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A Novel Video Surveillance System Based on Multimedia Messaging Service

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Abstract: Today's communication world ensures that anybody can communicate to anyone anywhere anytime across the globe. The new mobile communication systems include not only voice but also data and video messages. Natural way to communicate is to send and receive messages. Multimedia messaging are essential drivers for continuous growth in new services beyond voice. In this study, multimedia messaging services available in the video cell phones are used for constructing a prototype video surveillance system. In this study, such a system is desired to monitor an area continuously and to capture the hazardous momentary event and to send this video image to the user as an MMS or as an email immediately. Since the SMS can only give the message but not the image, MMS and email messaging systems are chosen in this work. Extensive simulation and experiments were carried out and it is found that MMS can be applied for video surveillance system.

Key words: Wireless Communication, Security, Video Surveillance, MMS, Email

INTRODUCTION

The communication world has witnessed a tremendous progress starting from the plain old telephone systems till the camera phones of today. Amidst this technological development, security has become an important issue in our lives. Banks, shops and museums spend an exorbitant amount of money for the alarm systems and for security personnel to monitor the system. This study is an effort, which tries to use the present day technology of Multimedia Messaging Service to tackle the growing security threats of people.

Security scenarios of the present day video surveillance systems are: i) The area to be supervised is constantly monitored by using a closed circuit television for security ii) An alarm system like a burglar alarm and an appropriate light sensor whose beam when cut by any intruder triggers the alarm. In this paper an alarm system is introduced which warns the concerned person with messaging systems like SMS, MMS and email. The SMS just give a preset message warning to the authorities while the MMS and email includes an image captured at the monitored area in addition to the warning text message.

This work consists of four modules viz., 1) video capture module 2) serial port interface module 3) image processing module 4) video surveillance software module. The video capture module is responsible for capturing an image of the monitored area on a trigger and storing the captured image in a memory. The main advantage of the block is that it does not use a computer instead uses only FPGA, decoder ASIC chip and a SRAM. Serial port interface module is responsible for transferring the memory contents to the PC for further processing. The image processing module compresses the raw image and converts it to JPEG format for the MMS image. The software part sends the MMS, SMS and the email messages to the concerned person.

The messaging systems available with the mobile world are email, SMS and MMS. Electronic mail (e-mail) is simply information that is sent electronically from one computer user to another through a local or worldwide communication network such as Internet. Short Message Service (SMS) is a globally accepted wireless service that enables the transmission of alphanumeric messages between mobile subscribers and external systems such as electronic mail, paging, and voice mail systems. MMS (Multimedia Messaging Service) is a new standard in mobile messaging. Like SMS Short Messaging Service), MMS is a way to send a message from one mobile to another. The difference is that MMS can include not just text, but also images, sound and video. It is also possible to send MMS messages from a mobile phone to an email address.

The objective of this work is to provide video surveillance for ensuring security to any valuable object or place by constantly monitoring through a video camera.

The project works with the following assumptions:

* Cell phone should always be kept on
* E-mail id, SMS and MMS id supplied by administrator must work correctly
* The administrator is the only person with access to the system

* A trigger to the video capture board is given by the user by pressing the switch which is on the video board.

HARDWARE DESIGN

The idea of the hardware design is to make a capture card to convert a composite video signal into digital video so that easy manipulation of the video can be made possible and to provide a secondary storage medium to which the captured video data from the camera can be stored. The data may come from conventional video camera and also from a digital camera. Up to four cameras can be connected at the same time which may be either digital or analog camera or also a combination of both. The main objective of the video board is to capture image and store it in the board itself without using a PC.

The working involves a main IC, a field programmable gate array (FPGA) which coordinates the other ICs. A Decoder gets the input from the camera and converts it into digital data. While capturing an image, the FPGA loops the digital data to the SRAM where it is stored. There are four SRAMs of 512KB each. Data up to 2MB can be stored in these RAMs. The coding for the FPGA is done using VHDL (Very high speed integrated circuit Hardware Description Language). The FPGA downloads the microcode for the Decoder and also controls the entire process. Thus this card acts as a generic one for capture of an incoming video image.

The top block of the project consists of three units, which work together to perform all the necessary tasks to make the capture card to store and print digital video. The major blocks are:

* Decoder
* SRAM
* UART

Block Description: The block diagram as shown in Fig.1 describes the overall working of the capture board.

The input is given by the camera which is connected at the camera pin connector of the capture card. The camera used here is a common composite video signal camera which makes use of a CCD (Charge Coupled Devices) image sensor. The composite video signal from the camera is converted to digital data format by the decoder. The alarm triggers the capture switch and the FPGA stores the digital data coming from the decoder in the SRAM. The FPGA retrieves the stored digital data from the SRAM and passes it to the PC.

In the design two signals, namely, clock and reset are used as global signals to achieve synchronization. Each block is described separately in the following modules.

Decoder Block: The decoder gets the input from the camera connected to the card. The output formats of the

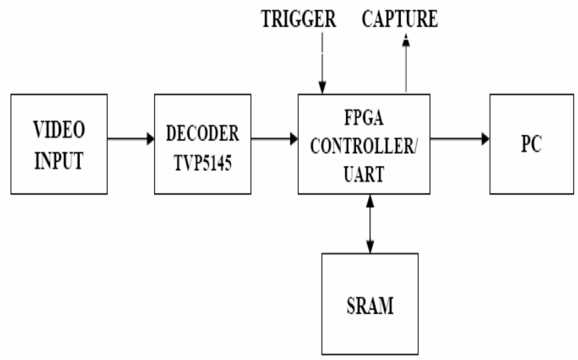

Fig. 1: Block Diagram of Video Capture Board

decoder are 8, 10 and 20 bits [1]. Here 8 bit format is used. The ASIC decoder chip used is TVP5145PFP, a NTSC/PAL/SECAM component digital video decoder. Every time upon power-up and reset condition a set of micro codes has to be downloaded to the decoder along with the hexadecimal values to configure the internal register of the decoder.

This work is done by the FPGA which downloads the necessary data to the registers of the decoder. For this, the register settings of the decoder as given in the data sheet are kept as constants in the FPGA and downloaded to the decoder. Once all the microcodes have been downloaded to the decoder the internal microprocessor of the decoder is invoked and it starts to convert the composite video to digital video. The first register address location where the data has to be stored is specified and the address location is automatically incremented by one after each eight bit data every register. The interface between the decoder and FPGA is done using I2C (Inter-Integrated Circuit) technique. By applying the proper bias to the appropriate pins of the decoder using pull up and pull down resisters, the decoder can be configured to work in I2C host port interface mode.

FPGA (Field Programmable Gate Array): The FPGA is the master controller of the capture card, which controls the overall activities of the decoder, encoder, SRAM and the printer. The coding for the FPGA is done using VHDL (Very high speed integrated circuit Hardware Description Language) and the results of the coding can be verified using a software simulation tool, ModelSim, developed by Xilinx Corporation. The FPGA chip used is the XCS200PQ, a chip which belongs to the Spartan series of XILINX FPGA chips.

Once the coding is simulated and errors were corrected if any, then the next part is the synthesis of the coding. The software used for this synthesis is Leonardo Spectrum. The FPGA initializes the decoder every time upon power-up and reset. The necessary register settings and the microcodes for the decoder are kept as constants in the VHDL coding and is downloaded to the

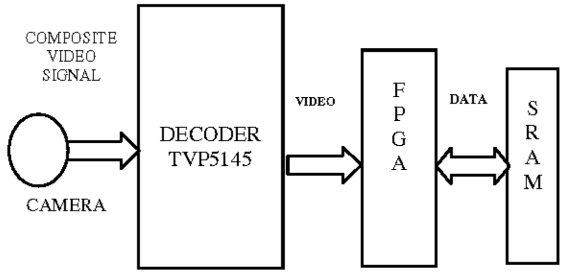

Fig. 2: Interfacing of FPGA with Decoder and SRAM

FPGA. Once the initialization process of FPGA is over, the decoder is initialized as per the specifications in the register settings. The FPGA now gets the digital data from the decoder and on activation of the capture switch it stores the data in the external memory which is a SRAM. After the entire frame is stored in the memory the FPGA starts sending the frame through the UART to the PC. Thus the FPGA can be programmed to take care of the entire capture process. Hence an OTP (One Time Programmable) memory is used which stores the VHDL coding that needed to be downloaded to the FPGA on power-up and reset conditions.

SRAM: The SRAM chip (K6T4008 manufactured by Samsung Electronics) is the external memory storage chip in this card. There are four SRAMs with a memory capacity of 512 KB each, providing memory of 2 MB. There are 19 address lines and eight data lines for each SRAM. And each one is provided with a read, write, output enable and chip select pins. The digital data from the decoder is stored to the first SRAM by the FPGA when the capture is activated. Once this SRAM is full the data is store in the next SRAM depending on the availability. To keep track of the address location of where the data of a captured frame is stored, the address location of the last eight bit of a single frame is stored at the first three memory locations of every SRAM. By analyzing the data values present in the first three memory locations of each SRAM the captured frame can be exactly retrieved.
When the write pin is pulled low the data is written to the SRAM and to read the stored data from the SRAM the read pin is pulled low. All the four SRAM's can be selected depending on the chip select data. The address is represented in a 21 bit format out of which the first two bits are chip select details.

UART (Universal Asynchronous Receiver Transmitter): To transfer the data from the capture card to the PC, a dedicated device called a universal asynchronous receiver transmitter (UART) is used to perform most of the serial-protocol conversion. The UART allows us to transmit and receive data serially without having to bother about parallel-to-serial or serial-to-parallel conversions since the UART does this job for us. Before the UART can be used, it must be told the desired BAUD rate, the number of DATA BITS, the type of PARITY and the number of STOP BITS. Once the UART has been "programmed" with this information, it can be used to send and receive serial data. The UART module is realized using the FPGA chip. The FPGA in addition to the controller program is also configured as the UART. The main function of this module is to transmit the contents of the SRAM to the PC through the serial port.

SERIAL /RS 232 PORT

Serial port is used to interface the video capture card with PC. At every instant data read from the serial port is written into a file which is later processed by MATLAB. The interfacing is done using TurboC. The electrical specifications of the serial port are contained in the EIA (electronics industry association) RS232C standard. The D-Type 9 pin connector both of which are male on the back of the PC is connected to the female connector on the video board.

IMAGE COMPRESSION

JPEG, an image compression standard sanctioned by the ISO (international standards organization), gives users the ability to take an image and compress it with little or no noticeable quality degradation [2]. The image obtained after the transfer through the serial port is converted into JPEG file for compressing the data as well to take care of compatibility for MMS messages. The algorithm [3] used is given below

JPEG Algorithm: There are four key steps (sub-algorithms) in the JPEG compression algorithm. The first step is to extract an 8x8 pixel block from the picture. The second step is to calculate the discrete cosine transform for each element in the block. Third, a quantizer rounds off the discrete cosine transform (DCT) coefficients according to the specified image quality (this phase is where most of the original image information is lost, thus it is dubbed the *lossy* phase of the JPEG algorithm). Fourth, the coefficients are compressed using an encoding scheme such as Huffman coding or arithmetic coding. The final compressed code is then written to the output file.

Pseudo Code: The JPEG compression manifest itself where there is a need to convert the raw date into the image format supported by the MMS. The raw image data of the digitized capture frame is taken from the file where it has been stored during the serial data transfer part, and it is converted to the image of JPEG format. The JPEG conversion code is written in MATLAB. The pseudo code for the JPEG image compression that we implemented is as follows:

To code the given image:

* Take an image (2D matrix) and divide it to 8x8 matrices.
* For each matrix (8x8) use the DCT conversion, an (8x8) matrix will be obtained. The coefficient no used was 30.
* Build an 8x8 matrix, which is the sum off all the matrices.
* Sort elements of the 8x8 matrix from the highest to the smallest and get the indices list.
* Save the partial list of indices, number of matrices (rows, lines) and from each matrix from step (2) save ONLY these coefficients.

Now this is the compressed data.

To reconstruct back the image:

* Build matrices of step (2) by the zero command: A = zero (8, 8); B = zero (8, 8);
* In each matrix, store the coefficients in the right places, such that the new A matrix is equal to the A matrix from step (2) of the encoding, except for the zeros where you don't know the coefficients.
* For each matrix, do the Inverse transform (IDCT).
* Compose these inverse-transformed matrices back into a big matrix.

SOFTWARE DESIGN

This software concerns with sending SMS, MMS and E-mail to the desired user who requests for video surveillance. An authenticated administrator controls the entire system. The authentication of administrator is done using a password. All or any of the following means, are selected by the administrator.

* SMS
* MMS
* E-mail

The administrator is expected to provide all the details like cell-phone number, E-mail address etc. to achieve the above objectives at the time of installing our software. The input to this software comes from the output of the MATLAB program which performs image compression. This software has three modules. They are SMS, MMS and E-mail. The software is coded in Microsoft Visual Basic 6.0.

SMS: SMS is a text based cellular phone application using which plain text can be sent to a cell phone from another cell phone or from an internet based computer system [4]. As the name short message implies text messages having a maximum of 160 characters can be sent to a cell phone [5]. Every cell phone service provider provides an E-mail address for their customers. The E-mail address is of the form:
<Cell Phone number>@<Service Provider Domain>
Any E-mail, which is sent to this E-mail address, is immediately delivered to the respective cell phone. To achieve this, the steps to be performed are:

* Get user information
* Get connection information
* Connecting to internet
* Send the above information as E-mail.

Get User Information: The following information has to be got from the user:

* E-mail ID of the cell phone connection
* From E-mail ID
* Subject of the Alarm
* Body-Alarm message (Maximum 160 characters).

Get Connection Information: The following details regarding Internet Connection are needed:

* Outgoing server name
* Server port number
* Username, password to logon to the outgoing server if authentication is required.

Connecting to Internet: Connection to Internet requires an Internet account provided by an Internet Service Provider (ISP) and a dialler to connect to ISP. A dialler provided with username, password, dial settings, dialling number must be set as default. Windows provides a MFC class "*WinInet*" which includes Microsoft Win32 Internet Functions. This assists in making the Internet an integral part of every application. WinInet provides a function called "Internetautodial" [6]. This function forces an unattended internet dialup to occur. "Internetautodialhangup" function disconnects an automatic dial connection.

Send E-mail: MFC provides a high level set of COM objects called *collaborative data objects* (CDO) that allows easy access to the E-mail system embedded in Microsoft Windows product line. CDO objects are generally used by client applications. For the most part, CDO objects are used by clients wanting to access the E-mail system. The CDO object provides two interfaces:

a. The Iconfiguration Interface: The *Iconfiguration* interface defines properties and methods that you can use to access configuration information for Microsoft collaboration data objects (CDO) objects. This interface configures the connection settings, which is got from the user.

b. Imessage Interface: The *Imessage* interface defines methods and properties used to manage messages. This interface packs the E-mail information. CDO collectively contains both the connection and message information. First Internet connection is established then CDO object is packed and sent, finally Internet session is closed.

MMS: Sending MMS is very similar to that of SMS. In MMS the object to be sent is embedded in the body of the message and is send to the same id as specified before.

RESULTS AND CONCLUSION

The decoder and encoder used were initialised using I^2C logic and the capture frame was stored in SRAM. UART was configured inside the FPGA and the video capture card was interfaced with personal computer through serial port. Using the serial port RS232C, data from the video capture card was written into a file using TurboC. The data written into a file using TurboC was used to construct the image. This raw image was further processed by MATLAB and converted into a JPEG image. Here is a sample output of the JPEG image compression technique. The images are reconstructed back to its original resolution or nearly same resolution depending on the number of the DCT coefficients chosen for reconstructing back the image. Its can be seen that the reconstructed image with just the half of the total number of coefficients look very much like the original image.

The video capture card was designed and developed using the FPGA Advantage 5.2 package for simulation and synthesis. MATLAB 6.1 and Turbo C were used for image processing and interfacing. The software module was coded in Visual Basic 6.0 and Visual C++ 6.0.

A test image was captured by the video capture board and was sent to the PC, where it was converted to the JPEG format.

This JPEG file was sent from the PC and received at the destination PC as an email message. The MMS message was verified using Cell phone simulators. As the mobile operators do not encourage sending multimedia messages to cell phone from e-mail in fear of spam, the concept could not be verified with cell phones.

Future work in this study could be the use of Infra red devices. You may have seen many electronic diaries and palmtop computers which have infrared capabilities build in. These devices use serial transmission to transfer the data. Therefore serial transmission is used where one bit is sent at a time. The interface between video card and the PC could be established using infrared devices. The prototype could also be developed into a monitoring system which regularly sends pictures of a monitored area.

Snap shot of a desired place to be monitored could be taken and sent to the user as MMS message on the user's request.

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