DEVELOPMENT OF A FINGERPRINT CAPTURE DEVICE FOR ATTENDANCE RECORDING USING ARDUINO PLATFORM AND FINGERPRINT MODULE.

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Abstracts- This project document presents the design and construction of a fingerprint based student attendance and examination authentication system. This is about the use of fingerprint to verify student attendance. In this system, a desktop-based attendance management system and a fingerprint hardware device would be constructed to verify student attendance in all classes; the attendance report will also be used to authenticate qualified students during examination; reports can be generated occasionally if need be. The main purpose of developing this project is to replace the current traditional attendance system by providing a faster, accurate and efficient system. This will eliminate some problems such as buddy signing, loss of attendance sheet, etc. Waterfall model had been used as the methodology that guides the direction of this project development. This project is planned to be developed using Intellij IDEA, SQLite manager, Arduino IDE and Proteus. The system analysis and design techniques are illustrated with necessary diagrams for the purpose of clarity. The implementation of this system will definitely provide more efficient, reliable, and accurate way to manage the student attendance data.

Index Terms- Intellij IDEA, SQLite manager, Arduino IDE, Proteus, and Waterfall Model

INTRODUCTION

As the world is going digital, means of executing tasks are becoming more efficient. Digital systems help convert manual processes into a format that is efficient, consistent and of good quality. An example of this system is the automated school attendance management system.

Over the years, for orderliness in the school environment and other institutions to be maintained, different techniques have been devised. One of these techniques is the attendance registry in schools. Traditionally, this system has been manual, which entails that an individual would have to append their signature to their names whenever they are present in order to keep record. With the advent of computer and digital system, techniques have been developed to make up for the lapses inherent to the traditional handwritten attendance registries. One of the most effective methods is the use of biometrics. Biometrics has the ability to identify individuals on the basis of some biological characteristics. Fingerprint is one of the most acceptable biometrics as it is unique to an individual.

Computer based "Attendance Management System" is important in every organization because of the ease with which it manages drawbacks of the manual attendance management system used in schools and other institution to track activities.

Fingerprint identification is one of the most well known and common biometric identification systems. Because of their uniqueness and consistency over time, fingerprints have been used for identification over many years, more recently becoming automated due to advancement in computing capabilities. Since every individual has his/her unique fingerprint, this makes it a good feat to be used for identification of individuals. School attendance systems can be built based on fingerprints so as to ensure the fidelity of the attendance process.

LITERATURE REVIEW

Biometrics' ability to uniquely identify a person on the basis of some biological characteristics of the person is an essential need in the personal device usage in public domain. Fingerprint is one of the most acceptable biometrics because it is a common method of identification that human use. Biometrics is related to identity confirmation technique that relies on measurable, individual biological characteristics. For example, fingerprint patterns may be used to enable access to a computer, to a room or to an electronic commerce account or authenticate presence.

Today there are many biometric devices based on characteristics that are unique for everyone. Some of these characteristics include, but are not limited to, fingerprints, hand geometry, and voice [1]. These characteristics can be used to positively identify someone. Many biometric devices are based on the capture and matching of biometric characteristics in order to produce a positive identification.

There are various biometric techniques available such as fingerprint, face, iris, retina, handwriting, voice recognition on an individual basis. The generally biometric system works in stages, the stages are divided into eight as stated in [2], they are:

1. Capture the chosen biometric.
2. Process the biometric, extract and enroll the biometric template.
3. Store the template in a local repository, a central repository or a portable token such as a smart card.
4. Live scan the chosen biometric.
5. Process the biometric and extract the biometric template.
6. Match the scanned biometric template against stored template.
7. Provide a matching score to business applications.
8. Record a secure audit trail with respect to system using database.

2.1.1 Fingerprints

The patterns of friction ridges and valleys on an individual fingertip are unique to that individual. Fingerprints are unique for each finger of a person including twins. It is one of the most commercially available biometric technologies widely available at a low cost. With fingerprint devices, users no longer need to type passwords, instead only a touch provides instant access. Fingerprint systems can also be used in Identification Mode. Fingerprints are unique to each individual and each individual has his own pattern in his fingerprints. There are some verification approaches that can detect if a live finger is presented, but not all of these approaches can provide this type of information [3].

2.2 Review of Related Works

There has been so much research in the development students attendance system, these include Internet systems like web-based system, mobile-based attendance system, some of the others computerized attendance system with hardware technology like fingerprint based attendance system, iris-based attendance system, face recognition based attendance system, RFID (Radio Frequency Identification) based attendance system, and others need communication technology like Bluetooth based attendance system, NFC (Near Field Communication) based attendance system [5] and other systems such as using technologies utilized in [6–8].

According to [9] the system uses a quick response (QR) Code technology to register the student presence by scanning the QR Code using a QR Code scanner. Then

this information delivered to the server, where the server makes the call to the API.

There is multitude developed Web-Based Student Attendance System using Radio Frequency Identification technology which will significantly improve the current manual process of student attendance recording and tracking system, especially in a university or school environment because it is easy to connect data of internet. The system promotes a semi-automated approach in capturing the student attendance, i.e. by having the students to flash their student cards to the RFID reader [10-13].

In most institutions attendance is part of student's continuous valuation or there are conditions that student must meet before they allowed to sit for examinations so very important to use attendance management in educational institutions. The system required minimal hardware, NFC tag, and NFC-enabled mobile device. The benefits of like these systems eliminate many paper works involved in it, removing the opportunity of losing attendance data, can generate different presence reports easily by a click of a mouse, etc [14, 15].

The proposed system i.e. fingerprint based school attendance and examination authentication system be because it is friendly and easy to use, less cost, no need extra hardware, and more than this a student cannot intentionally register fake attendance record in the daily presence sheet.

2.3 Literature Gaps

These various kinds of student attendance management systems like RFID based student attendance system, NFC based student attendance system, QR code based student attendance system, and SMS based student attendance system have their own pros and cons. Our system is better in many aspects. Problem with RFID based systems and QR Code based systems is that students may give proxies easily using friend's RFID card and QR code. SMS based student attendance system rely on the network of service provided to send report. These problems are not in our system. We used fingerprints as recognition criteria so proxies cannot be given. If portable devices are used, attendance marking will be done at any place and any time. Also, considering the fact that the essence of taking the students' attendance is for the valuation of their academic commitment, our system would not only be used for managing attendance registry, it also has the functionality of being used to authenticate students who met minimum attendance requirement to sit for examination.

3.1 Methodology

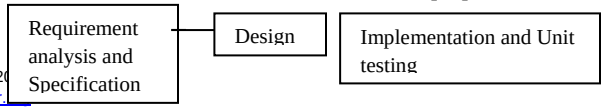
To solve actual problems in an organization, software developer or a team of developers must incorporate a development strategy that encompasses the process, methods and tools layers and generic phases. This strategy is often referred to as process model or a software developing paradigm. There are different system models like; Build and fix model, Waterfall model, Increment process models- (Iterative enhancement model, The rapid application development (RAD) model), Evolutionary process model(Prototyping model, Spiral model, The unified process). With respect to this research work waterfall Model will be made use of;

Waterfall Model

This model is the most familiar mode adopted software developers. It consists of five phases, which are [16]:

1. Requirement analysis and specification
2. Design
3. Implementation and unit testing
4. Integration and system testing
5. Operation and maintenance.

These five phases occur in this order listed above and do not overlap, that is to say that a particular phase must be completed before the next phase commences. This model is named "Waterfall Model", because its diagrammatic representation resembles a cascade of waterfalls [16].



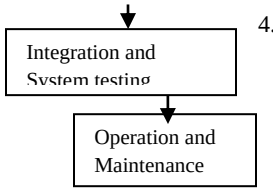


Figure 3.1: Waterfall model

Using the "Waterfall Model" for this project. However, there have been some variations from the theoretical waterfall model for this project lifecycle. They are:

i. Maintenance has been omitted from the current project.
ii. Not all testing methods which are present in theoretical model are implemented.

1. **Requirement analysis and specification phase:** This phase involves the feasibility study of the project, understanding the exact requirements of the customer, analyzing the requirements and documenting them properly. The requirements describe only what the system will do and not how it will do it.
2. **Design phase:** The document produced in the last phase is transformed into a structure that is suitable for implementation in a particular programming language. Here, overall software architecture is defined, and the high level and detailed design work is performed. The designs two designs that would be carried out here are the system design and the program design.
3. **Implementation and unit testing phase:** During this phase, the two designs are implemented. Coding and simulations of the modeled system is carried out. During this phase, the major activities are centered on the examination and modification of the code. Small modules are tested in isolation from the rest of the software. However, there are problems associated with testing a module in isolation. How do we run a module without anything to call it or to output intermediate values obtained during execution? Such problems are solved in this phase and modules are tested after writing overhead code.
4. **Integration and system testing phase:** Effective testing will contribute to the delivery of higher quality system, satisfied users, and accurate and reliable result. System testing involves the testing of the entire system, whereas software is a part of the system.

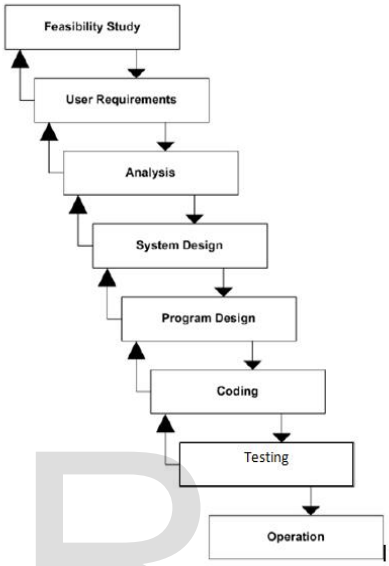


Figure 3.2: Modified Waterfall Model

3.2 System Requirement Study

3.2.1 User Characteristics

This system will be used in only one user module, which is the administrator. The administrator can: Access the system after authentication, Add, edit and delete students, Update attendance after every class, Generate reports.

Analysis of the Existing System

- The existing system is not user friendly because the retrieval of data is very slow and data is not maintained efficiently.
- All calculations to generate report are done manually so there is greater chance of errors.

- Existing system requires lot of paper work. Loss of even a single register/record leads to difficult situation because all the papers are needed to generate the reports.

Features of the New System

The new system is going to deal with the limitations of the existing system by; keeping historical data that makes it easy for lecturers to access and grade students, eliminate dubious signing of attendance for absent students by their friends, providing high level of security whereby making it impossible for imposters and impersonators in making their ways to examination halls. Moreover work becomes very easy because there is no need to keep data on papers.

3.4.1.1 **Context Diagram:** The context diagram is a top-level view of an information system that shows the boundaries and scope. It describes the main objective of the system and the entities involved

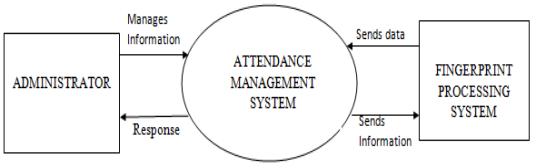


Figure 3.3: Context Diagram of the System

3.4.1.2 Data Flow Diagram (Level 1):

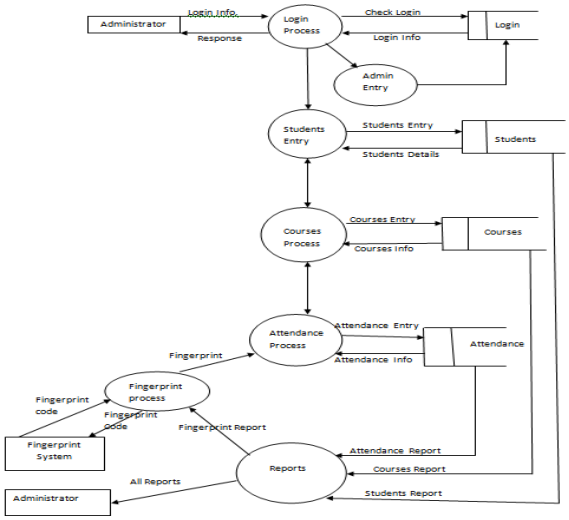


Figure 3.4: Data Flow Diagram of the System

3.4.2a Attendance Management Subsystem Flow Chart

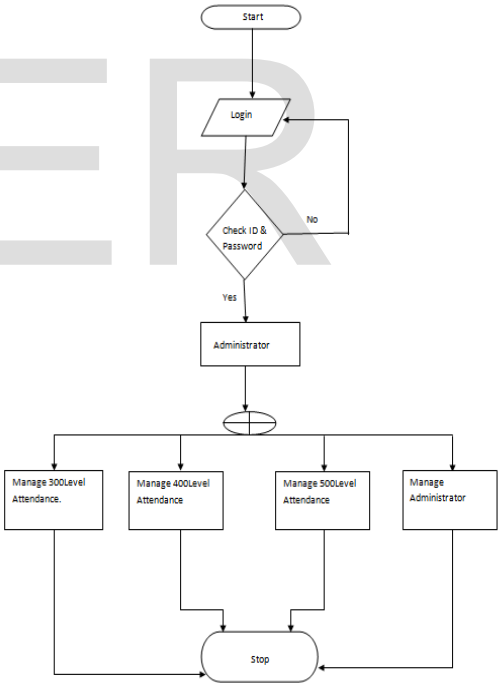


Figure 3.5: Attendance Management Subsystem Flow Chart

3.4.2b Attendance System Flow Chart

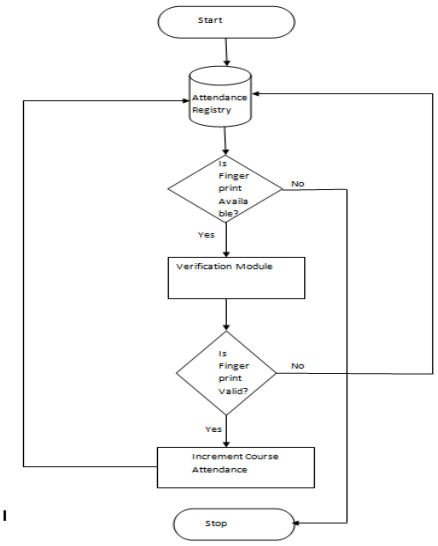


Figure 3.6: Attendance System Flow Chart

Table 3.3: Courses

S/N	Field Name	Data Type	Constraint	Description
1	ID	Integer	Primary Key	ID
2	RegdNumber	Text	Foreign Key	Registration Number
3	FirstName	Text	Not Null	First Name
4	LastName	Text	Not Null	Last Name
5	OtherName	Text		Other Name
6	LectureNumber	Integer	Not Null	Lecture Number
7	LecturesAttended	Integer	Not Null	Lectures Attended
8	AttendancePercentage	Integer	Not Null	Attendance Percentage
9	Fingerprint	Blob	Not Null	Fingerprint

Fingerprint Minutiae Extraction Algorithm

This minutiae extraction algorithm is based on binarization. Binarization converts a pixel image into binary image first, and then obtain the skeleton of the fingerprint which will be used to obtain the minutiae through the thinning process. The image obtained by this method shows either black or white and black is represented by 0 while white is represented by 1. Hence it can separate the ridge line from the background of fingerprint.

The basic principle of binarization is to compare the pixel intensity with the threshold, and setting the pixel whose value is less than the threshold to 0 and the other to 1. Threshold is divided into 2: global threshold and local threshold. Global threshold means that defining a single threshold for the whole image and local threshold means changing the threshold locally by adapting the average local intensity [17].

The integral sum image means that the intensity of a random pixel equals the sum of intensities of all pixels above and left [17]. The diagrammatic sketch is shown in Figure 3.8.

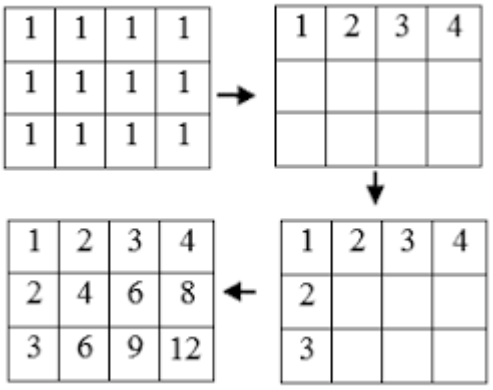


Figure 3.8: Calculation Steps of integral Sum Image

For this figure, the intensity of integral sum image can be calculated as [17]:

$$g(1,y) = I(1,y) + g(1,y-1), y = 2,\cdots,n$$

$$[Intensity\ of\ 1st\ row\ at\ (1,y)]$$

$$g(x,1) = I(x,1) + g(x-1,1), x = 2,\cdots,m, \quad (3.2)$$

$$[Intensity\ of\ 1st\ column\ at\ (x,1)]$$

$$g(x,y) = I(x,y) + g(x,y-1) + g(x-1,y)$$

$$-g(x-1,y-1), y = 2,\cdots,n, x = 2,\cdots,m. \quad (3.3)[Intensity\ of\ all\ pixels\ at\ (x,y)]$$

And the sum intensity in the centre of local window $(with\ size\ w \times w)\ s(x,y)$ can be calculated as [17]:

$$s(x,y) = [g(x+d-1, y+d-1) + g(x-d, y-d)]$$

$$+[g(x-d, y+d-1) + g(x+d-1, y-d)],$$

$$where\ d = round(w/2)\ and\ w\ is\ an\ odd\ number.$$

The local $mean\ m(x,y)\ at\ (x,y)$ within the window w×w can be calculated as [17]:

$$m(x,y) = \frac{s(x,y)}{w^2}$$

The threshold $T(x,y)$ can be used in following equation [17]:

$$b(x,y) = \begin{cases} 0, & \text{if } I(x,y) \le T(x,y), \\ 1, & \text{otherwise}, \end{cases}$$

where $b(x,y)$ is the intensity of binarized images. And $T(x,y)$ can be calculated as [17]:

$$T(x,y) = m(x,y)[1 + k(\partial(x,y)1 - \partial(x,y) - 1)],$$

$$where\ \partial(x,y) = I(x,y) - m(x,y)\ and\ k$$

is a constant that can control the level of adaptation of threshold.

(a) Original fingerprint image (b) Binarized image of fingerprint A

Figure 3.9: Binarization of Image of Fingerprint [17]

Thinning is the process that the ridge line thickness is reduced to one pixel width by deleting pixels at edge of ridge lines. The basic principle of thinning is to build deletion templates, and then compare the binary images with templates to determine whether pixels at the certain point should be deleted or not [17].

The thinning algorithm in this paper is based on hit-miss transformation that aims to compute the structure of series. The process is to hit image pixels with pattern. If the image is considered as a set, the operation of hit-miss transform can be described as below [17]:

$$X \otimes S = X - X \odot S, \quad (3.5)$$

where X is the image set and S is the pattern set. X⊗S means the operations between X and S , which result in the output image and X⊙S means the hit operation which result in a set of the pixels that should be deleted.

When applying this hit/miss transform on the fingerprint image, the result of the operation will be the skeleton image of the fingerprint [17]. Figure 3.10 shows the eight deletion pattern used in the operation. (3.6)

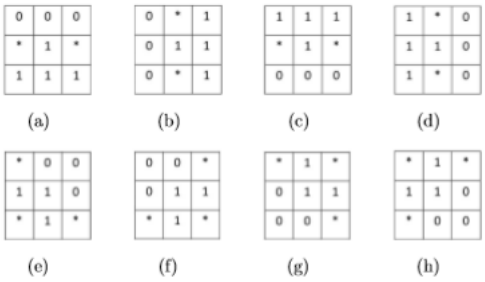


Figure 3.10: Eight Deletion Patterns [17]

P2	P1	P8
P3	P	P7
P4	P5	P6

Figure 3.11: Target Pattern [17]

Then algorithm consists of the following steps: 1. A point is selected as the target point randomly and a target pattern is established with the target point and 8 neighborhood points. 2. Target patterns are compared with deletion templates, if they match the deletion template, then delete the target pixels, otherwise, reserve it. 3. Repeat the above procedure until the pixel value of the fingerprint does not change [17].

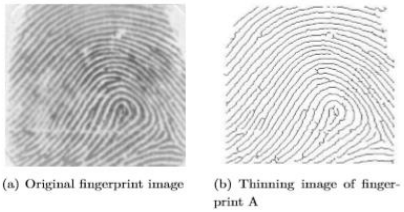


Figure 3.12: The Thinning Image of Fingerprint [17]

After getting the thinned fingerprint image, the next step is to use the neural network to extracts the correct minutiae points from the fingerprint image. This neural network has an input layer, a hidden layer and a output layer [17].

The input layer: The input layer consists of 9 neurons which is 3×3 pixel blocks from the fingerprint image.

The hidden layer: The hidden layer consists 3×3 patterns of bifurcations and terminations.

The output layer: The output layer is a map which is the same size as the fingerprint image. In the map, 0 for non-minutiae points, 1 for termination point and 2 for bifurcation point.

Implementation and Testing of the fingerprint module

The first step in using R307 fingerprint module with Arduino is to install the Adafruit Fingerprint Library in the Arduino, this is done using the Library Manager in Arduino IDE.

Open the Arduino IDE > Sketch > Include Library > Manage Libraries.

When the library manager loads, lookup for “Fingerprint”, the search result would be “Adafruit Fingerprint Sensor Library”. Install it.

After the installation, the fingerprint module is connected to the Arduino uno device as shown in figure 4.1 below. The connectors are colour coded (red, black, white, and yellow). The red is connected to the 3.3V power supply pin of the Arduino, the black is connected to the GND pin of the Arduino, the yellow and white are for serial communication and are connected to pin 9 and 10 of Arduino’s digital PWM. These connections are depicted in the figure below.

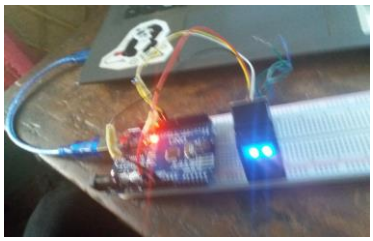


Figure 4.1: Connection of the Fingerprint Module

After connecting the module to the Arduino, the next is to test the module. This is done by connecting the Arduino a PC as shown below and using the Adafruit library to test if the module is well connected and functional. This is shown in the figure below.

Figure 4.2: Testing of the fingerprint module

Implementation and Testing of the LCD

The LCD is connected to the Arduino uno using the colour code (red, brown, orange and white). The red is connected to the 5V power supply, and the brown is connected to the GND. The orange and white are connected to the analog pins of the Arduino for serial communication. The connections are shown in the figure below

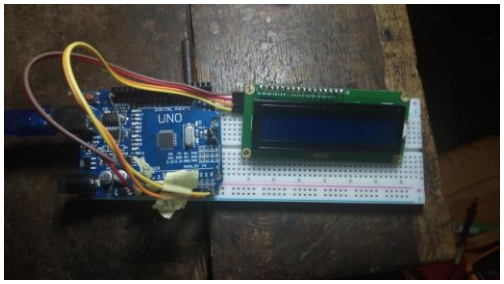


Figure 4.3: Connection of the LCD to the Arduino

To test the LCD, install LiquidCrystal_I2C library. We wrote a code to display a text on the LCD using the installed library on Arduino IDE. The testing is depicted as in the figure below.

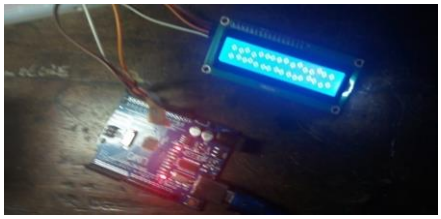


Figure 4.4: Testing of the LCD

4.2Packaging

The package for this project is dependent on the following factors: Portability, Durability, and Cost.These factors lead to the choice of a PVC casing. The working packaged system is as shown below

Figure 4.6: Packaging of the complete working device

Conclusion

This project can efficiently record and manage students attendance using their fingerprint making the whole attendance taking process to become more reliable, convenient, efficient, and accurate. The system testing revealed that the system is working exciting and is ready to use to manage students attendance for any department in this university and other institutions of learning.

Recommendation

The attendance management system developed only can be used on desktop or laptop. Therefore, in future work, this system should focus more on building on the existing system and implementing distributed database technology thereby ensuring protection of valuable data, modularity and improved performance of the system.

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