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Smart Attendance Management System (SAMSYS) for an Academic Institution

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Abstract:

Attendance management has been a great challenge over the years in Nigerian academic institutions. Ranging from university to polytechnics, colleges of educations and secondary schools, quality attendance management has been a freak. Manual authentication of attendance of logbooks has become an arduous task and this is also time-consuming. The academic attendance policy has generated a lot of questions at various quarters. In this paper, we present a system which maintains the attendance records of students adequately and automatically. The device is an efficient module that comprises a fingerprint sensor to manage the attendance records of students at all levels in an academic institution. The module enrols the students at the beginning of each semester with adequate semester course registration. This enrolment is a one-time process and their fingerprints are stored in the fingerprint sensor. The module provides percentage attendance results at the end of each semester so as to ascertain qualification by each student to write the semester examination.

Keywords:

Attendance, Authentication, Fingerprint, Semester, Sensor

1. Introduction

A survey of various academic establishments reveals that they all have criteria for authenticating students' attendance in class. For over fifteen years, one of our duties at every lecture period is to check and authenticate students' attendance both at undergraduate and postgraduate levels. During these years, our methods have been in three ways:

i. By calling out the names of all registered students for the particular course and marking them present or absent.

ii. By passing around a sheet of paper requesting each student present at various lectures to sign the attendance sheet just next to their names.

iii. By conducting a mini test which will not last five minutes after each lecture.

It has been observed that all the methods have their drawbacks. In the first method, if a large group of students attends the lectures, checking and authenticating these students usually takes several minutes out of the lecture period and always reduce the topic coverage every other time. The second and third method also has limitations because friends of absent students always write down the names of their friends and even write these mini-tests for them as observed on several occasions when comparing handwriting on the scripts. These methods which have also been used by other lecturers and have placed many lecturers, instructors and their institutions at considerable disadvantages when it comes to attendance taking. To overcome these failing methods, we have developed a quality smart attendance management system for an academic institution.

Over the years, the magnetic card attendance system has been widely used. The flaw in the magnetic card attendance is that the card can easily get lost or damaged. Users request for replacement too often and this increases the cost of producing additional magnetic cards. In addition, it cannot easily be determined whether students are absent from classes or lectures. At this traditional attendance system, a quality attendance management system is developed. This system makes use of biometrics technology to verify identity through unique fingerprints characteristics. This effort allows the fingerprint to become the most popular technology as automatic personal identification.

2. Related Work

There are quite a number of related works regarding attendance management system in [1,2,3,4,5,6,7] an attendance portal was developed. In this scheme, the portal form is used by the student to enrol for lecture attendance, mid-semester exam attendance and examination attendance. These forms are filled in the 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 fingerprint 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 [8, 9] but the presence of each student will be updated in a database and the data will be passed to the server using the 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 the attendance system based on RFID and GSM with respect to power saving concept was developed by some researchers [10,11,12,13]. 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 [10,14,15] developed an automated attendance monitoring system using an 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 of generating adequate reports.

Another set of authors in [13] designed, developed an effective and secure fingerprint-based biometric attendance device (ESFB2A). The device developed helped in reducing the workload and stress of inspecting each students attendance and calculation errors when obtaining the total attendance. The data from previous manual attendance data from another type of biometric device, the current manual based method and the fingerprint device developed were compared. The previous biometric device recorded a time of 13.81 secs while the newly developed ESFB2A recorded a time of 13.08 secs. The average execution time for the other type of biometric device yielded 16 secs while that of the newly developed ESFB2A yielded 11 secs.

3. Methodology

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

3.1. 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.

3.2. 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 the command to read the fingerprint, store it in a memory, delete fingerprint, compare the current image with one stored in the memory etc. it sends back the result to the microcontroller which it further processes and makes some decisions to mark attendance or to reject.

3.3. 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 use 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.

3.4. 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 devices such as a PC or an Android phone or Tablet. The Bluetooth module contains all the necessary circuitry to make connections with other device 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.

3.5. 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.

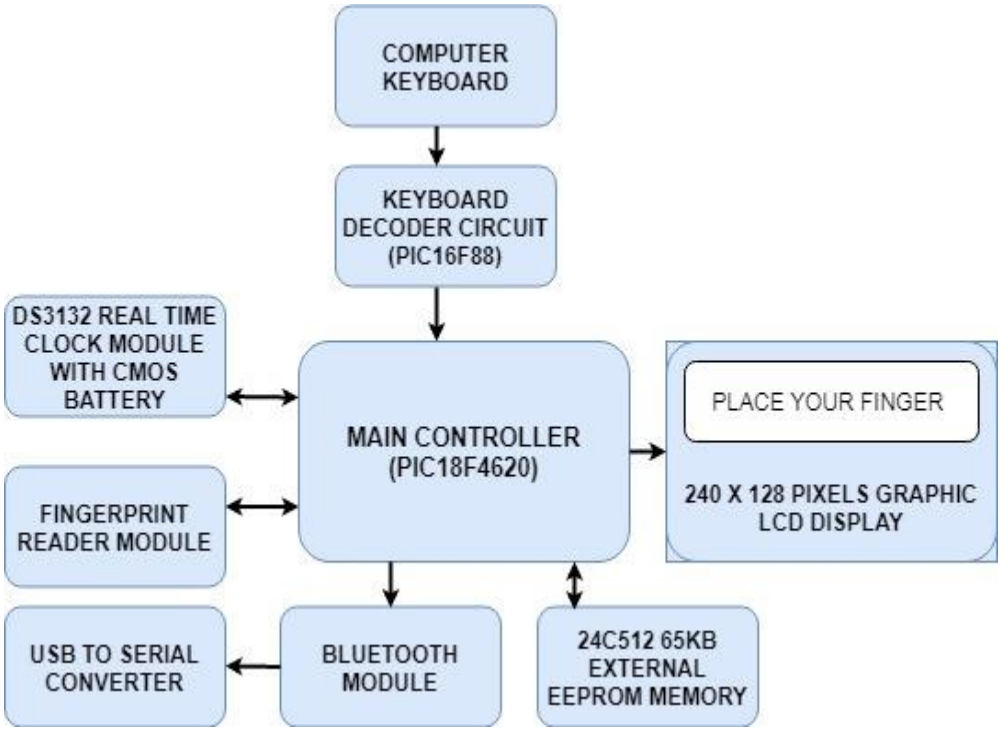

Figure 1. *Main Board Block Diagram of the System.*

3.6. 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 are not enough to store 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 student data. An extra EEPROM is used which is removable; it is used to back-up whatever is stored on the first EEPROM so, in the advent of data loss, we can still have them recalled from this removable storage.

3.7. 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 of the work it has to do. It is meant to ease the work of the main microcontroller, the main microcontroller reads the time, reads the fingerprint module, send data to the LCD simultaneously, so adding a keyboard to its list of the process will make the whole job slower.

The keyboard controller also filters out some functions keys and other special keys that are not needed for this project; it is also responsible for sending a 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 light weight membrane switch so thereby easy to carry and can be used for all administrative settings and registration with numbers only.

3.8. LCD Device

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 student by displaying what is being typed.

3.9. Circuit Explanation

The heart of the circuit is the PIC18F4620 microcontroller which does all the necessary processing and 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.

3.10. Power Section

This is responsible for providing electrical energy to all stages in the whole circuit. All of the stages need an average of 5volts 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 battery is fully charged.

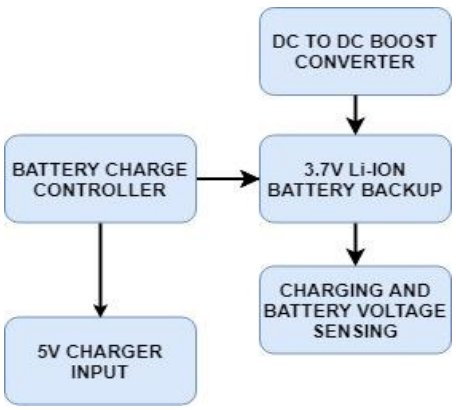

Figure 2. *Block Diagram of Power Section.*

3.11. System Overview

The coordinated working of the hardware circuit is made possible by the software firmware running in it. 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 bio-data with this project. The data is the student's name, matric, 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 thereby no attendance will be taken. (Check the flowchart and algorithm of the software for more information).

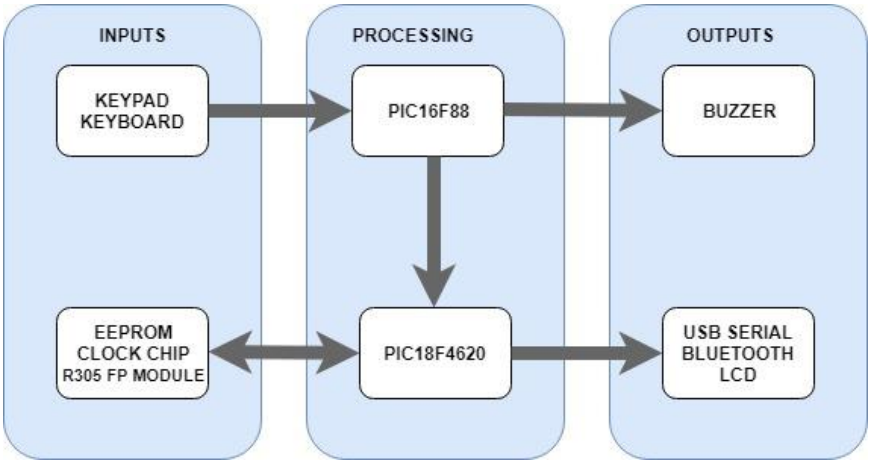

Figure 3. *Simplified Block Diagram of the System.*

The administrator can do a lot of settings on the system like changing the password of the system, Bluetooth password, registration of student, edition 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.

3.12. Circuit Component Functions

The circuit starts up by power supply powering all the initializing input, output and memory device and other peripheral components. As soon as they are powered, all of

the peripherals initializes 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 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 seconds (1 instruction takes 4 clock cycles) this speed is necessary for the microcontroller to do so many heavy-duty jobs very fast, such like addressing 65,000 external memory location, 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 are 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 set the timer chip when the user is doing time and date setting, 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 is connected to the main microcontroller via 2 pins SDA and SCL which is serial Data and serial Clock respectively and the pull-up resistor is connected between those pins and the VCC.

The fingerprint module is responsible for reading the fingerprint, this is done by the microcontroller sending a command to check for fingerprint match, or delete fingerprint, 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 per cent 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.

3.13. 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, the user enters the finger through the 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, the system will search the whole finger library for the matching finger. In both circumstances, the 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.

3.14. The Power Circuit

In the charging circuit, the AC to DC converter converts 220V to 5V charge the battery constantly. In other not to make the circuit unnecessarily complex, complex charging monitors circuit is not included but another efficient and safe way to charge the battery is employed. Normally we need 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.

3.15. Software

The software is like the machine in the heart pumping blood. The heart of the whole circuit is the microcontroller and without the software, the heart is dead and cannot do anything. The programming language used to write the software in Embedded C or C language for embedded systems. The software algorithm and flowchart goes as follows.

3.16. Algorithm

1. Start

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

3. Get time from DS1307 displays it on LCD, check if there is a finger on the fingerprint module, check if the button is pressed. If no finger, repeat 3 if the finger is found goes 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 the correct password is entered goto 8 else goto 3.

8. Displays the menu to perform a 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, viewing list of the registered student by only name and matric number or viewing full details of one student. He can also view or edit lecture details, view student attendance status, start a new class attendance, sending attendance result to a PC or a phone. If exit button is pressed go to 3.

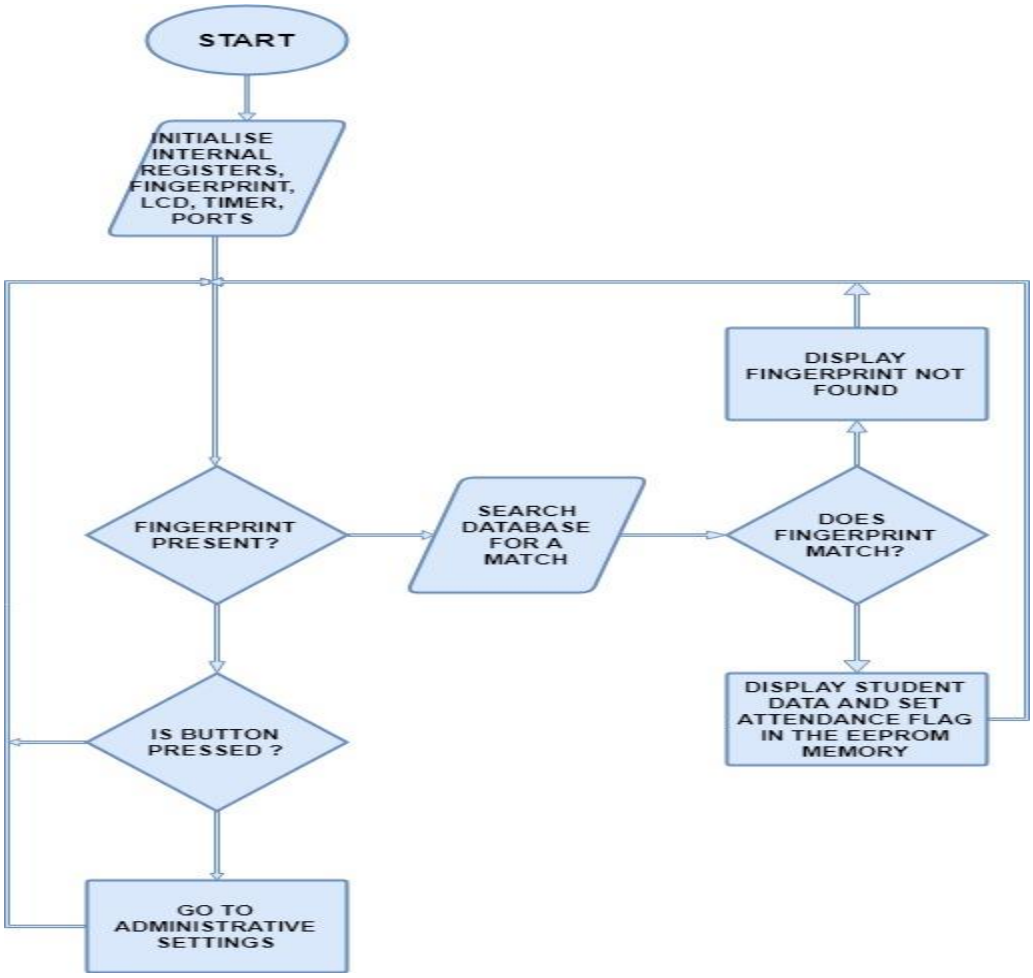

Figure 4. *Flowchart of the SAMSYS.*

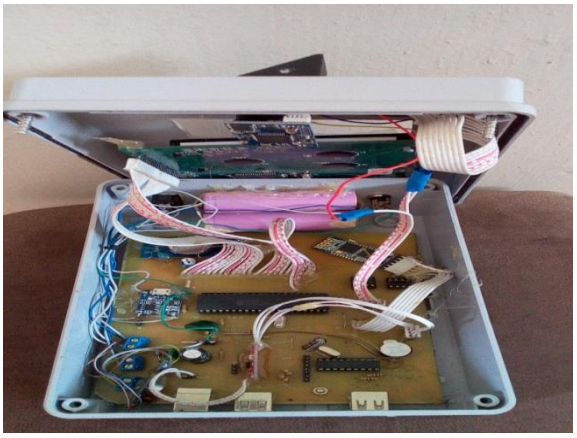

Figure 5. *Internal Composition of SAMSYS Circuit.*

4. Results and Discussion

The manual attendance system average execution time for twenty-five (25) students is approximately 17.83 seconds as against 3.79 seconds for the SAMSYS system using fingerprint identification. Reports generation for the attendance system takes approximately 30s. The table is a 25 student sample out of the 80 tests conducted. It can be shown in the graph below and thus, it can be seen that the SAMSYS system using fingerprint authentication is better and faster than the use sheets of paper.

Table 1. *Comparison of the execution time of Manual Attendance and SAMSYS.*

STUDENS	MANUAL ATTENDANCE (secs)	ATTENDA-NCE SYSTEM (SAMSYS) (secs)
1	22.78	3.81
2	12.82	3.43
3	19.65	4.12
4	11.38	3.63
5	12.65	2.53
6	16.24	2.49
7	14.66	2.72
8	15.23	3.35
9	15.03	4.01
10	16.31	4.21
11	14.97	4.31
12	15.16	3.85
13	15.18	4.32
14	16.54	4.78
15	16.59	4.23
16	16.92	3.55
17	16.95	4.34
18	17.61	5.11
19	17.72	3.36
20	17.78	4.57
21	18.01	3.12
22	18.25	3.31
23	18.62	3.10
24	19.19	2.92
25	19.34	2.84

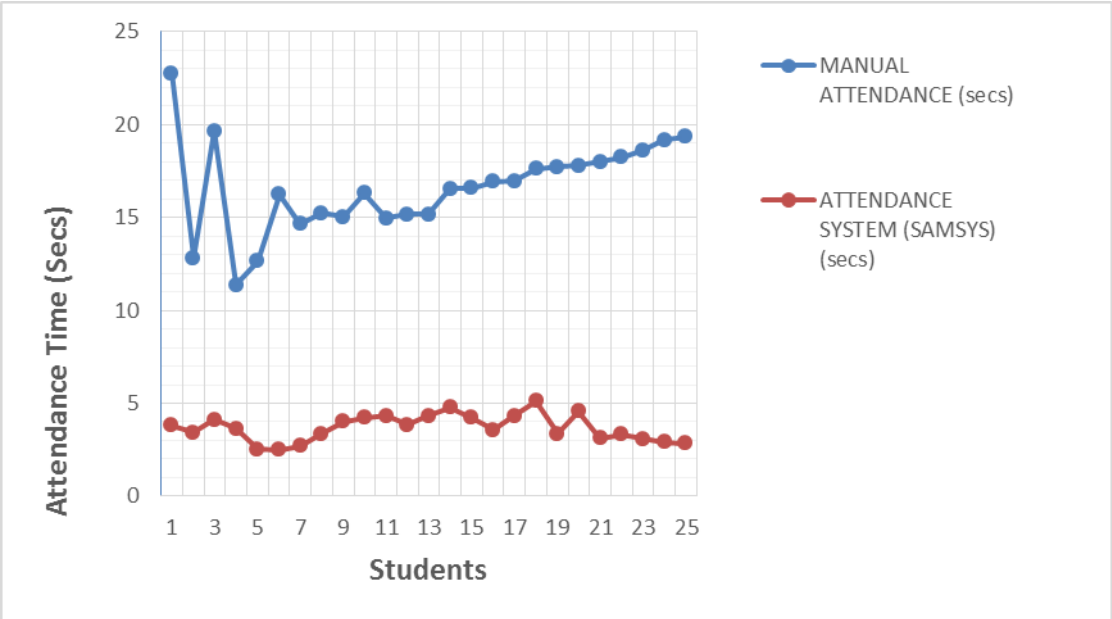

Figure 6. *Comparison of Manual Scheme with Proposed SAMSYS Scheme.*

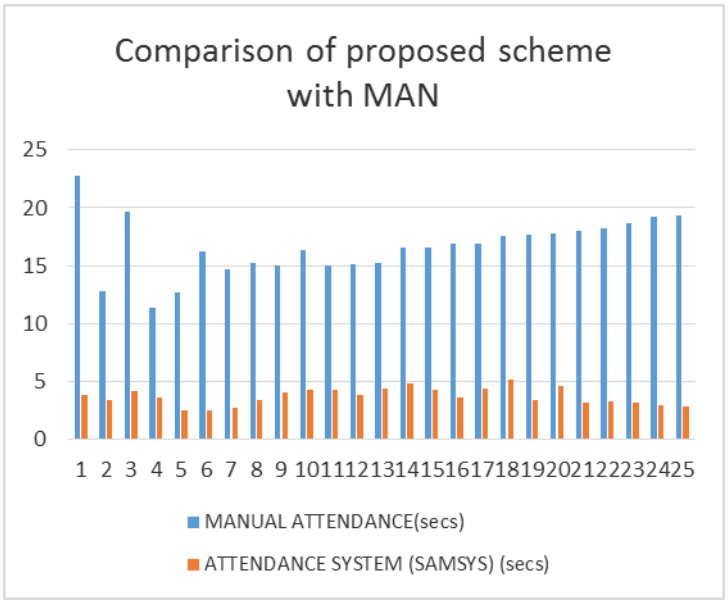

Figure 7. *Bar Chart of Comparison of Manual Scheme with Proposed SAMSYS Scheme.*

5. Conclusions

The system successfully took the attendance both at lectures and examinations. The prototype **SAMSYS** 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 **SAMSYS** 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.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Acknowledgments

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