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Development of camera and GSM interfacing system for home security surveillance

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This project is developed with aims to improve home security systems available in current market. This project claims to produce a prototype camera and global system for mobile communication (GSM) interfacing system for home security surveillance. This system uses two sensors, namely ultrasonic and passive infrared receiver (PIR). The ultrasonic sensor is used to detect movement of objects and PIR function is to detect changes in temperature of human in infrared radiation. In this project, the microcontroller used is ATMega 32, where it sends data to the computer to activate the camera when the microcontroller receives signals from PIR and ultrasonic. MAX232 is used as an interface circuit connecting the microcontroller to the computer. To develop software for the control circuits, software CodeVision AVR is used because the software supports microcontroller ATMega of 32. Once the camera is activated, it will capture images of intruder and the image will be saved and sent to the mobile phone. Then the sending process will automatically operate. For the transmission of picture (MMS), the software used is ActiveXperts because they support the process of sending picture from computer to phone via GSM/GPRS modem. In carrying out this project, the mobile phone Nokia 6000 series is used as a GSM/GPRS modem. In conclusion, this system operates by detecting the entry of an intruder to home by capturing the image and data (image) which will be automatically sent to the mobile phone.

Key words: Surveillance system, camera, GSM, ATMega 32 microcontroller.

INTRODUCTION

Security is the degree of protection against danger, damage, loss or any criminal activity. Security is defined as a condition so that one can develop and progress freely. An important aspect of security includes Home Security. It is very important, because we know that crime is increasing day by day and people have less time to spend at their houses. Moreover, there are many other reasons why people need security at their homes. The first reason that this system is established is to create a peace of mind for people so that they can feel safe inside or outside their homes. This will help them to execute their work without any fear of their security. The other reason is to help in getting timely information about visitors at home. Through the use of security cameras, users are able to monitor the situation at their homes and get timely information about persons visiting their homes (Singh et al., 2011).

With the fast advancing technology in recent years, camera is now widely used with the development of its content that is used in various applications. This includes visual surveillance that is in high demand in today's market. This is because of the rise in criminal rate, especially in metropolitan cities, that help boost the demand in security system that uses visual surveillance

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to monitor the house or other valuable assets. With the rapid development in computer and network, the internet based home security has advanced a lot in the residential areas. The remote controlling and monitoring of a house using internet requires a computer, which is large in size and heavy to carry around. The wireless technology has some amazing achievements in the home automation via Bluetooth (Tajika et al., 2003), ZigBee (Gill et al., 2009; Jin et al., 2008), and Wi-Fi (Ophir, 2004) and global system for mobile communication (GSM) (Yuksekkaya et al., 2006).

We know that old security systems uses human labor instead of hardware systems. As a result, threat detection and evaluation are limited to human's handling awareness. Moreover, the area under the human's surveillance can be too wide to be monitored by only a few workers and the number of camera can exceed their monitoring ability. As a result, more employees will be needed and this will increase the work cost, in contrary to the modern era in which the use of technology can reduce the cost when compared to human resources.

Home security has been a major issue where crime is increasing and everybody wants to take proper measures to prevent intrusion. In addition, there was a need to automate home so that user can take advantage of the technological advancement in such a way that a person getting off the office does not get melted with the hot climate. Therefore, many researches propose a system that allows user to control home appliances ubiquitously and also provide security on detection of intrusion via SMS using GSM technology (Khiyal et al., 2009; Azid and Kumar, 2011).

Big amount of data collected from video visualization need to be analyzed by something that is intelligent and with an autonomic structure. This intelligent system needs to have the ability to scan the surrounding area and extract useful information for further consideration. For example, to detect and analyze moving activity or to identify the objects that enters the screen area. Additionally, observation needs to be done 24 h a day, without interruptions. This is to ensure a more effective and accurate surveillance function of the system.

Not just limited to camera, mobile phones are also widely used. The uses of these mobile phones are not only for making and receiving calls, or for short messaging. It can also be use to send pictures that includes voice and texts to other mobile phones or email address users. This is known as multimedia messaging services (MMS). With this, mobile phone users can share their experiences and thoughts in a quick and easy way. MMS was first launched by Maxis Communication Bhd on 5th July 2003 and is the first telecommunication company in Malaysia that introduced such service.

MMS is a service that is capable to send and receive message in the form of image, graphic, video and audio in addition to text. This service plays an important part in the 3rd Generation (3G). It can be said that in terms of concept, MMS is similar to short messaging services (SMS) but with distinct difference in terms of technical for both services. Not only that, MMS users will also need to activate their general packet radio services (GPRS) network.

Problem statement

Nowadays, video surveillance system is developing rapidly. In the past, it is used as special equipment in high-risk area such as banks and airports, as a standard facility in open space for the public. Now, not only high-risk areas are using it but areas such as shopping complex, offices and also industry areas are now able to have the surveillance system. With combination of time lapse video recording, this small camera is playing an important role to monitor break-in and theft and collect evidence and data of the offender.

Even though commercially successful, video surveillance recorder is also getting small scale impact in residential markets, which also includes offices and private houses. According to the police, most of the offenders caught have to be released without penalty due to not having solid evidence. Because of this, a large number of residents have resort to installing video surveillance in their residential area.

Video surveillance recorder operates by recording everything that is happening at its surrounding and all the recordings are stored in tape-recorder. There is also other type of video surveillance recorder that will send its recordings directly to a computer through a transmission medium such as Fiber To The Home (FTTH), Global System for Mobile communication (GSM), Bluetooth model and Radio Frequency technology (RF), just to name a few.

Usually the quality of the recorded video is not good and blurry. This will make it hard for the police to identify the offender and it will take some time before the offender is caught because the police will need to do a thorough investigation beforehand. In the mean time, the offender could already have fled to other country.

For a high-quality home automation, the selection of sensors is very important. A control system is good if the sensors used to measure the desired variables are able to transmit the measured values of variables to the controller. It is crucial that the sensors provide accurate measurements of the variables to be controlled at the reference point in the control loop (Azid and Kumar, 2011).

Objective

The project overall were highlighted into two main objectives as follows:

1. Develop a system that is capable to identify intruder

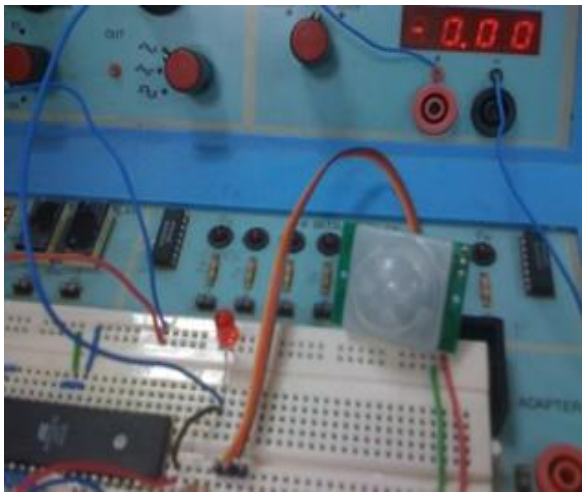

Figure 1. Initial state of PIR.

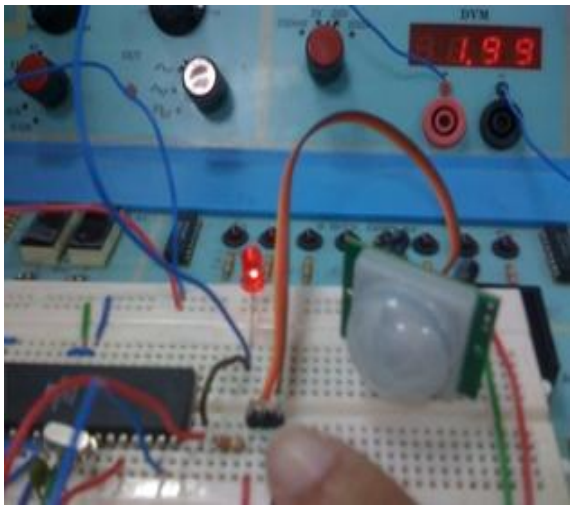

Figure 1. When human is detected.

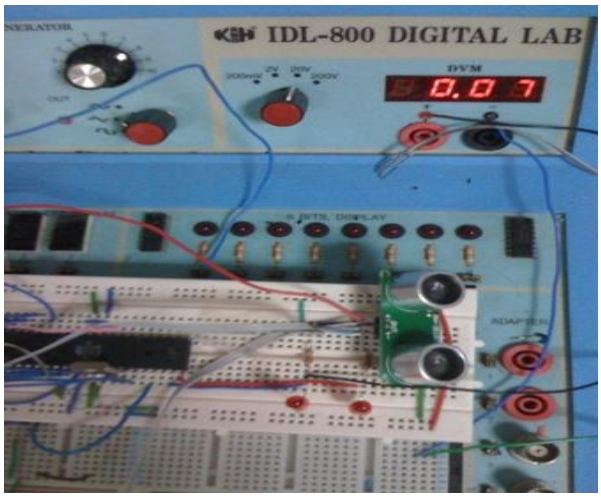

Figure 3. Initial state of ultrasonic.

and send information (image) to user regarding a break-in at their resident.
2. Develop programming that allows MMS to be automatically sent.

METHODS

This security system tool is developed to enhance the security features of our home. With the presence of this tool, the crime rate that is rising year by year is hoped to be reduced. In general, this system works by capturing the image of the intruder and the image will be automatically sent to the house owner in the case of a break-in. Some tests are done on the prototype that has been developed. These include test on the software used, microcontroller circuit test and test on the interface between microcontroller circuit and computer to mobile phones. Test on the whole system is also done towards the end of the testing.

Software testing

Two main software are used in carrying out this project which is CodeVisionAVR and Microsoft Visual C++ 2008 Express Edition. For CodeVisionAVR, it is used to write the coding for controlling the process that will be running to receive signal from PIR sensor and ultrasonic. This signal will then be sent to the computer to activate the camera. This programming will be embedded into ATMega 32 microcontroller in which ATMega 32 is the main part in this system. It is also known as the controlling point in this system. CodeVisionAVR is much simpler to use than any other software because the platform is easy to build and it support the ATMega 32 microcontroller. Whereas for Microsoft Visual C++ 2008 Express Edition, it is used to write the coding for sending the image to mobile phones through GSM modem.

Circuit test

In developing this project, a few circuit tests will be done. It is separated into different part to make it easier to identify the output that we will attain from these tests.

PIR circuit test

PIR is used to detect movement that passes its sensor area by using infrared radiation. Figure 1 shows the initial state of the PIR where there is no (human) temperature detected and the output is 0.00 volt. When the PIR detects (human) temperature, the output shows 1.99 volt and the LED will light up as shown in Figure 2. The maximum distance that can be detected when doing this PIR testing is approximately 290 cm. The PIR are not able to detect human presence when the human is more than 290 cm apart from it.

Ultrasonic circuit testing

Ultrasonic is used to detect object movement that passes through its sensing area. Figure 3 shows the initial state where the ultrasonic did not detect any movement and its output is 0.07 volt. When the ultrasonic detects movement, the output will change to 1.89 volt and LED will light up as shown in Figure 4. When this test is conducted, the maximum distance that this ultrasonic can detect is approximately 295 cm. Ultrasonic is not able to detect any

Figure 4. When movement is detected.

movement that is more than 295 cm away.

Microcontroller circuit testing

Microcontroller circuit will start operating when it receives signal from PIR and ultrasonic. When the PIR and ultrasonic become active, the microcontroller will activate the camera. Figure 5 shows the microcontroller circuit and it can also be known as ATMega 32 platform. To activate the camera, the microcontroller circuit needs to be interfaced with a computer. That is why the RS232 connecter is needed for the interfacing process between the microcontroller circuit and computer, as shown in Figure 6. To know whether the interface process is operating, it can be checked at the CodeVisionAVR windows. It has been mentioned before that CodeVisionAVR is a software that has many function, and is not limited only to writing program but also can be used as a platform and interface process. When there is an interface between microcontroller and computer, it can be seen at the terminal window where it will display the word “PENCEROBOH!!!” (“Intruder”) as shown in Figure 7.

Camera testing

Testing on camera will also need to be done to ensure that it is working correctly. Furthermore, this test is done to ensure that the camera will operate when there is interface process between microcontroller and computer. Figure 8 shows a few images that have been captured based on the movement detected by the sensor.

MMS setting

For the MMS delivery part, the setting process need to be done first to make sure the delivery process can run smoothly where the GSM/GPRS modem is chosen based on the type of device that will be used in the MMS delivery as shown in Figure 9. Next the MMS server setting needs to be done and this includes gateway number, server, login, password and APN. All this data depends on the type of network and country. It can be accessed through the website; *http://www.activexperts.com/xmstoolkit/MMSClist/* or can be directly clicked at the “Click Here” button as shown in Figure 10.

As shown in Figure 11, the MMS message part is the part where the message will be sent. The sender and receiver number will be inserted, where the sender number is the SIM card number that is used in the GSM/GPRS modem, whereas the receiver number is the telephone number of the house owner. For testing purposes, the message that is sent is the text “Hello World”, as shown in Figure 12. The button “Send Message” is pressed when done. Afterwards, the receiver will receive the message. The result and log segment will show the MMS delivery status for checking whether the message is successfully delivered. If successful, the “Result” box will display ‘0:Success’ and ‘The Specified TAPI device is already in use’ for otherwise, as shown in Figure 13.

Full testing

The last part in developing this project is the full testing to ensure the prototype is functioning. This prototype will be functioning when both sensor gives output, which is when the sensor can detect human presence by ultrasonic and infrared. Figure 14 show the initial state of the prototype while Figure 15 shows both the sensors detecting human presence. When the LED lights up, it shows that both of the sensor is giving output. This output will be connected to a microcontroller.

When both the sensor become active (detecting human presence), microcontroller will send the signal to computer to activate the camera and capture images of the offender. The captured images will then be stored in RAM and sent to the house owner mobile phone. For sending the captured image, it can be observed at the command window. When the image of the offender is captured by the camera, the sending process will occur automatically, where selecting the GSM/GPRS modem will take place as shown in Figure 16. This selection process has been done during the MMS setting which will take only approximately 5 s. As shown in Figure 17, when the selection is done the connecting process (“Connecting…”) will happen.

The connecting process is the process of connecting the computer with the GSM/GPRS modem that has been chosen. It will take approximately 20 s at which after the 20 s, the command window will tell whether the connection is successful or failed. As shown in Figure 18, the command window shows the connection is successful (“Success”). After the connection is successfully establish, the process of sending images to the house owner will commence. This is the last process in developing the camera and GSM interfacing system for home security surveillance. As shown in Figure 19, the sending process is a success. The time taken for this process is approximately 35 s. The whole system takes approximately 1 min to operate starting from the time the camera captures the images of the offender to the time the image is sent to the house owner. This shows that the system can operate quickly. In just 1 min the house owner will be informed of a break-in through MMS. Figure 20 shows the mobile phone of the house owner receiving the MMS.

RESULTS AND DISCUSSION

Table 1 shows the quality of the captured offender image based on the position of the sensor. From the table, the data that is available can be used to plot a graph to make it easier for analysis as shown in Figure 21. From the tests that were conducted, it can be seen that the quality of the capture image of the offender is low and blurry when the sensor is positioned at angle 110°. The quality of the captured image will improve when the sensor

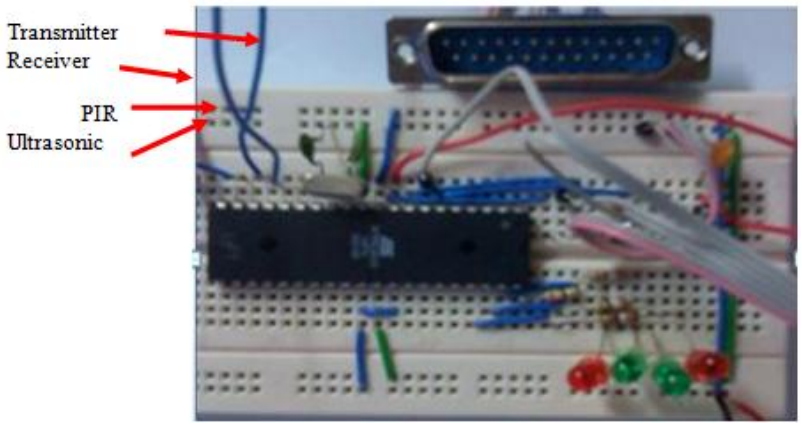

Figure 2. ATMega 32 Circuit.

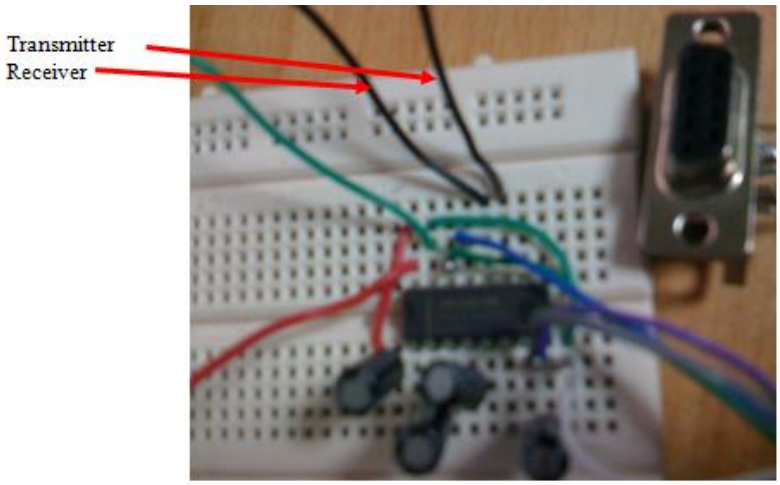

Figure 6. RS232 Connecter.

Figure 3. Interfacing process.

Figure 4. Images captured when movement is detected.

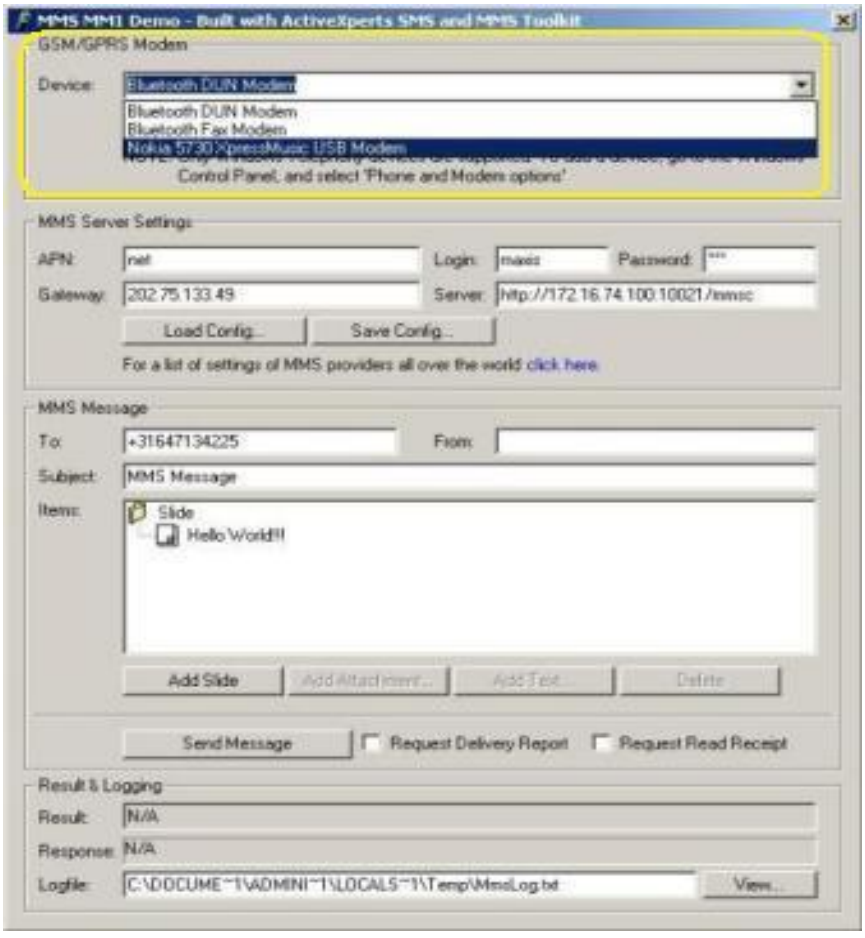

Figure 5. Selecting the GSM/GPRS Modem.

position is reduced to angle 25°.

For the sensor position at angle 0°, the camera will only capture image of the surrounding. This is because the sensor position is directly beneath the offender's head. When the offender passes through under the sensor area, the sensor will activate the camera. During that time

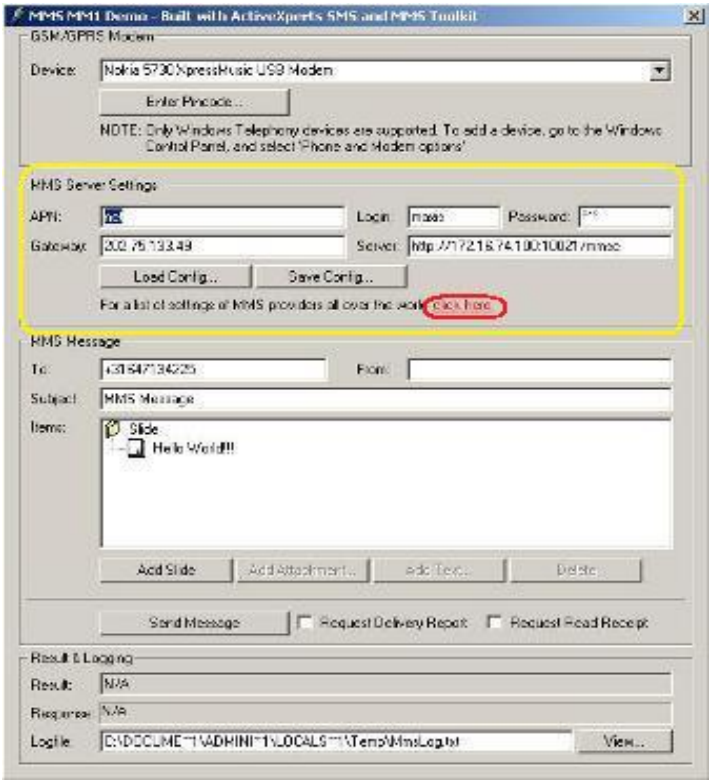

Figure 10. Setting the MMS Server.

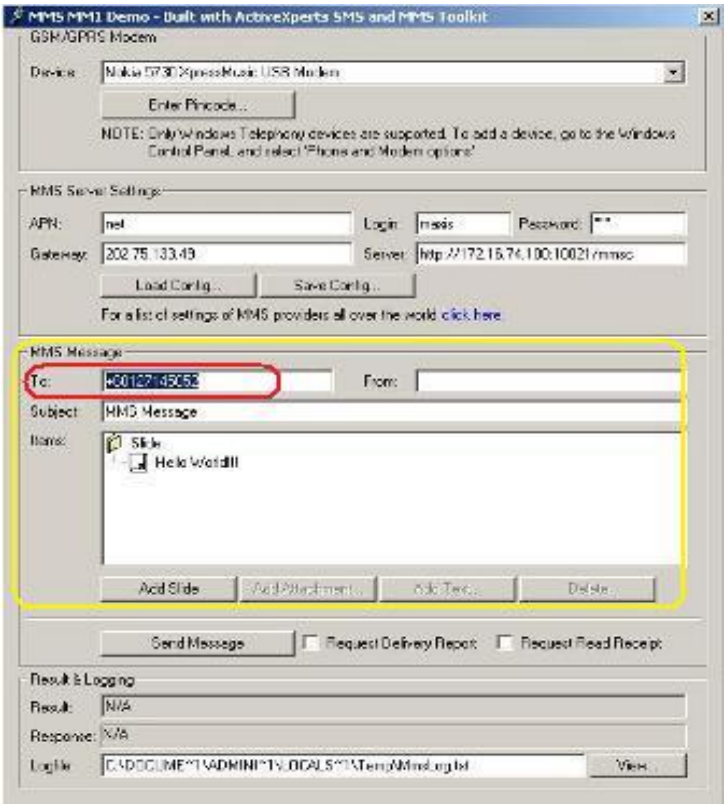

Figure 6. MMS Message from Sender.

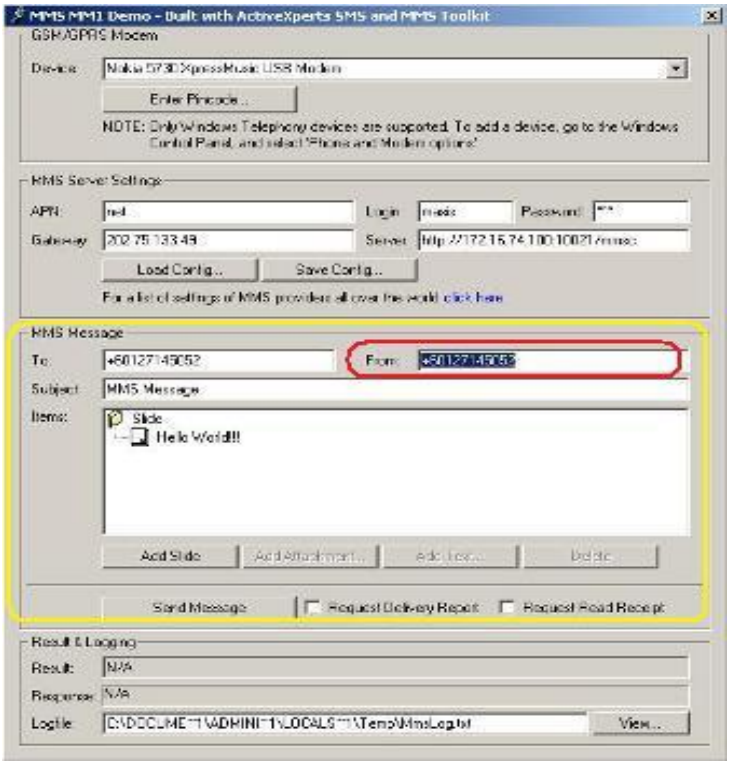

Figure 7. MMS Message for receiver.

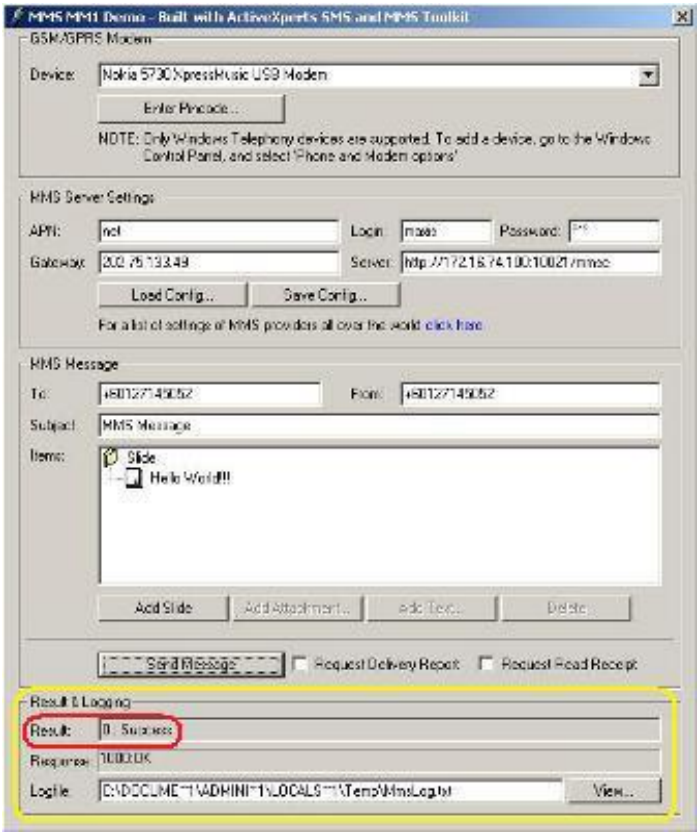

Figure 8. Result and Log Part.

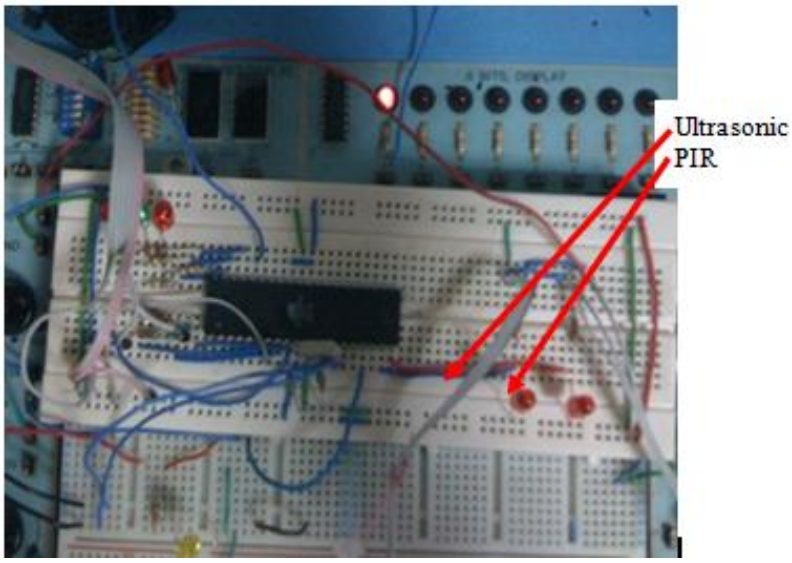

Figure 9. Sensor circuit initial state.

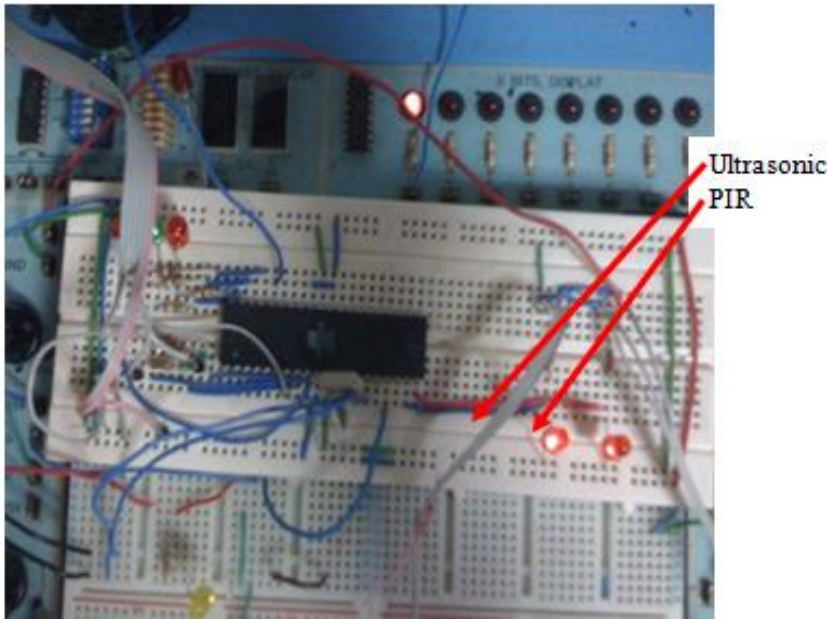

Figure 10. Sensor circuit detects human presence.

the offender will already be out of sensor area. Therefore the camera will only capture the surrounding area.

This is not the case for sensor at position angle of 110°. The sensor will not be able to sense the presence of the offender because the sensing area of the sensor is directly above the offender's head. During this time, the camera will not be activated.

The conclusion that can be made from the test that has been conducted is that the appropriate position to place the sensor in this project is at an angle of 45°. This position will be the best position to place the sensor to capture the highest quality of images.

Conclusion

Recent development in technology has made it more convenient for users. This is especially the case for communication networking in MMS development. That is why using MMS in the security system can reduce break-ins incident by sending the image of offender to user in approximately 1 min.

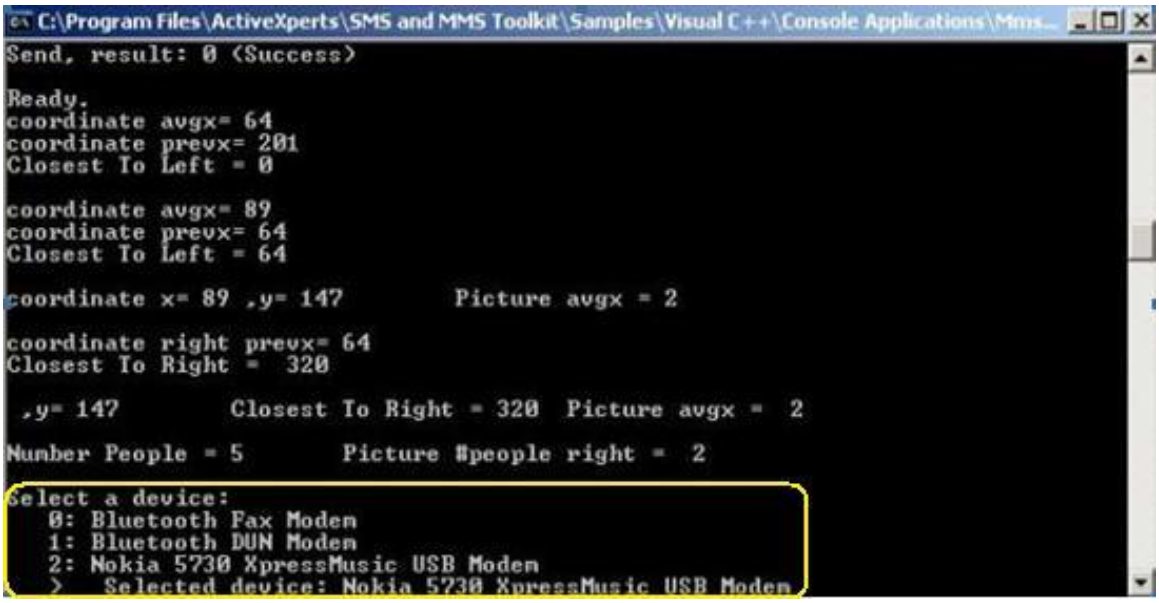

Figure 11. Selecting device process.

Figure 12. Connecting with device process.

Overall the objective of developing the camera and GSM interfacing system for home security surveillance has been achieved. These objectives include constructing a system where it can detect intruder and send data (image) to the house owner in case of a break-in at their house. Other objectives include identifying the type of software that can support the microcontroller used and developing the programming that can allow MMS to be automatically sent.

The important thing in this system is that it can detect the presence of an intruder that enters the residential area of the owner and captures the intruder image to be used as evidence for identifying and capturing process. The image will be sent to the owner through GSM modem.

In conclusion, this project has achieved all the stated objectives at the early stage of implementation. However, a few improvement need to done in the future to improve

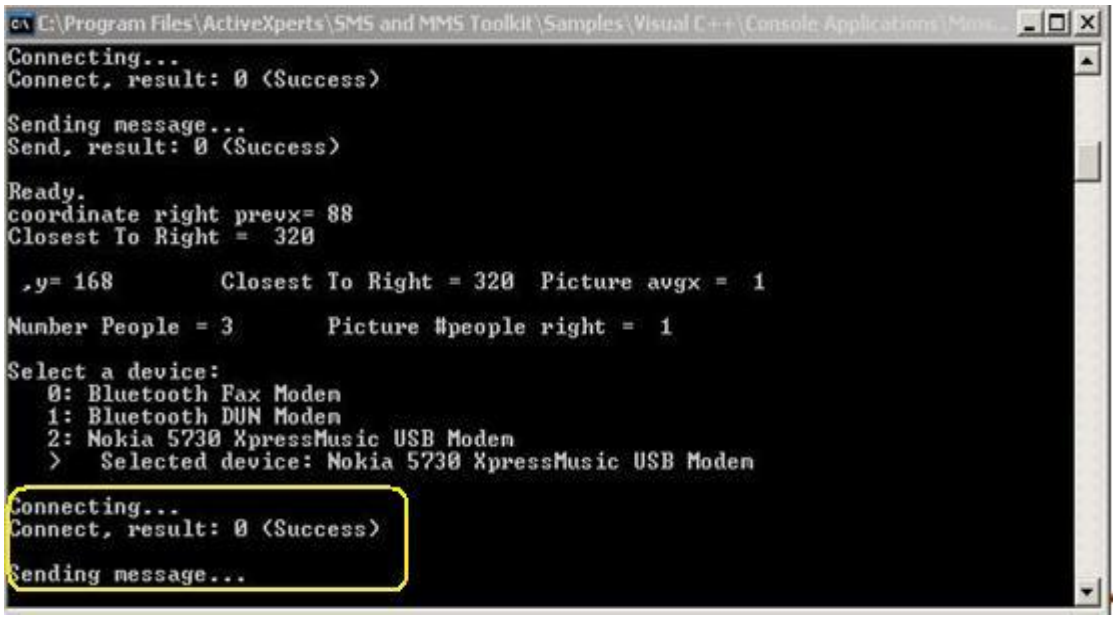

Figure 13. Connection process successful.

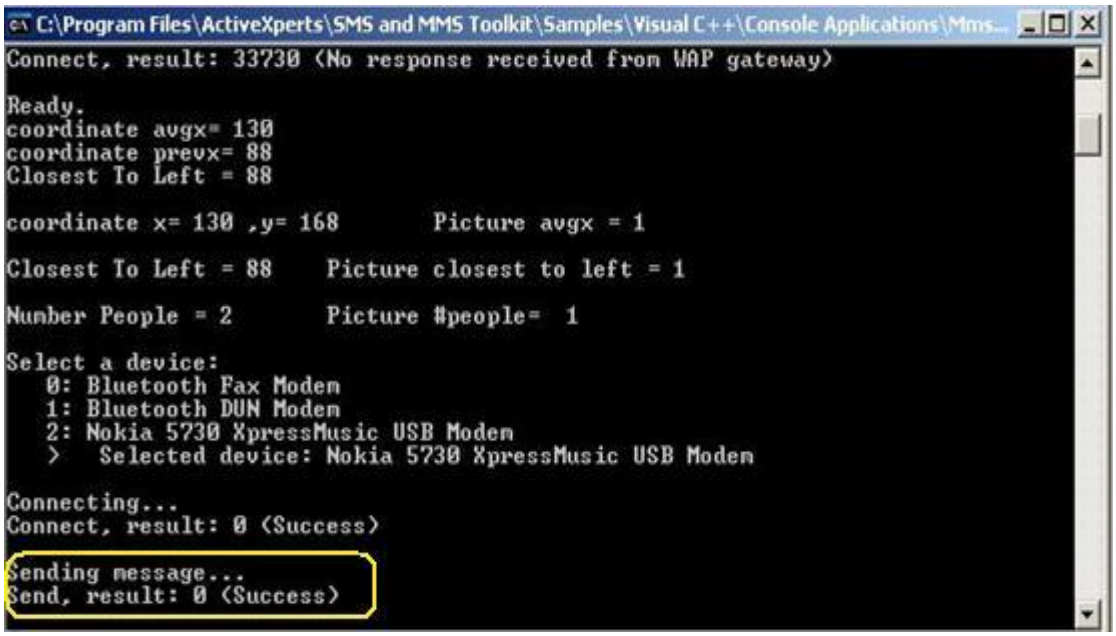

Figure 14. Sending images process.

the weakness that exist in the system.

Comparison with existing system

There is a lot of surveillance system available in the market to monitor the house security. One of them is the remote monitoring system using ethernet. This system operates by sending information to user through the web when there is an intruder in their house area. The limitation of this system when compared to the camera and GSM interfacing system is that the user has to surf the website to become aware of a break-in.

Additionally, it will make it harder for user to check when they are outside such as at workplace or if they go out of town and they need internet services to surf the

Figure 15. House owner's telephone receiving MMS.

Table 1. Clearness of captured image base on the position of sensor.

Position of sensor (°)	Distance taken (cm)	Captured images (Refer to image below)
0	0	Figure 22
25	5	Figure 23
45	125	Figure 24
75	203	Figure 25
90	278	Figure 26
110	Infinity	Figure 27
135	Infinity	No Figure

Figure 16. Graph on the quality of captured image.

Figure 17. Sensor position at angle 0°.

Figure 24. Sensor position at angle 45°.

Figure 23. Sensor position at angle 25°.

Figure 25. Sensor position at angle 75°.

website. Unlike the camera and GSM interfacing system where it will capture the image of the offender and the image will be sent to mobile phone in the form of MMS through GSM/GPRS modem. User will instantly be aware of a case of break-in without having to check the website or with the use of internet.

System disadvantages

In developing this system, there are a few disadvantages and weaknesses. Some of them that have been identified and include:

1. Message (MMS) that is sent is not instantly received by the user and is delayed. This is because it depends on the network operator. If the network is experiencing problem, MMS that is being sent will be kept until the network is fully operating again. This makes the MMS to arrive late to the user.
2. There is a possibility of not capturing the image of the offender's face. It could be the offender's body or the offender's back. This will make it hard for user to identify the offender.

Figure 26. Sensor position at angle 90°.

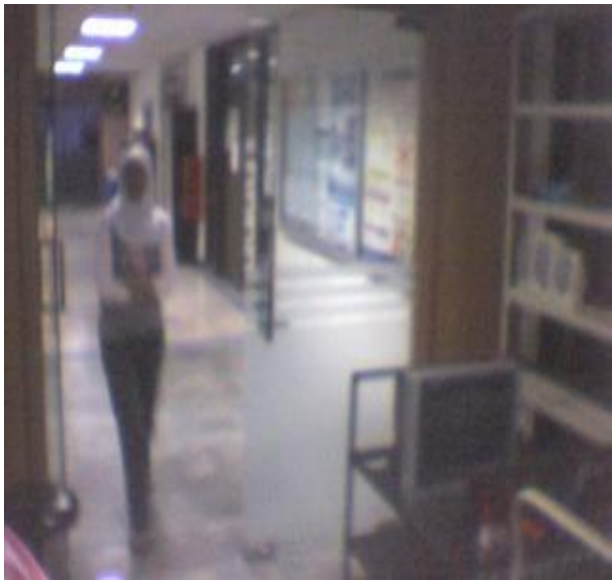

Figure 27. Sensor position at angle 110°.

3. This system cannot be implemented in areas that does not have 3G network such as in village or mountainous area.

Improvement suggestion

Even though the objective of this research has been achieved, but the camera and GSM interfacing system for home security surveillance that has been developed has a few disadvantages that it needs to overcome in order to improve its performance. There are a few suggestions to improve its disadvantages that have been identified during the development of this system. The objective can be further added to have a better security system.

Its main disadvantages is the low quality of the image captured resulting in blurry images. This is because the camera used has low pixel count. For the next improvement process, it is advisable to use a higher pixel camera. This is because with the use of a better camera, the image captured will be sharper and the process of identifying the offender will be easier.

The study done on this thesis is only limited to capturing image of individual moving in normal condition. Therefore, for further study, this system needs to take into account human behavior that moves really fast or really slow to see the quality of the captured images.

Other than that, the uses of two different sensors that sense different things are less effective. Thus to increase the effectiveness of the product's performance, the two sensor that is being used can be substituted with a sensor that have similar behavior. That sensor is called Dual-Technology Sensor and is developed with two sensors which are ultrasonic sensor and PIR. This sensor has high reliability and low coverage for trigger failure, where both the sensor will be used to activate the camera system.

The use of mobile phone as the modem gives a disadvantage to this system. The use of GSM/GPRS modem is favorable because it has the advantage of sending MMS quickly compared to the mobile phone. Additionally, GSM/GPRS modem does not need battery power to operate.

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