Enhanced Smart Biometric Based Attendance (ES2BASYS) System Interfaced with POS Facility for a Smart Academic Institution

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ABSTRACT

This effort presents a developed attendance register module for a smart academic institution. A convenient test on four courses was carried out on the register module for courses A, B, C, and D for five lecture days. A total of twenty students were involved in the test. This module is a careful improvement of the previous SAMSYS module.

Manual authentication of attendance of log books have become an arduous task and are also time consuming. The academic attendance policy has continually insisted on the 70/30 % benchmark which has also generated a lot of questions at various quarters. This improvement provides for instant print out of attendance after class lectures and after examination periods. In the design, the PIC18F462 microcontroller has been used to achieve adequate results. Also, the PIC16F88 was used for the keyboard decoder to convert scan codes to ASCII character for the microcontroller. Adequate attendance security measures have also been put in place for effective attendance management. The design presented here showed better performance over the previous design.

(Keywords: class, campus, design, module, POS, attendance management)

INTRODUCTION

In many academic establishments, there are various ways of marking attendance of students in classes and during examinations [1]. Also, many academic institutions are becoming a smart campuses due to improved technology and efficient managing of students' information. For a smart campus attendance, there is need for a smart register device to accommodate the real attendance of student during lecture periods and for same to average the attendance on a 70%/30% ratio. For a smart campus like Lagos State University (LASU), average student count for large classes is about 100. Projections of large classes have reached about 500 and students must mark attendance in every lecture.

It has been observed over the years, conventional and generic methods of calling out names will take between 10 to 15 minutes for marking attendance of the entire class. Then in a 14-week semester of two-hour courses, it transmits that more than 7 hours will be used for attendance marking. Some faculty members over the years have used signature methods, for attendance marking while some have used sitting arrangements for attendance marking. It is however noted that the challenges of attendance taking increases and becomes more severe with large class situations.

In the conventional method, a lot of fake attendance taking was recorded and never gave a true picture of the correct attendance for any particular academic session. This problem over the years resulted in an academic rule that a student must attend 70% of lectures as a pre-requisite for participating in the examination of any course to be evaluated at the end of the semester or academic session. It has also become very tiresome to compute the percentage on this manual attendance sheet. The best that has been obtained over the years was to retype the names of the students in an excel sheet table and also identify the number of times each student attended lectures and eventually carry out computations using simple percentage equations. This method has also been cumbersome and time consuming especially for large classes.

RELATED WORK

There are quite a number of related works regarding attendance management system [2, 3, 4, 5] and where an attendance portal was developed. This portal form is used by the student to enroll for lecture attendance, mid semester exam attendance, and examination attendance. These forms are filled in portal on a regular basis and an attendance report is also generated. Also, the lecturer selects the course code and the attendance type before the student places his/her finger on the finger-print reader. Immediately, a comparison test will take place with those stored in the databases.

Authors in [4] developed a fingerprint-based attendance system. The effort is very similar to [6,7] but the presence of each student will be updated in a database and the data will be passed to the server using Wi-Fi. This effort was for a college where SMS information will be sent to the parents of the students if a student is absent from a particular class. If a student is absent continuously for more than three days, a message will pop up to the parents to meet the HOD automatically. The implementation of attendance system based RFID and GSM with respect to power saving concept was developed by some researchers [8, 9, 10, 11]. The effort of the researchers kept in mind the importance of power saving and also adequate record keeping. But over the years, there have been observations that swiping occasionally takes time and there are challenges of magnetic fields that affect the cards. The misplacement of GSM is another big challenge.

A device providing an improvised electronic card and card reader serially interfaced to a digital computer known as an embedded computer-based attendance management system was proposed [1].

The authors in [8, 12] developed an automated attendance monitoring system using android platform. In their work, the results showed satisfactory improvements in accuracy as compared to using user-based paper-based approach. Their proposed technique provided an easy way for generating adequate reports.

Another set of authors in [11, 13] designed, developed an effective and secure fingerprint based biometric attendance device (ESFB2A).

The device developed helped in reducing workload and stress of inspecting each students' attendance and calculation errors when obtaining the total attendance. The data from previous manual attendance data systems and from other types of biometric devices were compared with the current manual-based method and the fingerprint device. The previous biometric device recorded a time of 13.81 sec while the newly developed ESFB2A recorded a time of 13.08 sec. The average execution time for the other type of biometric device yielded 16 sec. while that of the newly developed ESFB2A yielded 11 sec.

METHODOLOGY

In this section, the following will be briefly discussed such as main block diagram, hardware, software and algorithm.

Main Controller

This is the circuit that contains the main microcontroller which is PIC18f4620 the heart of the whole project. It is responsible for accepting data from the fingerprint reader, reading time information from the timer chip, getting input text from the keyboard and keypad decoder circuit, writing and reading data and information from the external EEPROM, then processing these data according to the software written for it and displaying information on a graphical LCD and also sending this information to a PC or any Bluetooth enabled device for permanent storage or printing.

Fingerprint Reader (R305)

This module houses the circuit responsible for reading and managing the fingerprint image information on the fingerprint reader. It communicates with the microcontroller; it accepts command to read the fingerprint, stores it in memory; deletes fingerprint; compares the current image with one stored in the memory; etc. and it sends back the result to the microcontroller which it further process and make some decisions to mark attendance or to reject.

DS3132 Timer Circuit

This is a module aimed at providing accurate time and date information to the main controller. Initially, the microcontroller has to send some data to it to set the time as desired by the user, then subsequently, the microcontroller requests time information from it and displays it on the LCD or uses it for some other time related function. The timer module has a CMOS battery that keeps the time settings even when power is switched off from the whole circuit.

Bluetooth Module

This is an all in one component that is responsible for transferring attendance status or student information on the main controller to an external Bluetooth enabled device such as a PC or an Android phone or Tablet. The Bluetooth module contains all the necessary circuitry to make connections with other devices and once it is paired with a device, the microcontroller can send information to the device. The receiving device must have software to display the information. Various software for Bluetooth serial monitoring is available online.

USB To Serial Converter

This is used to change the serial protocol easy to achieve by a microcontroller to a USB protocol generally available by all PC in cases where the PC is not Bluetooth enabled or PC busy with the Bluetooth for data or file transfer.

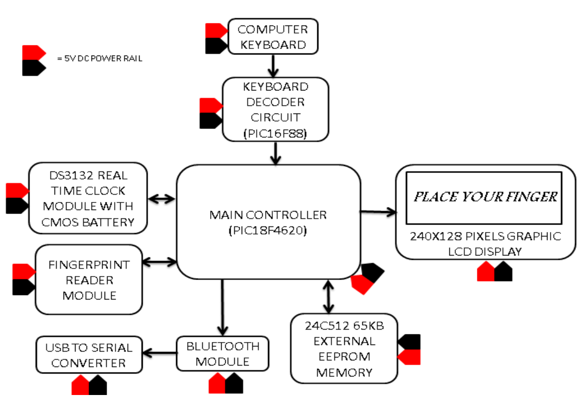


Figure 1: Main Board Block Diagram of the System

External EEPROM

This circuit is synonymous to an external memory card of a device. Due to the fact that the internal EEPROM of the PIC18f4629 is 1024 bytes which is not enough to store the information that we need, an external EEPROM is employed to do the job. It has 65kB of memory space which is used to store up to 400 sets of student data. An extra removable EEPROM is used is used to back-up whatever is stored on the first EEPROM so in the advent of data loss.

Keyboard and Keypad Input Circuit

This circuit contains a PIC16f88 responsible for decoding keyboard scan codes and 4x4 multiplexed keypad and converting it to ASCII characters for the main microcontroller. The need for this circuit is to support the main microcontroller. It is meant to ease the work of the main microcontroller which reads the time, reads the fingerprint module, and sends data to the LCD simultaneously, so adding a keyboard to its list of process will make the whole job slower.

The keyboard controller also filters out some function keys and other special keys that are not needed for this project; it is also responsible for sending signal to the keyboard tone buzzer anytime a valid key is pressed. The keyboard is used for alphanumeric input while the keypad is used for numeric input only. The keypad is a lightweight membrane switch so is thereby easy to carry and can be used for all administrative settings and registration with numbers only.

LCD Display

This stage is one of the main outputs of the whole system. This is responsible for accepting display information from the main controller and displaying it accordingly. The display is used as a user interface to monitor the state of the system and to see what is happening at real-time. It allows the administrative user of the project to register the student by displaying what is being typed.

Power Section

This is responsible for providing electrical energy to all stages in the whole circuit. All of the stages need an average of 5 volts DC to work, so this stage ensures that there is an uninterrupted power in all the circuits. This stage contains a battery backup which is a 3.7V 6600mAh and can power the circuit for almost 7 hours when it is fully charged. It can be charged though USB adapters, PC or power banks. Due to the fact that the battery is 3.7V and the voltage that powers the circuit is 5V, a DC to DC boost converter is employed to convert the 3.7V or even as low as 2V to 5V to power the circuits. The output from the power supply stage is connected to the power rails which all other stages that needs power taps from. The charger circuit is employed to effectively charge the battery and it contains a charge controller that switches off the charging when the battery is fully charged.

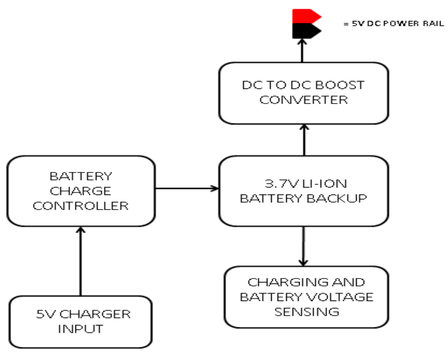


Figure 2: Block Diagram of Power Section.

CIRCUIT EXPLANATION

The heart of the circuit is the PIC18F4620 microcontroller which does all the necessary processing and is supported by peripherals like the DS3132 timer chip, external EEPROM, and the keyboard decoder that uses PIC16F88. The R305 fingerprint reader is the main input to the system, and also the keyboard used in inputting text to the system, the main output of the system is the 240x128 pixels graphical LCD supported by a buzzer for audio and also the Bluetooth and USB-serial module that transfers the result to a PC or any Bluetooth enabled device such as phones and tablets. An external 65kB EEPROM chip is used to expand the internal memory of the microcontroller, and a removable EEPROM used to backup data.

SYSTEM OVERVIEW

The coordinated working of the hardware circuit is made possible by the software firmware. So the real working can be well explained with the block diagram alongside the software flowchart and algorithm. The overall working principle of the fingerprint attendance system is that, initially the system is empty of data, the class captain, administrator or lecturer will have to register the students by capturing their biodata with this project.

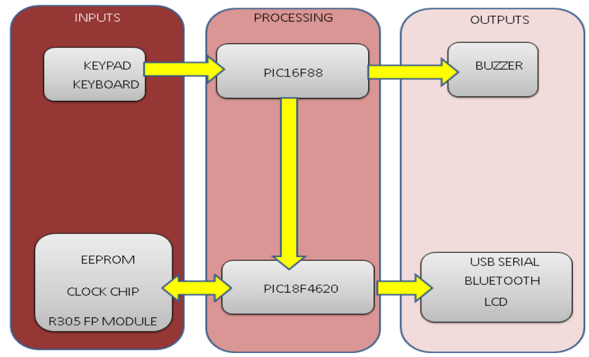


Figure 3: Simplified Block Diagram of the System.

The data is the students name, matriculation, department, phone number, blood group, etc. The admin will have to enter a password to gain access and could change the password as desired. The keyboard and keypad are used to easily input text to the system. After registering the student details, the system will save the finger image into the fingerprint reader and give the location a template number, then other data is permanently stored in the EEPROM. The admin can register up to 400 students.

To take the attendance, the system displays "place your finger", this tells the user that it is ready to read a fingerprint then the fingerprint light flashes continuously. The student places the particular finger he or she used to register on the fingerprint reader. The attendance flag for all student is reset initially logic 0 at the start of a new class, the current time and date is displayed on the system LCD.

When the student attends lectures, he places his finger on the FP reader, the reader generates an image for the finger and compares it with those on the memory. If the system finds a match, it takes the attendance by setting the attendance flag to a logic value "1" and again storing the current time of attendance in the memory space allocated to such student by the system.

If the system doesn't find a match, it displays "FINGERPRINT NOT FOUND" and there by no attendance will be taken. (Check the flowchart and algorithm of the software for more information).

The administrator can do a lot of settings on the system like changing the password of the system, Bluetooth password, registration of student, edit of student data, delete student data, edit the time and date settings, etc. He can also view or edit lecture details, view student attendance status, start a new class attendance (this will overwrite the former) and finally send attendance result to a PC or a phone.

CIRCUIT COMPONENT FUNCTIONS

The circuit starts up the power supply by powering all the initializing input, output and memory devices, and other peripheral components. As soon as they are powered, all of the peripherals initialize and are ready to do their various functions. The main microcontroller is ready to send commands and accept input from the fingerprint reader and the timer chip, it displays some data on the LCD and is ready to store data on the external memory when needed. The microcontroller runs on 32MHZ crystal to provide clocking for the processor which means it computes 8 million instructions per second (1 instruction takes 4 clock cycles) this speed is necessary for the microcontroller to do so many heavy duty jobs very fast, such as addressing 65,000 external memory locations, displaying data on 240x128 pixels LCD screen, and so on.

The PIC16f88 supports the main microcontroller to help decode the keyboard scan codes and the 4x4 keypad. This eases up the main microcontroller memory space both RAM and ROM and also saves some CPU resources that is needed for important jobs. The DS3132 timer chip helps the system to run time on the underground without the main microcontroller's intervention. The microcontroller only sets the timer chip when the user is doing time and date settings, then subsequently, the microcontroller gets time and date data from the timer chip when it needs to display time and date. The backup battery is to keep the clock running when power is switched off from the system. The EEPROM also extends the microcontroller memory space for it to be able to store so many student details. Both the timer chip and the EEPROM are connected to the main microcontroller via 2 pins SDA and SCL which is serial Data and serial Clock respectively and pull-up resistor is connected between those pins and the VCC.

The fingerprint module is responsible for reading fingerprints, this is done by the microcontroller sending a command to check for fingerprint match, delete fingerprint, or store fingerprint. The microcontroller communicates with the fingerprint module using the UART protocol. The Bluetooth module is a ready-made chip that just accepts ASCII characters from the microcontroller and transmits the characters directly to the computer it is paired to. The pairing password can be changed in the system settings of the user settings. The main microcontroller reads the charging status and the battery level via the ADC (Analog to Digital Converter) inputs. The microcontroller runs a subroutine to scale 3.2 to 4.2v to 0 to 100 percent battery level using mathematical interpolation formulas.

Other information displayed on the 'Home' screen is the time and date, Bluetooth connection status, the number of students present in class, the charging status, and the battery level.

OPERATION PRINCIPLE OF FINGERPRINT

Fingerprint processing includes two parts: fingerprint enrollment and fingerprint matching (the matching can be 1:1 or 1:N). When enrolling, the system will process the finger images, generate a template of the finger based on processing results, and store the template. When matching, user enters the finger through optical sensor and system will generate a template of the finger and compare it with templates of the finger library. For 1:1 matching, system will compare the live finger with specific template designated in the Module; for 1: N matching, or searching, system will search the whole finger library for the matching finger. In both circumstances, system will return the matching result, success or failure. The system can also delete images in any of the templates based on the commands from the controller.

THE POWER CIRCUIT

In the charging circuit, the AC to DC converter converts 220v to 5v to charge the battery constantly. In order not to make the circuit unnecessarily complex, complex charging monitors circuits are not included but another efficient and safe way to charge the battery is employed. Normally we should have built a battery charging cutoff system that automatically disables the charging when the battery is fully charged to protect the battery from overcharging, but the method used here achieves the same thing by charging the battery with the exact highest voltage it could accommodate.

This is achieved by using a diode; the 0.7v forward breakdown voltage of the diode is used to bring the 5v down to 4.3v. Although the nominal voltage of the battery we are using is 3.6v, the charging voltage can go as high as 4.2 without any damage. The 10 ohm resistor in series with the diode is to limit the charging current so that the battery will charge slowly. So when the battery charges up to 4.1 or 4.2 the voltage of the battery and the charger levels up and there is no more current flow, the 0.1 or 0.2V difference is dropped by the 10 ohms resistor. The charging can be left for a long time without any damage to the battery. It is advisable to remove power supply when the system is not in use for a long time to save energy.

The DC to DC converter converts the battery voltage from 2V - 4.3V to 5V used by all components of the circuit. This converter is necessary to boost the voltage of the battery even when the battery is as low as 2V.

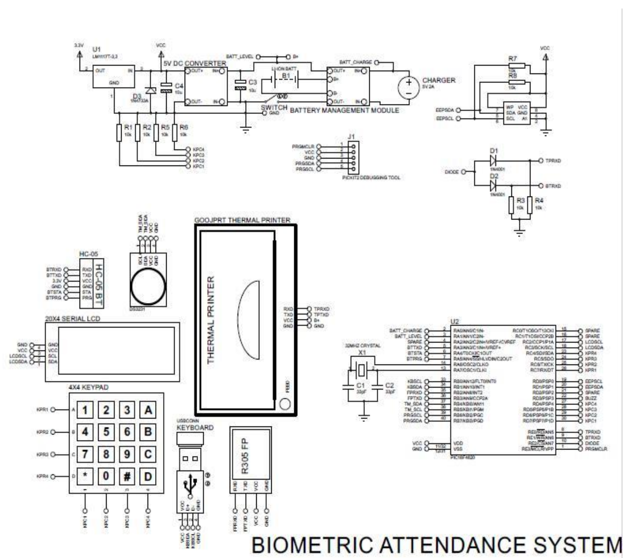


Figure 4a: The Complete circuit Diagram of Proposed Biometric Attendance System Interfaced with POS (ES2BASYS).

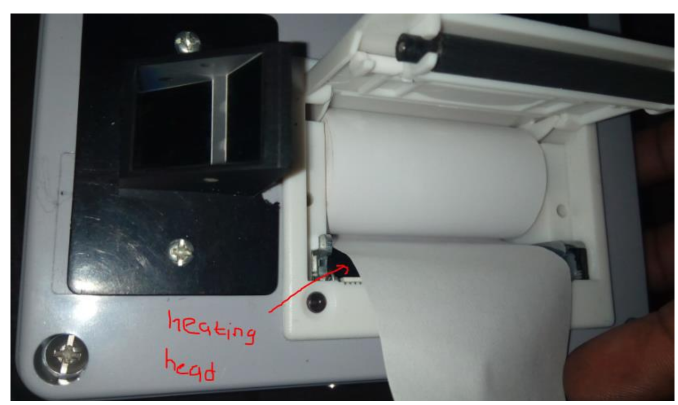
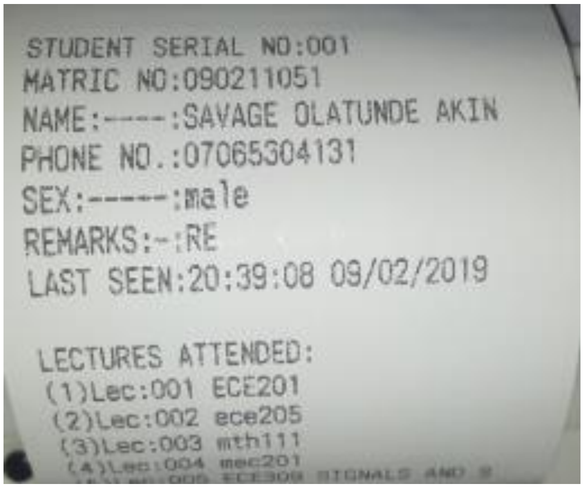
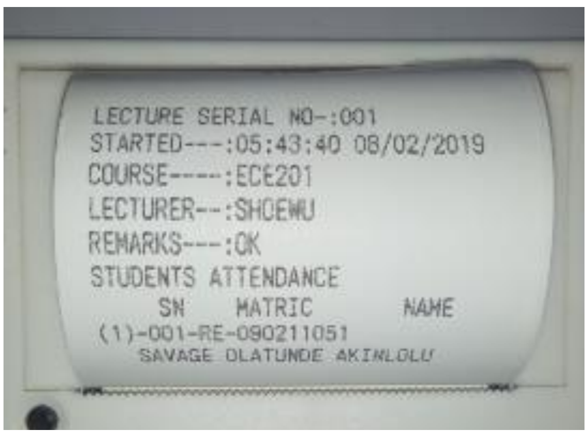


Figure 4b: Display of Biometric Input Processes in (ES2BASSYS).





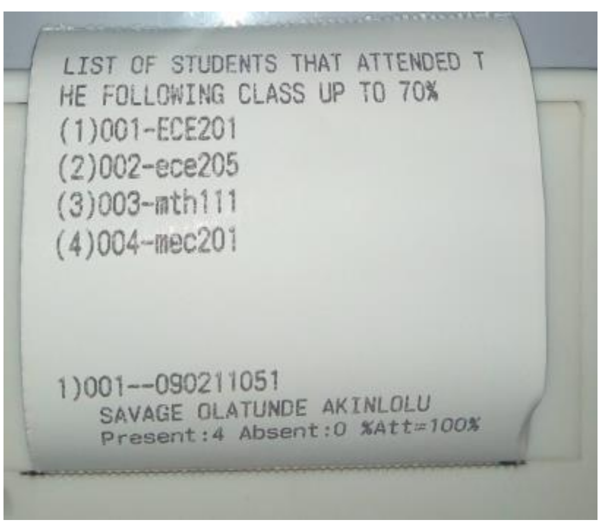


Figure 4c: Display of Output Processes in (ES2BASYS)

Figure 4d: Display of Device showing Model Number BFAS-2191.

SOFTWARE

The programming language used to write the software is Embedded C or C language for embedded systems. The software algorithm and flow chart goes as follows:

ALGORITHM

1. Start

2. Initialize ports, fingerprint, EEPROM, internal registers and LCD.

3. Get time from DS1307, display it on LCD, check if there is a finger on the fingerprint module, check if button is pressed. If no

finger, repeat 3, if finger is found go to 4, if button pressed, go to 7

4. Read student fingerprint from the fingerprint module.

5. Search database for a match if there is a match go to 6 else display “FINGERPRINT NOT FOUND” and go to 3.

6. Display student data and take attendance by setting the attendance flag to logic 1 and storing the time. The attendance is taken into a memory space allocated for the student. Go to 3.

7. Display “enter password”. If correct password is entered goto 8 else goto 3.

8. Display the menu to perform different function such as changing the password of the system, registration of student, delete student data (either one by one or all at once), edit the time and date settings, view list of registered student by only name and matriculation number, or view full details of one student. User can also view or edit lecture details, view student attendance status, start a new class attendance, or send attendance results to a PC or a phone. If exit button is pressed go to 3.

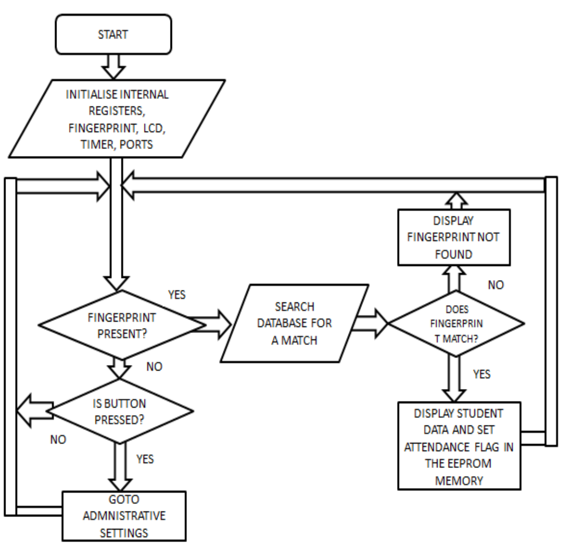


Figure 5a: Flowchart of ES2BASYS.

Figure 5b: Complete Construction of ES2BASYS.

This is a fingerprint based biometric attendance system that is designed for an academic environment to take the attendance of students that attend lecture classes. It can also be used in a business environment to take workers attendance for a month so that their paycheck can be calculated effectively. In this paper, we are going to focus on its design for an academic environment.

The system can store up to 400 sets of student data taking their matriculation number, name, phone, sex, and fingerprint; it can also record up to 100 lecture periods. The system stores the student attendance for all the 100 lectures and can process it to calculate the percentage attendance that students made for some lecture periods selected by the user. This is used to calculate student exam eligibility or awarding of marks for attendance.

The system has an embedded thermal printer that prints the hardcopy of the attendance in real-time or can be printed later. It also has a Bluetooth feature which is used to log the softcopy of the data printed to a phone and can be saved on the phone for later view.

It uses two character input method: embedded keypad and an external USB keyboard. Even though the keyboard is easy to use and can key-in alphanumeric data on single stroke, the keypad also can be used to fully operate the device. The 20x4 alphanumeric LCD makes it easy for user to interact with the operating system for easy operation and control.

It has an built-in battery power system that is charged by 5vdc 1A-2A using a mini USB or DC jack. The inbuilt battery is a 6-cell 3.7v lithium ion battery which can provide backup power for the device for at least 6 hours on fully charged.

Table 1: The Students with Four Different Courses.

	Course A		Course B		Course C		Course D	
	measured	samsys	measure	samsys	measure	samsys	measure	samsys
Student 1	15.51	3.57	21.30	2.22	14.14	2.81	22.87	3.21
Student 2	17.20	3.98	17.17	4.32	16.22	3.42	15.32	3.01
Student 3	14.15	4.15	19.19	3.17	18.10	4.35	16.59	3.56
Student 4	21.22	2.81	21.10	2.91	17.30	3.86	17.16	2.92
Student 5	23.00	2.98	15.20	4.10	21.16	2.93	21.01	4.01
Student 6	18.16	3.17	14.51	3.87	19.40	3.33	14.71	3.65
Student 7	19.17	4.19	16.71	2.49	15.22	4.15	15.63	3.25
Student 8	17.15	3.46	17.81	3.62	18.40	2.94	19.12	4.51
Student 9	20.17	2.98	15.64	3.14	20.70	3.16	17.41	3.20
Student 10	14.25	4.61	14.35	2.96	22.19	3.05	16.17	3.33
Student 11	16.39	3.94	18.91	3.44	21.31	4.19	15.19	3.53
Student 12	18.68	2.93	15.46	3.99	20.11	2.86	18.18	2.98
Student 13	17.66	3.16	20.23	3.21	14.71	4.22	20.30	3.14
Student 14	15.59	2.87	19.35	4.34	15.90	3.17	21.34	4.11
Student 15	21.48	2.79	16.14	5.10	20.22	2.88	19.43	2.94
Student 16	14.39	3.12	18.51	4.61	18.16	3.91	16.99	3.35
Student 17	16.77	3.88	17.49	3.07	19.19	2.89	18.77	4.00
Student 18	21.22	3.66	15.55	3.93	18.40	4.31	21.21	3.82
Student 19	19.18	4.17	20.18	3.47	19.74	3.61	15.99	3.77
Student 20	21.33	3.64	14.19	2.98	20.20	3.71	19.19	4.28

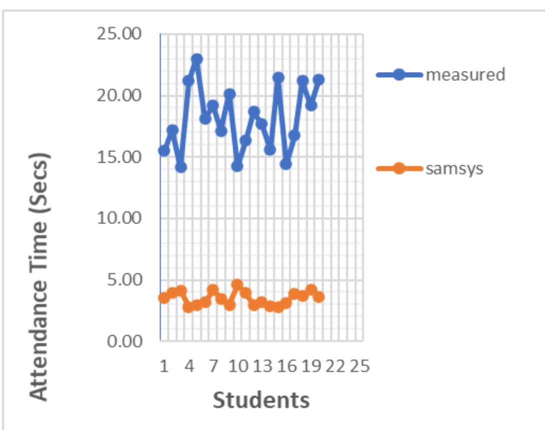


Figure 6: Comparison of Manual Scheme with Proposed Scheme.

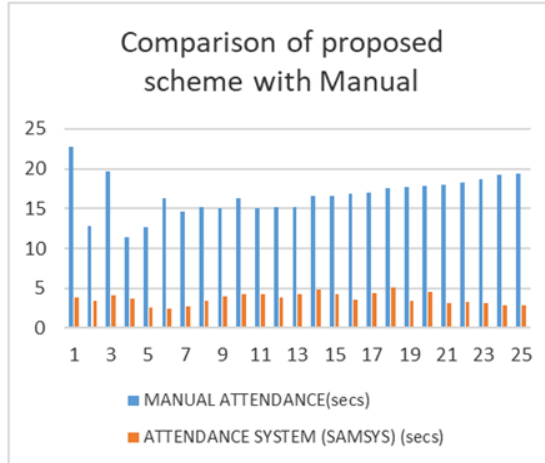


Figure 7: Bar Chart of Comparison of Manual Scheme with Proposed SAMSYS Scheme.

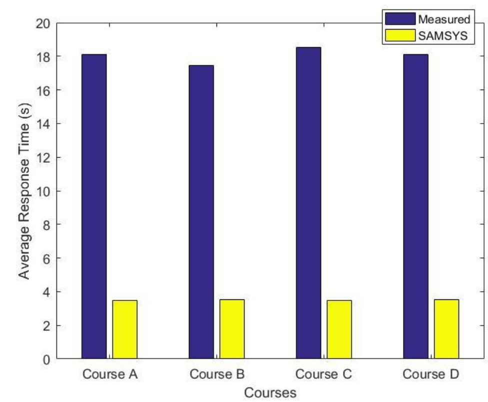


Figure 8: The Graph of Average Resonpse Time versus Courses(A,B,C,and D).

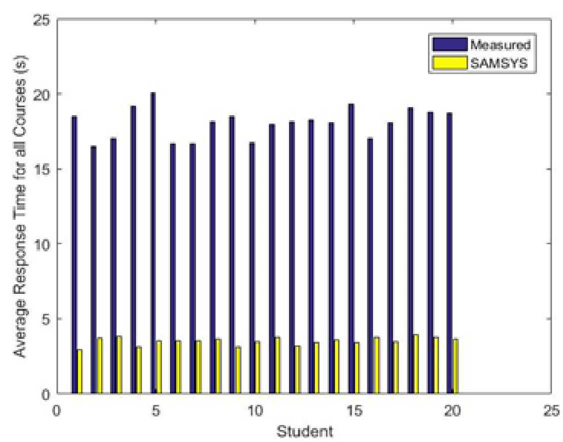


Figure 9: The Graph of Average Resonpse time versus Students.

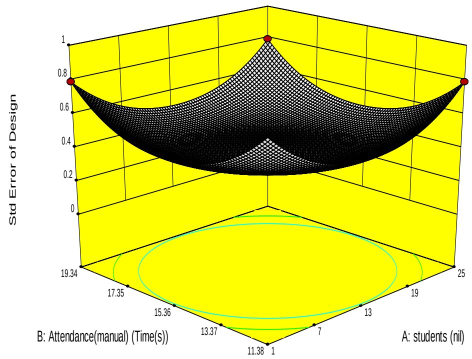


Figure 10: Standard Error of Design of ES2BASYS.

RESULTS AND DISCUSSION

A convenient test on four courses was carried out on the register module for courses A, B, C, and D for five lecture days, respectively. A total of twenty students were involved in the test. This module is a careful improvement of the previous SAMSYS module developed by the authors. Manual authentication of attendance of log books have become an arduous task and are also time consuming. The academic attendance policy has continually insisted on the 70/30% benchmark which has also generated a lot of questions at various quarters. The improvement outlined in this paper provides for instant print out of attendance after class lectures and after examination periods which have been shown in Figures 4a, 4b and 4c respectively. It can be shown in the Figure 11 that the SAMSYS system using fingerprint authentication interfaced with POS is better and faster than the use of manually recorded data on sheets of paper.

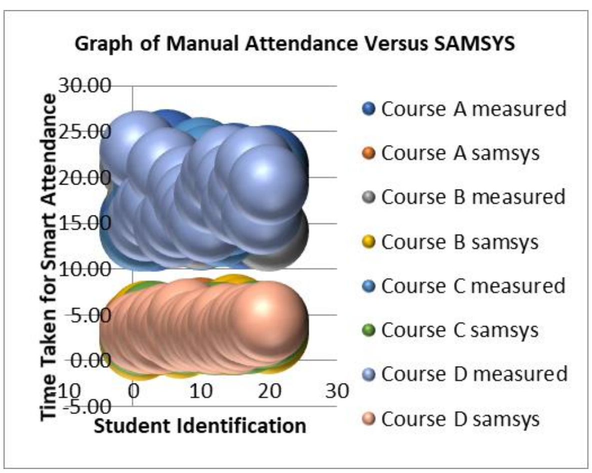


Figure 11: Graphical Analysis of Data of the New Design.

CONCLUSION

The system successfully took the attendance both at lectures and examinations. The prototype enhanced ES2BASYS successfully captured new fingerprints to be stored in the database; scanned fingerprints placed on the device sensor and compared them against those stored in the database successfully. The performance of the enhanced ES2BASYS device was satisfactory and would be considered for full implementation especially because of its short execution time and reports generation .Printing facilities will be included.

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