Real-Time Alert System for Home Surveillance

by

Ishrat bin Adi Azahar

Dissertation submitted in partial fulfillment of
the requirement for the
Bachelor of Engineering (Hons)
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CERTIFICATION OF APPROVAL

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A Project dissertation submitted to the
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Approved by,

(Ms Zazilah May)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
August 2011

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons

ISHRAT BIN ADI AZAHAR

ABSTRACT

Nowadays, there is an increasing awareness towards efficient home surveillance system. However, most of the home surveillance products in the market are costly and do not offer flexible alert systems platform for user customization. Real-time alert system is important for the user and as well as to those residing home. This project aims to emulate real-time alert system by implementing SMS technology and internet for e-mail and FTP storage. Users would be notified by SMS and e-mail if happens to be potential danger situation at home. The method for getting input data for triggering alert would of visual devices, having the capability to detect motion, recognition and tracking. A thorough research on the GSM technology, and programming libraries such as OpenCV, MATLAB and Microsoft Visual Studio 2005 is necessary to the success of this project, as well as immaculate and extensive study on the concepts behind module implementation to be translated into codes. This project is divided into two major parts; the motion detection of visual device and the automated alert system of SMS and e-mail. Here, home computer or laptop acts as the interface and data processor, controlled by the programming libraries. The project requires having hardware layouts, creating module codes, and then integrating the system together to be tested for its workability.

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LIST OF ABBREVIATIONS

CPU – Central Processing Unit

FTP – File Transfer Protocol

FPS – Frames per Second

GPRS – Global Packet Radio Service

GSM – Global System for Mobile communications

GUI – Graphical User Interface

IrDA – Infrared Data Association

MMS – Multimedia Messaging Service

OpenCV – Open Source Computer Vision

PC – Personal Computer

PIC – Programmable Integrated Circuit

SMS – Short Message Service

SMTP – Simple Mail Transfer Protocol

SSL – Secure Sockets Layer

Telnet – Telecommunications Network

USB – Universal Serial Bus

CHAPTER 1
INTRODUCTION

1.1 Background of Study

Most of monitoring products offer limited or minimal alert system if there happens to be hazardous event such as break-in or fire at home. This project attempts to provide enhancement to the monitoring system with real time alert system. Visual monitors will be installed and capable of detecting the event of hazards, sending alert message to the users for further action to be taken. The platform of real time alert system will be investigated for efficiency and design, and to be interfaced with the monitoring system for functionality.

1.2 Problem Statement

There is an increasing need of advancement in affordable home surveillance system for better quality due to society awareness of its high importance. Thus, a platform for flexible and ready to be customized to cater for different specifications of the user is in demand. Introducing flexiblity in the home surveillance system would prove to be beneficial in terms of cost and energy saving. Especially in the visual department, such as motion detection and tracking, the hardware involved in constructing such system is rather expensive and complicated for users to implement further customization.

1.3 Significant of the Project

The significance of this project is to develop the monitoring and the alert system specifically for motion detection and warning. The project seeks to be simple by design, but effective and maintain its important functionality.The system must adhere to the real environment where the hazard could happen. This includes setting the suitable detection method upon event of hazard, and the platform for relaying the warning to the owner efficiently.

1.4 Objective

The objective of this project is to find suitable monitoring system for home surveillance, and as well as designing the real time alert system. The method of sending the alert message to the user would be in the form of SMS (Short Message Service) or MMS (Multimedia Messaging Service). To achieve this, a GSM/GPRS modem would be used to send the SMS/MMS. The monitoring system needs to support audio/visual functionality and is able to be interfaced with the GSM/GPRS modem wirelessly, through serial data port or control circuit. The SMS sent would contain warning message while the MMS sent could contain pictures taken during triggered event. Users then would be able to observe and make decisions based on these information received.

1.5 Scope of Study

The scope of study will be focused on setting the monitoring system to detect certain triggering event indicating hazard cases, interfacing the monitoring system with GSM/GPRS modem, and setting the GSM/GPRS modem to send alert SMS/MMS to the user. Program libraries such as OpenCV and Microsoft Visual Basic 2005 are also to be explored and studied about its codings and functions to deliver the trigger.

1.6 Relevancy of the Project

The project is relevant to the study of GSM network as a medium for sending/receiving information, emulating a real time alert system. It is relevant to the modern home security/surveillance system, now with enhancement of GSM network concept for checking the status of sensors and even to control, all done while away from home. Also, for the interfacing part, between monitoring system and the GSM/GPRS modem, control circuits will also be analyzed, using microprocessing chips and as well as the programming.

1.7 Feasibility of the Project within the Scope and Time frame

The project will begin with exploring several options for methods of developing or emulating real time alert system. Upon decided on using GSM/GPRS modem as real time alert system platform, journals and technical reports were gathered as to further understand the underlying basis concept. At the same time, monitoring hardware that supports visual were explored to find the suitable hardware for detecting hazard and surveillance scenario and as well as its ability to interface with GSM/GPRS modem.

CHAPTER 2
LITERATURE REVIEW AND THEORY

2.1 GSM/GPRS for Real-time Alert System

The focus of the project will be on designing the interfacing method for monitoring system with the alert system [13], and configuring the GSM/GPRS modem to send alert SMS/MMS [1, 2]. Among interfacing options include wireless, control circuit, and computer serial data port [13]. The schematics of the project can be seen as [3]:

1) Data collecting (sensor/camera)
2) Data processing (via wirelessly, control circuit, serial data port)
3) Communication unit (GSM/GPRS modem)

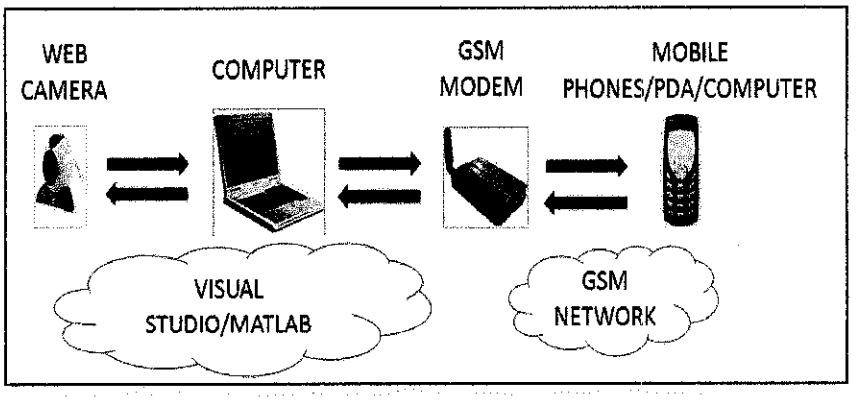


Figure 2.1 : Home Surveillance Alert System Schematics

2.1.1 Data collecting

The event of hazard will be detected using visual camera monitoring system [13]. Upon detection, this will trigger the camera to capture photographs, and prompting the GSM modem to send alert SMS to the user [3, 5]. The monitoring camera will also be triggered to capture photographs, ready to be sent as MMS or to user-defined e-mail.

2.1.2 Data processing

The data collected by the sensor/camera will be processed by the control circuit acting as the interface between the monitoring system and the GSM modem [5]. The control circuit will process the information into prompting the GSM/GPRS modem into sending alert SMS. Upon notified, the user can then send SMS containing pre-defined command to prompt the sending of the captured photographs via MMS or to the e-mail [4, 5].

Other than processing the data received from the sensors, the control unit will also be responsible for inputting different AT functions to prompt the GSM/GPRS modem to send alert SMS/MMS [3, 4, 5]. Of course, the control unit would also be needed to be connected to the GSM/GPRS modem via serial port [5, 9]. To perform all of these tasks altogether, the control unit would need [9] :

1) Microprocessor working as the core controller of the whole system.
2) Multipoint control unit. (save and process the data collected from the sensors)
3) Wireless communication implementation chip (can be controlled and communicated by the Multipoint control unit, and connected to the CPU)

It is important to note that, the interaction between clients and mobile sensors is determined by the specification by the manufacturers for its command sequences for initialization, delivery of data and data contents. This is an example for setting the data processing block wirelessly.

As for wired connections for the data processing block, the control unit would be consisted of microcontrollers and PICs. Control circuits can also be built to be connected directly to the GSM/GPRS modem, capable of handling the data from the sensors. Above all, the designing process of the data processing block would require some programming to set the working parameters of the microprocessors and chips. Depending on the desired functionality, the design of the data processing block can be as simple as connecting the control to the CPU that will handle the operation of the GSM/GPRS modem.

2.1.3 Communication Unit

The GSM/GPRS modem can be an external device or a PC card. External GSM modem is connected to a computer via serial cable or USB. The GSM/GPRS modem requires a SIM card to operate and is configured using AT commands. The compatibility with receiving mobile phone is very important.

Usually, GSM mobile phones do not present any problems communicating, but GSM modem are not compatible with BlackBerry phones, iPhones,Windows mobile devices, and Symbian based phones [1].

The proposed system has several important criteria relating to this project, among them [1]:

1) Good subjective speech quality
2) Number of messages a GSM/GPRS modem can process is about 30 SMS/minute
3) High data transmission speed
4) Support international roaming
5) Can be the platform for range of new services and facilities (example : SMS Gateway – enhancing SMS transmission rate)

The GSM modem uses specific programming language, or a set of commands called AT Commands, from the HAYES AT commands created by Dennis Hayes. Below are a few of the AT commands and their function, which is used in this project[10, 11] :

AT+CMGS	To send a text message
AT+CMGR	To read a text message
AT+CMGD	To delete a text message

Table 2.1 : Examples of AT Commands for SMS

This project attempts to improvise with the GSM network, giving functionality to request MMS/e-mail of data (captured pictures of camera in

event of abuse) in addition of sending alert SMS. The processor between sensor/camera with GSM modem will also be needed to be the acting control panel of the system.

2.2 Implementing Wireless Network

In order to achieve wireless connection of the overall system, several approach and methods of installation were explored. Among existing technologies used in realizing wireless home surveillance system are [4] :

1) IrDA infrared technology
2) Bluetooth technology
3) ZigBee technology

IrDA is a short distance for the half-duplex point-to-point communication. It is inconvenient and of high error rate, thus IrDA is not applicable to home network system. Bluetooth technology is also deemed not suitable for home surveillance networking due to possible large number of nodes usage (sensors, cameras, appliances) and is limited by network capacity and it is costly. Thus, ZigBee is the more preferred approach of home wireless networking implementation with moderate transmission range and larger network capacity.

Specifications of different available wireless technologies are as tabulated below [5]:

	ZigBee / IEEE 802.15.4	WLAN / IEEE 802.11b/ag	Bluetooth 1.2
Application focus	Monitoring & Control	Web, Email, Video	Cable Replacement
Stack Size (kBytes)	< 64	> 1000	> 250
Battery Life (days)	100 – 1000 +	0.5 - 5	1 - 7
Network Size (#nodes)	~Unlimited (65536)	Many	7
Bandwidth (kbps)	250	11 000 / 54 000	~1000
Range (meters)	100 +	100	10 +
Target BOM cost	$ 3	$ 9	$ 5

Table 2.2 : Comparison of specifications of existing wireless technologies

2.2.1 Wireless System Architecture

The system architecture implemented is of modular design installed on an embedded system. The enlisted modules are [5]:

1) ZigBee module : connects household appliances, the system motherboard with sensors and cameras, forming wireless networking.
2) MMS module : enables system controller send home security status information to mobile phone users.

ZigBee technology also offers multi-hop communication capability for data transfer, allowing unlimited range of communication provided that there are intermediate nodes that will pass data from one to another. In addition ZigBee is a protocol that supports flexible mesh networking with strong security tools, thus ZigBee module is the proposed approach to implement home wireless networking of devices.

It is important to note that, the area of wireless communication is limited by the capability of the wireless device used. In other words, device that gives wide coverage area will be expensive and still have its limitations.

Furthermore, the devices will consume more power, which will not be suitable for home monitoring and surveillance applications. Thus, in order to tackle the wireless range and power consumption of device problem, ZigBee multi-hop communication is proposed to be implemented.

The figure below illustrates how the data is being sent from source to the destination through a number of intermediate sensor nodes [4]:

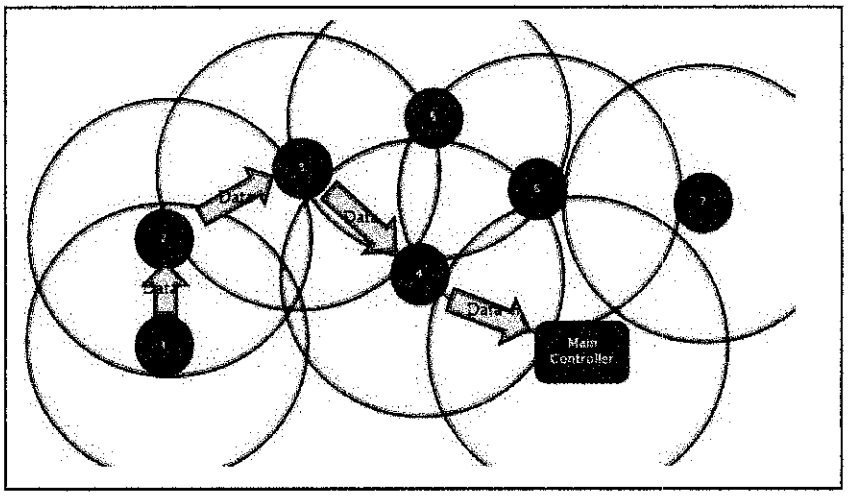


Figure 2.2 : Multi-hop Communication

2.2.2 System Software Design

The architecture of the wireless network will be divided into ZigBee wireless transceiver and SMS/MMS transceiver. According to the network, the level of ZigBee module data will be set to three operating modes :

1) Mode 1 : Connected to the system motherboard, ZigBee modules receive information and send the control command by the user to other ZigBee modules. This is the core of wireless communication and the motherboard.
2) Mode 2 : Connected with household devices (sensors, appliances), is placed in receiving state . Upon receiving the command, ZigBee module control the electronics to make the desired action.
3) Mode 3 : Enters the sent state, the ZigBee module receives the alarm signal and will be sent to other ZigBee module.

2.3 Motion Detection

Motion detection is the foremost vital process of information extraction in terms of moving objects and stabilization of tracking, identification and so on. Generally, detection is defined by the ability of a camera to detect movement in the 'region of interest' present in the 'region if awareness' or the field of view, is defined as the 'portion of environment being monitored' [6].

The region of interest is defined as the portion of environment with activity due to motions of moving objects. Thus, it is needed for the visual device to capture images when the motion exceed a certain threshold that is preset in the system. Introducing this threshold value will reduce the volume of

data that needs to processed. This is a convenient way of monitoring especially when multiple cameras need to be implemented.

There are two main components that concern with motion detection surveillance software selection, that is the GUI and method of detection. Here are the two popular methods in motion detecting [7]:

1) Temporal Difference
2) Background Modelling

2.3.1 Temporal Difference

Temporal difference is achieved by comparing consecutive frames on a pixel by pixel basis. The motion is calculated and a threshold value is applied to dictate object movement or is static [8].

However, temporal difference does not show the relationship if a pixel with its neighbourhood thus temporal difference approach is prone to false alarm. This is further reinforced by the fact that it possesses incomplete detection of the shapes of moving objects.

2.3.2 Background Modelling

Background modelling method is classified as pixel-based and region-based motion detection. Hence the name, the main idea behind this concept is using background substraction. This is achieved by averaging the 'static background' image sequences over a period of time on a mixture of Gaussian distribution. The likelihood of each incident pixel colour is computed by

comparing with every Gaussian density, thus, if the pixel do not match, motion is said to be detected [6,7].

There are two popular approach on implementing background modelling method as motion detection concept [6]:

- Three tiered algorithm – processes image at pixel, region and frame level
- Eigen-space decomposition method

Figure 2.3 : (a) Background model (b) Background modelling (c) After background modelling

2.4 Object Tracking and Recognition

Objects are tracked and recognized from frame to frame using [8]:

- Location
- Direction of motion
- Size
- Colour

2.4.1 P-N learning

For object tracking, the learning module that is to be implemented by the algorithm should be robust and real-time, so that it will be applicable for surveillance and long-term tracking projects. In P-N learning, semi-supervised learning where these variables are introduced [14]:

- P-constraints generator of positive examples
- N-constraints generator of negative examples

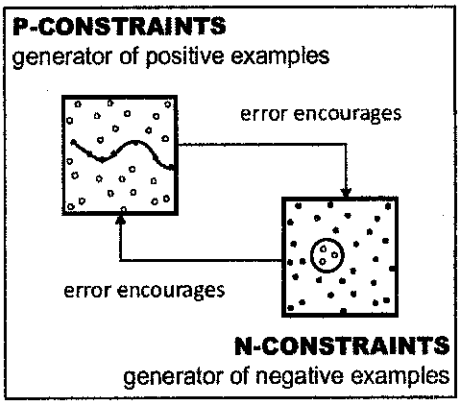


Figure 2.4 : P-N Constraints

2.4.2 Structural Constraints

Structural constraints restrict labelling of the unlabeled data or patches. This is better exemplified in the figure below [14]:

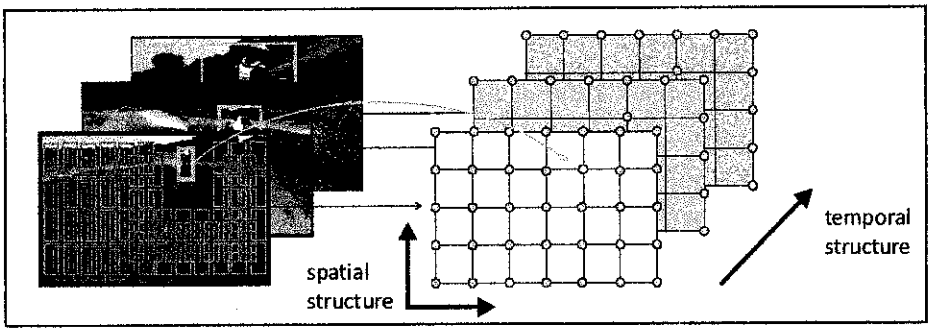


Figure 2.5 : Spatial and Temporal Structure of Data or Patches

P-constraints labelling define the pattern of positive examples in unlabeled data, while N-constraints define the pattern of negative examples in unlabeled data. For example, P-constraints (trajectory) whereby the object moves on a piece-wise continuous trajectory, thus the patches or data close to the trajectory are positive. While, N-constraints (non-maxima suppression) is where an unique object occupies a single location in a single frame, then all responses from the maximally confident patch are negative [14].

It is important to note that, every constraint introduces error (where the tracker drifts and the maximum response is a false positive). Errors of P-constraints encourage application of N-constraints and vice versa. Thus, the performance of the classifier grows until long-term stability is achieved.

2.4.3 Semi-Supervised P-N learning

A semi-supervised algorithm which guides the learning by a pair of structural constraints, generators of positive and negative examples. The flow of learning is as shown below [14]:

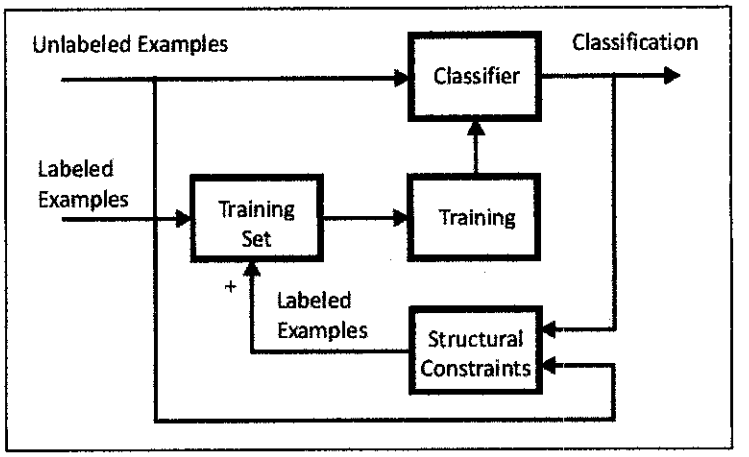


Figure 2.6 : Semi-Supervised Learning Algorithm

The core algorithm is to train a classifier using all labeled data available, iterating :

(1) Classify unlabeled data
(2) Discover structure in the data
(3) Apply P-constraints : generates positive data (false negative with respect to structure)
(4) Apply N-constraints : generates negative data (false positive with respect to structure)
(5) Update classifier

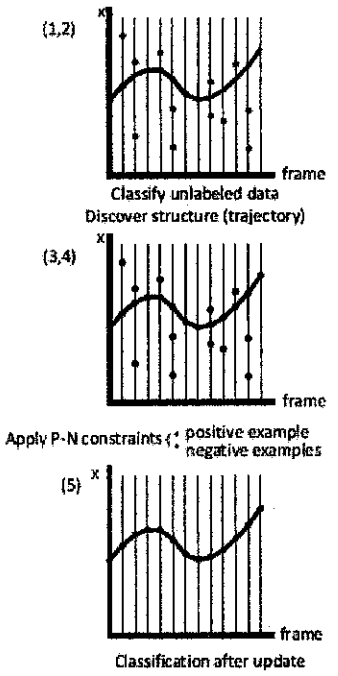


Figure 2.7 : Learning Flow of Constraints Pairs

2.4.4 Convergence Analysis

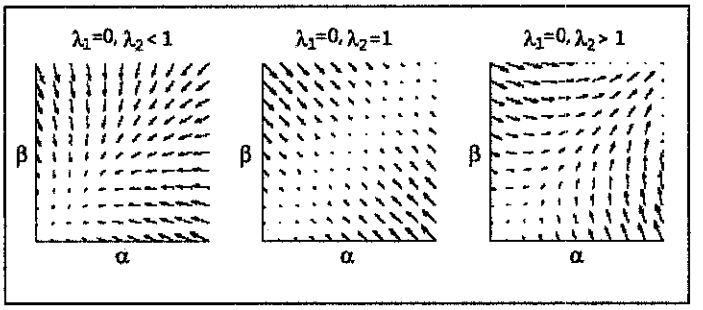
Model of constraints in convergence analysis [14]:

- P-constraints : Precision (P+), Recall (R+) (ability to identify false negatives)
- N-constraints : Precision (P-), Recall (R-) (ability to identify false positives)
- Classifier performance : $\alpha(k)$ false negative, $\beta(k)$ false positive

$$\begin{bmatrix}\alpha(k+1)\\ \beta(k+1)\end{bmatrix}=\begin{bmatrix}1-R^- & \frac{1-P^+}{P^+}R^+\\ \frac{1-P^-}{P^-}R^- & 1-R^+\end{bmatrix}\times\begin{bmatrix}\alpha(k)\\ \beta(k)\end{bmatrix}$$

$$x(k+1)=\mathrm{M}\cdot x(k)$$

(a)



(b)

Figure 2.8 : Convergence Analysis of constraints and classfier (a) mathematical expression (b) graphical representations

P-N learning improves the classifier, if the eigen values of M are smaller than one. Individual constraints can have arbitrarily precision/recall. Thus, the stability of the learning is achieved by mutual error compensation.

CHAPTER 3
METHODOLOGY

3.1 Research methodology

In achieving the goals of this project, deep understanding of the components aforementioned is required. Many journals, technical reports and official website for specifications were explored and researched by Internet. In addition to research, configuring and testing of the project components via simulation and analysis will be done. Important and relevant data will be documented correponding to the results obtained.

3.2 Tools and Equipments Required

Hardware Requirement

i. Web Camera
ii. GSM/GPRS modem
iii. System Control Panel (PC or laptop)

Software Requirement

i. MATLAB
ii. Microsoft HyperTerminal
iii. OpenCV
iv. Microsoft Visual Studio 2005

3.2.1 *Flow chart of firmware*

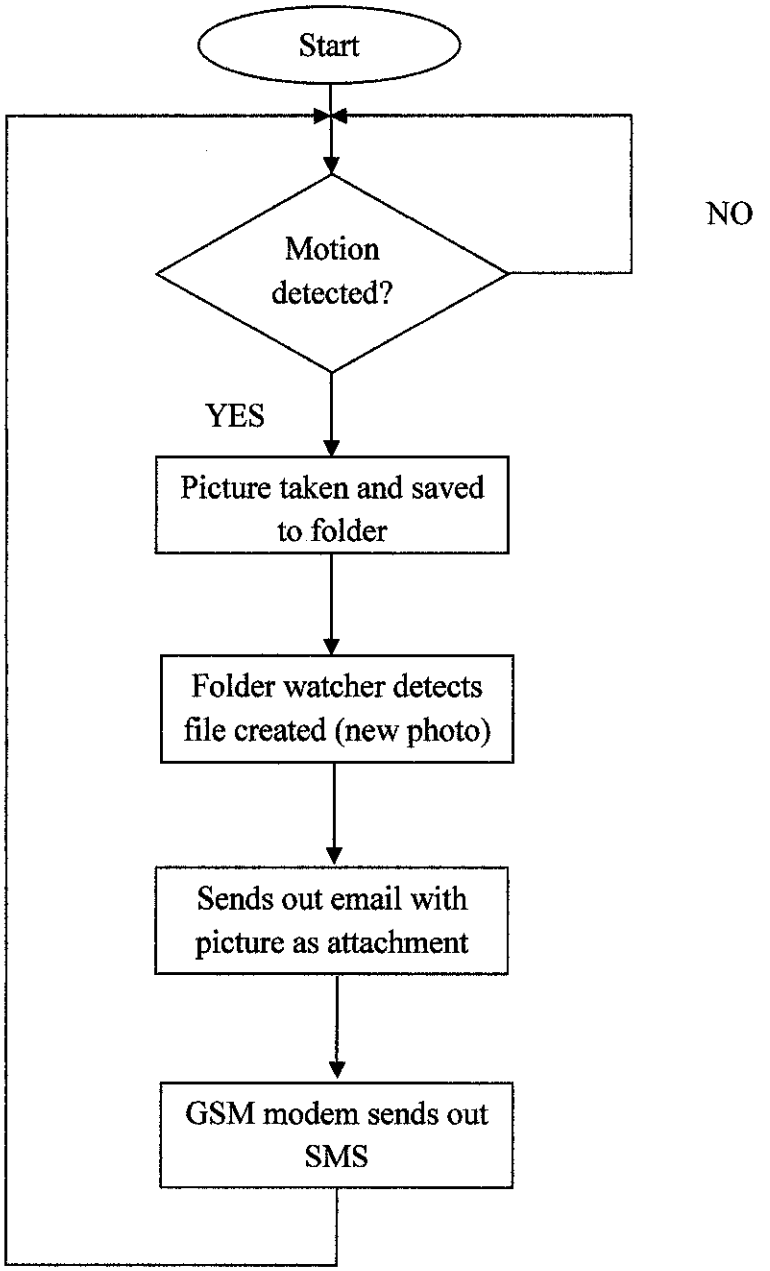


Figure 3.1 : Flow chart of firmware

3.3 Project Activities

1) Testing the sensor/camera hardware

This will be the input that will be sent to the GSM modem to send the alert SMS. The hardware will also be initialized and prompt by software that is to be programmed.

2) Configuring the control panel for data processing between monitoring system to GSM modem.

For this activity, several options for interfacing both of these systems will be explored. It can be through a control circuit, serial data port (computer), or wirelessly (implementing receiver). The design will adhere to the architecture, emulating home surveillance system.

3) Testing the setting the GSM/GPRS modem for sending/receiving SMS/MMS.

The testing of the GSM/GPRS modem functionality will be done through the Microsoft HyperTerminal. A set of AT commands will be used to check whether the modem was installed and working properly, and for the testing of sending and receiving of SMS/MMS to pre-defined end users.

4) Building and testing the codes for hardware control

Relevant coding libraries were sought after such as OpenCV and Microsoft Visual Studio 2005. Tutorials on code writing were read through for controlling hardware that is connected to the PC via USB and serial data port. Functions on prompting email and SMS notification were explored and tested.

5) Reconfiguring codes algorithm

Codes were constructed adhering to theory and concepts discussed previously. The modules were executed for test run individually. Upon successful individual code execution, these functions were connected together.

6) Full system testing

Motion were simulated, rendering the input device to prompt the sequence of the system. Any code functions that were not called or handled properly are revisited for debugging or using another approach.

3.4 Review and Analysis

The project aims to provide a basic approach to home security by exploiting several computing resources. As aforementioned, camera sensor and as well as a personal computer executing a scheduler program for detection and sending the alert message to user's mobile phone. It is also designed to provide mobility for intended user using mobile phones enablement to the security system. Thus, the user can plan out the next appropriate approach by figuring out and analyzing the alerts.

3.4.1 Market Research

People both at home and office spend a great amount of budget for the purpose of providing efficient security system. Among of the common identifiable characteristics of home security system are listed below [n] :

1) 24 hours monitoring
2) Ease of use
3) Difficult to hack
4) Reliability
5) Sensors (motion, sound, etc)
6) Efficient, fast and precise alert system

3.4.2 Technical Research

Further research was conducted to find out the best and suitable technology to be used in this project, adhering to several technical aspects of the system for conveniency and widely available technology.

1) Operating System :

Most of home personal computers use Microsoft operating system and related products. Thus, with Microsoft framework, it is proposed that the scheduler and Web based programming is done in Microsoft Visual Studio 2005, OpenCV and MATLAB which is easily deployed at any web server and at any platform.

2) Database :

Research on few available databases for storing snapshots from the surveillance camera include : Oracle, SQL server 2000, Sybase, FoxPro, MYSQL etc. Gearing towards minimum cost and easy access, it is proposed that MYSQL to be used in the system providing integrated relational database.

3) Web Browsers :

It is known that most of the home personal computers used Internet Explorer as Microsoft related product, Firefox and Google Chrome. Therefore, the system is designed to run on these browsers.

4) SMS-Server :

Choosing the appropriate server for sending alert messages implementation upon detection with respect to cost and efficiency, google email SMTP server is mostly attuned to the system need.

5) Hardware :

Among most widely used models of mobile phones are Nokia mobile phones and stand alone GSM modem device. Thus, the software, Microsoft Visual Studio 2005 is found compatible with most of programming interfaces and could easily cope up with the system performance. Microsoft Visual Studio 2005 set with a GSM modem featuring a GPRS connection is utilized as a message sender to communicate during event.

Also, with different sensors available in the market for photo capturing and motion detection, web camera is easily suited to the cost and consumption estimate. Additionally, the cameras can easily be configured and installed at any obscure location in a house. There are several software that is compatible with Microsoft WDM video device such as Java Media framework.

3.5 Camera Placement

In this system, the camera placement plays an important role to ensure better surveillance performance. It is very important to understand the specifications of the visual device used for the system such as its frame rate, resolution and know how to deal with the trade-offs between these two important details. Usually, it is recommended of using higher frame rate visual device, suitable for live streaming especially in the context of real-time alert system.

The camera resolution is the size of the captured image measured in pixels or dots per inch. Typically, resolution ranges from 160x120 all the way up to 1600x1200. Standard resolution is usually 640x480. Take note that this resolution used to be the upper end but now it is the norm. Keep in mind that each pixel carries data or meaning. Thus, the larger the resolution, the greater the data flow and storage space required. In other words, one can conclude that resolution is directly proportional to speed.

Frame rate on the other hand, is the number of pictures captured and transmitted per second. This holds true as the very definition of a video is just a series of still images. The faster the frames per second, the better the video will look. For example, at 10 frames per second, a video looks choppy whereas around 25 frames per second or greater, the resulting output begins to see the still images as flowing.

There is a trade-off on both frame rate and resolution. Higher resolution means more data per picture , while higher frame rate means more pictures per second. Thus, it is very important to adhere to the specifications by having a system is able to handle this tremendous data flow.

Further customizations can be made with the camera placement because it supports to several type of camera connections such as via USB cable wire and even wirelessly. Compared to the standard visual surveillance products, employing this approach of visual peripherals for monitoring can be cheap. Additionally, multiple of these devices can be assembled to a single PC, laptop or its equivalent.

Figure 3.2 demonstrates the possible layout for camera placement for this proposed system. This is assuming the type of camera used in this system, which is a HP Pavillion dv2000 integrated web camera, having the specifications of 1.3 Megapixel and supporting up to 640 x 480 resolution.

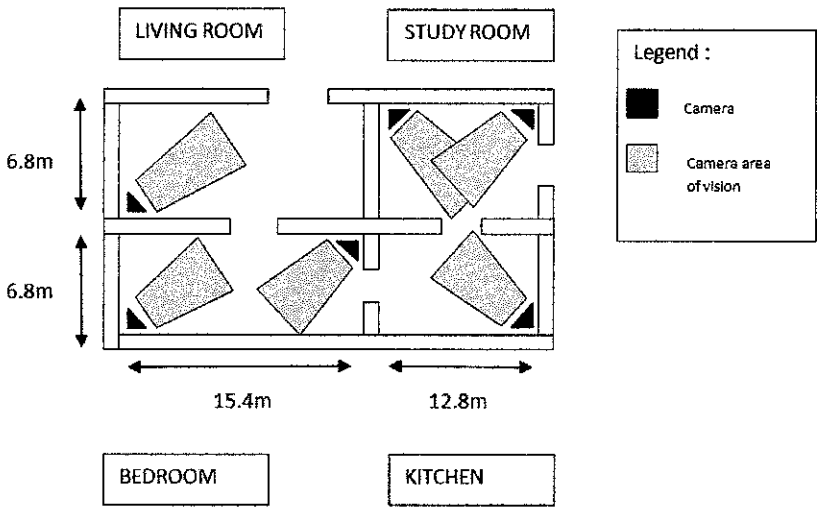


Figure 3.2 : Camera placement example

3.6 Key Milestone

Details/Week	1	2	3	4	5	6	7	Mid Semester Break	8	9	10	11	12	13	14
Project Work Continue															
Submission of Extended Progress Report															
Project Work Continue															
Pre-Edx															
Submission of draft Dissertation															
Oral Presentation															
Submission of Final report (hardbound)															

Figure 3.3 : Key Milestone of project

3.7 Gantt Chart

Activities/Weeks	1	2	3	4	5	6	7	Mid Semester Break	8	9	10	11	12	13	14
Testing the sensor/camera hardware															
Configuring data processing to devices															
Testing and setting GSM modem for SMS send															
Building and Testing the codes for hardware control															
Reconfiguring Codes Algorithm															
Full System Testing															

Figure 3.4 : Gantt Chart of project

CHAPTER 4
RESULT AND ANALYSIS

4.1 Result

This chapter talks about the results gained from the work done on the parts of the project and the discussion that follows.

4.1.1 GSM Modem

For the SMS part, the microcontroller needs to connect to a GSM modem. A GSM can be represented by a mobile phone or as a device itself. Most commercial mobile phones are more accessible and cheap, for this project a stand-alone GSM modem is used instead.

This is because a GSM modem found in mobile phones require the use of a protocol called an F-BUS protocol. An F-BUS protocol is a protocol made for Nokia mobile phones that would allow users to send and receive messages. However, this protocol is tedious and complicated to an amateur programmer.

Using a GSM modem device, the programming is much simpler and less complicated that the F-Bus. A GSM modem uses a set of commands called AT Commands. AT Commands is used for communication between modems. AT is short for the word 'Attention', which is basically what the commands are used for – to demand the attention of the modem.

AT Commands has a set of fixed commands used to send and received text messages. Table shows how to use the commands to send an SMS [10].

AT+CMGF=1	To format SMS as TEXT message, 1 is the code to use.
AT+CSCA="+xxxxx"	Set the SMS center's number. This number needs to be checked with the service provider. For example, Maxis's service center number is +60120000015.
AT+CMGS="+yyyyy"<Enter> >Your SMS text message here <Ctrl-Z>	The command is used to send a text message. The "+yyyyy" is the recipient's mobile number.

Table 4.1: Examples of AT Commands used to send SMS

In receiving text messages, the GSM modem can have it in two ways; immediate or by notification. With the GSM modem, the text messages received are notified, when a SMS is received, the host computer will be notified of the new message. The computer will then have to read from the indicated memory location and clear the memory location [11].

When a new SMS is received by the GSM modem, the serial communicator will receive the following as shown in Table 4.2.

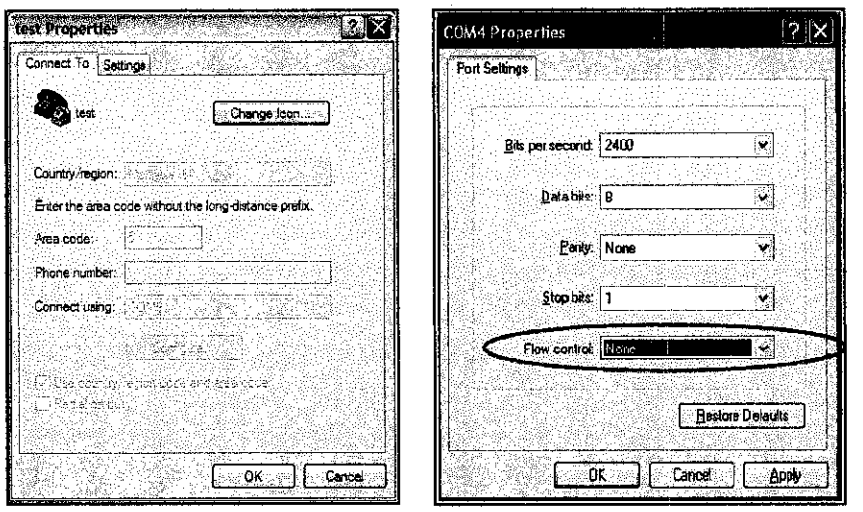
+CMTI: " SM",3	This is to inform that the text message is in the SIM memory, and it is in location number 3.
AT+CMGR=3 <Enter>	The following AT command is sent to read the received SMS from

	modem. The <> is to indicate that the Enter key is pressed. The modem will then send to the computer details of the received SMS from the specified memory location (example : number 3)
+CMGR: "REC READ","+61xxxxxx",,"07/07/11,22:15:33+40"	This is the new SMS received by the GSM modem.

Table 4.2 : Examples of AT Commands Used to Read New SMS

The GSM modem is tested first by using a serial communicator. This is to make sure that the AT command set is working perfectly with the modem. Only then will it be programmed into the system controller.

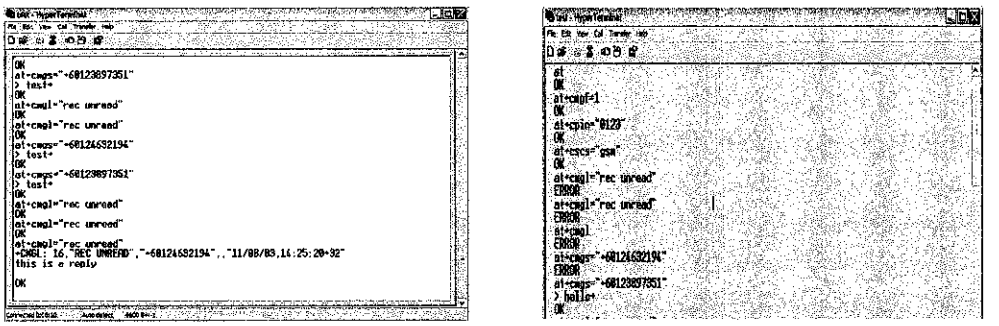
Figure shows the Serial Communicator that is used to test the workability of the GSM modem. The GSM modem is connected to the computer using a serial port at COM4. The default setup for the serial communicator is shown in the figure below. Baud rate used is set at 9600, with flow control set to none. The default settings would be 9600-8-N-1-N.



(a) (b)

Figure 4.1 : (a) Microsoft Hyperterminal setup Properties (b) COM Properties Setting

Figure x shows the result if the GSM modem SMS commands done on serial communicator of Microsoft Hyperterminal.



(a) (b)

Figure 4.2 : (a) GSM modem results for reading and sending SMS (b) GSM modem results for reading received SMS

Table outlines the results from the GSM modem and serial communicator connection of Microsoft Hyperterminal.

AT+CMGF=1	To format SMS as a TEXT message, 1 is the code to use.
AT+CMGS="0126338938" <Enter> >Welcome to MyPOS	The command is used to send a text message.
AT+CMGL="rec read" <Enter>	The command is used to read the received SMS from modem.
+CMGR: 2, "REC READ","+60124632194",,"11/08/03,14:25:20+32" This is a reply	This is the new SMS received by the GSM modem.

Table 4.3 : GSM modem results outline

4.1.2 Camera Detection and Tracking

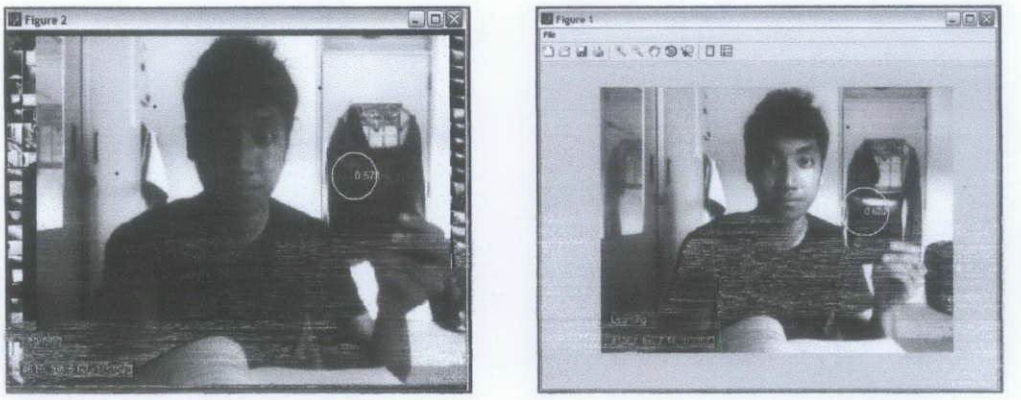
For camera detection and tracking, a simple web camera is being used as prototype testing. The web camera is connected to the PC or laptop via USB cable. The control of its detection is tracking is done using OpenCV library of programming functions, later converting its routines and functions into MATLAB. This is achieved using a ready available code converter available for software developer.

Using OpenCV, we can also change the properties of the web camera such as its frame per second, gamma, and brightness enabling us to customize the camera for many situations deemed suitable for surveillance purposes. Using web camera connecting to the laptop, the programming is much simpler and is less expensive than having to invest in surveillance cameras that are usually expensive. Also we can teach the web camera to learn of its tracking, further improving its precision and generating less error in triggering false alarm.

Figure shows the result of the web camera initiated and controlled via OpenCV library converted to MATLAB functions .

(a) (b)

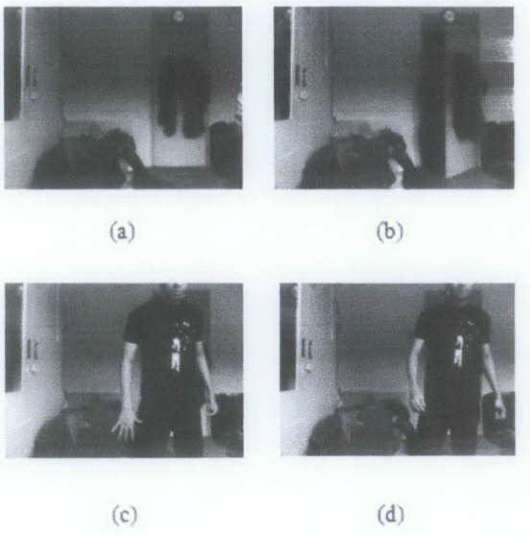
Figure 4.3 : (a) Web camera face tracking learning (b) Web camera face tracking main interface



(a) (b)

Figure 4.4 : (a) Web camera object tracking learning (b) Web camera object tracking main interface

Figure shows the result of the web camera initiated and controlled via Microsoft Visual Studio 2005.



(a) (b)

(c) (d)

Figure 4.5 : (a), (b), (c) and (d) Series of motion caption detection

4.1.3 SMS Notification

Upon the capture of image due to motion detection, the picture will be saved to a folder. This event will trigger the GSM modem to send SMS alert to a pre-defined user number. The execution of code algorithm is shown in the figure below :

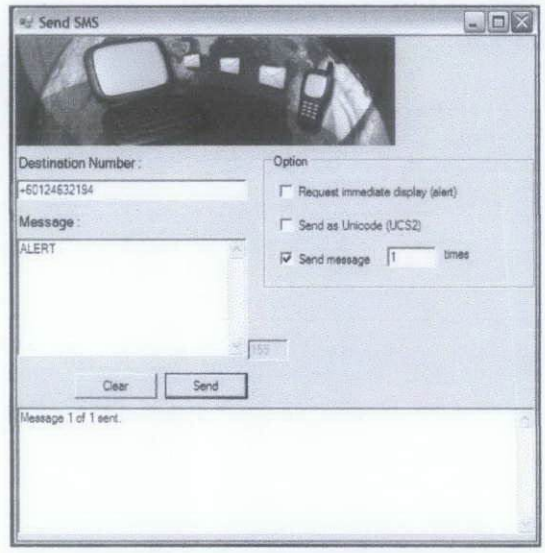


Figure 4.6 : SMS Panel

By using Microsoft Visual Studio 2005, the trigger for sending SMS alert or notification can be done thus automated SMS sending is achieved and as well as providing GUI for easier user access and control.

4.1.4 E-mail Notification

Email notification will also be sent out to pre-defined user destination email address. Prompted by the image capture during motion detection, the email sent out will have the image as its attachment as well for user clarification and proof.

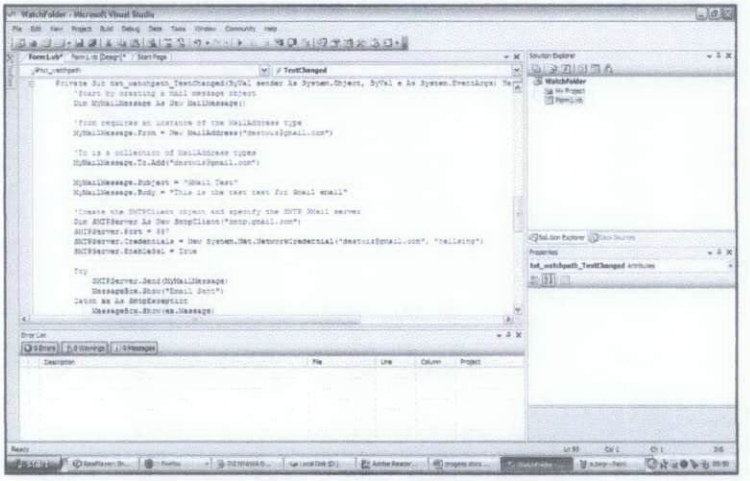


Figure 4.7 : Visual Studio Email e-mail sending functions

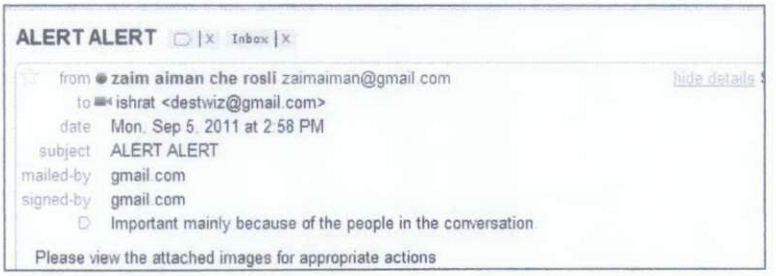


Figure 4.8 : E-mail notification

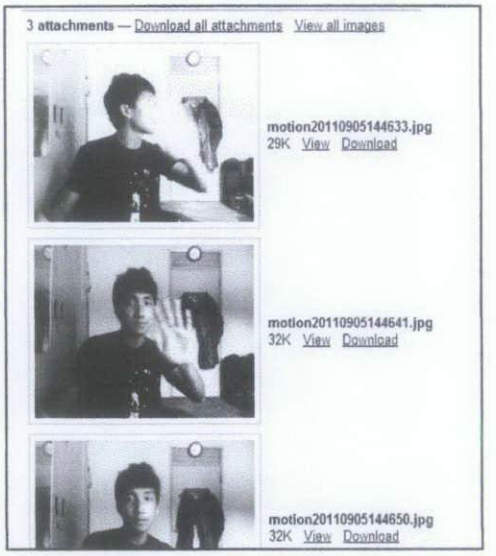


Figure 4.9 : Attached images

For email notification module, e-mail is being sent through the SMTP server of corresponding email service provider. The attachment of captured image by web camera in the e-mail will also be done automatically as written in the code.

4.1.5 Folder Watching

Microsoft Visual Basic 2005 provides excellent methods for handling events and triggers of devices connected to the PC or laptop. This includes covering the aspect of automated SMS and e-mail notification to user as alert. The concept of raised event for real-time alert is when the image is being capture due to motion detection by web camera, thus prompting e-mail and SMS alert.

Figure below shows an example of notification in text box of a file creation inside the 'watched' folder :

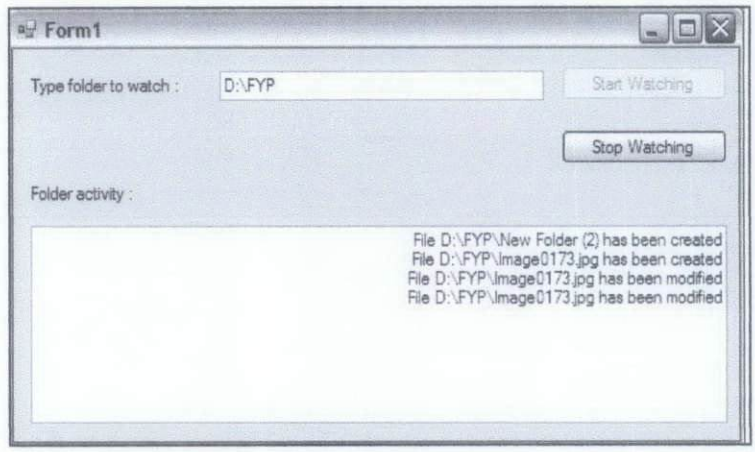


Figure 4.10 : Handling raised events for trigger

4.2 Discussion

4.2.1 GSM modem

There are two ways to implement the SMS system, using GSM modem from a mobile phone or a GSM modem device. A GSM modem is used due to the less complicated nature of configuration and programming. AT Command set is used for the sending and receiving of text messages.

AT Commands set simplifies the process of sending and receiving messages. Instead of communicating with the telephone memory like F-Bus protocol does, AT Commands communicates directly with the modem. By just typing a few of the commands, the GSM modem can receive and send text message.

A serial communicator is used to test the workability of the AT Command with the GSM modem. Configuration settings at the serial communicator need to be done before attempting to send a text message.

When sending and receiving SMS using a system contoller (microcontroller), additional programming needs to be added. The microcontroller needs to know when to send the message and how to process received messages. It also needs to synchronize with the GSM modem in order to determine the time of the message being sent or received.

Serial communication is an important aspect in the communication between GSM modem and the microcontroller. An RS232 cable that is wired using the most basic configuration is not sufficient enough for message transmission. A GSM modem is a DCE (Data Communicaton Equipment) and needs a make DB9 connector. The microcontroller also uses a male DB9 connector for serial communication. This DCE/DCE communication or cable is called a Null Modem, and requires a special configuration known as handshaking. This configuration allows messages to be sent.

Initially when a SIM card from a non-prepaid line was used, the LED indicator on the GSM modem blinks on and off every second. When AT is typed the answer received is Error instead of OK. After further testing it shows that if the LED is blinking fast, the modem is not connected to the GSM-network. Either the pin has not been properly entered yet or the SIM card is not allowed to do data transfer. The problem is solved when a pre-paid SIM card is used. The LED blinks in even seconds and messages were able to be sent and received.

4.2.2 Web Camera Detection and Tracking

With OpenCV library programming code, we can teach a simple web camera the ability motion detection and tracking. This complies with the objective of the project that is to provide a platform for flexible and ready to be customized. Web camera used here is cheap and can be obtained easily at any computer hardware shops compared to CCTV or any other surveillance type cameras.

While motion detection is achieved with executing Microsoft Visual Studio 2005. The web camera will be prompted to capture image upon detection of motion in its vision field. Using Microsoft Visual Studio 2005, we can call other similar functions for handling this event by sending SMS and email notification.

However, its learning for better tracking would be faster and smoother if it is executed in better processing environment. Here, the concept of motion tracking and identification lies not in the specific algorithm, but the idea of using images' patches close to the object trajectory to update the detector. The non-maximally confident detections do produce errors, but the learning stability is achieved by compensation of error or negative points with positive points.

This functionality of tracking and learning of web camera is yet to be implemented together with the real-time alert system using GSM modem due to OpenCV library programming code only support manipulation of computer vision and does not supply codes for handling raised events of detection.

4.2.3 SMS Notification

This code function can only work when the GSM modem is properly connected to the PC or laptop prior to sending SMS. In the code line, the correct COM port in which the GSM modem is connected must be stated correctly for successful sending of the SMS.

The SMS sending module is fitted together with a GUI for control panel. Here the SMS sending function can be customized and preset, for example : the amount of SMS to be sent per trigger. Further testing shown that, using these codes, any device that supports AT Command can be triggered to send SMS this way.

4.2.4 E-mail Notification

The firmware written for e-mail notification must comply to several settings. To begin use automated e-mail sending, an user must first possess a working e-mail and then determine its SMTP server for relaying e-mails.

However, this is different from the concept of webmail. Some of the tutorials on programming e-mail sending might require the system to have IIS installed. Usually, machines that operate on Windows XP Home edition would suffer from this problem. In order to get around this limitation, we use our corresponding e-mail provider SMTP server, thus enabling our machine as gateway to send out e-mails.

Note that for SSL connection, the external port is set to 465 because usually, the local ISP will block the default external port 25 to reduce spam mails. As to check whether the external port 25 is being blocked by the ISP, a simple telnet test can be done in Windows command window. As shown below :

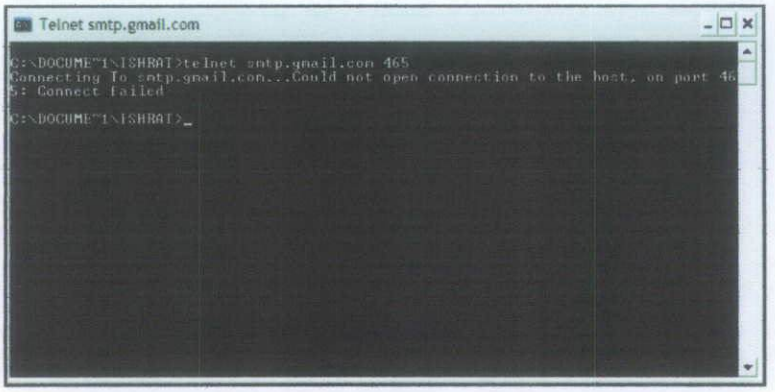


Figure 4.11: Port check using Telnet test

CHAPTER 5
CONCLUSION

5.1 Conclusion

Real-time Alert System for Home Surveillance can provide flexible and efficient surveillance system, cheaper than most surveillance products and improve operating performance by reducing energy consumption and ability to set multiple surveillance posts without expanding costs.

The research was done in the first part of this project, in order to fully understand the operation of GSM modem, OpenCV, MATLAB and Microsoft Visual Studio 2005 programming libraries. After the research was completed, the layout was developed and the program codes were built and tested separately for each function of modules so that troubleshooting will be easier.

This project has managed to avoid from implementing expensive surveillance products for means of input and alert system. It has managed to detect motion and capture image, sends out SMS via GSM modem as alert emulating real-time and as well as e-mail notification attached together with the image file.

This project makes room for many further improvements. For example, using this approach, the system could also be configured to automation in addition as alert system, controlling home electrical appliances via SMS. The home surveillance system project proved to be interesting, would benefit the society highly and having many rooms for further improvements and customization.

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Appendix A

This is the code in Microsoft Visual Studio 2005 for folder watching :

```
Imports System.IO
Imports System.Diagnostics
Imports System.Net.Mail


Public Class Form1

    Public watchfolder As FileSystemWatcher



    Private Sub logchange(ByVal source As Object, ByVal e As _
                          System.IO.FileSystemEventArgs)
        Control.CheckForIllegalCrossThreadCalls = False
        If e.ChangeType = IO.WatcherChangeTypes.Changed Then
            txt_folderactivity.Text &= "File " & e.FullPath & _
                                       " has been modified" & vbCrLf
        End If
        If e.ChangeType = IO.WatcherChangeTypes.Created Then
            txt_folderactivity.Text &= "File " & e.FullPath & _
                                        " has been created" & vbCrLf
        End If
        If e.ChangeType = IO.WatcherChangeTypes.Deleted Then
            txt_folderactivity.Text &= "File " & e.FullPath & _
                                       " has been deleted" & vbCrLf
        End If
    End Sub

    'handling renamed event
    Public Sub logrename(ByVal source As Object, ByVal e As _
                          System.IO.RenamedEventArgs)
        txt_folderactivity.Text &= "File" & e.OldName & _
                    " has been renamed to " & e.Name & vbCrLf
    End Sub


    Private Sub Button1_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btn_startwatch.Click
        watchfolder = New System.IO.FileSystemWatcher()

        'this is the path we want to monitor
        watchfolder.Path = txt_watchpath.Text

        'add list of filters we want to specify
        'use OR for filters
        watchfolder.NotifyFilter = IO.NotifyFilters.DirectoryName
        watchfolder.NotifyFilter = watchfolder.NotifyFilter Or _
```

```
                                        IO.NotifyFilters.FileName
        watchfolder.NotifyFilter = watchfolder.NotifyFilter Or _
                                        IO.NotifyFilters.Attributes

        'add handler to each event
        AddHandler watchfolder.Changed, AddressOf logchange
        AddHandler watchfolder.Created, AddressOf logchange
        AddHandler watchfolder.Deleted, AddressOf logchange

        'add the rename handlers as the signature is different
        AddHandler watchfolder.Renamed, AddressOf logrename

        'set this property to true to start watching
        watchfolder.EnableRaisingEvents = True
        btn_startwatch.Enabled = False
        btn_stop.Enabled = True

        'end of code for button start click
    End Sub


    'Private Sub txt_watchpath_TextChanged(ByVal sender As System.Object,
ByVal e As System.EventArgs) Handles txt_watchpath.TextChanged


    'End Sub

    Private Sub btn_stop_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btn_stop.Click
        'stop watching the folder
        watchfolder.EnableRaisingEvents = False
        btn_startwatch.Enabled = True
        btn_stop.Enabled = False
    End Sub




    Private Sub Button1_Click_1(ByVal sender As System.Object, ByVal e As
System.EventArgs)

    End Sub

    Private Sub Form1_Load(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles MyBase.Load

    End Sub
End Class
```

Appendix B

This is the code in Microsoft Visual Studio 2005 for sending SMS :

```
Option Explicit On

Imports System
Imports System.Threading
Imports System.ComponentModel
Imports System.IO.PortsPublic Class SMSCOMMS

Private WithEvents SMSPort As SerialPort

    Private SMSThread As Thread
    Private ReadThread As Thread
    Shared _Continue As Boolean = False
    Shared _ContSMS As Boolean = False
    Private _Wait As Boolean = False
    Shared _ReadPort As Boolean = False
    Public Event Sending(ByVal Done As Boolean)
    Public Event DataReceived(ByVal Message As String)

    Public Sub New(ByRef COMMPORT As String)
        SMSPort = New SerialPort
        With SMSPort
            .PortName = COMMPORT
            .BaudRate = 9600
            .Parity = Parity.None
            .DataBits = 8
            .StopBits = StopBits.One
            .Handshake = Handshake.RequestToSend
                .DtrEnable = True
              .RtsEnable = True
            .NewLine = vbCrLf
        End With
        ReadThread = New Thread(AddressOf ReadPort)
        End Sub
```

```
    Public Function SendSMS(ByVal CellNumber As String,
        ByVal SMSMessage As String) As Boolean
        Dim MyMessage As String = Nothing
        'Check if Message Length <= 160

        If SMSMessage.Length <= 160 Then
            MyMessage = SMSMessage
        Else
              MyMessage = Mid(SMSMessage, 1, 160)
        End If
        If IsOpen = True Then
                SMSPort.WriteLine("AT+CMGS=" & CellNumber & vbCr)
                _ContSMS = False
                SMSPort.WriteLine(MyMessage & vbCrLf & Chr(26))
                _Continue = False
                RaiseEvent Sending(False)
        End If
    End Function

    Private Sub ReadPort()
          Dim SerialIn As String = Nothing
        Dim RXBuffer(SMSPort.ReadBufferSize) As Byte
        Dim SMSMessage As String = Nothing
        Dim Strpos As Integer = 0
        Dim TmpStr As String = Nothing

            While SMSPort.IsOpen = True
            If (SMSPort.BytesToRead <> 0) And (
                SMSPort.IsOpen = True) Then
                While SMSPort.BytesToRead <> 0
                    SMSPort.Read(RXBuffer, 0, SMSPort.ReadBufferSize)
                    SerialIn =
                        SerialIn &
System.Text.Encoding.ASCII.GetString(
                        RXBuffer)
                    If SerialIn.Contains(">") = True Then
                        _ContSMS = True
                    End If
                    If SerialIn.Contains("+CMGS:") = True Then
                        _Continue = True
```

```
                        RaiseEvent Sending(True)
                        _Wait = False
                        SerialIn = String.Empty
                        ReDim RXBuffer(SMSPort.ReadBufferSize)
                    End If
                End While
                RaiseEvent DataReceived(SerialIn)
                SerialIn = String.Empty
                ReDim RXBuffer(SMSPort.ReadBufferSize)
            End If
        End While
    End Sub

    Public ReadOnly Property IsOpen() As Boolean
        Get
            If SMSPort.IsOpen = True Then
                IsOpen = True
            Else
                IsOpen = False
            End If
        End Get
    End Property

    Public Sub Open()
        If IsOpen = False Then
            SMSPort.Open()
            ReadThread.Start()
        End If
    End Sub

    Public Sub Close()
        If IsOpen = True Then
            SMSPort.Close()
        End If
    End Sub

End Class
```

Appendix C

This is the code in Microsoft Visual Studio 2005 for sending e-mail :

```
Imports System.IO
Imports System.Diagnostics
Imports System.Net.Mail

'Start by creating a mail message object
    Dim MyMailMessage As New MailMessage()

    'From requires an instance of the MailAddress type
     MyMailMessage.From = New MailAddress("destwiz@gmail.com")

    'To is a collection of MailAddress types
       MyMailMessage.To.Add("destwiz@gmail.com")

     MyMailMessage.Subject = "GMail Test"
     MyMailMessage.Body = "This is the test text for Gmail email"

    'Create the SMTPClient object and specify the SMTP GMail server
    Dim SMTPServer As New SmtpClient("smtp.gmail.com")
      SMTPServer.Port = 587
      SMTPServer.Credentials = New
System.Net.NetworkCredential("destwiz@gmail.com", "hellsing")
     SMTPServer.EnableSsl = True

      Try
         SMTPServer.Send(MyMailMessage)
         MessageBox.Show("Email Sent")
     Catch ex As SmtpException
        MessageBox.Show(ex.Message)
    End Try
```