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Original Research Article

Active Displays in Secret Surveillance

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ABSTRACT

There is a proliferation of electronic display boards for dissemination of information and close circuit television (CCTV) for security surveillance in our society. Hence, this paper presents the use of electronic active display board for secret surveillance in the public. Public displays used for signs, textual and/or pictorial information are usually passive. The information changes from time to time without feedback from the environment in which they are installed. The system presented here feedbacks happenings from the environment through video surveillance capability for security and monitoring while displaying remotely updated information to the public using GSM technology. This work was realized using LED matrix array, an A7 SIM card module, a PIC16F877A microcontroller and CX901 camera module. The CX901 camera module is used for surveillance, and the video data is stored in the SD card which is made accessible using a Universal Serial Bus (USB). Test result from the system showed that active display functions can be extended to serve as surveillance tools in public places for feedback information replacement for CCTV camera systems that are easily noticeable.

1. INTRODUCTION

Electronic display boards are commonly used indoor and outdoor in public places for dissemination of information. The information to be displayed could be diagrams, symbols, letters, numbers etc. depending on what is needed at a particular place and time (Gowrishankar *et al.*, 2014). Electronic display boards are usually made using liquid crystal display (LCD) or light emitting diodes (LEDs). LEDs are the most used because of size, flexibility and cost. Most often, the display board requires a cable connection to a computer in order to update the displayed information. This brings a problem of accessibility, since the display board will need to have a physical connection via serial cable to a PC at its location (Nallaparaju, 2014). However, one way of addressing this challenge is by having wireless access to the electronic display board using GSM technology.

Interestingly, surveillance and monitoring of public and private places using close circuit television (CCTV) is now very common especially in places where electronic displays boards are also employed. CCTV which is a system of surveillance cameras that sends signals to a specific location has the advantage of providing immediate supervision of possessions, people, environment and property etc. (Singoee, 2016). They are commonly used to monitor banks, shopping malls, and government facilities. These days, as the technology becomes more affordable and easier to use, more and more people are installing CCTV cameras in their homes and businesses (Mwongeera, 2009). One shortcoming however is that installed CCTV cameras are usually visible to passersby and can be easily compromised as seen in the recent burglary of the office of a Senator in the Nigeria's National Assembly (Vanguard, 2019). This brings a huge possibility for the development of a system which will have the ability to integrate the features of displaying information electronically while inherently been use for video surveillance and monitoring of the environment especially now that many cities and motorway networks now have extensive electronic display boards for information dissemination and traffic-monitoring systems which uses closed-circuit television to detect congestion and notice accidents separately.

In recent times, various works have been carried out on LED display systems. These systems use different technological approach for the formation of text and picture information on a number of LED arrangements. The most popular arrangement is a matrix connection of the LEDs in rows by columns that can be energized using different approaches and power sources option. Febaide *et al.* (2015) designed and constructed a solar powered microcontroller based digital LED display board using a nonconventional display technology format popularly known as HUB 12 driven from a PIC18F4620 microcontroller through a serial peripheral interface (SPI) communication protocol. This display was not made wireless; hence every change of information would require the manual labour of an operator to connect a computer to the display before it can be edited. Ovaradua, (2016) designed and constructed a GSM based LED display board which was achieved by using LEDs connected in a dot matrix format to make a display board, and connected to a display driver unit (ULN2003) and a shift register (CD4094. The functionality of this work was limited because the GSM module that was used did not have an effective antenna which caused it to have huge delay before it receives a message. Patil *et al.,* (2014), in their work made use of the Wi-Fi wireless technology that allows an electronic device to exchange data wirelessly over a computer network, including high-speed wireless connections. Wi-Fi which was used as a means of communication has an indoor range of 32 meters and outdoor range of 9.5 meters which means at any distance outside the range, the information to be displayed cannot be communicated to the display device. Sonawane *et al.* (2016) in their work, made use of a microcontroller to control all the functions of the notice board and also continuously monitor whether the message was received or not. Nallaparaju (2014) in his work made use of wireless technology with LED display boards formalized by designing and integrating the hardware and software with AT89S51 microcontroller, GSM module, and moving LED display. Masood *et al.* (2015), used a GSM wireless technology for controlling electronic notice boards using LPC2148 microcontroller IC. The major constraints in this work were the use of Bluetooth to interface the PC and the modem, because Bluetooth has a limited range for connectivity. Bhoyar *et al.* (2017), developed a wireless notice board using ZigBee and GSM technology. A software was developed in a personal computer to assist the user to send the notices to the students through emails and to display the notices at the notice board. The major drawback of this work was the use of ZigBee technology for communication between the PC and the notice board, because ZigBee has a short range of connectivity.

The aforementioned works all have their drawbacks, from being expensive to being less efficient. However, none incorporated any surveillance system for security purposes. Hence, this work proposes an electronic display board that can be wireless controlled using GSM technology with video surveillance capability which saves cost, proliferation of bill boards/CCTVs and enhances security of the environment.

2. METHODOLOGY

A number of methods exist for the design of motion display systems. These methods offer different capabilities to drive and manipulate both indoor and outdoor display systems alike. Indoor displays do not require much brightness and compete only with other artificial lights within their environments. Hence, indoor displays require less energy and are always close to the mains power source. On other hand, outdoor displays have to compete with the sun light in addition to the surrounding artificial lights. More brightness is required of outdoor displays which transcends to higher energy demand. Energy is scarce and its use must be minimized whether for indoor or outdoor display systems. To reduce energy usage, a method that activates display elements (LEDs) in a selective manner through scanning was used. In this method, the LEDs are connected in rows and columns to form a matrix which can be maneuvered to produce desired images. Depending on the environment, the required amount of current can be driven into the rows and columns to produce the needed brightness.

The display is expected to receive text data from a remote device through the GSM network and as well process and manipulate same for presentation. To meet these requirements, the method employed a microcontroller as the system processing unit. With software code implementing the systems algorithm, the microcontroller is made to receive data from any GSM enabled device through a Universal Asynchronous Receive Transmit (UART) terminal. The received data are processed and manipulated for presentation in the display area.

2.1. Hardware Design

Figure 1 shows the block diagram of the system's hardware design. It comprises of a power supply unit, communication unit, processing unit, matrix display unit, surveillance and storage unit.

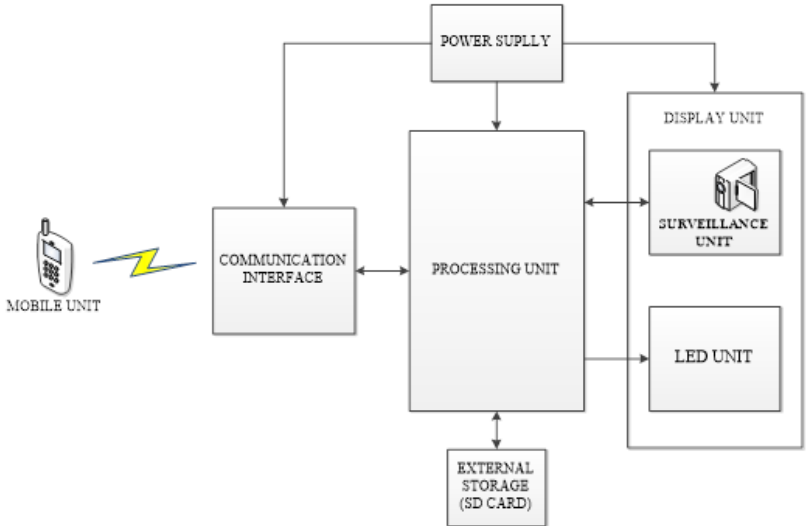

Figure 1: System block diagram

The power supply unit provides +5 VDC to power the processing unit and its accompanying devices for system's operation, and +12 VDC for driving the display area through the rows and column drivers.

2.1.1. Communication unit

This system is an A7 GSM/GPRS module, which communicates with a mobile phone (with GSM/GPRS communication with an unlocked micro SIM card). The component chosen for SMS message communication was an A7 GSM/GPS/GPRS module. The device function is to receive SMS messages sent to the device from a GSM enabled device e.g. mobile phone, through GSM/GPRS connection. The text messages are sent using the programmed format described in Table 1. The module receives and transmits information through the microcontroller Universal Asynchronous Receiver Transmitter (UART) interface using AT commands as shown in Table 2. The choice of GSM connectivity was made because of the need for long distance and secure communication with the microcontroller. A7 GSM/GPS/GPRS module was chosen over SIM900 shield and 800L GSM modules due to the added features of GPRS connectivity.

Table 1: SMS commands and their descriptions

SMS Command	Description
#ADM#PNONE NUMBER#	This command is used to change the administrator phone number. I.e. the phone number that is allowed to send text messages to be displayed
#NEW#NEW MESSAGE#	This command clears all the previous messages shown on the display and sends a new message to be displayed
#ADD#MESSAGE#	This command appends an additional message to the one already being displayed on the system

Table 2: AT commands used and their descriptions

AT Command	Description
AT+CMGF	This command is used to configure the format of messages sent to the module.
AT+CREG	This gives the network registration status.
ATE0	ECHO DISABLED. This command I used to disable echoing of commands received by the module.
AT+IPR	It is used to set the baud rate of the serial interface of the device.
AT+IFC	This sets the flow behaviour of the serial port in both directions.

2.1.2. Processing unit

The processing unit is essentially a microcontroller and is responsible for the processing of received information into a recognizable format for display as well data storage and general control of information flow within the system. The microcontroller used for this work is the 40 pin PIC16F877A chip from microchip with features including a 20 MHz clock, a 368 × 8 bytes of data memory (RAM), a 256 × 8 bytes of EEPROM data memory, a total power dissipation of 1 W and a UART interface.

2.1.3. Display unit

When the display unit is operating, the messages displayed on the board are updated through shift registers and an LED driver (ULN2803) connected to the microcontroller. The LEDs are arranged in an 8 by 8 matrix to display a character as shown in Figure 2 and the complete display holds 10 characters, each one connected to an individual shift register through a latch. This formed the main circuit that was used to visually present

the characters sent through SMS. Each character represented on the display board is an eight by eight matrix of LEDs, making a total of 64 LEDs per character as seen in Figure 2 and 640 LEDs for the complete ten characters. The number of characters to be represented however, can be extended by adding more units of 8-by-8 matrix and shift registers.

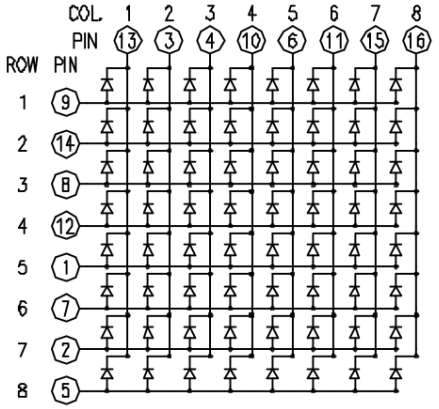

Figure 2: LED matrix array

Due to the number of inputs to the LED matrix, it would not be possible to run them without the shift registers and this is because the processing microcontroller has a limited number of input/output (I/O) pins, therefore the amount of I/O needed is reduced through shift registers. In this work, the shift register chosen was the 74HC595 IC shift registers. 74HC595 is an 8 bit shift register, whose bits can be thought of as memory locations for the instructions sent to the LED. The input to the shift registers come serially from processing IC to the SER input of the shift register. To shift each 1 bit instruction, the shift register is clocked and after clocking 8 bits the instructions are set in the latch. To send the bits to the LEDs the latch is then clocked. This process is done multiple times to display the appropriate characters on the matrix.

2.1.4. Surveillance unit

The device used for surveillance in this work is a CX901 portable spy camera shown in Figure 3. This camera features portable SD card storage to save surveillance video. It also includes a microphone for sound recording. The device automatically switches on and starts recording as soon as the device is switched on. CX901 features include MJPEG video format at 30 frames per second, JPEG photo format, and an optional motion detecting functionality.

Figure 3: CX901 PCBA

2.2. Design implementation

Figure 4 shows the circuit diagram of the display system. The LED display board was implemented using a PIC16F877A microcontroller as its processing unit, a CX901 spy camera for surveillance and a GSM/GPRS module for wireless communication. A text message is sent from a designated phone number in a mobile device using the appropriate commands given in Table 1 to the SIM card inserted in the communication unit.

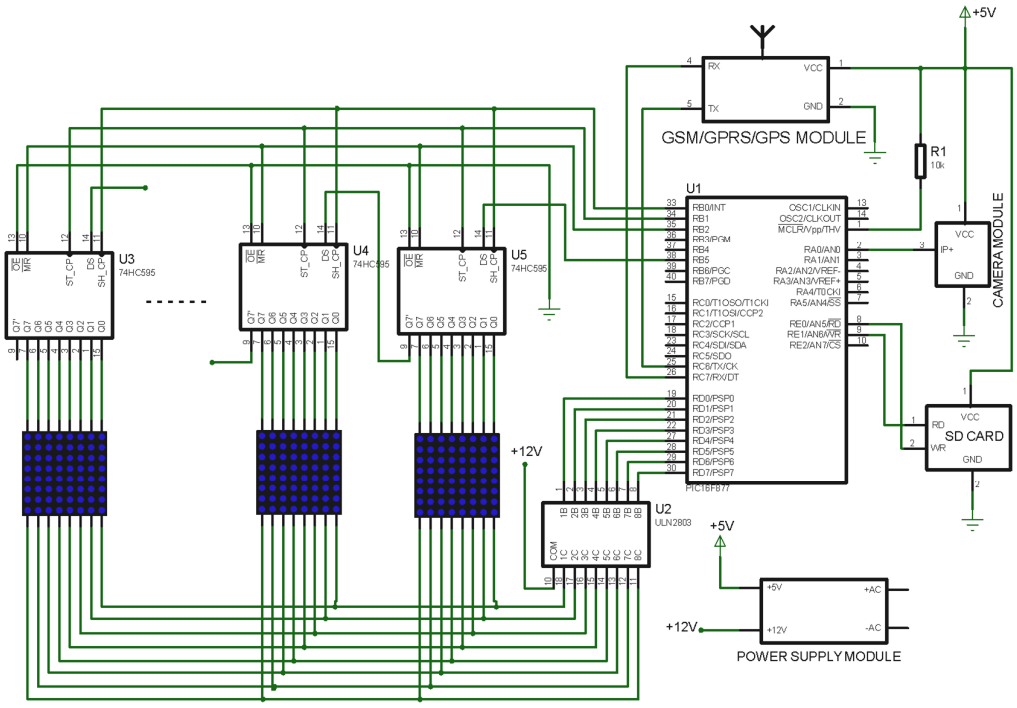

Figure 4: Complete circuit diagram of active display in secret surveillance

2.3. Software Design

The main control algorithm of the system is depicted in Figure 5. The software code implementing this algorithm was written in C language and compiled with the MP LAB for PIC compiler.

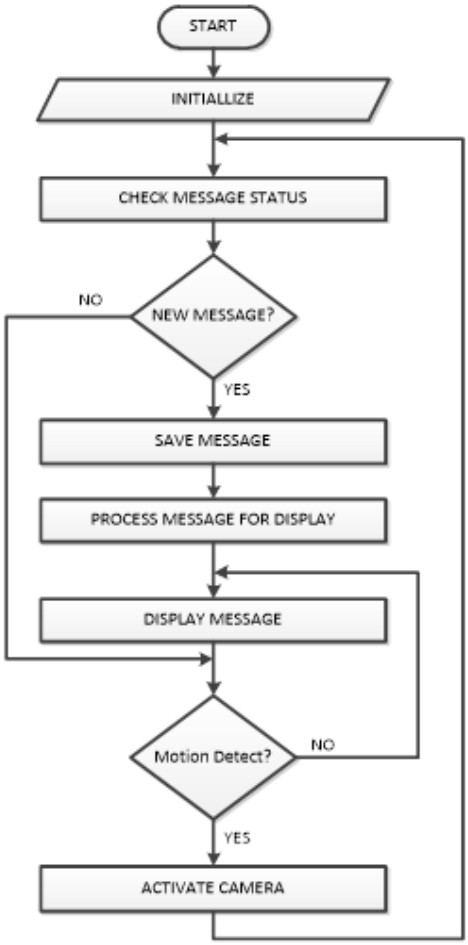

Figure 5: Main system flowchart

3. RESULTS AND DISCUSSION

Figure 6 shows the complete system in an aluminum profile work. A default static message is displayed on the board at power up and can be changed to any message of up to 500 words through a text message from an authorized mobile phone.

The default message on the display was changed to "ELECTRICAL AND ELECTRONICS ENGINEERING" as shown in Figure 7, by means of an SMS from an authorized mobile number using the format #NEW# ELECTRICAL AND ELECTRONICS ENGINEERING#. A video capturing process was started by a wave of hand or walking across the front of the screen. The stored video was viewed on a computer through a universal serial bus (USB) as shown in the screen-shot image of Figure 8.

Figure 6: Pictorial view of complete case of unit (88 cm × 17.7 cm × 8 cm)

Figure 7: Completed work displaying information and connected to computer showing video

Figure 8: A screen-shot image from captured video

4. CONCLUSION

An electronic display board that is capable of displaying messages and inherently recording video of the environment for security surveillance purposes was developed in this work. This system is considered here as a better replacement for single-function electronic display boards as it combines both display and

surveillance functions in one piece. With embedded GSM/GPRS communication device, distance is no barrier in operating the system as SMS can be sent from virtually any part of the world provided there is GSM network coverage in both surroundings. It eliminates the proliferations of displays boards and CCTVs that are commonly used independently in our environment making for cleaner environments and better public security penetration with the use of embedded secret eyes. The use of such devices in our ever-evolving information age will enhance information dissemination and ensure proper surveillance of the environment. It should be noted however that further work is required to transmit recorded video wirelessly to a remote distant receiver and to ensure that the system operate in real-time.

5. ACKNOWLEDGMENT

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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