Fire Detection with SMS Notification for Household Security using Fuzzy Logic Approach

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The occurrence of fire in a household specifically in Davao City is not easy to notice. Because of the country's climate where there are only two seasons, wet and dry, there are greater possibilities for fire to occur, for at most of a year the season is dry. This means that every household should have the capacity to secure their houses against fire. By the means of computer vision and GSM modem, this project can secure houses by notifying the household for each time it detects fire via SMS.

This project aims to develop a fire detection software that will be used for indoor purposes specifically for households that transmits an SMS Alert to a phone when it captures visible fire. With the use of EmguCV, a cross-platform of OpenCV library in .NET framework, it can now integrate color detection with HSV library using fuzzy logic algorithm, motion detection and geometric analysis in Visual C#.

For sending SMS to a specific mobile number, a GSM modem with a sim card will be connected to the computer, a specified com port for pc and modem interaction will be used to send/transfer data to the modem. The sim card must have a remaining balance in order to send alerts to mobile phones. The number including the alert logs were stored in the MySQL database. The number registered on the database can be updated and will be able to get alerts incase the application detects fire.

For testing purposes, gathered videos were examined through the application. The data were categorized into two: Fire and Non-Fire. The accuracy was based if the application can detect visible or false fire and whether it can send SMS after fire was detected.

Keywords: EmguCv, Microsoft Visual C#, SMS, GSM Modem, Fire Detection, Fuzzy Logic

Categories and Subject Descriptors: Computer Vision, Fire Detection Method

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1. CHAPTER 1

1.1 Introduction

Fire is essential for human. It gives man light, heat and can even give us the ability to cook food, synthesize and form metal and pottery. Despite of its help to people, it can also be a bad thing. Intense fire can be difficult to control. It has an outstanding skill in destroying houses, possessions and even life. Some of the causes of fire are from appliances being left switched on, cigars, gas stoves, lamps and candles that is left near to lightweight materials and accidents commonly made by children. These causes are mostly occurs in indoor household, and monitoring the household is isolated and hard to look after when you view it from the outside. That's why people make actions to prevent fire. The idea of making an indoor monitoring with fire detection system in each household has a lot of help in securing and avoiding them from burning.

1.2 Background of the Study

Security is a primary need of every family as everyone wants to live as safe as possible. This study aims to develop a fire detection application that focuses on detecting the occurrence of fire in households. The idea is to make an application that has a handy alarm system. With the use

of mobile phone, the person can be alerted in any place at any time through SMS. With this, it is more convenient for the person to secure his house and be informed when there is an occurrence of fire.

Since there are already applications implemented through the concept of computer vision, the proponents have made a fire detection system that uses it which can be used for households. This project gives convenience on securing houses and establishments from fire. In which it has the capacity to give current information to each household owners in fire detection through an SMS notification. So as the fire just started out it can easily be prevented and controlled.

1.3 Technology Application Context

There are plenty of methods that can be used in detecting fire from a video with OpenCV. Some of it are: distinguishing fire by color, motion and its geometry, the usage of color clues, using hidden Markov Model where it test the temporal variation of each frame, motion detection scheme to detect flicker in fire regions, Fourier Transform where it detects fire by its peaks and shape, a wavelet based fire detection, the usage of Fuzzy Logic Algorithm, etc. In this study, Fuzzy Logic Algorithm is applied, and to verify that fire is real, it is required to detect its flicker and measuring its size by geometric analysis.

[11] EmguCv is a cross platform that allows OpenCV library functions to be called from .NET compatible programming languages such as C#, VB.NET, C++ and IronPython. The wrapper can possibly be compiled in Mono and run on Windows, Linux, Mac OS X, iPhone, iPad and Android devices. EmguCV can also be run in on your Ubuntu or Fedora PC. This study uses an ImageBox which is highly recommended by the EmguCV platform. This was used to determine the image pixels values and video frames when the image is being displayed.

GSM modem (Global System for Mobile Communications) is wireless modem that accommodates a SIM card. Looking from the perspective of a mobile operator, GSM modem appears like a mobile phone. The main use of this is for internet connectivity and can also be use in sending MMS and SMS messages. Aside from this, GSM modem can also be used to build applications like automating business process, machine to machine communication and SMS Gateway to send and receive SMS. GSM modem is shown in Figure 1.

In this study, the proponents created an application obtained from EmguCV and one particular application of GSM modem which is the connecting to a communication port. Using the OpenCV, video input was scanned through a series of methods (Fuzzy Logic Algorithm) in order to detect fire. The captured videos will be viewed in an ImageBox, and will be processed through the use of EmguCV. GSM modem is connected to a communication port (must be connected to c# .net library) before the alert message will be sent.

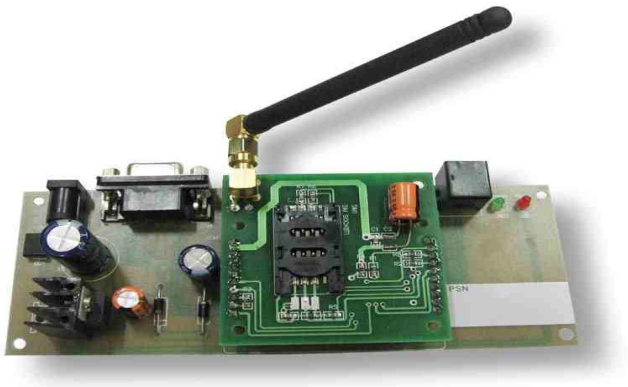

Figure 1. GSM Modem

1.4 Objectives of the Study

1.4.1 General Objectives

- To make a convenient fire-detector that can secure each households through sending SMS notification to mobile phones. This application is corresponded with a fire detection system programmed in OpenCV synchronized to a direct video input. If the system detects fire, it will automatically send a message to the numbers registered in the system.

1.4.2 Specific Objectives

- To use OpenCV for video processing in C# language
    - To make use of the Fuzzy Logic Algorithm in determining the presence of fire colors in a video and validating if the fire is present and by distinguishing its motion through flicker frequency and fire geometry.
- To notify people by sending SMS Notification
    - To send an SMS alert to the phone number registered.
    - To give real-time information as soon as the fire is detected by the application whether it is a false alarm or not.

1.4 Significance of the Study

Fire Detection using computer vision had been presented in several papers. Mostly are implemented in outdoor areas while this study focuses on indoor security. Some existing indoor fire detection system didn't use computer vision. Many existing systems are tested with their ability to notify the owners. But the problem of these systems is when the owners are away or outside the area. This research study made a unique means of alarming the recipients. In case the owners are away, alerts were delivered through SMS. It is convenient and affordable.

Moreover, this study are helpful for all types of businesses and institutions. With the kind of environment they have, the place must be provided with safety alarms. Some fire alarms equipment like flame detectors and fire-gas detectors are prone to fire alarms, narrow field of vision, difficult to maintain and expensive.

1.5 Scope and Limitation

The scope of this project is solely for the usage of fire detection on an enclosed space; for indoor purposes. This limits the movement a camera can capture. The application is used when the household is away from the house. With a minimum movements on the captured frames, the application can identify fire only when there is a moving fire colored object detected.

2. CHAPTER 2

2.1 Review of Related Works, Literature & Technologies

[1] The use of camera in fire detection has already been studied; the advantage of the system is that the user can have a direct data gathering in fire detection by the use of a low cost camera. There are five steps in data gathering for detecting fire and smoke based on low-cost camera. The steps in data gathering are: first, to detect movement by subtracting the current image from the previous image. Second is to convert the image into greyscale for it to threshold. Third is the threshold where there are only two colour values, black and white, and its level is being set to make the contour of smoke is still visible. Fourth is to detect the size of the contour and compare it to the previous image. And lastly is the movement of the smoke's contour in which if there is a growth of contour, then the size of smoke is continuous and there is a great possibility of fire.

The methods of this study were implemented in C# and OpenCV. From testing five different videos, Ng Ching Hau made a table to get the accuracy of system for video. Where accuracy is the percentage of correct readings over the total readings. The average accuracy off the system made was 92.8% with an average delay of 20 frames, which would equate to 4 seconds. True positives represent smoke correctly detected as smoke, false positive is no smoke incorrectly identified as smoke, true negative is no smoke correctly identified as no smoke and false negative is smoke incorrectly identified as no smoke.

The significance of these values is that it shows that the system actually works but there is much of detecting false positives than of true negatives.

[2] Celik conducted five steps in detecting fire in colored videos. First is the use of cumulative time derivative matrix in detecting areas with high frequency luminance flicker. Second is to analyze each frame of the area detected if it falls within the range of fire color. Third, the detected frames that falls within the fire colored range, will be dilated to combine if it is closely located. This is to make sure that it is a moving object. Fourth, is to analyze the previous conditions for temporal variations. Fifth is the analysis of the areas for spatial variations. Fire presence is determined by the ratio of the pixels of fire color to the number of non-fire colored pixels. If the ratio is greater than a determined threshold then fire is considered present.

From the sample tests, it did not show any false fire detection and is 100% accurate. The videos taken are in a minimum frame rate of 25 frames per second in a minimum of 320x240 resolution. The limitation of this system implemented is that it cannot run efficient in real time thus it cannot be performed as a preventative alarm system.

[3] Chen have distinguished fire through three different methods to come up with the fastest fire detection algorithm. The first method is FFT or Fast Fourier Transform where it detects fire through its shape and edges. It uses segmented images of fire. Second method used is the method based on color and temporal variations called as Hidden Markov Model. The third method used is a method proposed by Chen, T.H. [3]. In his study, the method which is based on Hidden Markov algorithm gives the fastest process time. But in some parts of the study they showed a graph of accuracy which shows that FFT gives the highest accuracy rate.

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[1] Celik, T., Demirel, H., Ozkaramanli, H., and Uyguroglu. M. 2007. Fire detection using statistical color model in video sequences. *J. Vis. Commun. Image R. 18* (2007) pages 176–185

[2] Çelik, T., Özkaramanli, H. and Demirel. H. 2007. Fire Pixel Classification Using Fuzzy Logic and Statistical Color Model. *Gazimağusa, TRNC, Mersin 10*, ICASSP (2007) pages 1205 – 1208.

[3] Chen, T.H., Kao, C.L., and Chang, S.M. 2003. An Intelligent Real-Time Fire-Detection Method Based on Video Processing. *IEEE*, 2003.

[4] Processing the video data generated by a camera is what Dedeoglu applied in detecting fire. It uses motion, color clues, flame and fire flicker to detect fire by analysing the video in wavelet domain. This article also studies the behaviour of fire to utilize the gathered data. Spatial wavelet transform of moving fire-colored regions is being computed to detect the color variations of fire. The irregularity of the boundary of the fire colored region and its growth is also used as clues. This article also shows an easy way of how Fast Fourier Transform can be used as a rule of fire detection. It shows that not just the color but also the motion are the big factors in differentiating a fire from a video. The second method does not recognize stationary fire-colored objects and is successful determining fire, but it gives false alarms when fire-colored objects starts to move.

[5] In this paper, Ebert and Shipley used a fuzzy logic algorithm which determine the fire on an image based on its color. They used RGB color space as their first base rule as they translated it to YCbCr color space as the second base rule to give a more accurate values in detecting fire. In this study it shows that YCbCr has a better result compared to RGB because it has more variations based on the Y(luma) or brightness of each color on the color space. The comparative study shows that YCbCr gives a lesser rate of false alarms and a 99% rate of detected fire. The proposed model made a huge difference in detection and false alarm rate. With their given result it shows: chrominance and luminance is where the fuzzy logic was applied into. A rule based from both factors, which is made up of a total of 25 rules, made a more accurate detection of 99% and lesser false alarm rate of 9.50%.

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[4] Dedeoglu, Y., Toreyin, B.U., Gudukbay, U. and Cetin. A.E. 2005. Real-Time Fire and Flame Detection in Video. *Bilkent University, TR-06800 Bilkent, Ankara, Turkey.* ICASSP (2005).

[5] Ebert, J., and Shipley, J. 2009. Computer Vision Based Method for Fire Detection in Color Videos. *Connecticut College, Utah State University.* (2009).

2.2 Theoretical Framework

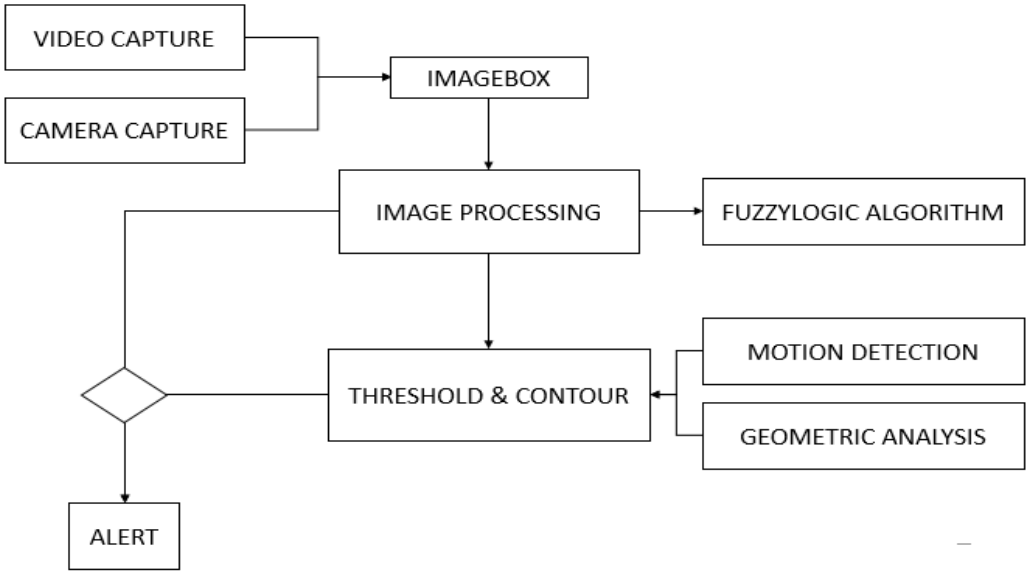


Figure 2. Theoretical Framework

The theoretical framework shows that a video capture or camera capture is processed to extract the occurrence of fire in every frame captured. Captured frames are viewed in an imagebox. In processing the colors by detecting a fire color in each frame, the detected frames of fire occurrence will be validated by threshold and contour which is complying to motion detection and geometric analysis before it gives alert via SMS.

3. CHAPTER 3

3.1 Research/Project Design

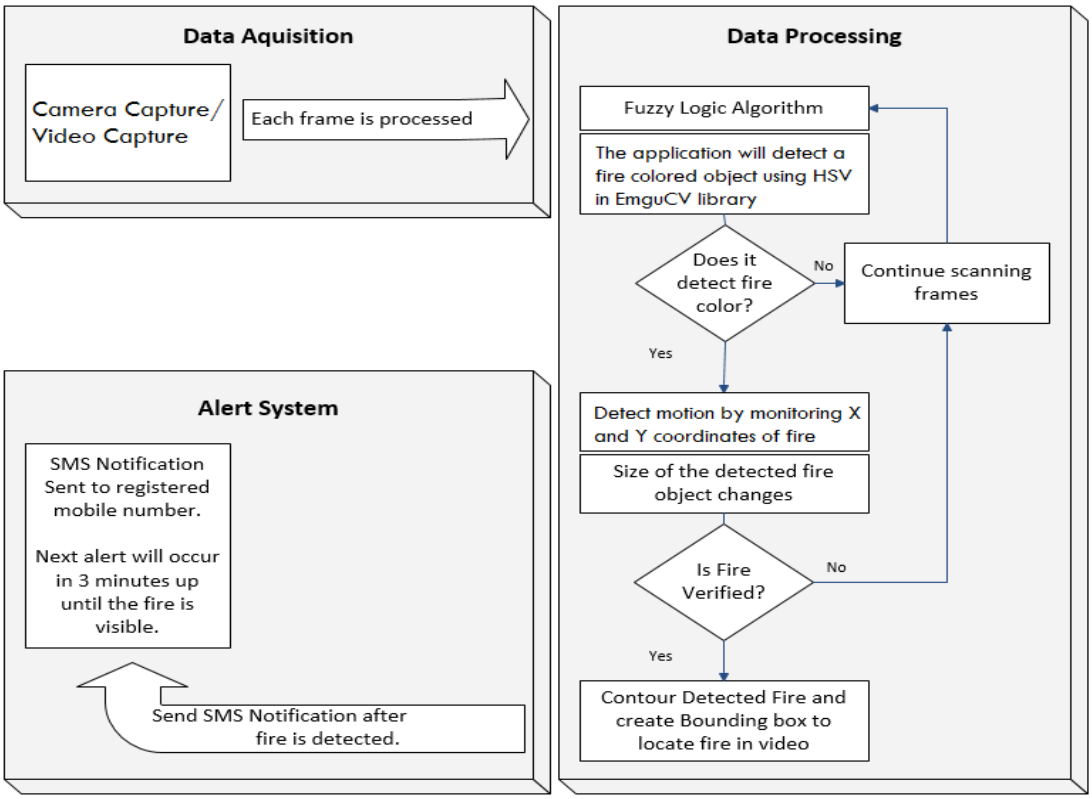


Figure 3.1.1 Conceptual Framework

3.2 Methodology

3.2.1 Data Gathering

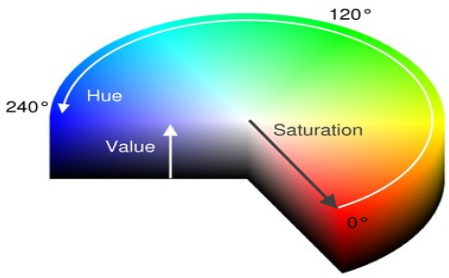
By the use of a video input, data is being processed within the application. The standard data to be used is directed from the camera or called as camera capture. Videos of selected scenes will be processed for testing called as video capture.

3.2.2 Implementation

The application is made in Microsoft Visual Studio in .NET platform with OpenCV/EmguCV library. OpenCV/EmguCV is also coded in C# language. From the video input, p nnseries of methods is used for fire detection; Fuzzy Logic algorithm, to know if fire is visible in the video being processed,

detecting the edges and the area of fire and to verify if the fire is valid in which it will not create false alarm. When fire is detected, the application will automatically send an SMS Notification to a registered phone number.

a. Fire color recognition using Fuzzy Logic Algorithm



In color recognition, RGB color space will be the rule base of hue in determining fire colors, where R>G>B for in a fire, Red has the highest value. Processed Image in RGB color space will be converted to HSV color space in order to set the saturation and value of hues presented. Not only is the pigmentation of color value demarcated but also the saturation and intensity of fire's color. Fire colored regions are calculated per frame and are joined as an accumulated fire color matrix. A variable will be used to store a mask that only focus on the values between the range of red and yellow. This variable will determine that a fire is present in the video. To evaluate the process, it should follow this Fuzzy Logic Algorithm:

1. Define the linguistic variables and terms
   In this step, Fire color is ranged from yellow to red hues. The image will be processed using OpenCV's threshold and HSV properties. The hue values of basic colors are 0-22 for orange, 22-38 for yellow, 38-75 for green, 75-130 for blue, 130-160 for violet and 160-179 for red. Saturation and Value of color has a range of 33-255 and 230-255 respectively.

2. Construct the membership functions
   Every pixel scanned in every frame will be compared to the RGB color space. Hue will first be scanned, after is to measure its saturation and value.

3. Construct the rule base
   The value of Red is greater than Green, and Green is greater than Blue; R>G>B. the greatest value will be considered fire in color. From the ranges of hues given, we will use 0-38 and 160-179 as our hue values of fire colors and represents the group of highest value.

4. Convert crisp input data to fuzzy values using the membership functions
   The membership functions are knowledge based numeric terms used for figuring the crisp input (non-fuzzy) that is based from the colors of every pixel scanned. The input data are interpreted into fuzzy values in the interval [0, 1]. Scanned pixels on each frame will be translated into a fuzzy values based on its hue.

5. Evaluate the rules in the rule base
   If the pixel color is among the hue range of 0-38, its fuzzy value is 1; it is a fire color.
   If the pixel color is among the hue range of 39-159, its fuzzy value is 0; it is not a fire color.
   If the pixel color is among the hue range of 160-179, its fuzzy value is 1; it is a fire color.

6. Combine the results of each rule
   Hues that range from 0-38 and 160-179 are fire colors, Hues that range from 39-159 are non-fire colors.

7. Convert the output data to non-fuzzy values

Fuzzy values of 0 are non-fire objects, and fuzzy values of 1 are fire objects.

Once the fire color is detected, its area and motion should also be analysed to verify if it has a true characteristic of fire.

b. Motion Detection and Geometric Analysis

Using the first method, the fire region is already detected through its color, giving an instinctive representation of fire contour. We can calculate the contour fluctuation to decide whether the region is characteristically fire or not due to the shape of fire that changes every frame. In these sample frames, we can see that fire has a distinctive changes illustrated in each frame:

Figure 4.1 The first five frames of a blazing fire

Figure 4.2 The contours of fire regions

There are implementations of computing the area and creating bounding boxes in contour from EmguCV library that can be used in this project. From a series of videos to be processed, a survey will be made for validation to test the accuracy of the methods used with regards to the scenarios and the quality of video.

As the contour marks the fire and placed in a bounding box, the area now of the box will be computed. The difference of area in current and previous frames must be higher than 500 pixels if the resolution is higher than 1080p to conclude that a fire is growing. And for the motion detection, X and Y positions of the bounding box of previous contour must have a difference of at most 100 pixels in a 1080p resolution of either camera or video capture.

c. Sending SMS Notification from C# application to mobile phone

C# in .NET framework has a library of sending SMS to a mobile phone but before it can send an alert, it should first be connected to a gateway or connect it to a GSM Modem using a communication port. With this project, a GSM Modem is applied only by sending SMS to a registered number. The recipient's mobile number is stored in MySQL database and can be updated occasionally.

3.2.3 Testing and Validation

To validate that the video has an occurrence of fire, the application's result should return a fire occurrence and sends an SMS alert to the phone number listed. And when the result returns true without a fire occurrence, there is a false alarm which means a decrease of accuracy. To test the accuracy of the methods used, it should reflect a lesser percentage of false alarms being made.

Scenes	**Real Fire Videos**	**Fire Detected**	**False Fire Detected**	**Accurate Fire Detection**	**Alert Sent**

1. Scenario 1	□	□		□	□
2. Scenario 2	□	□		□	□
3. Scenario 3	□	□		□	□
4. Scenario 4		□	□		□
5. Scenario 5				□	

Table 1. Sample table with data to be used for testing

The accuracy of the method used can be calculated as the **average of accurate count from the number of scenarios tested**. In the sample table, it shows that it has an accuracy rate of 4/5 or 80%. And for alert attempts, the accurate alert rate is 3/4 or 75%.

4. CHAPTER 4

4.1 Technology Background

EmguCV, GSM Modem, Fuzzy Logic, and MySQL were applied in the study.

Nowadays, many programmers are developing applications that deals with lots of media like images and videos. One easy way of dealing with that is to find a library that can help increase its efficiency. OpenCV or Open Source Computer Vision Library provides general tools for computer vision application. It is an open source which means it can be used freely by anyone and will be used to develop this project. OpenCV codes can be modified, from methods of different studies, a new method is formulated which will be programmed in it. The computer language to be programmed in OpenCV is C++ and for the application is C#. EmguCV is a cross-platform library of OpenCV for .NET framework that is useful in exploring interesting features from image capturing to character recognition. Good thing about EmguCV is that, it can be used from several different languages, including C#, VB.NET, C++ and IronPython. One common application using EmguCV is the Face detection.

GSM Modem is a type of modem that accommodates sim card. It has a serial, USB or Bluetooth connection or it can possibly be a mobile phone that provides GSM modem capabilities. Even though a normal mobile phone can be used as GSM Modem, it is highly recommended that a special industrial grade terminal to be used as a GSM Modem due to its stability, and reliability. Computers use AT commands to control modems. GSM modems support an extended set of AT commands. These extended AT commands are defined in the GSM standards. With the extended AT commands, you can do things like: Reading, writing and deleting SMS messages, Monitoring the signal strength, and Reading, writing and searching phone book entries.

Fuzzy logic is type of logic that recognizes more than simple true and false values. With fuzzy logic, propositions can be represented with degrees of truthfulness and falsehood has proved to be particularly useful in expert system and other artificial intelligence applications. It is also used in some spell checkers to suggest a list of probable words to replace a misspelled one.

Many computer programs, including web-based programs like blogs, photo galleries and content management systems need to store and retrieve data. For example, blog software needs to store the posts (ie, articles) you write, and retrieve them when a visitor goes to your site. MySQL is a database used on the web and runs on a server. It is an open source RDBMS that relies on SQL for processing

the data in the database. It also provides APIs for the languages C, C++, Eiffel, Java, Perl, PHP and Python. MySQL can run on UNIX, Windows and Mac OS.

5. CHAPTER 5

5.1 Results and Discussions

The goal of this project is to make a simplified fire alert system that uses camera as fire detector and can send SMS to a validated phone as its alert. The proponents had implemented the project based on the way a checklist was made. Segregating the modules to simplify each task and avoid conflicts on the code and the libraries.

On the checklist, modules for video capture, camera capture, color detection using fuzzy logic algorithm, geometric analysis, motion detection, data collection, SMS alert, and documentations are listed. Each module was made separately and was integrated as a whole.

For the video capture module, which was intended for testing, it can scan videos by file selection. Along the process, a button for video file import is provided. When a video file is selected, it is automatically captured and viewed on the Image box of the form. This module is in separate form with camera capture to avoid errors in managing Image boxes and to provide a smooth tests with a better quality image frames.

```
Stream myStream = null;
OpenFileDialog openFileDialog1 = new OpenFileDialog();

openFileDialog1.InitialDirectory = "E:\\testvideos"; //directory of files for testing
openFileDialog1.Filter = "Video files (*.mov)|*.mov|All files (*.*)|*.*";
openFileDialog1.FilterIndex = 1;
openFileDialog1.RestoreDirectory = true;

if (openFileDialog1.ShowDialog() == DialogResult.OK)
{
    try
    {
        if ((myStream = openFileDialog1.OpenFile()) != null)
        {
            using (myStream)
            {
                capwebcam = null;
                capwebcam = new Capture(openFileDialog1.FileName);
                capwebcam.Height.Equals(240);
                capwebcam.Width.Equals(320);
            }
        }
    }
    catch (Exception ex)
    {
        MessageBox.Show("Error: Could not read file from disk. Original error: " + ex.Message);
    }
```

Figure 5.a.1 Video capture file selection source code

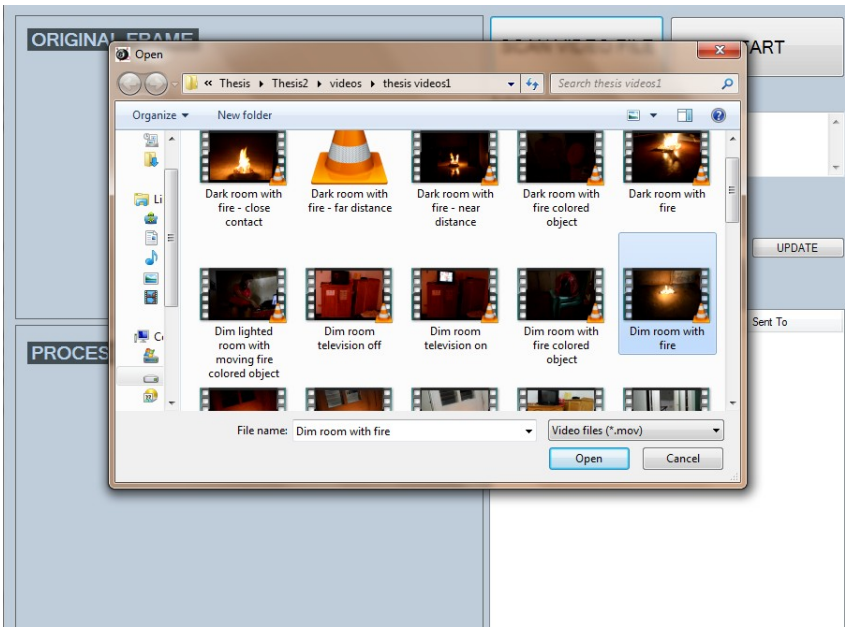


Figure 5.a.2 Video capture file selection window

In camera capture, which is intended for distribution of the project, the application can detect a live video feed from the webcam. Along the implementation, handling libraries, dll files and other executable files was a big hindrance for time management. Some of the errors are caused by CvInvoke by which the application cannot connect or detect the webcam. The proponents fixed the bugs through the right process of referencing static files. Both camera capture and video capture forms use the same codes of image detection.

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Threading.Tasks;
using System.Windows.Forms;
using System.IO;
using System.IO.Ports;
using System.Threading;
using MySql.Data.MySqlClient;
using System.Timers;


using Emgu.CV;
using Emgu.CV.Structure;
using Emgu.Util;
using Emgu.CV.CvEnum;
```

Figure 5.b Imported Libraries

In color detection, geometric analysis and motion detection source codes were provided by the references. Using fuzzy logic algorithm in color detection, the proponents formulated a solution by which they integrated fuzzy values to a selected range of colors based on the numeric values of HSV library in EmguCv library.

```
int lowHue1  = 0;
int highHue1 = 38;
int lowHue2  = 160;
int highHue2 = 179;
int satLow   = 33;
int satHigh  = 255;
int valLow   = 230;
int valHigh  = 255;
```

```
Image<Gray, byte> huefilter = imghue.InRange(new Gray(lowHue1), new Gray(highHue1)).
                              Or(imghue.InRange(new Gray(lowHue2), new Gray(highHue2)));
Image<Gray, byte> satfilter = imgsat.InRange(new Gray(satLow), new Gray(satHigh));
Image<Gray, byte> valfilter = imgval.InRange(new Gray(valLow), new Gray(valHigh));
```

Figure 5.c.1 Fire color detection

```
if (Math.Abs(tempX - Int32.Parse(currentContour.BoundingRectangle.X.ToString(""))) > 50 )
    if (Math.Abs(tempY - Int32.Parse(currentContour.BoundingRectangle.Y.ToString(""))) > 50)
    {
        inMotion = true;
    }
```

Figure 5.c.2 Motion Detection

```
if (Math.Abs(tempArea - double.Parse(currentContour.Area.ToString(""))) > 500)
    changeArea = true;
```

Figure 5.c.3 Geometric Analysis

Videos inputs were intended to test the hypothesis of how accurate fuzzy logic algorithm and other methods used in the detection of fire. Tested videos include false fire, real fire and non-fire scenes. It also varied on the angle of lighting and the absence or presence of light in a specified indoor location.

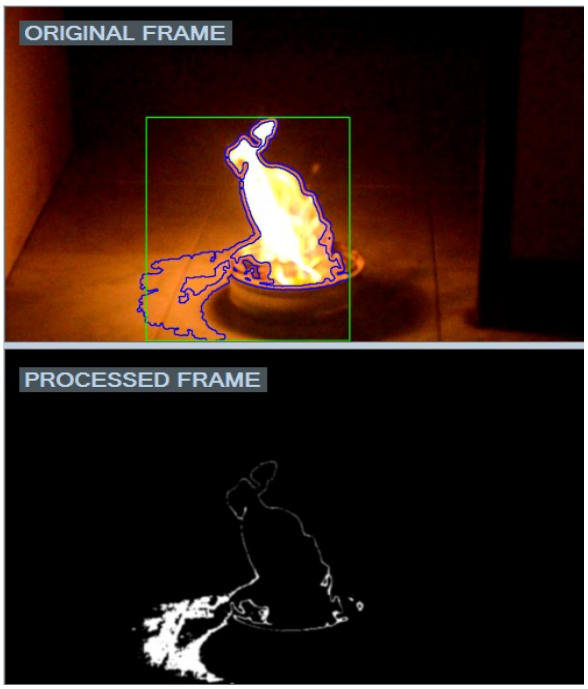


Figure 5.d Processing Image with Fire

In SMS alert, source codes are also provided in sending and receiving SMS using GSM modem in C# application. The proponents had validated the module by sending SMS to a foreign SIM. The SIM used by the modem should have the capacity to send SMS through its network provider. To solve this, credits are loaded on the SIM number. The application saved the data to the MySQL database every time it sends an SMS alert. The recipient of the alert was also saved and updated in the database.

```
if (isFire && inMotion && changeArea && flag)
{
    timer = new System.Timers.Timer();
    timer.Enabled = true;
    timer.AutoReset = false;
    timer.Elapsed += new System.Timers.ElapsedEventHandler(timer_Elapsed);
    timer.Start();
}
flag = false;
```

```
        string message = "ALERT! FIRE DETECTED AT " + time.ToString();
        _serialPort = new SerialPort("COM13", 115200);
        Thread.Sleep(1000);
        _serialPort.Open();
        _serialPort.Write("AT+CMGF=1\r");
        _serialPort.Write("AT+CMGS=\"" + number + "\"\r\n");
        _serialPort.Write(message + "\x1A");
        Insert();
        MessageBox.Show("Message Sent to " + number);
        _serialPort.Close();
```

Figure 5.e Conditions for SMS Alert

5.1.1 Validation and Testing

On the documentation, validation and testing are implemented. 55 sample videos are scanned by the application. It is shown in the graph how the application responds to each video, as how it verifies a fire in each video.

Scenarios	Real Fire/ Non-Fire	Detection	False Fire Detected	Send Alert	Accuracy
1. Dark room with fire - Close	Real Fire	Yes	No	Yes	Yes
2. Dark room with fire – Far Distance	Real Fire	Yes	No	Yes	Yes
3. Dark room with fire - Near	Real Fire	Yes	Yes	Yes	Yes
4. Dark room with fire colored Object	Non-Fire	No	No	No	Yes
5. Dark room with fire	Real Fire	Yes	No	Yes	Yes
6. Dim lighted room with moving fire colored object	Non-Fire	No	No	No	Yes
7. Dim room television on	Non-Fire	Yes	Yes	No	No
8. Dim room television off	Non-Fire	Yes	Yes	No	No
9. Dim room with fire colored object	Non-Fire	No	No	No	Yes
10. Dim room with fire	Real Fire	Yes	No	Yes	Yes
11. Fire in dark room	Real Fire	Yes	No	Yes	Yes
12. Fire in dim room	Real Fire	Yes	No	Yes	Yes
13. Fire in lighted room	Real Fire	Yes	No	Yes	Yes
14. Full lighted room with wood furnished	Non-Fire	Yes	Yes	Yes	No
15. Lighted room television on	Non-Fire	Yes	Yes	No	No
16. Lighted room with fire – Far distance	Real Fire	Yes	No	Yes	Yes
17. Lighted room with fire (Far)	Real Fire	Yes	No	Yes	Yes
18. Lighted room with fire colored object	Real Fire	Yes	No	No	Yes
19. Lighted room with fire	Real Fire	Yes	No	Yes	Yes
20. Lighted room with large fire	Real Fire	Yes	No	Yes	Yes
21. Light room light in front	Non-Fire	No	No	No	Yes
22. Lighted room with moving fire colored-object	Non-Fire	Yes	Yes	No	No
23. Lighted room – against the light with moving fire colored object	Non-Fire	No	No	No	Yes
24. Semi-sun-lighted room	Non-Fire	No	No	No	Yes
25. Sun lighted room (Covered)	Non-Fire	Yes	Yes	Yes	No
26. Sun lighted room fronting sun with yellow	Non-Fire	No	No	No	Yes
27. Sun lighted room fronting sun	Non-Fire	No	No	No	Yes

28. Sun lighted room with sunlight behind	Non-Fire	No	No	No	Yes
29. Sun-lighted room far against the light	Non-Fire	No	No	No	Yes
30. Sun-lighted semi covered	Non-Fire	Yes	Yes	No	No
31. Sun-lighted side view	Non-Fire	No	No	No	Yes
32. Lighted candle - Near	Fire	Yes	Yes	No	No
33. Lighted candle – Very Near	Fire	Yes	Yes	No	No
34. Lighted candle- Against the light	Fire	Yes	Yes	No	No
35. Lighted candle- Close up	Fire	Yes	Yes	No	No
36. Lighted candle- lights on	Fire	Yes	Yes	No	No
37. Lighted candle(near) - Dim	Fire	Yes	No	No	Yes
38. Lighted room - Low Quality Video 1	Non-Fire	No	No	No	Yes
39. Lighted room - Low Quality Video 2	Non-Fire	Yes	Yes	No	Yes
40. Lighted room - Low Quality Video 3	Non-Fire	No	No	No	Yes
41. Lighted room - Low Quality Video 4	Non-Fire	No	No	No	Yes
42. Lighted room - Low Quality Video 5	Non-Fire	No	No	No	Yes
43. Lighted room - Low Quality Video 6	Non-Fire	Yes	Yes	No	Yes
44. Lighted room - Low Quality Video 7	Non-Fire	No	No	No	Yes
45. Lighted room - Low Quality Video 8	Non-Fire	Yes	Yes	No	Yes
46. Lighted room - Low Quality Video 9	Non-Fire	Yes	Yes	No	Yes
47. Lighted room - Low Quality Video 10	Non-Fire	No	No	No	Yes
48. Lighted room - Low Quality Video 11	Non-Fire	No	No	No	Yes
49. Lighted room - Low Quality Video 12	Non-Fire	No	No	No	Yes
50. Lighted room - Low Quality Video 13	Non-Fire	No	No	No	Yes
51. Yellow and Red Paper 1	Non-Fire	No	No	No	Yes
52. Yellow and Red Paper 2	Non-Fire	No	No	No	Yes
53. Yellow and Red Paper 3	Non-Fire	No	No	No	Yes
54. Yellow and Red Paper 4	Non-Fire	No	No	No	Yes
55. Yellow and Red Paper 5	Non-Fire	No	No	No	Yes

56. Yellow Wallpaper – Lighted room	Non-Fire	Yes	No	No	Yes
57. Yellow Wallpaper – Dim room	Non-Fire	No	No	No	Yes
58. Yellow Wallpaper – Dark room	Non-Fire	No	No	No	Yes
59. Yellow wallpaper – Dark with fire	Real Fire	Yes	No	Yes	Yes
60. Yellow wallpaper Light – Dark with Christmas Lights	Non-Fire	Yes	Yes	Yes	No
61. Wall with red painting – Lighted room	Non-Fire	Yes	No	No	Yes
62. Blinking Red Light in Dark room	Non-Fire	Yes	Yes	Yes	No
63. Red electric fan turned on – Lighted room	Non-Fire	No	No	No	Yes
64. Pink curtains- Lighted room	Non-Fire	Yes	No	No	Yes
65. Orange objects at kitchen – Lighted Room	Non-Fire	No	No	No	Yes

Table 5.1.1.a Testing Fire and Non-Fire Videos for Accuracy on Fire Detection with Alarm

CHAPTER 6

6.1 Conclusion

The Study has developed a fire detection application that focuses on detecting the occurrence of fire in households. From the 65 videos that were tested, it showed that the accuracy rates of all the videos are **78.46%.** Therefore, the error is only 21.54% which means that the system has satisfying results. For the SMS notification, the registered number received an alert message 10 seconds after the fire was verified by the application. Then followed by the next occurrence which is 1 minute in interval.

The proponents agreed that this application is not just suitable for households but also reliable for education, economic and industrial institutions. It is highly recommended that this type of approach will be used for future studies and usage for the benefit of every person's safety.

CHAPTER 7

7.1 Recommendation and Future Work

The following recommendations are stimulated to perform for the improvement of this study.

- In .NET framework, System.Timer depends on the process time and not on the system clock. The proponents recommends that future works will include the improvement on the time intervals between SMS Alerts.

- Fire color detection, motion detection and geometric analysis does give inaccurate results regarding on the flicker frequency. The proponents recommends to include a more complex flicker calculation.
- Security for houses does not limit on indoors, the proponents recommend to have a specialized detection for indoor and outdoor security.

DEFINITION OF TERMS

Contour – an outline, especially one representing or bounding the shape or form of something; a line joining points on a diagram at which some property has the same value (Oxford Dictionary). In this case, the object we put contour on is fire-colored object.

Direct Video Processing – current video capture; a video from a camera is processed the same time it is captured.

False Alarm – When the application detects a fire from a non-fire video; fire is detected and verified from a fire-colored object but not a real fire. When an SMS Notification is sent to the registered mobile phone without the occurrence of fire.

Fire-color – a real fire or objects that contain a color that ranges from yellow to red.

HSV – Hue, Saturation and Value of color dependent to RBG color space.

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