white at lightness 1 or value 1, the top

The main conversion process is as follows:

$R' = R/255$

$G' = G/255$

$B' = B/255$

$Cmax = \max(R', G', B')$

$Cmin = \min(R', G', B')$

$\Delta = Cmax - Cmin$

Hue calculation:

$$H = \begin{cases} 0^\circ & \Delta = 0 \\ 60^\circ \times \left(\frac{G'-B'}{\Delta} \bmod 6\right) & , C_{max} = R' \\ 60^\circ \times \left(\frac{B'-R'}{\Delta} + 2\right) & , C_{max} = G' \\ 60^\circ \times \left(\frac{R'-G'}{\Delta} + 4\right) & , C_{max} = B' \end{cases} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad 1$$

Saturation calculation:

$$S = \begin{cases} 0 & , C_{max} = 0 \\ \frac{\Delta}{C_{max}} & , C_{max} \neq 0 \end{cases} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad 2$$

Value calculation:

$V = Cmax$

(b) Binarization on the basis of threshold value

In this process we use 46 pure smoke images to calculate the threshold value of smoke. The calculation process will be as follows:

Mean $(\mu) = (\mu_1+\mu_2+\ldots..+\mu_{46})/46$ 3

Average Variance $(\partial^2) = (\partial_1^2+\partial_2^2+\ldots..+\partial_{46}^2)/46$ 4

Average Standard Deviation $(\partial) = (\partial_1+\partial_2+\ldots..+\partial_{46})/46$ 5

According to the above calculation we can calculate the final threshold value by using these threshold value we can use the binarization. Our final threshold equation is:

Threshold $(T) = \mu+2\times\partial$ 6

Where,

μ= Average mean value

∂= Average Standard Deviation.

Thresholding image dataset is given below:

Image 01

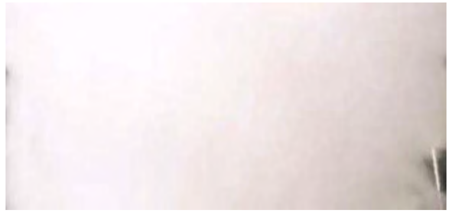

Image 02

Image 03

Image 04

Image 05

Image 06

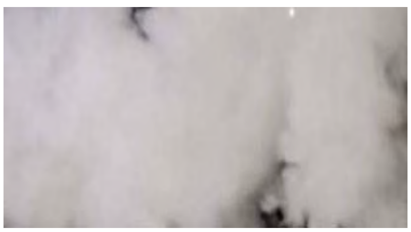

Image 07

Image 08

Image 09

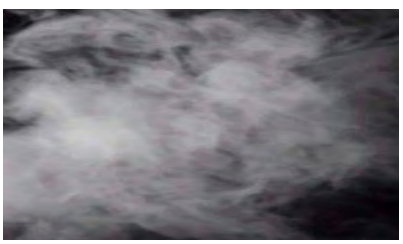

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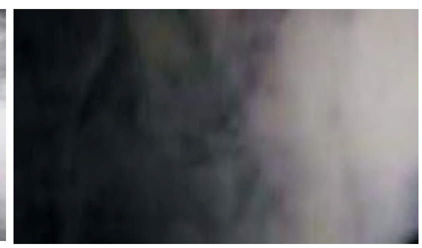
Image 11



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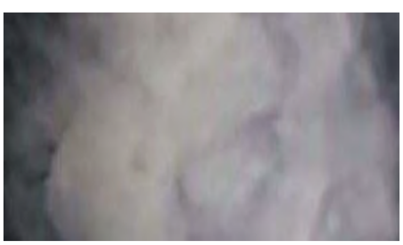


Image 13

Image 14

Image 15

Figure 3.3a Threshold Dataset

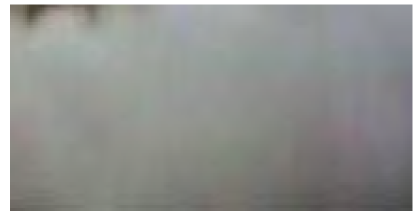
Image 16

Image 17

Image 18

Image 19

Image 20



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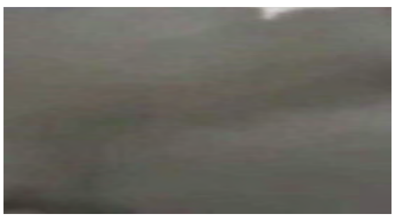

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Image 23

Image 24

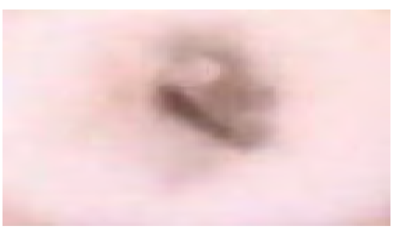

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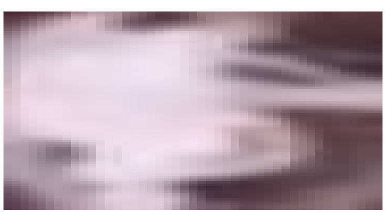
Image 26

Image 27



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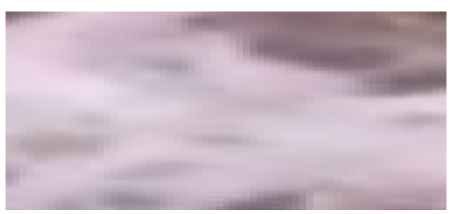

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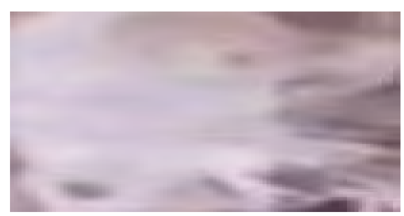
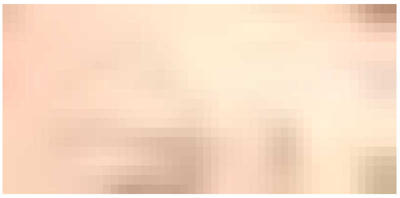


Image 30

Figure 3.3b Threshold Dataset



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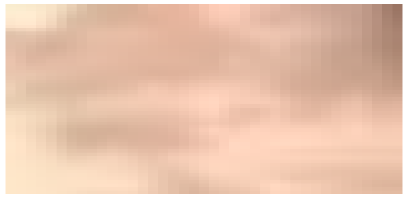

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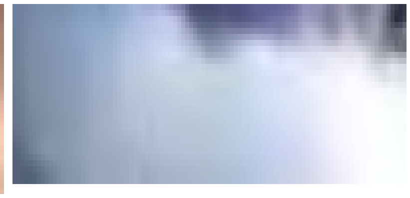

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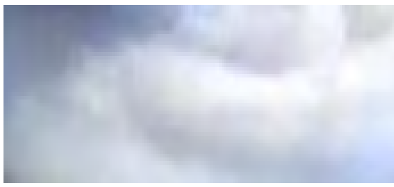

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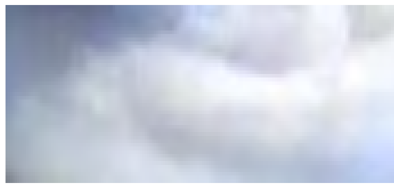

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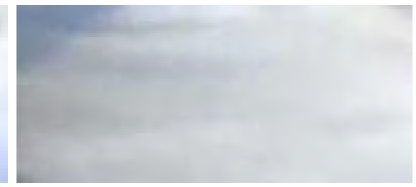
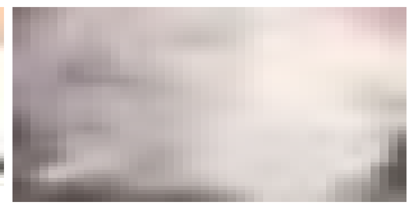


Image 36

Image 37

Image 38



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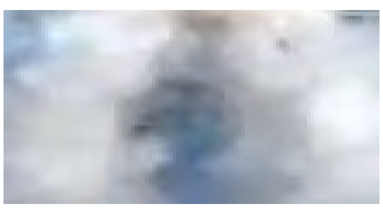

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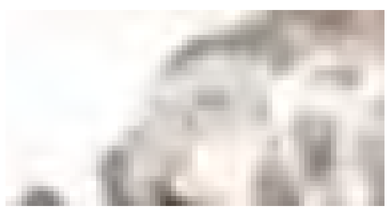

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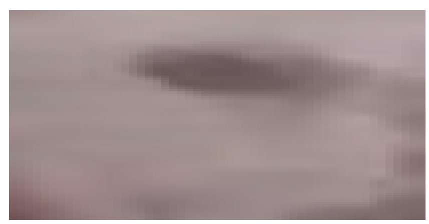

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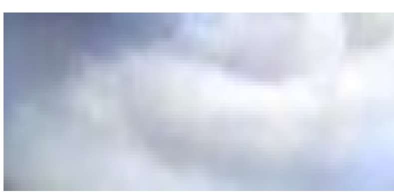


Image 43

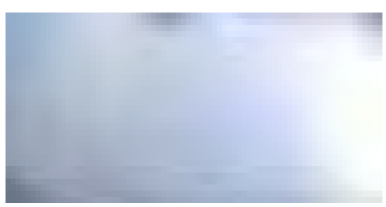


Image 44

Image 45

Figure 3.3c Threshold Dataset

3.1.3 Detecting smoke step by step

(a) Converting RGB to HSV

First we convert our sample picture RGB to HSV then we took Saturation (S) and Intensity (V) plate ignoring the Hue (H) because our sample smoke is white color and we know black and white color do not have a hue.

(a)

(b)

Figure 3.4 (a) Intensity Plate (V), (b) Saturation Plate (S)

(b) Apply the calculated threshold value

Now we tried to use our calculated threshold value on our intensity plate (V) and saturation plate (S). After that we did binarization of both plates on the basis of our calculation.

(a)

(b)

Figure 3.5(a) Saturation on calculated result, (b) Binarization of saturation plate

(a) (b)

Figure 3.6(a) Intensity on the basis of threshold, (b) Binarization

(C) Joining the saturation and intensity plate

After getting our calculated binary image of both saturation plate (S) and intensity plate (V)

We added that two plate for getting selected smoke area.

Figure 3.7 Selected smoke region

(D) Finally showing Result

Finally after the all calculation the final result is shown on the basis three things calculated saturation, calculated threshold of intensity and area which is fixed on the basis of trial and error.

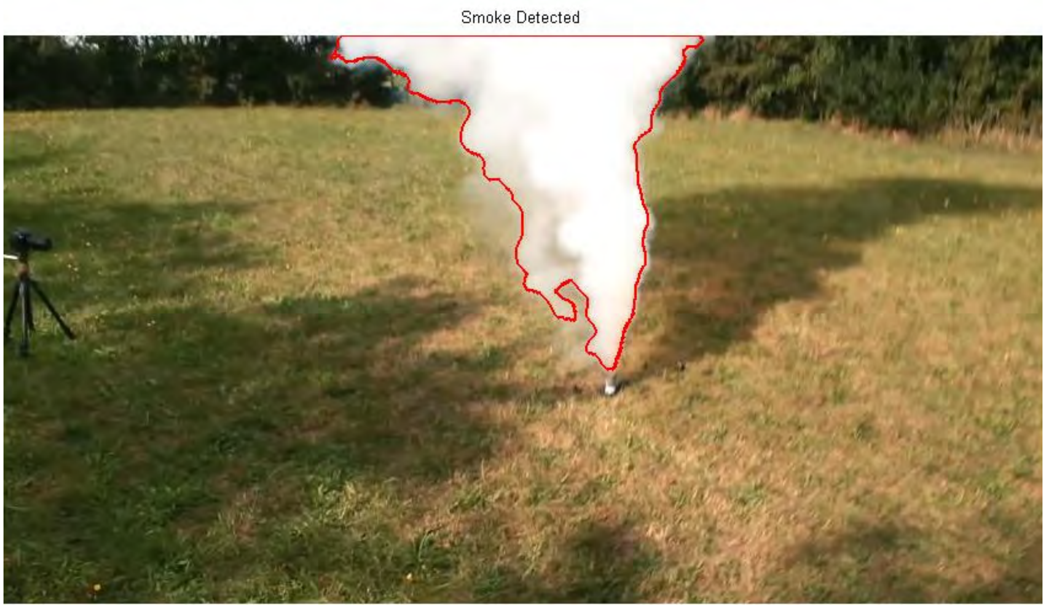


Figure 3.8 Show detected smoke

In the figure 3.8 finally smoke is detected and detected smoke is shown by the red mark.

CHAPTER 4

EXPERIMENTAL SETUP & RESULT ANALYSIS

Experimental setup includes the following steps:

- Creation of Smoke Dataset
- Detect smoke and extract features
- Selecting classifier
- Showing result

For our project we create our own dataset for the smoke. This dataset is created with the help of the internet. Each smoke picture stored in the dataset. Figure No: shows the image of dataset for smoke. We have collected 90 picture of smoke for our experiment.

Capture 01

Capture 02

Capture 03

Capture 04

Capture 05

Capture 06

Figure 4.1a Smoke Dataset

Capture 07

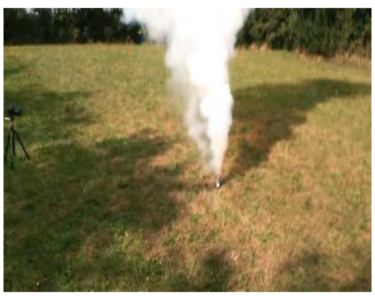
Capture 08

Capture 09

Capture 10

Capture 11

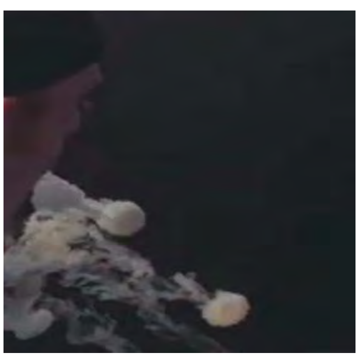
Capture 12



Capture 13

Capture 14

Capture 15



Capture 16

Capture 17

Capture 18

Figure 4.1b Smoke Dataset

As platform we are using MATLAB R2013 a. First job is to acquire the image then we had to use feature extraction which include the RGB to HSV conversion. After converting the image from RGB to HSV we took only the saturation (S) plate and intensity (V) plate for our calculation.

Fire and Smoke Detection without Sensors: Image Processing Based Approach by Turgay Çelik, Hussein Özkaramanlı, and Hasan Demirel .They use only Saturation to categorize the smoke which will not work properly. Sometimes due to some light illumination saturation cannot shows the same result. In our experiment we have found the worst result using only saturation. The success and failure rate of is shown in the following figure 4.2a and figure 4.2b

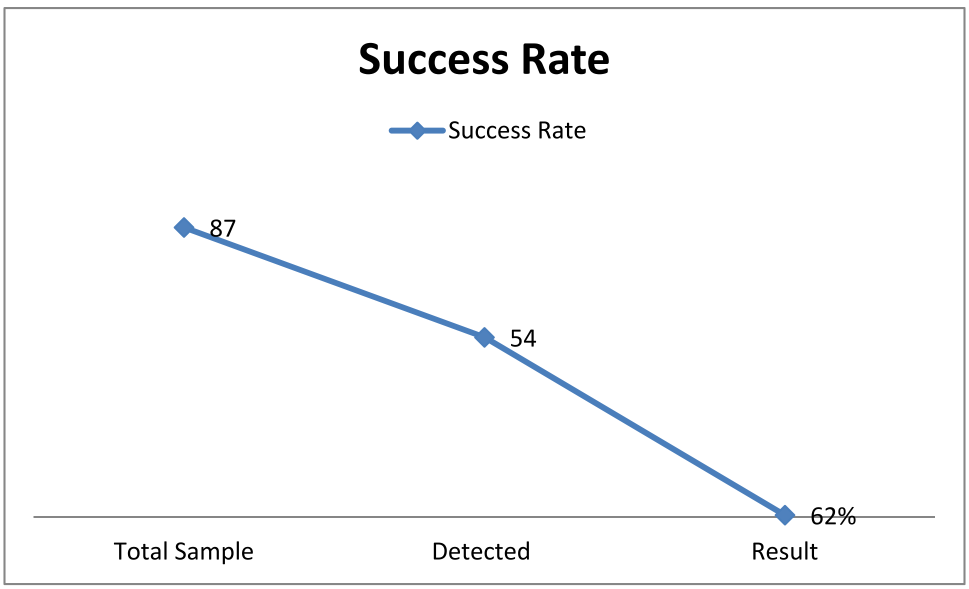


Figure 4.2a Success Rate of Saturation

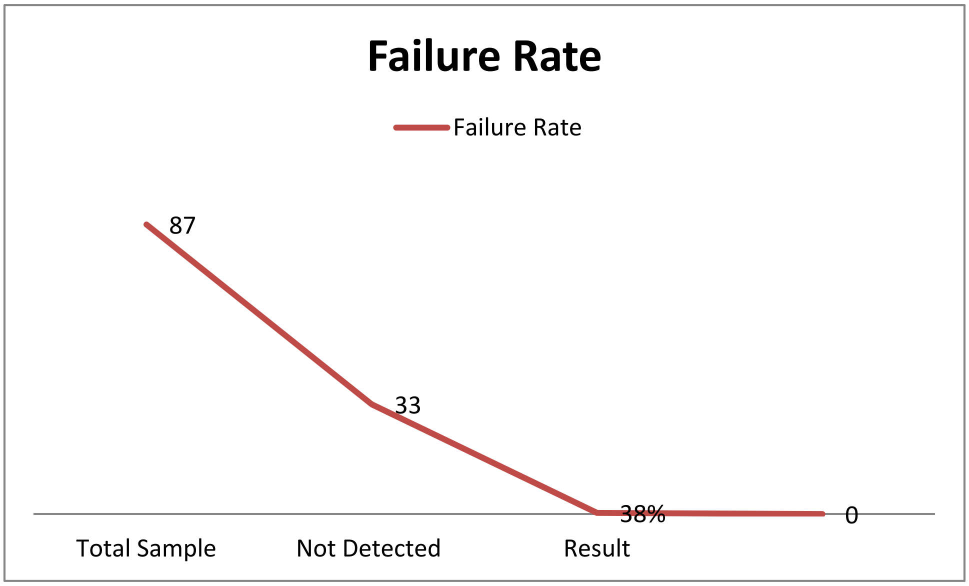


Figure 4.2b Failure Rate of Saturation

In the some paper they try to use only the intensity by directly converting the image from RGB to gray and they only used the intensity to detect smoke from the image. The detection rate smoke for our image dataset is not fruitful. The success and failure percentage of smoke is shown in the following figure 4.3a and figure 4.3b

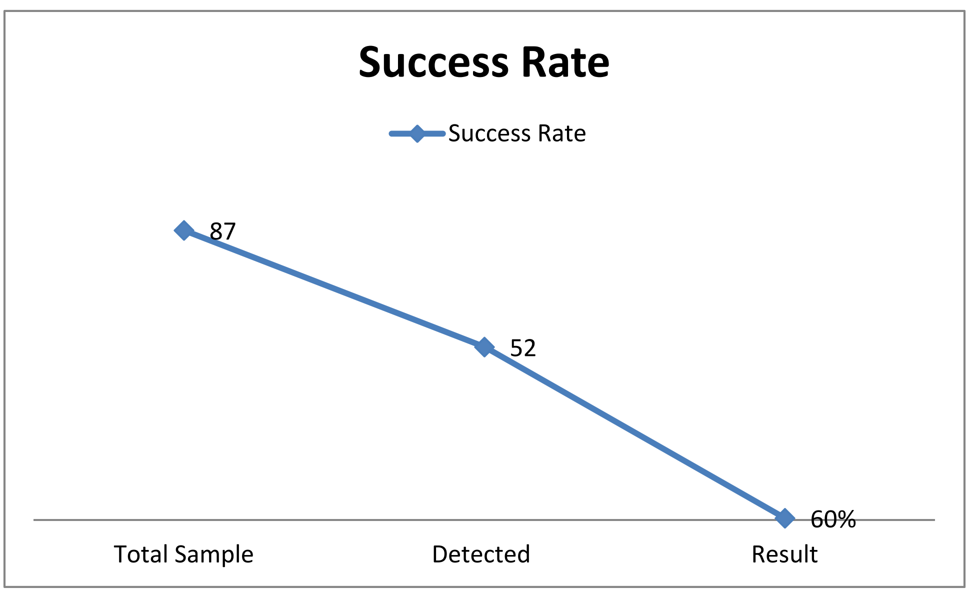


Figure 4.3a Success Rate of Intensity

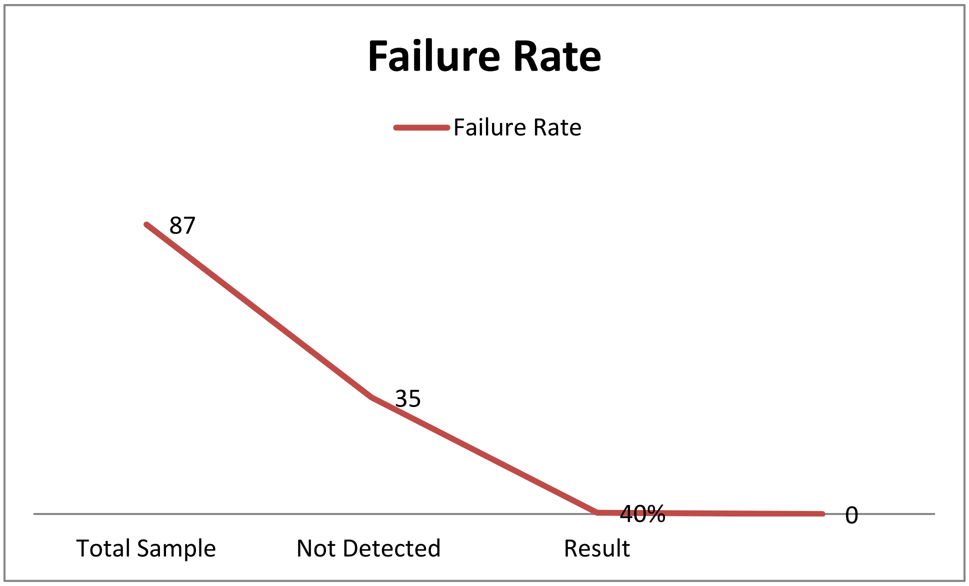


Figure 4.3b Failure Rate of Intensity

In our SDIPS we use both the saturation and intensity to detect smoke. We also use a pure calculation method for our thresholding. Due to use our pure calculation technique we get a good result. And for our experiment the success and failure percentage by using SDIPS system is shown in the following figure 4.4a and figure 4.4b

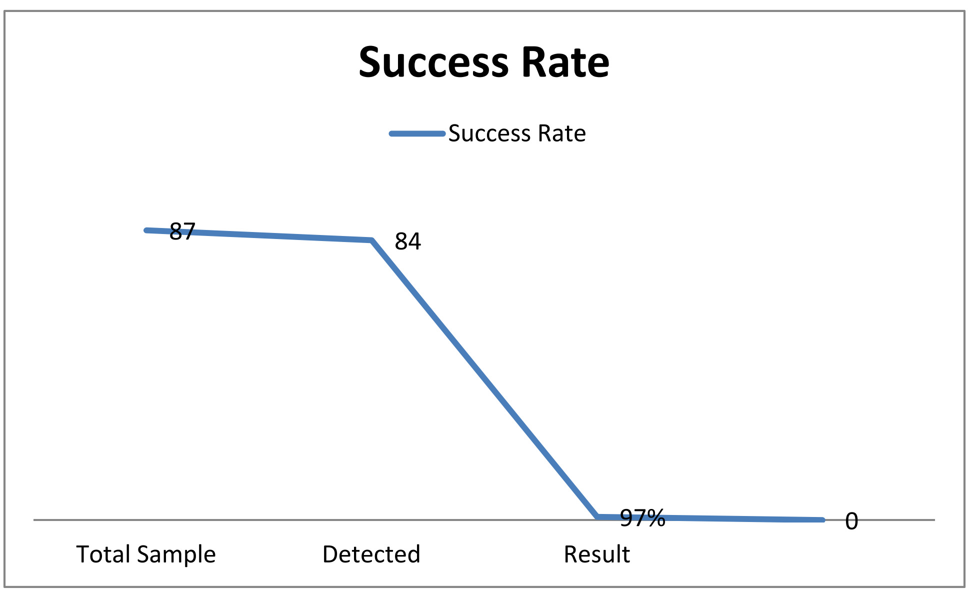


Figure 4.4a Success rate of SDIPS

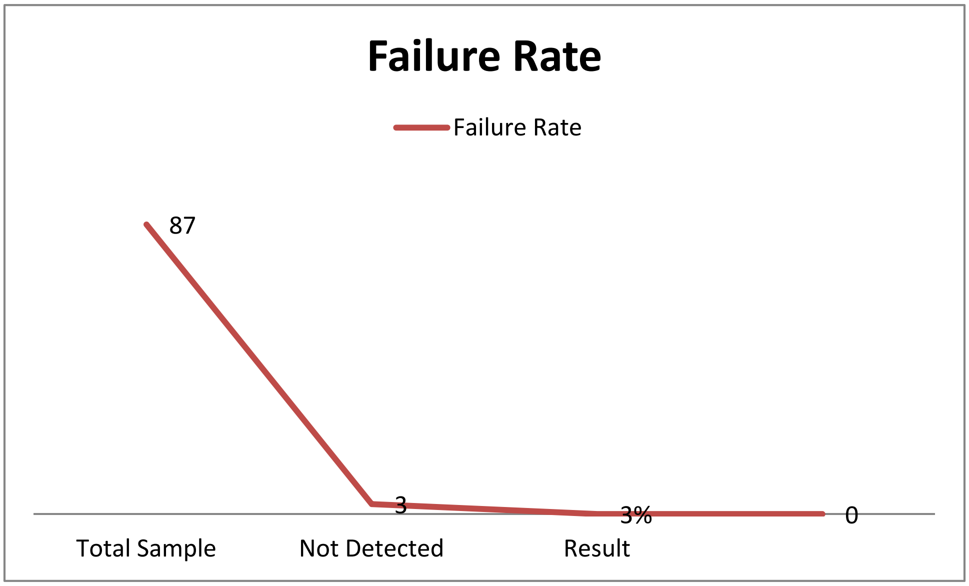


Figure 4.4b Failure rate of SDIPS

In our experiment we tried to compare our result and other method used previously. For our experiment we used 87 smoke pictures. Using only Saturation the detection success rate is 62 percent and using calculated intensity the success rate only 60 percent. But the success rate of our SDIPS is 97 percent. The details about the comparison in our experiment we have found is given in the following table 4.1

Table 4.1 Result Comparison

Procedure	Detected Image	Not Detected Image	Success Rate (%)
Saturation	54	33	62
Intensity	52	35	60
SDIPS	84	3	97

As per our experiment and our comparison we can say without any hesitation that our SDIPS is far better than using only saturation or intensity.

Chapter 5

CONCLUSION AND FUTURE WORKS

In the report, we proposed an efficient algorithm to detect smoke from captured image. For our experiment we use 46 images of smoke for calculating threshold value and 87 images for detection of smoke. We use some pure statistical formulae for the calculation of image properties such as mean, median, standard deviation. These are very helpful for thresholding. By using these statistical values we create a procedure for thresholding. We use trial and error based model to calculate the result. In our experiment we have found that our algorithm works much better that others.

In conclusion, we can say that the implementation of Smoke Detection using Image Processing System (SDIPS) is very important in our real life. However, this system has certain limitations .In the current implementation it can identify white smoke only. The relative position and the size of smoke and color can be black can be vary. Now-a-days the rapid growth of industrialization has played an important role in economic section. In Bangladesh, recent time lots of industries are spoiling there future due to the fire. Smoke is the starting point of fire so if we are able to develop an intelligent system to detect smoke then we can protect of our industries from fire.

5.1 Future Improvement

Smoke detection using image processing system (SDIPS) is very important for our real life implementation, from the perspective of system applications in a wider area, needs further study. The following steps may be taken to make the project more reliable and more accurate in the future so that it can be used as a product. Here we give some extensions which may be possible:

1. Our implementation is only based on the white color smokes, which are commonly found in the world.
2. In our proposed method, if the smoke is black or gray, then the SDIPS will not work.

3. In our proposed model angel of the camera is very crucial sometimes if intensity matches then sky or cloudy sky can be detected as smoke.
4. In our proposed model we cannot able to differentiate artificial smoke and original smoke etc.

References

[1] Turgay celic, huseyin özkaraman and hasan demirel, "Fire and Smoke Detection without Sensors: Image Processing Based Approach", 15th European Signal Processing Conference (EUSIPCO 2007), Poznan, Poland, September 3-7, 2007

[2] Dong Keun Kim and Yuan-Fang Wang, "Smoke Detection in Video", World Congrss on Computer Science and Information Engineering, 2009

[3] Kolesov, P.Karasev, A. Tannenbaum, "Fire and Smoke Detection in Video with Optimal Mass Transport Based Optical Flow and Neural Network", Proceedings of 2010 IEEE 17th International Conference on Image Processing September 26-29, 2010, Hong Kong.

[4] Pietro Morerio, Lucio Maracenaro, Carlo S. Regazzoni, "Early Fire and Smoke Detection Based On Colour Features and Motion Analysis", Technoaware s.r.l, Genoa, Italy.

[5] Celik, T., Demirel,H., Ozkaramanli,H., Uyguroglu, M. , "Fire Detection in Video Sequences Using Statistical Color Model", Proc. Internet Conference on Acoustics, Speech and Signal Processing, vol. 2 no.pp. II-2013-II-2016, May 2006.

[6] Celik,T., Demirel,H., Ozakaramanli, H., "Automatic Fire Detection in Video Sequences", European Signal Processing Conference, EuSIPCO-06, Sept. 2006.

[7] Chen, T., Wu, P., Chiou, Y.,"An Early Fire-Detection Method Based on Image Processing", Proc, IEEE Internat, Conference on Image Processing, ICIP'04, pp. 1707-1710, 2004.

[8] Klir, G. J., Yuan B., "Fuzzy Sets and Fuzzy Logic", Prentice Hall 1995.

[9] Mathews, J.H., Fink, K.D., "Numerical Methods using MATLAB", Prentice Hall, 1999.

[10] Toreyin, B.U., Dedeoglu, Y., Cetin, A.E., "Contour Based Smoke Detection in Video Using Velets", European Signal Processing Conference, EUSIPCO-06, September, 2006.

[11] Turgay Celik, Huseyin Ozkaramanli, Hasan Demirel, "Fire Pixel Classification Using Fuzzy Logic and Statistical Color Model", ICASSP 2007.

[12]Turgay Celik, Hasan Demirel, Huseyin Ozakaramanli, Mustafa Uyguroglu, “Fire Detection Using Statistical Color Model in Video Sequences” Journal of Visual Communication and Image Representation (2007), doi:10.1016/j.jvcir.2006.12.003.

[13] Che-Bin Liu and N.Ahuja, “Vision Based Fire Detection”, IEEE International Conference on Pattern Recognition, Cambridge, UK, August 2004.