Faculty of Electrical Technology and Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

IMPLEMENTATION OF AN ATTENDANCE SYSTEM AT UTEM MOSQUE UTILIZING RFID AND FINGERPRINT TECHNOLOGY

MARY MAGDALENE A/P JESUDAS

Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours

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IMPLEMENTATION OF AN ATTENDANCE SYSTEM AT UTEM MOSQUE UTILIZING RFID AND FINGERPRINT TECHNOLOGY

MARY MAGDALENE A/P JESUDAS

A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics)
with Honours

Faculty of Electrical Technology and Engineering

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FAKULTI TEKNOLOGI DAN KEJURUTERAAN ELEKTRIK

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TS. DR. MOHD HANIF BIN CHE HASAN
PENSYARAH
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DEDICATION

My appreciation to my parents, whose boundless love, unwavering support, and countless sacrifices have been the driving force behind my educational journey. To my friends, the shared moments of triumph and challenge have made this final year project unforgettable. I am grateful for your encouragement and understanding. A special acknowledgment to my supervisor, Ts. Dr Mohd Hanif Bin Che Hasan whose guidance, wisdom, and commitment to my project growth have shaped my perspective and approach to this project. This achievement is as much yours as it is mine. Thank you all for being the essential pillars of strength throughout my final year project.

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ABSTRACT

In the 21st century, rapid technological advancements have permeated various aspects of our lives, emphasizing safety and efficiency. This project proposes an automatic attendance system tailored for UTeM Mosque, leveraging RFID and biometric fingerprint technology, powered by the ESP32 microcontroller. Traditional pen-and-paper systems have become unreliable and challenging to maintain, prompting the need for a modern solution to meet UTeM Mosque's attendance monitoring needs. The existing manual attendance system presents challenges such as long queues, the risk of data misplacement, and unnecessary time consumption. To address these issues, our project aims to construct a reliable and user-friendly attendance system. The integration of RFID tags and biometric fingerprint recognition enhances security and accuracy, aligning with the technological advancements of the 21st century. The main objectives of the project include developing the attendance system, integrating it with Google Sheets for electronic record-keeping, and testing its accuracy and efficiency at UTeM Mosque. The implementation showcases a successful fusion of hardware, software, and attendance management, providing a comprehensive solution for tracking attendance during congregational prayers. The attendance system captures vital information, including attendees' names, matriculation numbers, and timestamps, securely stored in Google Sheets for reliable record-keeping and future analysis. Real-time feedback through an LCD displayer and an audible signal from a buzzer enhances the user experience and reduces uncertainties. Overall, this project demonstrates the effective utilization of RFID and fingerprint technology, supported by the ESP32 microcontroller, to enhance attendance management at UTeM Mosque. The system streamlines operations, reduces manual effort, and contributes to effective attendance management, ensuring a smooth and organized congregational prayer experience for all attendees. The successful integration of hardware, software, and Google Sheets highlights the commitment to leveraging technology for the improvement of mosque operations.

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ABSTRAK

Pada abad ke-21, kemajuan teknologi yang pesat telah meresapi pelbagai aspek kehidupan kita, menekankan keselamatan dan kecekapan. Projek ini mencadangkan sistem kehadiran automatik yang direka khusus untuk Masjid UTeM, menggunakan teknologi RFID dan cap jari biometrik, dikuasakan oleh mikropemproses ESP32. Sistem tradisional menggunakan pena dan kertas telah menjadi tidak dapat dipercayai dan sukar dipelihara, memerlukan penyelesaian moden untuk memenuhi keperluan pemantauan kehadiran di Masjid UTeM. Sistem kehadiran manual sedia ada menimbulkan cabaran seperti barisan panjang, risiko kehilangan data, dan pembaziran masa yang tidak perlu. Untuk menangani masalah ini, projek kami bertujuan untuk membina sistem kehadiran yang boleh dipercayai dan mesra pengguna. Pengintegrasian tag RFID dan pengiktirafan cap jari biometrik meningkatkan keselamatan dan ketepatan, selari dengan kemajuan teknologi abad ke-21. Objektif utama projek termasuk membangunkan sistem kehadiran, mengintegrasikannya dengan Google Sheets untuk penyimpanan rekod elektronik, dan menguji ketepatan serta kecekapan sistem di Masjid UTeM. Pelaksanaannya mempamerkan penyatuan yang berjaya antara perkakasan, perisian, dan pengurusan kehadiran, menyediakan penyelesaian menyeluruh untuk mengesan kehadiran semasa sembahyang berjemaah. Sistem kehadiran menangkap maklumat penting, termasuk nama peserta, nombor matrikulasi, dan capaian waktu, yang selamat disimpan di Google Sheets untuk penyimpanan rekod yang dapat dipercayai dan analisis masa depan. Maklum balas secara langsung melalui paparan LCD dan isyarat lantang daripada loceng memperbaiki pengalaman pengguna dan mengurangkan ketidakpastian. Keseluruhannya, projek ini menunjukkan penggunaan yang berkesan teknologi RFID dan cap jari, yang disokong oleh mikropemproses ESP32, untuk meningkatkan pengurusan kehadiran di Masjid UTeM. Sistem ini menyederhanakan operasi, mengurangkan usaha manual, dan menyumbang kepada pengurusan kehadiran yang efektif, memastikan pengalaman sembahyang berjemaah yang lancar dan teratur untuk semua peserta. Penggabungan berjaya perkakasan, perisian, dan Google Sheets menonjolkan komitmen untuk memanfaatkan teknologi demi peningkatan operasi masjid.

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ACKNOWLEDGEMENTS

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CHAPTER 1

INTRODUCTION

1.1 Background

In the 21st century, technology has rapidly advanced, encompassing various aspects of our lives, with a focus on ensuring personal and environmental safety. Traditional pen and paper attendance systems have become unreliable and difficult to maintain, lacking the capability for remote monitoring over long distances. To address this, we propose an automatic attendance system using RFID and biometric fingerprint technology, specifically designed for UTeM Mosque. This system allows the management team to keep an accurate record of people entering the mosque. Attendance data is automatically updated on a dedicated Google sheet, accessible from any internet-enabled device, providing convenience and remote accessibility. The integration of RFID tags and biometric fingerprint recognition enhances security and accuracy, ensuring the correct identification of individuals. This modern solution improves efficiency and eliminates the need for manual control, aligning with the technological advancements of the 21st century while meeting the requirements of UTeM Mosque's attendance monitoring needs.

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1.2 Problem Statement

The majority of the attendance system currently in use relies on manual processes, where users are required to provide their information on a paper sheet or logbook, and the mosque manager needs to update it regularly. However, this manual system presents several challenges.

i. Individuals attending the mosque must wait in queues outside to fill in their information before entering.

ii. Risk of the logbook or paper being misplaced, leading to the potential spread of congregants' personal information.

iii. The requirement to wait in queues leads to unnecessary time consumption.

1.3 Project Objectives

The main objectives of this project are:

1. To construct a reliable and user-friendly attendance system using fingerprint and RFID technology.
2. To integrate a Google sheets system for storing and managing attendance records electronically.
3. To test the accuracy and efficiency of the system in recording attendance in UTeM Mosque.

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1.4 Scope of the Project

- The project's main focus is an attendance system based on fingerprint biometrics and RFID which connected to ESP32 microcontroller.
- Design the Google sheets schema to efficiently store fingerprint and RFID tag-based attendance data.
- Monitor the system's performance based on time consume by user, Google sheets capability and the effectiveness of the system.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A literature review is a thorough summary of all published research papers on a specific subject. It should list, characterise, condense, analyse, and provide clarification on the body of prior research. Additionally, it presents the most recent information about a subject, including original discoveries as well as theoretical and methodological advancements. This section will cover the present existing system, various types of solutions that can address the drawbacks of the conventional attendance system by using the current existing system, as well as the advantages and disadvantages of contemporary systems.

2.2 Biometric based attendance system

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With the help of biometrics, users can be authenticated or identified by their distinctive patterns of physical or behavioural characteristics [1]. In order to solve the flaws in knowledge-based identity data, enterprises have progressively turned to biometric systems in recent years. Additionally, there have been other areas of innovation: in addition to the use of physical biometrics like the fingerprint, face, or palm, vendors have created systems that recognise behavioural patterns and have included new capabilities like liveness detection and the accompanying security processing [2]. A person's fingerprint, finger vein, iris, voice, face, and other biometric characteristics are only a few examples of the attributes that can be defined for them [1]. Because human fingerprints differ from one another, it is challenging to fake biometric data. A lot of company had introduced various types of biometric authentication device and software for attendance marking.

2.2.1 Fingerprint

One of the most established and well-known technologies for using fingerprints for individual identification is one that everyone has on their finger. Fingerprint consists of patterns of ridges and valleys which are formed as a result of genetic and environmental factors [3]. Finger print recognition is regarded as the most reliable and accurate biometric identication system available [4].Shoewu and Idowu [5] suggested that a fingerprint scanner attendance system are more secured and faster compared to manual attendance system. The motivation behind why is that finger impression confirmation is mainstream is on the grounds that fingerprints are special as an individual ID, it was significantly steadier, enduring and effectively taking. Each area fingerprint scanner (sensor) has a unique scanner pattern that can be used to distinguish one scanner from another [6]. Unique Finger Impression Based on participation the board framework, finger impression verification is adjusted into participation the executives' interactions with students. It is composed of the two approaches of enrollment and approval. The purpose of enrollment is to recognise a user by utilising their ID, capture their biometric fingerprint, and save it in the database following feature extraction. It will be referred to as the minutiae point of the fingerprint in feature extraction. The properties of the print, such as orientation and variations in the direction of ridges, arches, circles, and threads, can be filtered out. The format that is used to determine the client's personality and organise the confirmation cycle is built around these capabilities. The user's biometrics will be once again taken during authentication, and the characteristics will be compared to the biometric data already stored in the database to find matches. The users' id used in the matching templates will be utilised to track attendance after a successful match. This work creates a programme with a fingerprint recognition and identification system that includes a database that saves user information using a fingerprint reader as input to obtain attributes. The user's attendance history as well as other biometric information, such as their fingerprint template, will be stored in the database. The suggested attendance system's ability to match scanned IDs with IDs stored in databases was examined by the authors of the study, and they also compared how long it took the proposed system to check attendance with the manual system. Based on their implemented method, which beat the manual technique by an average of 12 seconds with a 94 percent success rate while using the manufacturer's fingerprint scanner Self Development Kit (SDK) and Microsoft SQL. According to the time duration reports, fingerprints have also been employed in to identify individuals and determine the attendance percentage [7,8]. Figure 2.1 shows the general architecture of a fingerprint based attendance system. Figure 2.2 and 2.3 shows the comparison of success rate and failure rate of attendance system where it is compared with the manual attendance system.

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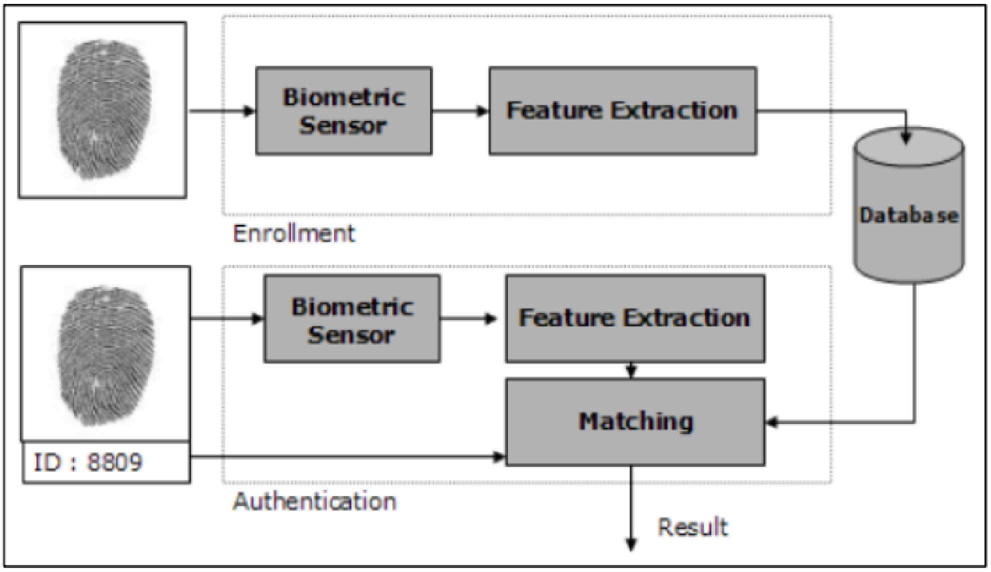

Figure 2.1 General architecture of a biometric system [5]

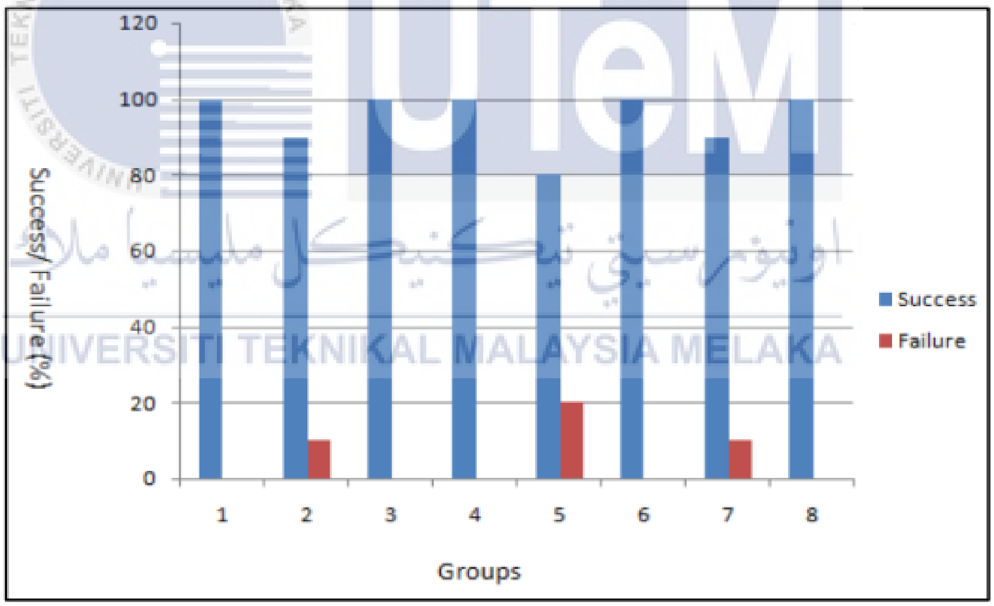

Figure 2.2 Shoewu and Idowu: Comparison of success rate and failure rate [5]

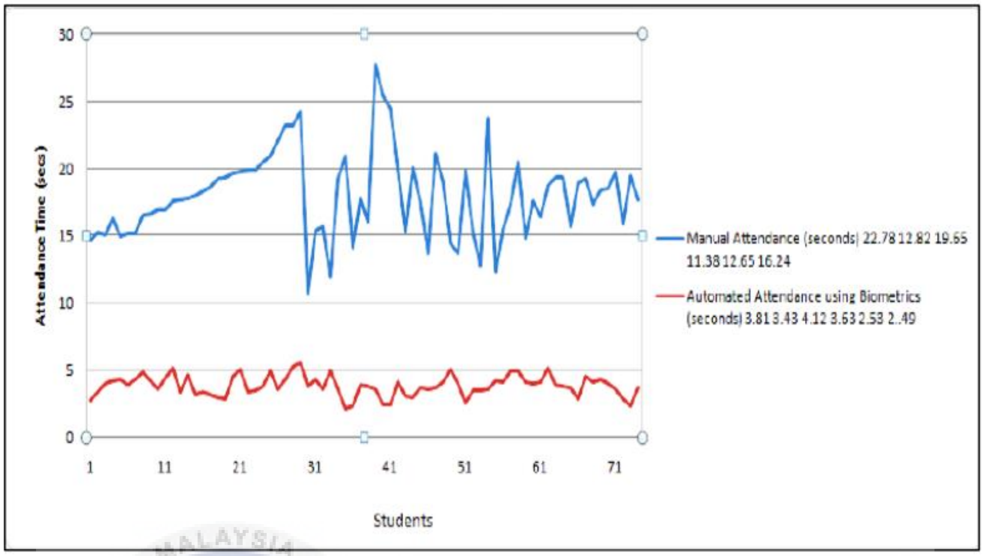

Figure 2.3 Shoewu and Idowu: Comparison between manual attendance system and the proposed system [5]

2.2.2 Iris Recognition

Iris pattern is a very efficient alternative method for human identification that is very dependable, especially when searching huge databases without producing any false matches [9]. Iris recognition uses stability and individuality to consistently identify a person. One of the most discriminative biometric techniques, iris recognition, uses the chaotic patterns that exist in each individual's iris [10]. No two irises are same, even those of the same person's left and right eyes do not look the same, which explains why it is growing in popularity. Iris structure is fully developed by the time a person is ten months old and stays the same throughout their lifetime, although other identifying characteristics can alter as people mature [11]. Because it compares 240 different iris reference points, iris recognition technology has a higher level of precision. The idea of identifying someone based on their iris pattern originally featured in the James Bond film, which was released in 1962 [12]. In 1936, ophthalmologist Frank Burch presented the mechanism to identify a person using iris pattern. In 1987, two other ophthalmologists, Aran Safir and Leonard Flom, filed a patent for this concept. In 1989, these two doctors approached John Daugman to develop iris recognition algorithms. It is clear why iris recognition-based identification systems are so popular because to the iris extraction feature's outstanding high-dimensional information [13,14]. The iris, which is located between the cornea and the lens and is a circular diaphragm perforated by the pupil, is present on the eye. The iris determines the amount of light that can pass through the pupil, a circular aperture area. The iris's diameter, which is about 12mm, can vary from 10% to 80% of the pupil's size [15]. Instead of signing an attendance sheet, each person will have their iris pattern matched, and once matched, they will be registered. A live image of a person's iris is captured by the proposed system's camera, and the data is then saved in a database. A secure biometric approach was presented by Sadhya and Raman in 2019 and is based on the creation of a cancellable IRIS template, known as a Locally Sampled Code (LSC), from IRIS code sampling using a localised sensitive hashing (LSH) technique [16]. This approach groups samples that are distinct into one group and those that are similar into another bucket. Estimates were made of the intra-group and inter-group collision probabilities of two different IRIS codes. In comparison to other systems of a similar design, it offers a high level of security against numerous threats and also has a better EER (0.105 in CASIA v3 and 1.4% in ITTD). Ma et al. developed an authentication method for the Smart grid in 2020 that combined eye movement with a system for object detection based on iris scans [17]. As a result, iris recognition is regarded as one of the most accurate and trustworthy biometric technologies,

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and it is used in a variety of applications, including commercial products, citizenship verification, border control, and forensics [18]. However, a number of acquisition elements, such as the eyes (posture, motion, and occlusions), devices (optical lens, sensor, electronic control unit), and surroundings (illumination), invariably affect the recognition performance of the system [19]. Figure 2.4 shows the iris recognition based attendance system and figure 2.5 shows an block diagram on how the attendance has taken and recorded on database.

Figure 2.4 Iris recognition-based attendance system [15]

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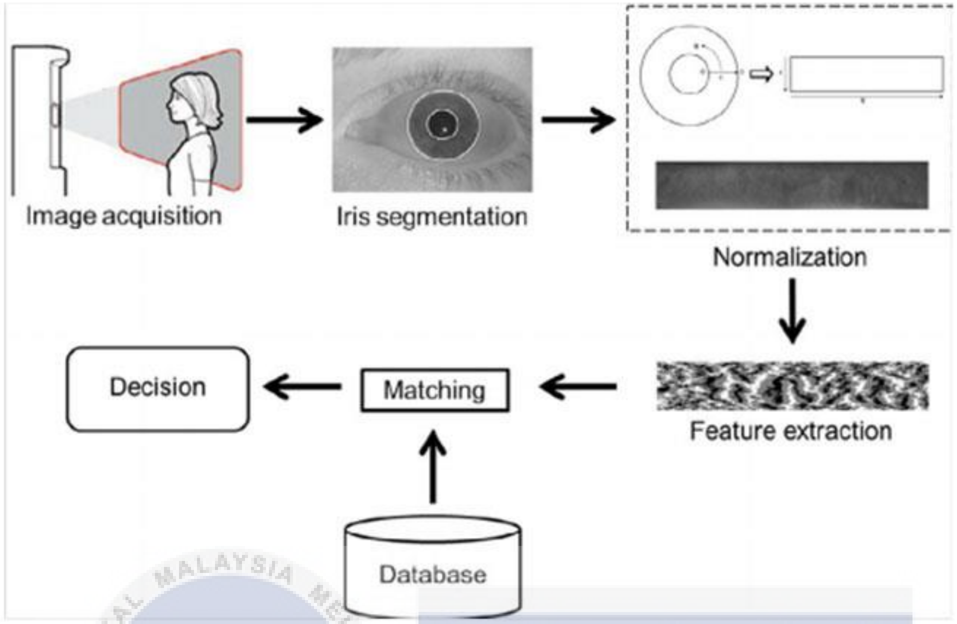

Figure 2.5 A block diagram of an Iris recognition-based attendance system [18]

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2.2.3 Face Recognition

A facial recognition system is a computer programme that takes numerous pictures of a person and retains the information about that person's face so that it can identify that person when they reappear in front of the camera [20]. Face detection, feature extraction, and face recognition are the three fundamental procedures needed to create a reliable face recognition system [21,22].There are many applications for this technology in daily life, particularly in security and surveillance systems. Using a framework or programme called facial recognition technology, it is possible to verify a person's identity by reviewing an image or piece of video. Face recognition is a simple procedure for people. We have specialised nerve cells for particular natural characteristics of a scene, like lines and edges, as established by Hubel and Torsten Elie Wiesel. Humans do not view the earth as a collection of random objects, thus our vision should synthesise the various sources of information into a coherent and beneficial pattern [23]. Automatic face identification requires taking significant details out of a picture, turning them into a meaningful representation, and then quietly categorising them. OpenCv, an open source module, is used for face recognition, three-dimensional reconstruction, and target recognition. To avoid utilising a proxy, this might be utilised. As a result of improved facial recognition algorithms, support systems, and equipment, the stability and efficacy of the attendance quality in workplace settings are guaranteed [24]. The updated facial recognition architecture in was proposed by Shebani et al., and it combines three- and four-patched LBP with Linear Discriminant Analysis (LDA) and Support Vector Machine (SVM) to improve face identification accuracy by embedding similarities between nearby pixel patches [25]. The accuracy of the facial recognition model was further increased to 87-90% by T. V. Dang et al. [25]. The feature extraction from the histogram has also had an effect on the recognition process [26]. Figure 2.6 shows the attendance system of face recognition.

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Figure 2.6 Face attendance system [21]

2.2.4 Voice Recognition

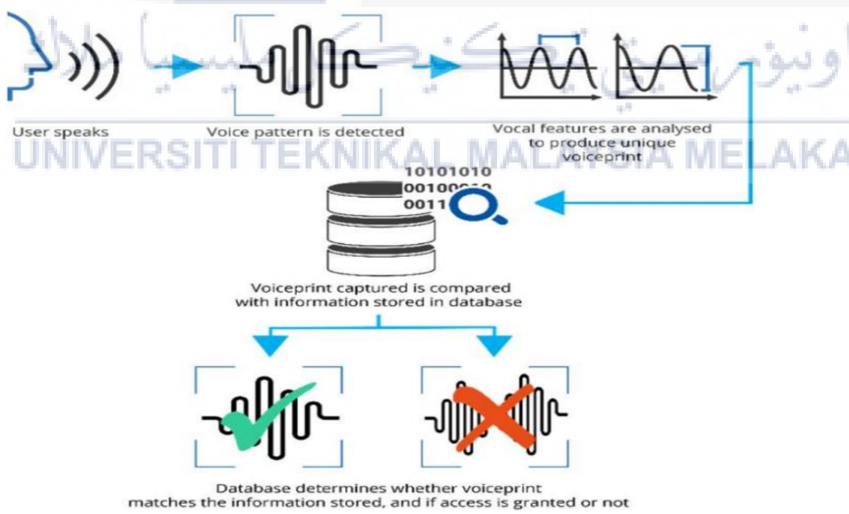

Figure 2.7 Voice recognition attendance system [30]

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The combination of the moving parts in the mouth and throat, which have both physiological and behavioural qualities, is what gives the human voice its sound [27]. Voice can be used as a vital biometric system based on a variety of factors. The distinctiveness of each individual voice is defined by the acoustic composition of the language with varied frequencies and amplitudes.Due of the numerous applications it can be used for, voice biometrics has recently grown in prominence. This biometric system as a whole is distinctive for its rigidity, precision, and incapacity to adapt to environmental changes. The majority of systems use both speaker detection and voice detection, although each has a different purpose and implementation strategy and relies on human speech [28]. Though popular and reasonably priced, voice recognition is less accurate and frequently takes longer [29].Voice recognition software transforms audio input into text. It is then saved in the database [30]. Figure 2.7 shows on how the audio input changes into text and saved in the database. Voice based recognised system is one of the most distinctive human biometric features. In this system, we have a microphone that records the voices of the students. The recorded voice is segmented into different parts, such as frequency, frequency band, amplitude, and top pitch. The voice signal is then converted into an electrical analogue signal, which is then converted into a digital signal processing method [31]. Development of Voice Recognition for Student Attendance examines speaker recognition's characteristics and the efficiency of using the Euclidean distance feature to speaker recognition [32]. First, the background noise should be reduced to a minimum for increasing the accuracy of the voice biometric system. Filtration will help for that but also increases the complexity of the amplitude range of the recognized voice. This will help the admin to record the correct voice of the individuals who comes with multiple sets of data, to gain accuracy in the system. It is also observed that the software can increase the blockage of incorrect data from being displayed. To keep the security system and easy authentication access, the biometric system is capturing a way out with all consumer electronic devices such as home security, transportation, automobiles, logistic and defence as well [33,34].

2.3 Non biometric attendance system

2.3.1 Barcode

Optical scanners are used in barcode technology to read information such as numbers, letters, pictures, and locations. Either a one-dimensional or two-dimensional coding may be used [35]. Linear barcodes, commonly referred to as one-dimensional barcodes, are a type of barcode. They are made up of vertical lines of various widths separated by predetermined gaps to form a particular pattern. Although linear barcodes have many benefits, they also have some serious drawbacks, such as the limited data storage capacity and serious encoding problems brought on by barcode breakage and distortion [36]. Figure 2.8 shows the anatomy of barcode about one-dimensional coding. However, two-dimensional code is created as geometric objects with various features, such as boxes, hexagons, and other shapes [35]. When reading a barcode, a barcode reader uses a laser beam that is reflection-sensitive. Reading a direct and flattened code is necessary since barcode data transmits via optical signal. The ease of use, low cost, and extensive application of barcode technology in a variety of industries including those that deal with goods and services are its primary benefits [37]. While reading and inputting data may now be done more quickly and accurately thanks to barcodes [38].

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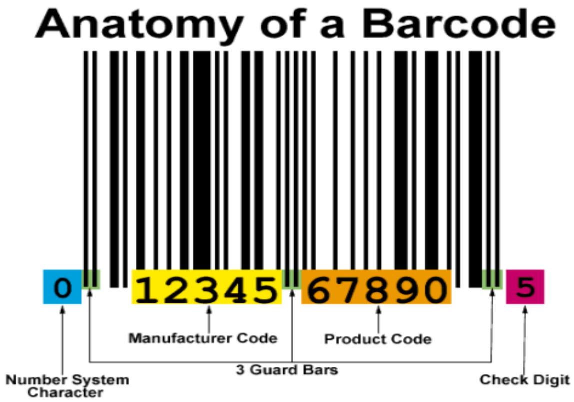

Figure 2.8 Anatomy of barcode [35]

The effectiveness of a barcode attendance system for students attending various sections in their university was demonstrated by Kizildag et al [39]. Figure 2.9 shows the proposed offline and online system of Kizildag et al. The issue arises when a sizable gathering of students must quickly vacate the designated space in order to attend their lectures. 300 students' attendance was able to be recorded utilising a barcode reader and both an online and offline attendance system in 15 minutes as opposed to 35 minutes after stamping each student's attendance card. In addition to saving time when recording attendance for big groups, the suggested barcode approach also enables administrators to verify the accuracy of the attendance and examine the specifics of the event that a particular student or group attended.

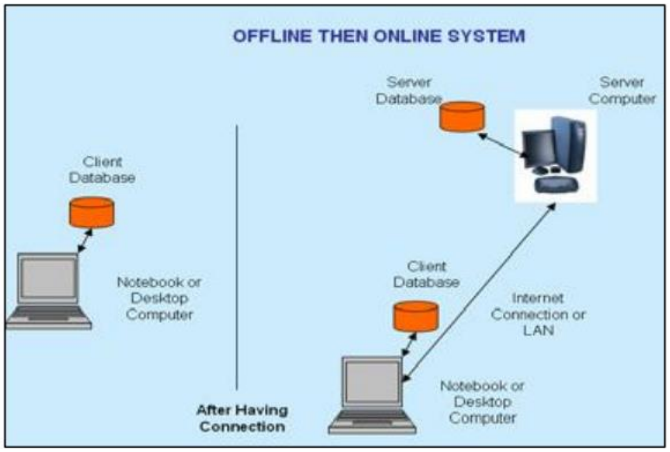

Figure 2.9 Kizildag et al: Proposed offline then online system [39]

2.3.2 RFID Tag

An RFID tag is a tiny item, about the size of a rice grain, that contains an antenna and a microchip. The Electronic Product Code (EPC), a unique hexadecimal code found on each RFID tag, is used to identify products. Radio waves are used to transmit the information. In order for a user to access the data stored on the microchip inside an RFID tag, an RFID reader is required. RFID tags come in two varieties: passive tags and active tags. Passive tags can only transfer data over limited distances and require an external power supply from an RFID reader in order to do so. Contrarily, an active tag includes a built-in battery that means it can transmit data over a long distance without the need for an additional power source. Figure 2.10 shows passive and active RFID tag. Commerce, healthcare, education, and security are just a few of the sectors that employ RFID technology extensively. Radio frequency identification (RFID) is mostly used for tracking individual objects [44].

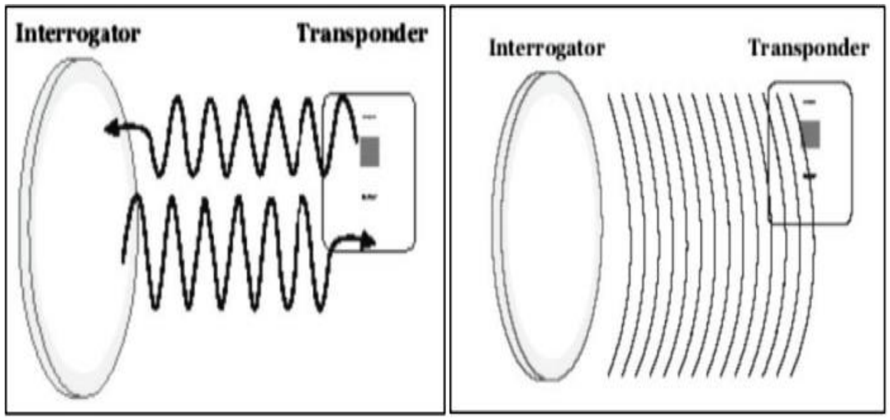

Figure 2.10 Passive and active RFID Tag [44]

One or more tags plus a reading device called a reader make up an RFID system. Each RFID system may use a low, high, or ultra-high frequency band to operate. Between 30 KHz and 300 KHz are the frequencies covered by the low-frequency band (LF). LF RFID systems typically operate at 125 KHz. Three to thirty MHz make up the high band (HF). The majority of HF RFID systems operate at 13.56 MHz and have reading ranges of 10 cm to 1 m. The 300 MHz to 3 GHz range is covered by the ultra-high frequency band (UHF), often known as the recurrence band [45]. To make your presence known, all it takes is one swipe. The user must always be in possession of the RFID card that the reader can read. The card is immediately recognised by the reader, who then extracts its contents [46,47]. We can determine whether or not he entered the building with the help of this information. The traditional RFID scanning method was integrated with a remote monitoring capability by Singhal and Gujral [48]. The device will automatically mark students as present and add a time stamp after they place their matric cards on the RFID reader as shown in Figure 2.11. Because all of the hardware components were manufactured by the authors and did not primarily rely on other sources, the studies concentrate on both hardware and software advances. In contrast, Qaiser and Khan [49] scan and read an active RFID tag using an interrogation field. The authors emphasised benefits of RFID tags over barcodes, such as reading even when there is no line of sight on the tag, a substantial reading distance, and the ability to read many tags at once. The proposed system's key benefit is that everything is automated and doesn't need any human input. Via the offered website, the administrator has access to the data.

Figure 2.11 RFID based attendance system [48]

2.3.3 QR Code Attendance System

In the phrase "QR Code," the letter "QR" stands for "Quick Response." It is a member of the two-dimensional coding family, which was founded by barcodes [50]. Data are stored both vertically and horizontally in a 2D barcode, which is a graphic image. As opposed to the 20 characters in a one-dimensional barcode, this allows storage of up to 7,089 characters. In contrast to ordinary barcodes, it can store a lot of information and is quickly readable. Today, a lot of people utilise QR codes for marketing strategies and as an alternative to business cards. Numerous businesses have strategically adopted QR codes, and they are now reaping the rewards [51]. A QR code-based method that displays the QR code to pupils at the start of or throughout each lesson is advised by F. Masalha and N. Hirzallah [52]. The suggested method was to employ cloud services

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to save, retrieve, and maintain records of attendance. Student attendance system based on QR code with unique identifying capturing [53]. The system was split into three sections, where the teacher must log in to the web module and students must use the mobile module to scan the QR[53] as shown in Figure 2.12. A web-based application called Student Attendance Information System Using QR Code (Quick Response) [54] was created and can work with mobile apps. The system administrator must oversee all website data, including student information, lecture content, and class schedules.

Figure 2.12 QR code based attendance system [53]

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2.3.4 Mobile Application

University attendance records must be replaced as a result of the internet of things (IoT) taking off in the digital era. As a result, an Android-based mobile application using an attendance system was created [40]. The Figure 2.13 shows the Android-based mobile application. This mobile application attendance system will need to be included to the allocation form input initially. It will be made on the timetable, subject entry, and student details forms. Calculating attendance by subject will be made easier. Additionally, every necessary verification is described in detail on the forms. This mobile application's attendance system offers the option to submit attendance information for a single subject or for all subjects. A database that contained student data and attendance records was connected to the attendance system. Additionally, the user interface presented the attendance records in a pleasing manner and made it simple for lecturers or system administrators to handle them [41]. As a result, B. Soewito, F. E. Gunawan, and M. Hapsarain, the researchers, made full use of the features offered by smartphones [41]. This tool enables users to communicate with students and record attendance on their mobile devices. The teachers can also amend their attendance and add marks to the system database for later retrieval using this programme [42]. Calculations of the attendance percentage can be done using the data that has been saved, and SMS reminders can be sent to the parent to keep them informed about their child's attendance in the school [43].

Figure 2.13 Attendance by android [40]

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2.4 Comparison

Table 2-1 Comparison of biometric attendance system

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Biometric system	Advantages	Disadvantages
1. Fingerprint based attendance system	i. High Accuracy: Fingerprint biometrics provide a high level of accuracy in identifying individuals [55]. ii. Quick and Efficient: Fingerprint scanning is a fast and efficient process [55]. iii. Integration with Database Systems: Fingerprint attendance systems can be easily integrated with database systems, Google sheets allowing seamless recording, storage, and retrieval of attendance data [55].	i. Environmental Factors: External factors, such as dirt, moisture, or injuries to fingers, may affect the accuracy of fingerprint recognition [55]. ii. Privacy Concerns: Some individuals may have concerns about their personal privacy when their biometric data, such as fingerprints, is stored and used for attendance tracking [55]. iii. User Acceptance: Some individuals may be uncomfortable or hesitant to use fingerprint scanning technology, leading to initial resistance or skepticism [55].

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Biometric system	Advantages	Disadvantages
2. Iris Recognition-Based Attendance System	i. No physical contact when scanning [55]. ii. Accurate matching performance [55]. iii. Can be captured from a distance [55].	i. Cannot use a regular camera: requires IR light source and sensor. Visible light must be minimized for highest accuracy required for search [55]. ii. Generally, require close proximity to camera, which can cause discomfort for some [55]. iii. Expensive: Iris scanners are relatively higher in cost compared to other biometric modalities. As one of the leading and latest technologies of modern times, the cost of iris devices is fairly high [55].

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Biometric system	Advantages	Disadvantages
3. Voice Recognition-Based Attendance System	i. Security: Voice recognition attendance systems provide a high level of security by verifying the identity of the person based on their unique vocal characteristics. This reduces the chances of fraudulent attendance marking or buddy punching [55]. ii. Accuracy: Voice recognition technology has significantly improved in recent years, resulting in high accuracy rates [55]. iii. Convenience: Voice recognition attendance systems offer a convenient way for employees or students to mark their attendance without the need for physical contact or manual input [55].	i. Language barriers: Voice recognition systems can be affected by language variations, accents, or dialects [55]. ii. Privacy concerns: Voice recognition systems involve the collection and storage of individuals' voice samples, which raises privacy concerns [55]. iii. Integration complexity: Implementing a voice recognition attendance system may require integration with existing attendance management software or infrastructure [55].

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Table 2-2 Non-Biometric attendance system

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Non- biometric system	Advantages	Disadvantages
1. Barcode Attendance System	• Simplicity: Barcode attendance systems are relatively straightforward to implement and use [56] • Cost-effective: Barcode systems are generally more affordable compared to other attendance tracking methods [56]. • Accuracy: Barcode scanners provide accurate and reliable attendance tracking. Scanning barcodes eliminates the chances of manual errors that can occur with paper-based systems [56].	• Vulnerability to fraud: Barcode attendance systems are susceptible to barcode duplication or sharing [56]. • Limited data capture: Barcode systems primarily capture attendance data but may not provide additional information about the attendees, such as their identity or specific details [56]. • Maintenance and wear-and-tear: Barcode scanners may require periodic maintenance and calibration to ensure proper functionality. Over time, scanners can become less accurate or suffer from wear-and-tear, which can impact the reliability of attendance tracking [56].
2. RFID Attendance System	• Easy and Convenient: RFID attendance systems offer a convenient and user-friendly method [57].	• Card Management: Administrators need to manage the distribution and maintenance of RFID cards, ensuring they are issued to the correct individuals and replacing lost or damaged

Non- biometric system	Advantages	Disadvantages
	• Fast and Efficient: RFID technology enables quick and efficient attendance recording, allowing multiple attendees to be processed rapidly. ording attendance [57]. • Scalability: RFID systems can easily scale to accommodate a large number of attendees [57].	cards when necessary [57]. Need for • Card/Tag Carrying: Attendees must carry their RFID cards or tags to record attendance accurately [57]. • Range Limitations: RFID systems typically have limited range capabilities. The RFID reader must be in close proximity to the RFID card or tag to detect and record attendance [57].
3. QR Attendance System	• Ease of use: QR code attendance systems are user-friendly and convenient. Attendees can easily scan the QR code using their smartphones or dedicated scanners, eliminating the need for complex technology or training [53]. • Cost-effective: QR code systems are	• Smartphone dependency: QR code attendance systems rely on attendees having smartphones with QR code scanning capabilities [53]. • Privacy concerns: QR code systems may raise privacy concerns, especially if additional attendee information is captured beyond just attendance [53]. • Vulnerability to fraud: While QR codes are more secure compared to barcodes, they can still be vulnerable to duplication or sharing. Attendees could

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Non- biometric system	Advantages	Disadvantages
	typically more affordable compared to other advanced attendance tracking methods [53]. • Real-time data capture: QR code attendance systems can capture attendance data in real-time. This enables administrators to monitor attendance instantly and generate up-to-date reports [53].	potentially share their QR codes with others, leading to attendance discrepancies and compromising the accuracy of the system [53].
4. Mobile Application for Attendance System	• Real-time Data: The mobile application can provide real-time attendance data, allowing administrators to view attendance information instantly [40]. • Automated Data Syncing: Attendance data recorded through the mobile application can be automatically	• Device Compatibility: Mobile applications may not be compatible with all smartphone operating systems or device models, potentially limiting the accessibility for some users [40]. • Device Reliability: The performance and reliability of attendance recording can be affected by factors such as battery life, device malfunction, or application crashes [40]. • Network Connectivity: Mobile applications rely on stable internet or cellular connectivity

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Non- biometric system	Advantages	Disadvantages
	synchronized with the central database [40]. • Efficiency and Time-saving: Mobile attendance applications streamline the attendance recording process, saving time for both attendees and administrators [40].	for real-time data syncing and attendance recording [40].

2.5 Summary

Based on the literature reviews, the main components that had been chosen for this project are RFID based attendance system and fingerprint based attendance systrem because users can either scan RFID card or fingerprint in order to mark attendance.

1. Accurate and Reliable: Both fingerprint and RFID card systems offer accurate and reliable attendance tracking, minimizing the chances of errors, fraudulent attendance, or buddy punching.
2. Unique Identification: Fingerprint systems utilize biometric technology to identify individuals based on their unique fingerprints, while RFID card systems use unique card IDs. Both methods ensure that attendance records accurately reflect the presence of the actual person and prevent sharing or misuse of identification.

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3. Durability and Reusability: RFID cards are durable and can be reused multiple times, making them a cost-effective option. They can withstand wear and tear, providing long-lasting identification.
4. Convenience and Speed: Both systems provide convenient and efficient ways for attendees to mark their attendance. Fingerprint systems require individuals to place their finger on the scanner, while RFID card systems require a simple swipe or tap of the card on a reader.
5. Scalability: Both systems can handle a large number of attendees, making them suitable for places with high attendance rates. They provide fast and efficient data capture, accommodating future growth.

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CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter presents the methodology employed for implementing the attendance system based on multi-input identification using RFID and biometric fingerprint at UTeM Mosque. The methodology consists of several phases, each serving a specific purpose in the system's development and deployment. The chapter provides a detailed overview of each phase, outlining the activities and tasks involved. Furthermore, the necessary tools for system development, encompassing hardware and software components, are identified based on their relevance and suitability for the project. Additionally, the chapter outlines key milestones that act as checkpoints and targets throughout the project timeline, ensuring progress and successful completion of the attendance system.

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3.2 Project flow model

In this section, the methodology will explore various software development life cycle (SDLC) models that are relevant to the development of the attendance system. Each SDLC model will be evaluated to determine the most suitable approach for this project. Factors such as project requirements, timeline, team size, and risk management will be considered in selecting the appropriate SDLC model. By carefully assessing the strengths and weaknesses of each model, the methodology will identify the SDLC model that aligns best with the goals and constraints of the attendance system implementation at Utem Mosque.

The first model is iterative model.Iterative modelling is the original SDLC methodology. The incremental development method used in this SDLC approach is well renowned for being able to construct projects more quickly than the regular SDLC method. A large application is typically divided into smaller components, each of which is then improved iteratively to create a useful application for the project's development. At the end of each iteration, this process will continue to be repeated, and at that point, a better version of the application will have been improved. This might be explained by the possibility of reviewing, implementing, and testing the project's previous iteration before advancing to a more sophisticated and intricate programme as shown in the Figure 3.1. The benefit of an iterative approach is that it may start off some modules faster and more efficiently. More time and money will be saved by using the SDLC model early in the development process. Supporting shifting demands will be the next benefit. To prevent a system failure in the future, it may be necessary to replace or modify some functional requirements when they do not produce the desired results.

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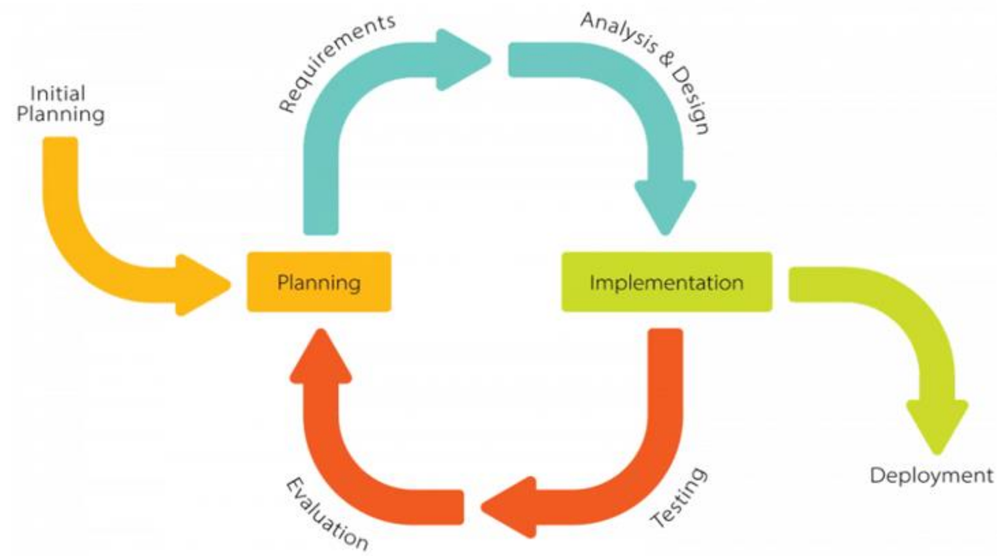

Figure 3.1 Iterative model

Agile is the following SDLC model. As an incremental improvement to the SDLC technique, it was identical to the initial iterative SDLC model. In order to develop a project quickly, there will be a greater focus on the development process and client feedback. It might be said that since project requirements can change often and are then followed by client feedback, limited preparation will be sufficient for personnel to begin the project. The frequent delivery and shorter total development time are benefits of the agile paradigm. The project can be developed quickly by the developer, who can then use client input to decide whether or not the product needs adjustments. Other than that, this SDLC approach's technique will call for less documents that need planning and analysis. This could imply that delivering the prototype to the client could cut down significantly on development time for the developer. In Figure 3.2 it shows the flow of agile model.

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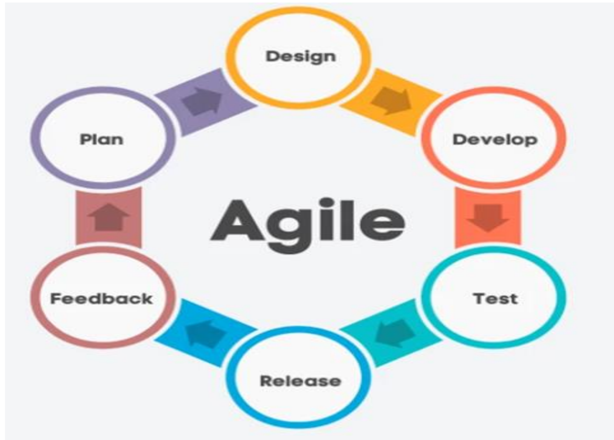

Figure 3.2 Agile model

Thirdly, the classic SDLC model is the one that is most frequently used for software development. This SDLC approach to software development was still being used in many projects. Any software development team can easily comprehend and apply this SDLC paradigm. In this SDLC model, each of the phases that make up the model must be finished before moving on to the next phase as shown in Figure 3.3. This may imply that each step must be completed in order. The workflow and documentation under this approach will also be well-organized, making it simple to go back and find the material from earlier phases. The advantage of this waterfall paradigm is that each phase, procedure, and result were well-documented. This could be explained by the fact that the SDLC strategy will keep thorough records throughout each step, making it easy to look back on them once the maintenance phase arrives. Other than that, this waterfall approach has the benefit of making task organisation during the development phases simple. Every stage of development will be carried out in a precise order that is made evident to everyone while the development team is performing its duties.

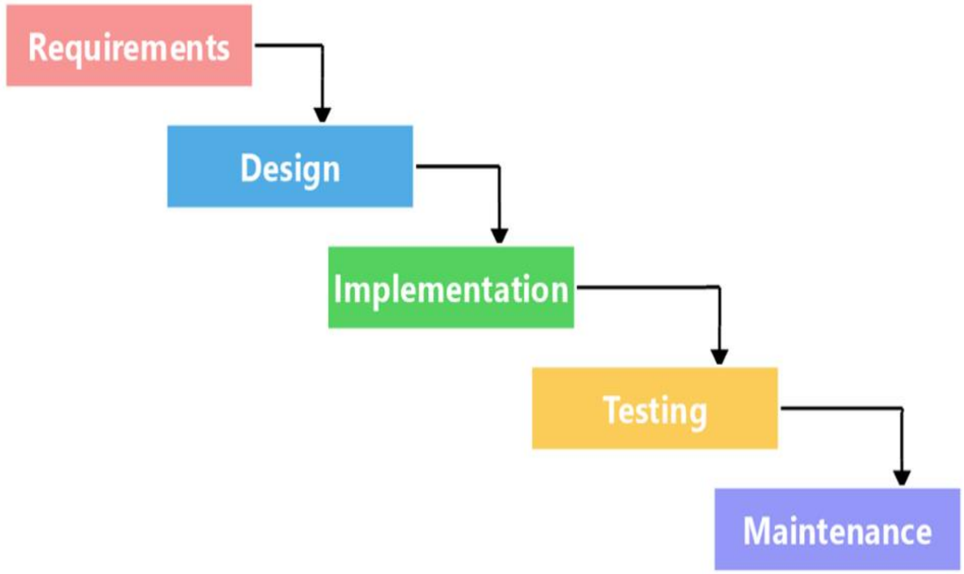

Figure 3.3 Waterfall model

The selected model for the implementation of a fingerprint and RFID attendance system project, the Iterative SDLC strategy has consistently been found to be very suited due to its inherent advantages in the SDLC research. The project team can respond successfully to shifting requirements, feedback, and emergent needs thanks to the flexibility and adaptability of this technique. Stakeholders can see real progress and offer early feedback by splitting the project down into smaller iterations, each of which delivers a functional portion of the attendance system. Due to the incorporation of feedback and modifications from stakeholders into successive iterations, this incremental delivery promotes ongoing improvement. Throughout the project, it is encouraged for stakeholders to participate, ensuring that the attendance system satisfies their particular demands and is compatible with the particular requirements of the mosque community. Additionally, the iterative approach allows for early risk assessment and mitigation, addressing problems and difficulties in succeeding iterations while minimising delays to the overall schedule. A shared understanding of project progress, requirements, and expectations is fostered via improved communication and collaboration between the development team and stakeholders. To sum up, the iterative method provides the adaptability, continuous development, stakeholder involvement, risk mitigation, and improved communication needed for the project to successfully implement a fingerprint and RFID attendance system in a mosque.Figure 3.4 shows the project flowchart where it starts with research the initial design. After completed both of it the next process will be hardware integration and during test if the hardware integration is passed then it will continue to the next process which is software and hardware development. If the hardware integration fails it returns to the harware integration part again. As for software and hardware development also, if it is pass the move to final design of project then end. If it did not pass the process will return to software and hardware development. This whole process will be repeated until each phase completed without any error.

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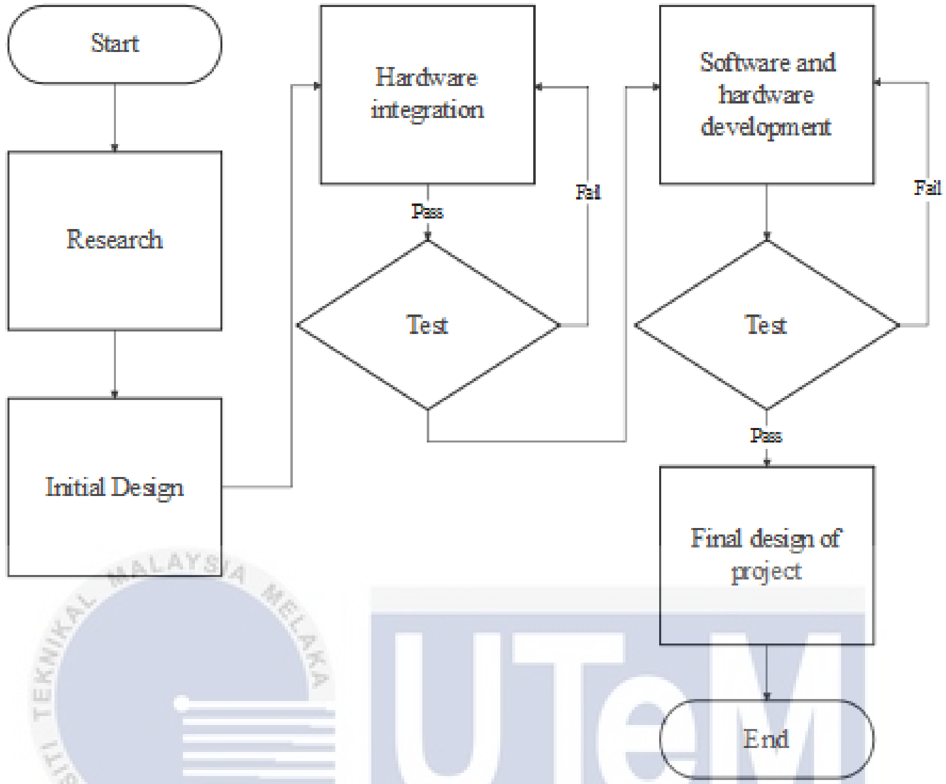

Figure 3.4 Project flowchart

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3.3 System hardware

Figure 3.5 shows the flowchart for the fingerprint based attendance system. Firstly, the attendees must scan their fingerprint in order to mark their attendance.The sensor will read the signal of the fingerprint and if it is matched then the attendance will be recorded in the Google sheets. If the matching is failed then the attendee must scan their fingerprint again.

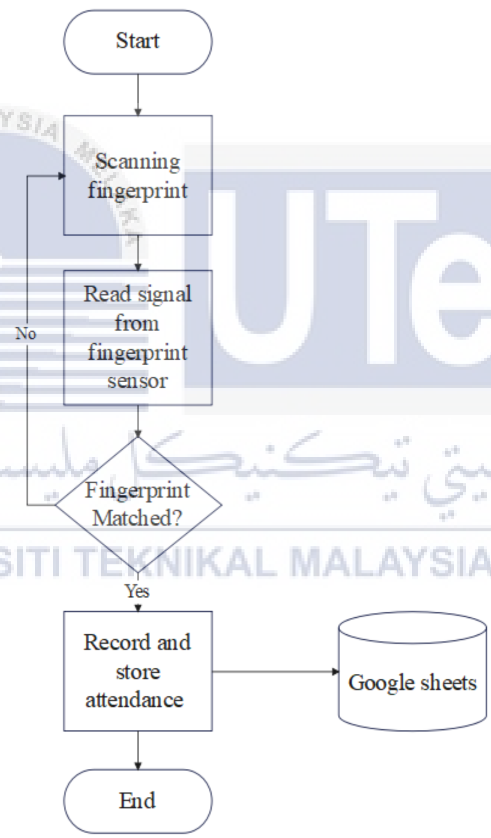

Figure 3.5 Flowchart for fingerprint based attendance system

Figure 3.6 shows the flowchart for the RFID based attendance system. Firstly, the attendees must scan their RFID tag in order to record their attendance.The RFID reader will read the signal of the RFID tag and if it is matched then the attendance will be recorded in the Google sheets. If the matching is failed then the attendee must scan their RFID tag again.

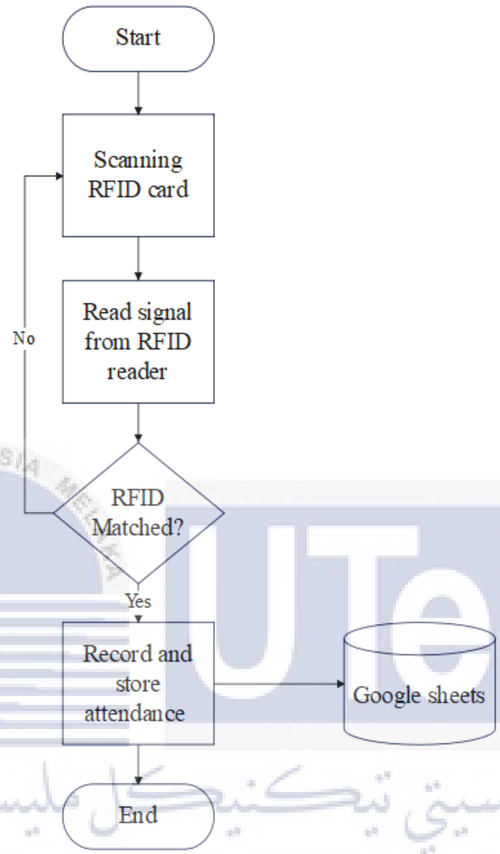

Figure 3.6 Flowchart for RFID based attendance system

Figure 3.7 shows the block diagram of the overall attendance system where all the components such as RFID reader, fingerprint scanner, LCD display, buzzer and power supply connects to the ESP32 microcontroller. The attendance will be send to Google sheets and stored there.

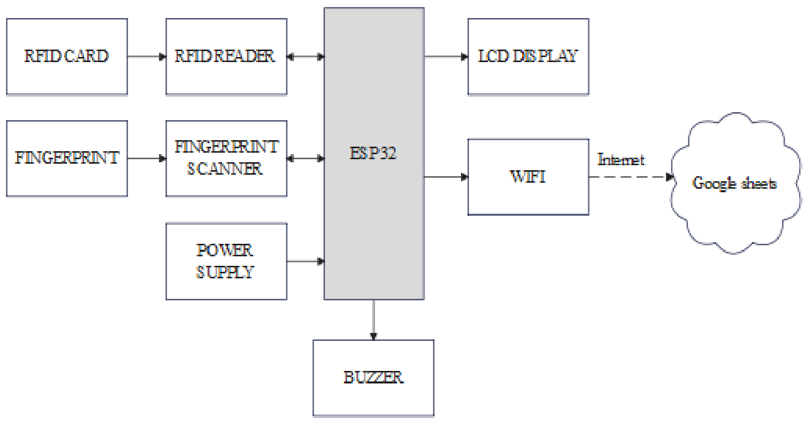

Figure 3.7 Block diagram of RFID and fingerprint based attendance system

Hardware Components

- ESP32

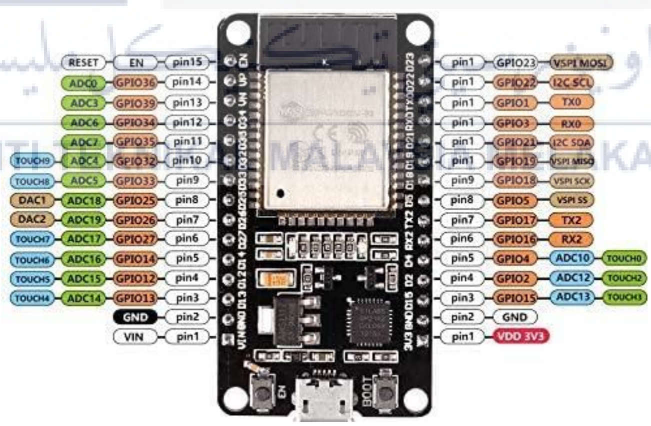

Figure 3.8 ESP 8266

The ESP32 as shown in Figure 3.8 serves as a powerful microcontroller with a built-in processor, memory, and GPIO pins. It can handle data processing tasks, manage sensor inputs from the fingerprint and RFID readers, and control the overallsystem operations.

- Fingerprint Sensor

Figure 3.9 Fingerprint sensor (AS 608 model)

A fingerprint sensor as per as Figure 3.9 is required to capture and read the unique fingerprint patterns of individuals. There are various types of fingerprint sensors available, for this project, optical sensor (AS 608) used to collect fingerprint data.Table 3-1 shows the detailed specification of AS608 fingerprint sensor.

Table 3-1 Specification of AS608 Fingerprint Sensor

Operation Voltage: (3.3~5)Vdc.
Interface: TTL Serial.
Baud rate: (9600~57600) (default 57600).
Rated Current: ~120mA.
Fingerprint imaging time: <1.0 seconds.
Storage capacity: 162 templates.
Template file: 512 bytes.
False Acceptance Rate: <0.001% (Security level 3).

False Reject Rate: <1.0% (Security level 3).
Safety Level: 1~5 low to high safety.
Temperature: -20 - +50 degrees.
Sensing Window: (16x18) mm.
Dimension: (56x20x21) mm.

- RFID Reader

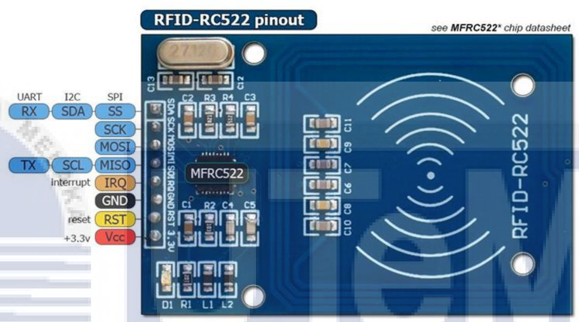

Figure 3.10 RC 522 RFID reader module

An RFID reader as shown in the figure 3.10 model RC 522 is necessary to read the data stored on RFID tags. The reader communicates with the RFID tags wirelessly and retrieves the unique identification information encoded on them. Table 3-2 shows the detailed specification of RFID reader, model RC522.

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Table 3-2 Specification of RFID reader

Operating voltage: 2.5V to 3.3V
Communication : SPI, I2C protocol, UART
Maximum Data Rate: 10Mbps
Read Range: 5cm
Current Consumption: 13-26mA
Power down mode consumption: 10uA (min)

- RFID Tags

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Figure 3.11 RFID Tags

RFID tags as per as figure 3.11 are small devices that contain unique identification information. Each employee or individual would typically have an RFID tag assigned to them, which they can carry with them and present to the RFID reader during attendance registration.

- Power Supply: Adequate power supply is necessary to power the components of the attendance system. This can be achieved using batteries, power adapters, or a combination of power sources.

- Buzzer

Figure 3.12 Buzzer

When an individual registers their attendance by presenting a fingerprint or RFID tag, the piezo buzzer as shown in the Figure 3.12 can provide an audible confirmation. This can be a brief beep or tone to acknowledge that the attendance has been successfully recorded. Table 3-3 shows the detailed specification of piezo buzzer.

Table 3-3 Specification of piezo buzzer

Rated Voltage: 12V
Operating Voltage: 3-24V
Rated Current (MAX): 10mA
Min Sound Output at 10cm: 90dB
Resonant Frequency: 3300+-500Hz

Operating Temperature: -20~+80ºC
Housing material: ABS
Diameter: 22.5mm
Dimension: 35mmx12mm(LxH)
Weight: 10g

- LCD display

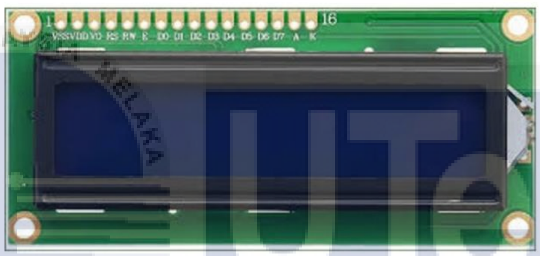

Figure 3.13 LCD display (I2C 16x2)

The LCD display (I2C 16x2) module as per as Figure 3.13 can show attendance-related information such as date, time, and the employee's name or ID. This provides users with immediate visual feedback about their attendance status. Table 3-4 shows the detailed specification of I2C 16x02 LCD.

Table 3-4 Specification of I2C 16x02 LCD

I2C Address:0x38-0x3F (0x3F default)
Supply voltage: 5V
Interface: I2C to 4bits LCD data and control lines.
Contrast Adjustment: built-in Potentiometer.

Backlight Control: Firmware or jumper wire.	
Board Size: 80x36 mm.	

Figure 3.15 shows the schematic diagram of RFID and fingerprint based attendance system on how its connection made.

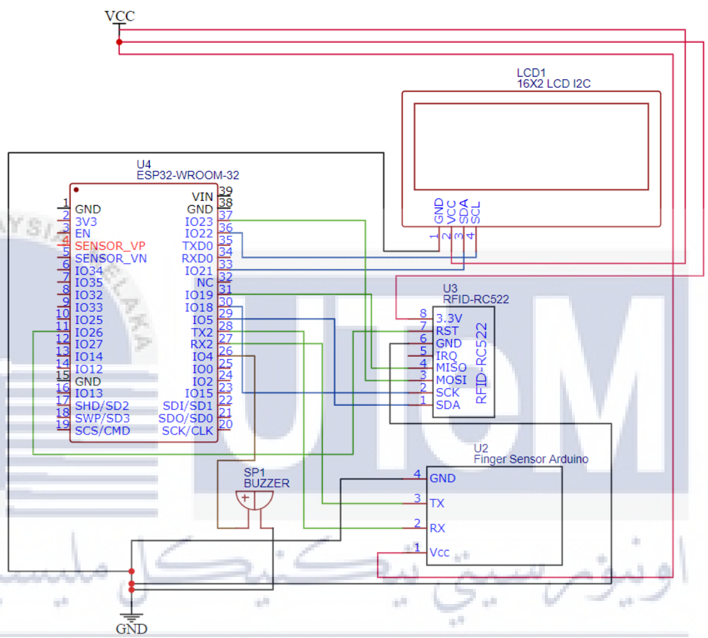

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Figure 3.14 Schematic diagram of RFID and fingerprint based attendance system

3.4 System software

- Arduino IDE

Figure 3.15 Arduino Ide software

The Arduino IDE as shown in Figure 3.16 serves as a programming platform for developing a fingerprint and RFID-based attendance system. It allows to write, compile, and upload code to an microcontroller, which acts as the brain of the system.

- Google sheets

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Figure 3.16 Google sheets

Google sheets as shown in Figure 3.17 serves as the central repository for storing attendancedata. It allows to define fields to store information such as user details, timestamps, and attendance records. By storing data in a structured manner, Google sheets enables efficient retrieval and management of attendance information.

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The flowchart in the Figure 3.18 shows the registration of fingerprint in the coding. Firstly, to register student's fingerprint, the sensor will capture the fingerprint and if the fingerprint quality is clear then the fingerprint registers under specific id (1-127), then student's information will be registered under the specific id in the coding. Upon successful registration the details of the students will be stored in the sensor and will be used to verify the student's information when they try to record an attendance. If it is failed to verify then the fingerprint need to recapture. The flowchart in the Figure 3.19 shows the registration of RFID tag in the coding. Firstly, to register student's RFID tag, the RFID reader will scan the tag and gets the tag's address, then the student's information will be registered under the address in the coding. Upon successful registration the details of the students will be stored in the RFID tag and will be used to verify the student's information when they try to record an attendance. If the RFID reader failed to scan the tag, then the tag needs to rescan again.

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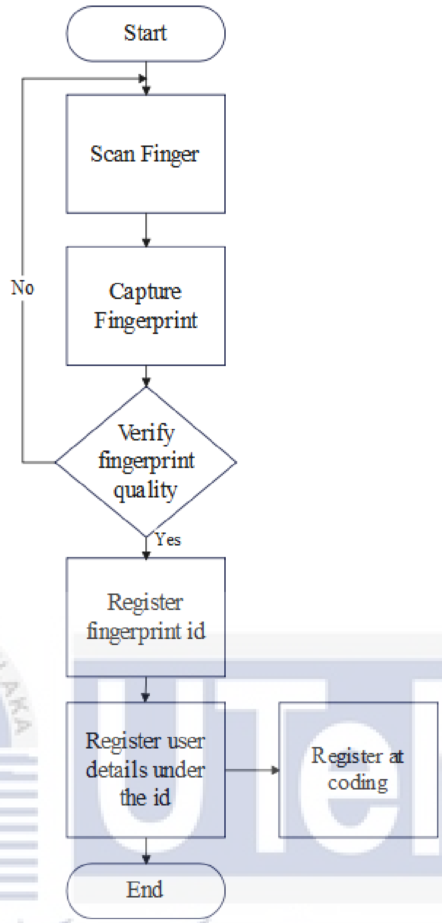

Figure 3.17 Fingerprint registration in database

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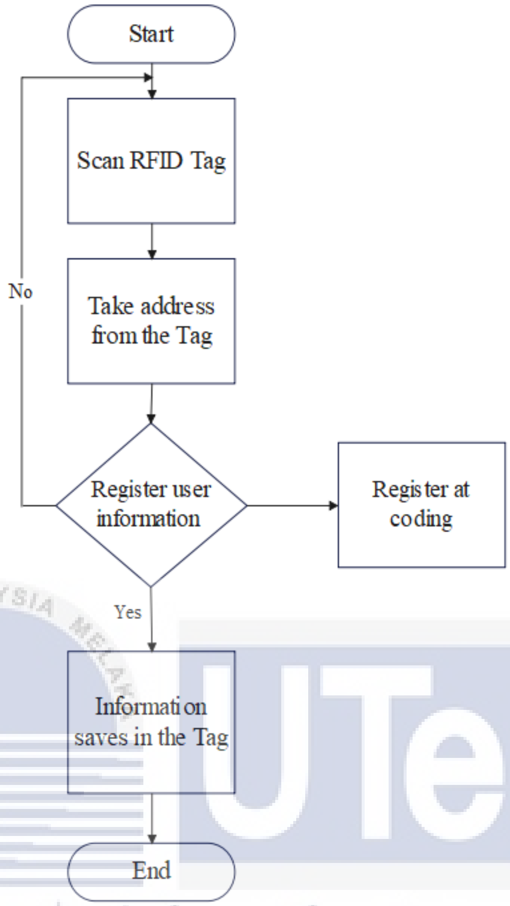

Figure 3.18 RFID registration in database

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3.5 Summary

The methodology for this project involved analyzing the requirements and objectives of the attendance system, designing the system architecture, and integrating RFID and fingerprint sensors with the ESP32 microcontroller. The system was developed using the Arduino IDE, with code written to capture attendance and store it in a Google sheets. Testing and validationensured the system's functionality, and the final implementation involved deploying the system at UTeM Mosque. The methodology followed a systematic approach, resulting in the successful development and deployment of the RFID and fingerprint-based attendance system.

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CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

The results and discussion section of this project provides an analysis of the outcomes and findings of the attendance system implemented at UTeM Mosque using RFID and fingerprint technology. This section presents a concise overview and evaluation of the collected data, focusing on the effectiveness, usability, and implications of the system in capturing and managing attendance records. The discussion highlights the recorded attendance data, success rates of the scanning methods, user feedback, and the impact of the system on administrative tasks and decision-making processes. The analysis provides valuable insights into the performance and potential improvements of the attendance system, contributing to the understanding of its effectiveness in enhancing attendance management at UTeM Mosque.

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4.2 Hardware Prototype

As per as planned in chapter 3, each and every component had been connected accordingly. Figure 4.1 shows the initial stage of the components where some of the components had been eliminated at final stage of the project as shown in Figure 4.2 since the particular components are not necessary in the implementation of the project. Figure 4.3 shows the complete hardware of the project where the circuit connection installed inside an enclosure box to secure connection of the components. Figure 4.4 shows the AutoCAD drawing of the project from top view, front view, side view and ISO. As for Figure 4.5, Figure 4.6 and Figure 4.7 shows the 3D drawing of the project from various sides.

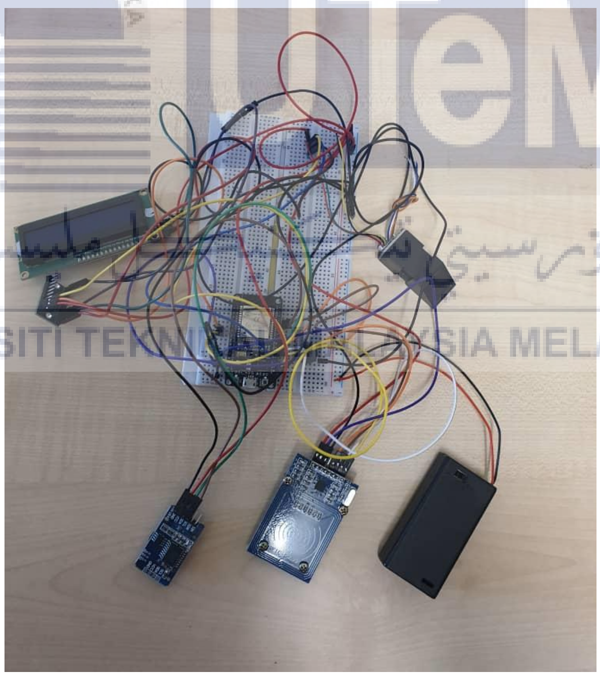

Figure 4.1 Circuit connection at initial stage

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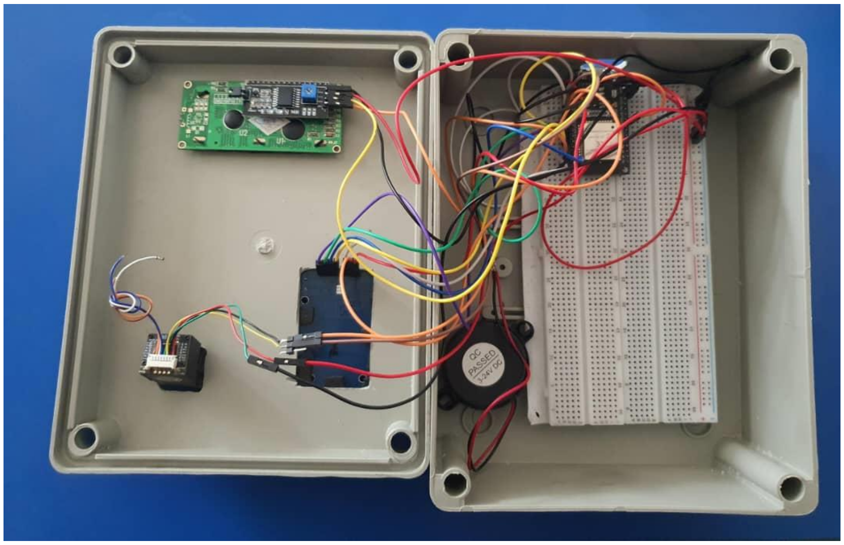

Figure 4.2 Circuit connection at final stage

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Figure 4.3 Complete hardware of the project

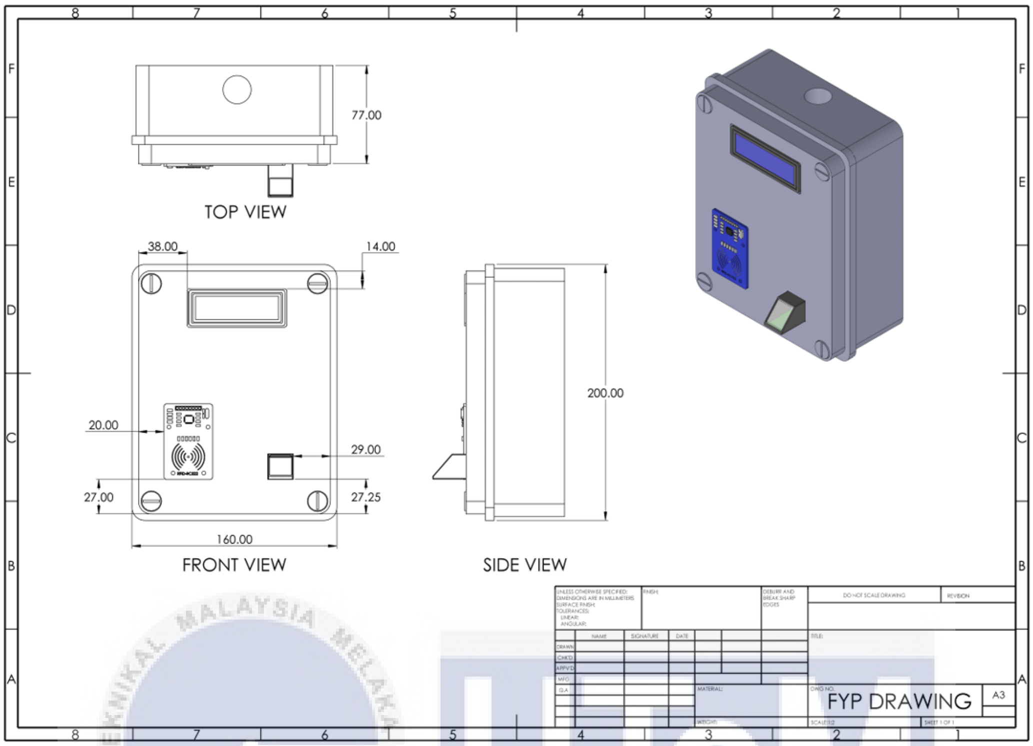

Figure 4.4 AutoCAD drawing of the complete project

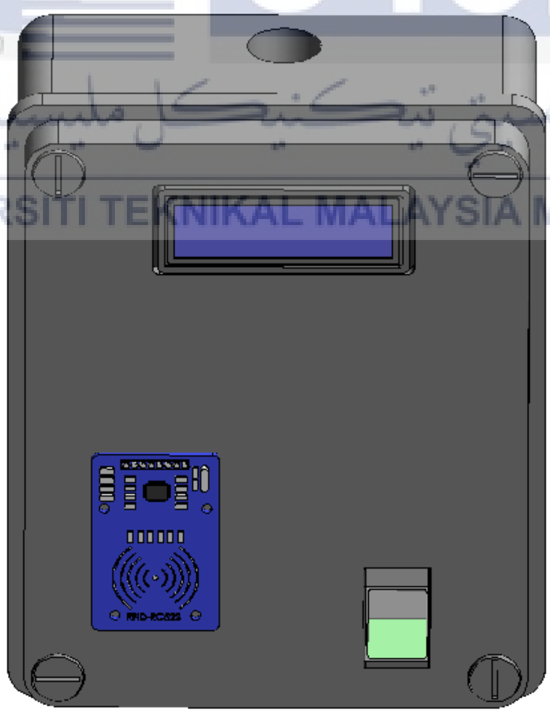

Figure 4.5 3D drawing of the project from front view

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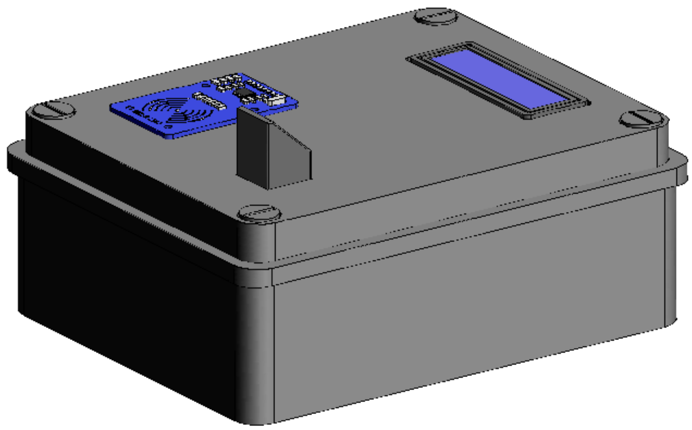

Figure 4.6 3D drawing of the project from right side view

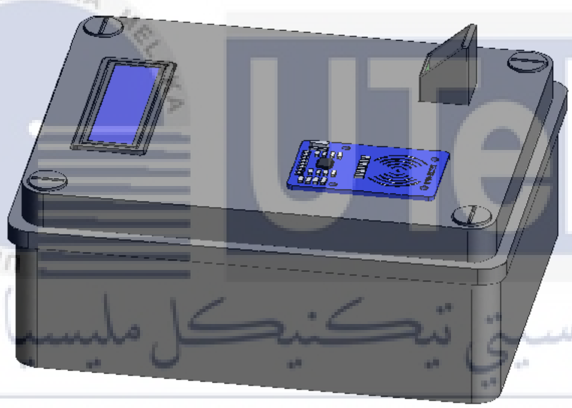

Figure 4.7 3D drawing of the project from left side view

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4.3 Software Prototype

Figure 4.8 shows the setup of the attendance system in the Google sheets where all the attendance had been saved. Figure 4.9 shows the deployment of the Google sheets. In the Google sheet a simple coding should be create so that the Google sheets can connect easily with the ESP32 microcontroller in order to record attendance.

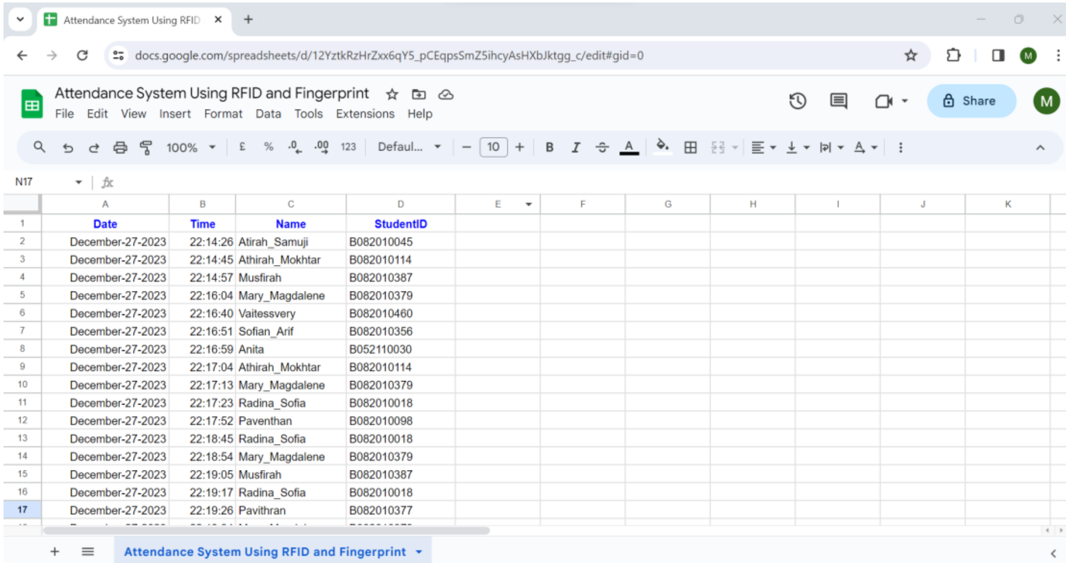

Figure 4.8 Setup of Google sheets for attendance

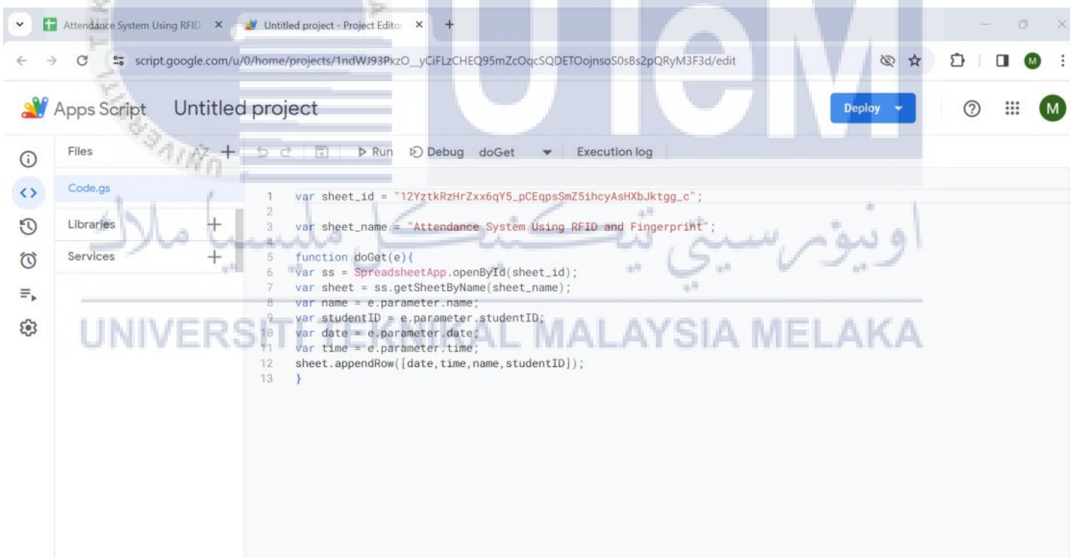

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Figure 4.9 Deployment of the Google sheets

4.4 Project Testing

The project testing is a systematic evaluation of software and hardware to find and fix the problems of the project. It involves creating test, running them and reporting any issue found. Different testing techniques and tools are used to ensure the product works well, performs smoothly, and is secure. The goal is to improve the product's quality and make users happy. Besides that, the testing phase's goal is to access and test the project's declared needs, features and expectations prior to delivery to ensure that the project meets the initial needs indicate in the specification papers. For this project, the testing are progress as the Table 4-1 below:

Table 4-1 Project Testing of the complete project

No	Condition	Expected result	Outcome
1.	ESP32 connect with the Wi-Fi	The serial monitor at Arduino ide shows that ESP32 connected with the Wi-Fi.	PASS
2.	ESP32 did not connect with the Wi-Fi	The serial monitor at Arduino ide shows that ESP32 did not connect with the Wi-Fi.	PASS
3.	Fingerprint sensor connection uninterrupted	Serial monitor shows fingerprint sensor found; LCD displays 'please scan'	PASS
4.	Fingerprint sensor connection interrupted	Serial monitor shows fingerprint sensor not found; LCD does not display any wording	PASS
5.	RFID reader found after connection	LCD displays 'please scan'	PASS
6.	RFID reader found after connection	LCD does not display any wording	PASS
7.	LCD connections are correct	LCD display wording	PASS
8.	LCD connections are wrong	LCD does not display wording	PASS

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No	Condition	Expected result	Outcome
9.	Registered fingerprint placed in the fingerprint sensor	LCD displays ‘success!’ and the name of the person; attendance recorder in the Google sheets. Buzzer will produce beep sound upon successful scanning.	PASS
10.	Fingerprint that not registered placed in the fingerprint sensor	LCD displays ‘please scan’ as the data of the person is not found; attendance will not record in the Google sheets. Buzzer will not produce any sound.	PASS
11.	Registered RFID Tag placed in the RFID reader	LCD displays ‘success!’ and the name of the person; attendance recorder in the Google sheets. Buzzer will produce beep sound upon successful scanning.	PASS
12.	RFID Tag that not registered placed in the RFID reader	LCD displays ‘not authorized!’ as the data of the person is not found; attendance will not record in the Google sheets. Buzzer will not produce any sound.	PASS

4.5 Result and Analysis

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The project focused on developing an attendance system at UTeM Mosque using RFID and fingerprint technology since traditional pen and paper attendance systems have become unreliable and difficult to maintain, lacking the capability for remote monitoring over long distances. In order to achieve the implementation of attendance system, ESP32 microcontroller interface with AS608 fingerprint sensor, RC522 RFID reader, I2C 16x02 LCD display, buzzer and also Google sheets. Both RFID reader and fingerprint sensor makes this project unique where the attendee can scan either one of them in order to record attendance. LCD display uses to make the attendance system easier by displaying messages based on the status of the attendance recording. The buzzer will produce a beep sound upon successful scanning showing the attendance had been recorded successfully. The Google sheets known as one of the simple and easiest platform where the admin of the Mosque can access the attendance system through any device. The system reduces the difficulty in maintaining the attendance system. Table 4-2 shows the result of scanning for both RFID Tag and fingerprint. Table 4-3 shows the overall result of the attendance system where the attendance will be recorded successfully if student who had been registered, scan using either RFID Tag or fingerprint. Table 4-4 shows sample taken from fellow students for the attendance system. Total of 20 samples taken from the students for testing purpose. Figure 4.10 and 4.11 shows the sample data that taken from both fingerprint and RFID Tag scanning for attendance recording.

Table 4-2 Output result of scanning for attendance

Output	Result of scanning for both rfid tag and fingerprint	
	Success	Fail
Buzzer	Produce a beep sound	Did not produce a beep sound
Lcd display	Success! and displays name of the person	'Not Authorized!' for RFID Tag scanning and 'Please Scan' for fingerprint scanning
Google sheets	Recorded in the Google sheets	Did not recorded in the Google sheets

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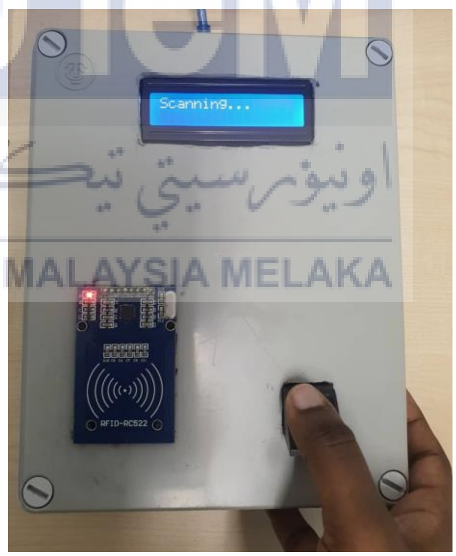
Table 4-3 Result of the project

Condition	Result
1. Initial condition of the system	
2. Scanning the fingerprint in the fingerprint sensor	

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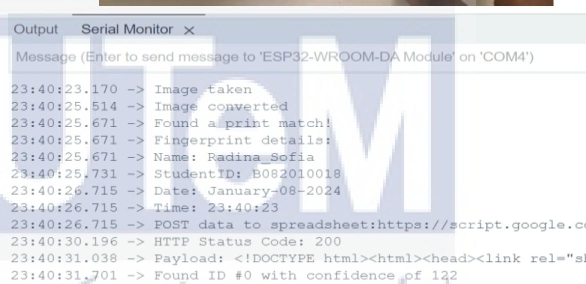
Condition	Result
3. Successful scanning of fingerprint	  Output Serial Monitor × Message (Enter to send message to 'ESP32-WROOM-DA Module' on 'COM4') 23:40:23.170 -> Image taken 23:40:25.514 -> Image converted 23:40:25.671 -> Found a print match! 23:40:25.671 -> Fingerprint details: 23:40:25.671 -> Name: Radina_Sofia 23:40:25.731 -> StudentID: B082010018 23:40:26.715 -> Date: January-08-2024 23:40:26.715 -> Time: 23:40:23 23:40:26.715 -> POST data to spreadsheet:https://script.google.com 23:40:30.196 -> HTTP Status Code: 200 23:40:31.038 -> Payload: <!DOCTYPE html><html><head><link rel="sh 23:40:31.701 -> Found ID #0 with confidence of 122

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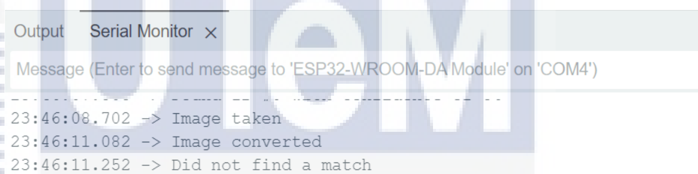
Condition	Result
4. Failed scanning of fingerprint	 
5. Scanning the RFID Tag	

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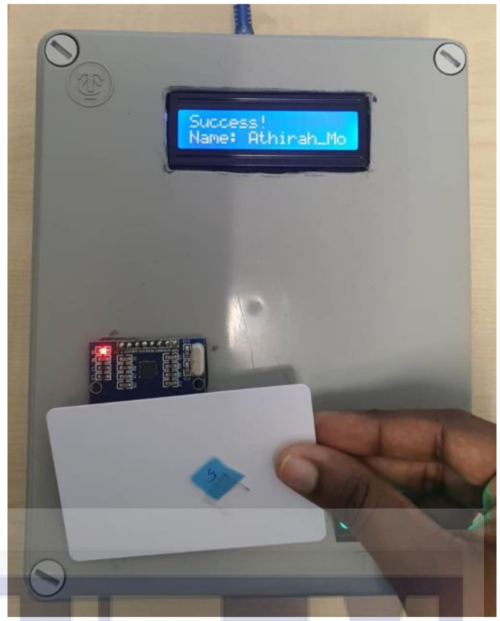
<table>
<tr><th>Condition</th><th>Result</th></tr>
<tr><td>6. Successful scanning of RFID Tag</td><td>


</td></tr>
</table>

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<table>
<tr><th>Condition</th><th>Result</th></tr>
<tr><td>7. Failed scanning of the RFID Tag</td><td>

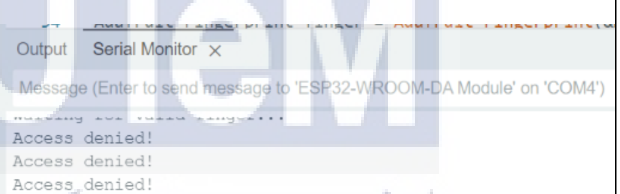
</td></tr>
</table>

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Table 4-4 Sample taken from fellow students for attendance system

Sample name and matriks number	Fingerprint ID	RFID tag address
Mary_Magdalene B082010379	#1	13 92 78 05
Musfirah B082010387	#2	33 99 CB 12
Radina_Sofia B082010018	#3	43 34 F7 11
Atirah_Samuji B082010045	#4	E3 48 AC 12
Athirah_Mokhtar B082010114	#5	43 A3 6D 11
Pavithran B082010377	#6	73 CA 0C 2E

Sample name and matriks number	Fingerprint ID	RFID tag address
Gokulan B082010260	#7	BC 00 33 49
Dinesvari B082010017	#8	2C D8 ED 2B
Mishalan B082010417	#9	CA 26 97 B2
Paventhan B082010098	#10	3C A0 DE 2B
Vaitessvery B082010460	#11	BC 89 EE 2B
Khivisha B082010327	#12	BC C7 DD 2B
Mosseni B082010360	#13	EC 6D E1 2B
Sofian_Arif B082010356	#14	E0 8E 16 19
Anita B052110030	#15	FC 94 E1 2B
Ratul_Ruhin B082010471	#16	0C CE F4 2B
Suva B052110151	#17	4C DA EC 2B
Khairin_Najmi B082010088	#18	1C CD E1 2B
Agiilan B062010034	#19	6C 66 E8 2B
Hanis_Saadah B082010323	#20	5C 18 D5 2B

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Attendance System Using RFID and Fingerprint

	A	B	C	D
22	DATE	TIME	NAME	STUDENTID
23	December-18-2023	23:57:48	Mary_Magdalene	B082010379
24	December-18-2023	23:58:00	Musfirah	B082010387
25	December-18-2023	23:58:17	Mosseni	B082010360
26	December-18-2023	23:58:25	Hanis_Saadah	B082010323
27	December-18-2023	23:58:38	Ratul_Ruhin	B082010471
28	December-18-2023	23:58:48	Mishalan	B082010417
29	December-18-2023	23:59:09	Vaitessvery	B082010460
30	December-18-2023	23:59:20	Paventhan	B082010098
31	December-18-2023	23:59:28	Khivisha	B082010327
32	December-18-2023	23:59:36	Radina_Sofia	B082010018
33	December-18-2023	23:59:45	Anita	B052110030
34	December-18-2023	23:59:57	Khairin_Najmi	B082010088
35	December-19-2023	00:00:07	Suva	B052110151
36	December-19-2023	00:00:20	Dinesvari	B082010017
37	December-19-2023	00:00:29	Pavithran	B082010377
38	December-19-2023	00:00:39	Gokulan	B082010260
39	December-19-2023	00:00:52	Athirah_Mokhtar	B082010114
40	December-19-2023	00:01:03	Agiilan	B062010034
41	December-19-2023	00:01:22	Sofian_Arif	B082010356
42	December-19-2023	00:01:28	Atirah_Samuji	B082010045

Figure 4.10 Attendance recorded using fingerprint

Attendance System Using RFID and Fingerprint

	A	B	C	D
1	Date	Time	Name	StudentID
2	December-18-2023	23:41:48	Mary_Magdalene	B082010379
3	December-18-2023	23:43:27	Radina_Sofia	B082010018
4	December-18-2023	23:43:45	Vaitessvery	B082010460
5	December-18-2023	23:44:02	Athirah_Mokhtar	B082010114
6	December-18-2023	23:44:12	Atirah_Samuji	B082010045
7	December-18-2023	23:44:26	Musfirah	B082010387
8	December-18-2023	23:44:35	Gokulan	B082010260
9	December-18-2023	23:44:44	Dinesvari	B082010017
10	December-18-2023	23:44:53	Mishalan	B082010417
11	December-18-2023	23:45:05	Paventhan	B082010098
12	December-18-2023	23:45:16	Pavithran	B082010377
13	December-18-2023	23:46:50	Mosseni	B082010360
14	December-18-2023	23:47:03	Sofian_Arif	B082010356
15	December-18-2023	23:47:41	Anita	B052110030
16	December-18-2023	23:48:54	Khivisha	B082010327
17	December-18-2023	23:49:53	Ratul_Ruhin	B082010471
18	December-18-2023	23:50:09	Suva	B052110151
19	December-18-2023	23:50:27	Khairin_Najmi	B082010088
20	December-18-2023	23:50:39	Agiilan	B062010034
21	December-18-2023	23:51:17	Hanis_Saadah	B082010323

Figure 4.11 Attendance recorded using RFID Tag

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4.6 Discussion

The implementation of an attendance system at UTeM Mosque through the integration of RFID and fingerprint technology marks a significant departure from the conventional pen-and-paper method, which has proven to be unreliable and challenging to sustain. The project adopts a holistic approach by employing an ESP32 microcontroller, AS608 fingerprint sensor, RC522 RFID reader, I2C 16x02 LCD display, buzzer, and Google Sheets for comprehensive attendance management. The dual functionality of the RFID reader and fingerprint sensor provides attendees with the flexibility to choose their preferred method for recording attendance, enhancing user convenience. The LCD display plays a crucial role in simplifying the attendance system by presenting real-time status messages during the recording process, further contributing to a seamless user experience. The inclusion of a buzzer, signalling successful attendance recording with a beep sound, adds an auditory confirmation element to the system. Leveraging the simplicity and accessibility of Google Sheets, mosque administrators can remotely monitor attendance from any device, offering an efficient solution for long-distance supervision. Overall, this project not only resolves the drawbacks of traditional attendance systems but also introduces a user-friendly, technology-driven solution that reduces the complexities associated with attendance management at UTeM Mosque.

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4.7 Summary

The project focused on developing an attendance system at UTeM Mosque using RFID and fingerprint technology. The result was the creation of a user-friendly system where attendees could mark their attendance by scanning their fingerprint or RFID tag. The system stored attendance data in a Google sheets, including details such as name, matriculation number, date, and time. With the integration of ESP32 microcontroller, AS 608 fingerprint sensor, RC522 RFID reader, LCD displayer, and buzzer, the project successfully delivered an efficient attendance tracking solution that simplified the process, enhanced accuracy, and provided immediate feedback to attendees. Overall, the implementation of the attendance system showcased its potential to streamline attendance management and improve the overall experience at UTeM Mosque.

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CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, the implementation of the attendance system at UTeM Mosque utilizing RFID and fingerprint technology, powered by the ESP32 microcontroller, presents a comprehensive and efficient solution for tracking attendance during congregational prayers. By providing the option to scan either fingerprints or RFID tags, the system ensures accurate identification and enables seamless recording of attendance data. The attendance records, including attendees' name, matriculation number, date and time, are securely stored in a Google sheets, offering easy access and management of attendance information.

The integration of an LCD displayer serves as a real-time feedback mechanism, instantly displaying a message confirming the successful recording of attendance, enhancing the user experience and reducing uncertainties. Additionally, the inclusion of a buzzer adds an audible signal, generating a beep sound upon successful scanning, further reinforcing the confirmation of attendance.

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This attendance system, powered by the ESP32 microcontroller, provides a reliable and user-friendly solution for both attendees and administrators. It simplifies the attendance tracking process, reduces manual effort, and enhances accuracy and efficiency. Furthermore, the system contributes to effective attendance management at UTeM Mosque, enabling timely and reliable data analysis, and facilitating decision-making processes related to attendance monitoring and resource allocation.

Overall, the attendance system based on RFID and fingerprint technology, with the integration of the ESP32 microcontroller, LCD displayer and buzzer, showcases the successful fusion of hardware, software, and attendance management in a Google sheets. Its implementation at UTeM Mosque demonstrates the commitment to leveraging technology for enhancing mosque operations, improving attendance monitoring, and ensuring a smooth and organized congregational prayer experience for all attendees.

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5.2 Potential for Commercialization

The attendance system developed for UTeM Mosque using RFID and fingerprint technology has promising potential for commercialization. The system's successful implementation and usability can be extended to educational institutions, businesses, and event management. By targeting schools, universities, corporations, and event organizers, the system can simplify attendance tracking, enhance administrative efficiency, and provide valuable attendance data for analysis and planning. Strategic market research, highlighting the system's features and benefits, and exploring partnerships can pave the way for successful commercialization. Customizations and enhancements can also be considered to meet specific industry requirements and maximize market adoption.

5.3 Future Works

There are several potential future improvements that can be considered for the attendance system project at UTeM Mosque:

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1. Mobile Application Integration: Develop a mobile application that allows attendees to mark their attendance using their smartphones. The application can communicate with the ESP32 or the database to record attendance, providing an alternative and more convenient method for attendees.
2. Biometric Performance Improvement: Continuously explore advancements in biometric technology to enhance the accuracy and speed of fingerprint recognition. Upgrading the fingerprint sensor or exploring alternative biometric methods can improve the overall user experience and reduce false positives or false negatives.

3. Multi-Language Support: Develop multilingual support within the system to cater to the diverse community at the mosque. This would ensure inclusivity and enable attendees to interact with the system in their preferred language.
4. Integration with Online Platforms: Explore the integration of the attendance system with online platforms such as the mosque's website for registration. This would allow for seamless communication and even online registration for specific events or programs.
5. Automated Reminders and Notifications: Implement automated reminders and notifications to notify attendees about upcoming prayer times or special events at the mosque. This can be achieved through SMS alerts, push notifications, or email notifications, helping attendees stay informed and engaged.

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REFERENCES

[1] Minaee, S., Abdolrashidi, A., Su, H., Bennamoun, M., & Zhang, D. (2023). Biometrics recognition using deep learning: A survey. Artificial Intelligence Review, 1-49.

[2] M. Sharif, M. Raza, J. H. Shah, M. Yasmin, and S. L. Fernandes, "An overview of biometrics methods. Handbook of multimedia information security: techniques and applications," pp. 15–35, 2019.

[3]V. Patil and D. R. Ingle, "An association between fingerprint patterns with blood group and lifestyle based diseases: a review," Artif. Intell. Rev., vol. 54, no. 3, pp. 1803–1839, 2021.

[4] S. Hemalatha, "A systematic review on Fingerprint based Biometric Authentication System," in 2020 International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE), 2020.

[5] O. Shoewu and O. A. Idowu, "Development of Attendance Management System using Biometrics," Pacific Journal of Science and Technology, vol. 13, 2012.

[6] Kumar, M., & Priyanka. (2019). Various image enhancement and matching techniques used for fingerprint recognition system. International Journal of Information Technology, 11(4), 767-772.

[7] A. V. Fassio et al., "Prioritizing virtual screening with interpretable interaction fingerprints," J. Chem. Inf. Model., vol. 62, no. 18, pp. 4300–4318, 2022.

[8] Y. Jiang, "Space Debris Fingerprint Definition and Identification," The Journal of Brief Ideas, 2022.

[9] S. Kadry and K. Smaili, "A design and implementation of a wireless iris recognition attendance management system"," INFORMATION TECHNOLOGY AND CONTROL, vol. 36, no. 3, 2007.

[10] S. Kawakami et al., "A Simple and Accurate CNN for Iris Recognition," in 2022 Asia-Pacific Signal and Information Processing Association Annual Summit and Conference (APSIPA ASC), 2022.

[11] R. Y. F. Ng, Y. H. Tay, and K. M. Mok, "A review of iris recognition algorithms," in 2008 International Symposium on Information Technology, 2008.

[12] U. Gawande, M. Zaveri, and A. Kapur, Improving iris recognition accuracy by score based fusion method. 2010.

[13] J. Daugman and C. Dowing, "Epigenetic randomness, complexity, and singularity of human iris patterns," Preceding soft the Royal Society, B, vol. 268, pp. 1737–1740, 2001.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

[14] J. Daugman, “Statistical richness of visual phase information: update on recognizing Persons by iris patterns,” Int. J. Comput.Vis, vol. 45, no. 1, pp. 25–38, 2001.

[15] H. Qin, C. Gong, Y. Li, X. Gao, and M. A. El-Yacoubi, “Label enhancement-based multiscale transformer for palm-vein recognition,” IEEE Trans. Instrum. Meas., vol. 72, pp. 1–17, 2023.

[16] D. Sadhya and B. Raman, “Generation of cancelable Iris templates via randomized bit sampling,” IEEE Trans. Inf. Forensics Secur., vol. 14, no. 11, pp. 2972–2986, 2019.

[17] Z. Ma et al., “EmIr-auth: Eye movement and Iris-based portable remote authentication for smart grid,” IEEE Trans. Industr. Inform., vol. 16, no. 10, pp. 6597–6606, 2020.

[18] C. Wang, Z. He, C. Wang, and Q. Tian, “Generating intra- and inter-class Iris images by identity contrast,” in 2022 IEEE International Joint Conference on Biometrics (IJCB), 2022.

[19] J. Wei, H. Huang, Y. Wang, R. He, and Z. Sun, “Towards more discriminative and robust Iris recognition by learning uncertain factors,” IEEE Trans. Inf. Forensics Secur., vol. 17, pp. 865–879, 2022.

[20]. W. Zhao, R. Chellappa, P. J. Phillips, and A. Rosenfeld, “Face recognition: A literature survey,” Acm Computing Surveys (CSUR), vol. 35, no. 4, pp. 399–458, 2003.

[21] State of the Art” Faizan Ahmad1, Aaima Najam2 and Zeeshan Ahmed3 Face Recognition Systems: A Survey Received. 2019.

[22] Millán EscriváD., P. Joshi, G. MendonçaV., and R. Shilkrot, Building Computer Vision Projects with OpenCV 4 and C++ : Implement Complex Computer Vision Algorithms and Explore Deep Learning and Face Detection. Birmingham: Packt Publishing Ltd, 2019.

[23] R. Schalkoff, Pattern Recognition Statistical Structural and Neural Approaches. Wiley.

[24] W. Chunming and Z. Ying, “MTCNN and FaceNet Based Access Control System for Face Detection and Recognition,” Autom. Control Comput. Sci, vol. 55, pp. 102–112, 2021.

[25] T. V. Dang, “Design of a Face Recognition Technique based MTCNN and ArcFace,” in MMMS 2022, LNME, .

[26] T. V. Dang and D. K. Nguyen, “Research and Design the Intelligent Mechatronics system applying with face recognition and deep learning in student’s diligencet,” 7 th Nat,” Conf. Sci. Eng. Meas, pp. 239–246, 2020.

[27] M. Al Rousan and B. Intrigila, “A comparative analysis of biometrics types: Literature review,” J. Comput. Sci., vol. 16, no. 12, pp. 1778–1788, 2020.

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[28] A. Abozaid, A. Haggag, H. Kasban, and M. Eltokhy, “Multimodal biometric scheme for human authentication technique based on voice and face recognition fusion,” Multimed. Tools Appl., vol. 78, no. 12, pp. 16345–16361, 2019.
[29] B. Saliha, E. Youssef, and D. Abdeslam, “A Study on Automatic Speech Recognition,” Journal of Information Technology Review, vol. 10, no. 3, pp. 77–85, 2019.

[30] A. Kousar Nikhath, N. V. Sailaja, R. Vasavi, and R. Vijaya Saraswathi, “Road traffic counting and analysis using video processing,” in Advances in Intelligent Systems and Computing, Singapore: Springer Singapore, 2021, pp. 645–651.

[31] “Face Recognition and Fingerprint based Attendance Monitoring System Prof. Mohini Mohan Sawarkar Department of Instrumentation, Bharati Vidyapeeth College of Engineering,” Bharati Vidyapeeth College of Engineering, 2020.

[32] M. M, A. V, C. K Prudhvi, A. P, D. V, and P. S Phani, “Smart and multi-way attendance tracking system using an image-processing technique,” in 2022 4th International Conference on Smart Systems and Inventive Technology (ICSSIT), 2022.

[33] A. Yassine, S. Singh, M. S. Hossain, and G. Muhammad, “IoT big data analytics for smart homes with fog and cloud computing,” Future Gener. Comput. Syst., vol. 91, pp. 563–573, 2019.

[34] Y. Ren, Z. Fang, D. Liu, and C. Chen, “Replay attack detection based on distortion by loudspeaker for voice authentication,” Multimed. Tools Appl., vol. 78, no. 7, pp. 8383–8396, 2019.

[35] S. Elaskari, M. Imran, A. Elaskri, and A. Almasoudi, “Using barcode to track student attendance and assets in higher education institutions,” Procedia Comput. Sci., vol. 184, pp. 226–233, 2021.

[36] R. Wudhikarn, P. Charoenkwan, and K. Malang, “Deep learning in barcode recognition: A systematic literature review,” IEEE Access, vol. 10, pp. 8049–8072, 2022.

[37] N. K. Singh, “Near-field communication (NFC) An alternative to RFID in libraries,” in Information technology and libraries, 2020.

[38] A. J. Gomez, B. G. Grepon, N. G. Liwanen, and C. J. C. Ranido, “Faculty attendance monitoring system: An improved with barcode scanner,” 2021.

[39] M. Kizildag, E. Basar, M. Celikag, and S. Mousavi, “An Automated Attendance Monitoring and Registration System for EMU’s SPIKE Seminar Series,” in International Conference Integration of Information Technology in Science Education, G.Magusa-TRNC, 2007.

[40] A. F. A. Fatah, R. Mohamad, and F. Y. A. Rahman, “Student attendance system using an android based mobile application,” in 2021 IEEE 11th IEEE Symposium on Computer Applications & Industrial Electronics (ISCAIE), IEEE, 2021, pp. 224–227.

[41] A. F. Abdul Fatah, R. Mohamad, F. Y. Abdul Rahman, and N. I. Shuhaimi, “Student attendance system using an android based mobile application,” in 2021 IEEE 11th IEEE Symposium on Computer Applications & Industrial Electronics (ISCAIE), 2021.
[42] D. A. A. G. Singh, E. J. Leavline, and P. M. Vijayan, “Mobile application for student attendance and mark management system,” International Journal of Computational Intelligence Research, vol. 13, no. 3, pp. 425–432, 2017.

[43] A. Vamshi and K. Ganapathy, “Mobile application for uploading marks and student attendance management system,” International Journal of Engineering and Advanced Technology, vol. 8, pp. 379–383, 2019.

[44] Ramani, Pradeepkumar, Palanisamy, A. Preethi, V. Sekhar, and N. S. Kumar, “Smart attendance monitoring system using IoT,” in 2023 9th International Conference on Advanced Computing and Communication Systems (ICACCS), 2023.

[45] S. N. Shah and A. Abuzneid, “IoT Based Smart Attendance System (SAS) Using RFID,” in 2019 IEEE Long Island Systems, Applications and Technology Conference (LISAT), 2019.

[46] G. Pradeepkumar, S. S. Rahul, N. Sudharsanaa, S. Suvetha, and D. Ponnusamy, “A Smart Helmet for the mining industry using LoRaWAN,” J. Phys. Conf. Ser., vol. 1916, no. 1, p. 012089, 2021.

[47] A. S. Nadhan et al., “Smart Attendance Monitoring Technology for Industry 4.0,” Journal of Nanomaterials, 2022.

[48] Z. Singhal and R. K. Gujral, “Anytime Anywhere- Remote Monitoring of Attendance System based on RFID using GSM Network,” International Journal of Computer Applications, vol. 39, 2012.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

[49] A. Qaiser and S. Khan, “Automation of Time and Attendance using RFID Systems,” in 2006 International Conference on Emerging Technologies, 2006.

[50] A. J. Moshayedi et al., “Automation attendance systems approaches: a practical review,” Automation Attendance Systems approaches: A Practical Review, 2022.

[51] A. B. Nath and T. Varghese, Factors Influencing The Effective Usage of QR Code: A Study Among Readers of Trivandrum City. 2020.

[52] K. J. Liew and T. H. Tan, “QR code-based student attendance system,” in 2021 2nd Asia Conference on Computers and Communications (ACCC), 2021.

[53] S. K. Ng, Student attendance system based on QR code with unique identification capturing (Doctoral dissertation, UTAR). 2021.

[54] A. Liyando Hermawan Hasibuan, A. Arif Munaji, and N. C. E. Deolika, “Student Attendance Information System Using QR Code (Quick Response),” Journal of Sisfotek Global, vol. 12, no. 2, pp. 101–107, 2022.

[55] Y. Moolla, A. De Kock, G. Mabuza-Hocquet, C. S. Ntshangase, N. Nelufule, and P. Khanyile, “Biometric recognition of infants using fingerprint, iris, and ear biometrics,” IEEE Access, vol. 9, pp. 38269–38286, 2021.

[56] Chanda, D. A. (2019). Barcode technology and its application in libraries. Akanbi, LM, Bashorun, MT, Salihu, UA, Babafemi, GO, Sulaiman, K., & Kolajo, SO (2019).

[57] S. Sun, J. Hu, Y. Cao, and W. Zhou, “Discussion on the application of RFID technology in medical waste management,” in 2019 10th International Conference on Information Technology in Medicine and Education (ITME), IEEE, 2019, pp. 120–124.

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APPENDICES

Appendix A PSM 1 and PSM 2 Timeline Gantt Chart

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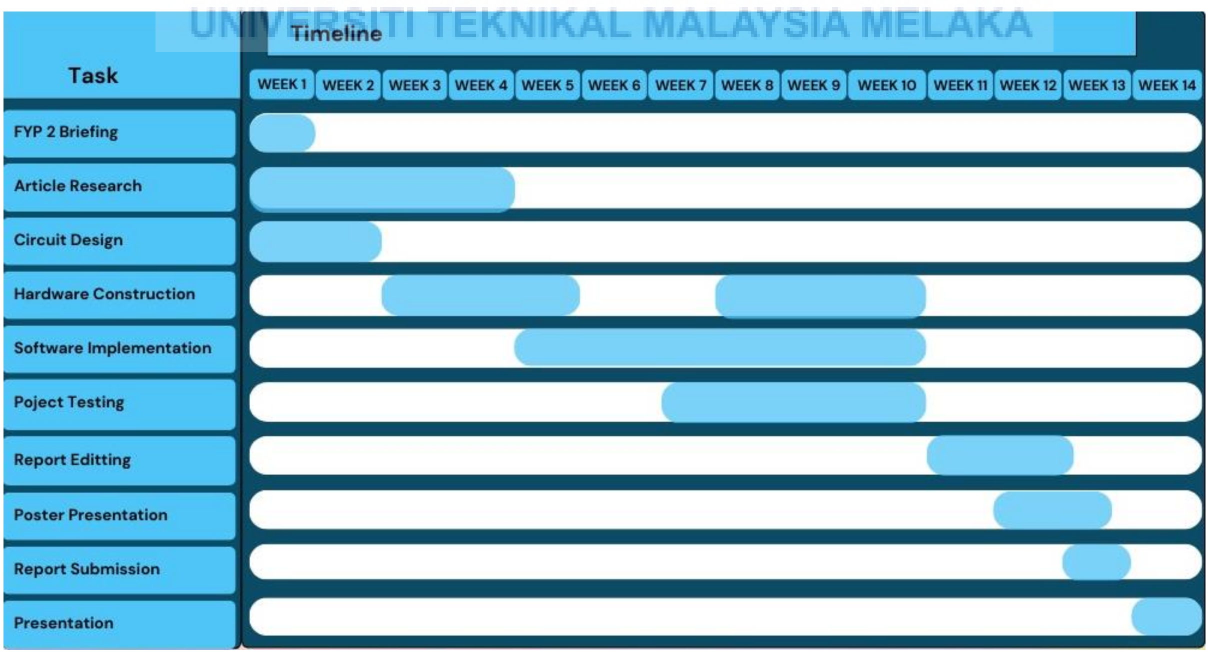

Appendix B Coding For RFID And Fingerprint Attendance Recording

```
#include <Adafruit_Fingerprint.h>
#include "WiFi.h"
#include <HTTPClient.h>
#include "time.h"
#include <LiquidCrystal_I2C.h>
#include <SPI.h>
#include <MFRC522.h>

#define BUZZER_PIN 4
#define RST_PIN 26
#define SS_PIN 5
MFRC522 rfid(SS_PIN, RST_PIN);

int lcdColumns = 16;
int lcdRows = 2;
LiquidCrystal_I2C lcd(0x27, lcdColumns, lcdRows);

const char* ntpServer = "pool.ntp.org";
const long gmtOffset_sec = 28800;
const int daylightOffset_sec = 0;

// WiFi credentials
const char* ssid = "Mary";               // change SSID
const char* password = "Mary0505";   // change password

// Google script ID and required credentials
String GOOGLE_SCRIPT_ID = "AKfycbw_kyVpI7c9jqL5Y8_81K7yJuPGuMAKRv7sSz9R-
VvGuDzjr03kFYgRp3aHa8CGDcU";  // change Gscript ID
//https://script.google.com/macros/s/AKfycbw_kyVpI7c9jqL5Y8_81K7yJuPGuMA
KRv7sSz9R-VvGuDzjr03kFYgRp3aHa8CGDcU/exec

#define MODEM_RX 16
#define MODEM_TX 17
#define mySerial Serial2  // use for ESP32

Adafruit_Fingerprint finger = Adafruit_Fingerprint(&mySerial);
```

```
struct FingerprintDetails {
  byte tagId[4];
  uint16_t id;
  String name;
  String studentID;
};

// Create an array of fingerprint details
FingerprintDetails fingerprintDatabase[20] = {
  { { 0x13, 0x92, 0x78, 0x05 }, 1, "Mary_Magdalene", "B082010379" },
  { { 0x33, 0x99, 0xCB, 0x12 }, 2, "Musfirah", "B082010387" },
  { { 0x43, 0x34, 0xF7, 0x11 }, 3, "Radina_Sofia", "B082010018" },
  { { 0xE3, 0x48, 0xAC, 0x12 }, 4, "Atirah_Samuji", "B082010045" },
  { { 0x43, 0xA3, 0x6D, 0x11 }, 5, "Athirah_Mokhtar", "B082010114" },
  { { 0x73, 0xCA, 0x0C, 0x2E }, 6, "Pavithran", "B082010377" },
  { { 0xBC, 0x00, 0x33, 0x49 }, 7, "Gokulan", "B082010260" },
  { { 0x2C, 0xD8, 0xED, 0x2B }, 8, "Dinesvari", "B082010017" },
  { { 0xCA, 0x26, 0x97, 0xB2 }, 9, "Mishalan", "B082010417" },
  { { 0x3C, 0xA0, 0xDE, 0x2B }, 10, "Paventhan", "B082010098" },
  { { 0xBC, 0x89, 0xEE, 0x2B }, 11, "Vaitessvery", "B082010460" },
  { { 0xBC, 0xC7, 0xDD, 0x2B }, 12, "Khivisha", "B082010327" },
  { { 0xEC, 0x6D, 0xE1, 0x2B }, 13, "Mosseni", "B082010360" },
  { { 0xE0, 0x8E, 0x16, 0x19 }, 14, "Sofian_Arif", "B082010356" },
  { { 0xFC, 0x94, 0xE1, 0x2B }, 15, "Anita", "B052110030" },
  { { 0x0C, 0xCE, 0xF4, 0x2B }, 16, "Ratul_Ruhin", "B082010471" },
  { { 0x4C, 0xDA, 0xEC, 0x2B }, 17, "Suva", "B052110151" },
  { { 0x1C, 0xCD, 0xE1, 0x2B }, 18, "Khairin_Najmi", "B082010088" },
  { { 0x6C, 0x66, 0xE8, 0x2B }, 19, "Agiilan", "B062010034" },
  { { 0x5C, 0x18, 0xD5, 0x2B }, 20, "Hanis_Saadah", "B082010323" },
};

FingerprintDetails* getFingerprintDetails(uint16_t id) {
  for (int i = 0; i < sizeof(fingerprintDatabase) /
sizeof(fingerprintDatabase[0]); i++) {
    if (fingerprintDatabase[i].id == id) {
      return &fingerprintDatabase[i];
    }
  }
  return NULL;  // ID not found in the database
}
```

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```
void setup() {
  Serial.begin(9600);
  pinMode(BUZZER_PIN, OUTPUT);
  SPI.begin();
  rfid.PCD_Init();
  lcd.init();
  lcd.backlight();
  while (!Serial)
    ;  // For Yun/Leo/Micro/Zero/...
  delay(100);

  Serial.print("Connecting to wifi: ");
  Serial.println(ssid);
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("Connected to WiFi!");

  // Init and get the time
  configTime(gmtOffset_sec, daylightOffset_sec, ntpServer);

  Serial.println("\n\nAdafruit finger detect test");

  // set the data rate for the sensor serial port
  finger.begin(57600);

  if (finger.verifyPassword()) {
    Serial.println("Found fingerprint sensor!");
  } else {
    Serial.println("Did not find fingerprint sensor :(");
    while (1) { delay(1); }
  }

  finger.getTemplateCount();
  Serial.print("Sensor contains ");
  Serial.print(finger.templateCount);
  Serial.println(" templates");
  Serial.println("Waiting for valid finger...");
}

void loop()  // run over and over again
{
```

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```
if (rfid.PICC_IsNewCardPresent() && rfid.PICC_ReadCardSerial()) {
    byte tagId[4];
    for (byte i = 0; i < 4; i++) {
      tagId[i] = rfid.uid.uidByte[i];
    }

    FingerprintDetails* details = get2fingerprintDatabase(tagId);
    if (details != NULL) {
      Serial.println("RFID details:");
      Serial.print("Name: ");
      Serial.println(details->name);
      Serial.print("StudentID: ");
      Serial.println(details->studentID);

      lcd.clear();
      lcd.setCursor(0, 0);
      lcd.print("Success!");
      lcd.setCursor(0, 1);
      lcd.print("Name: ");
      lcd.print(details->name);
      digitalWrite(BUZZER_PIN, HIGH);
      delay(1000);
      digitalWrite(BUZZER_PIN, LOW);

      sendSheet(details->name, details->studentID);
    } else {
      Serial.println("Access denied!");
      notAuth();
    }

    rfid.PICC_HaltA();
    rfid.PCD_StopCrypto1();
  }
  finger.fingerID = 0;
  delay(50);
  getFingerprintIDez();
  delay(50);
  FingerprintDetails* details = getFingerprintDetails(finger.fingerID);
  if (details != NULL)
{

  }
}
```

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```
void sendSheet(String tName, String tStudentID) {
  struct tm timeinfo;
  if (!getLocalTime(&timeinfo)) {
    Serial.println("Failed to obtain time");
    return;
  }
  char timeStringBuff[50];  // 50 chars should be enough
  strftime(timeStringBuff, sizeof(timeStringBuff), "%B-%d-%Y-%H:%M:%S",
&timeinfo);

  String asString(timeStringBuff);

  int firstHyphenIndex = asString.indexOf("-");
  int secondHyphenIndex = asString.indexOf("-", firstHyphenIndex + 1);
  int thirdHyphenIndex = asString.indexOf("-", secondHyphenIndex + 1);

  String month = asString.substring(0, firstHyphenIndex);
  String dayYear = asString.substring(firstHyphenIndex + 1,
secondHyphenIndex);
  String Year = asString.substring(secondHyphenIndex + 1,
thirdHyphenIndex);
  String time = asString.substring(thirdHyphenIndex + 1);

  Serial.print("Date: ");
  Serial.println(month + "-" + dayYear + "-" + Year);  // Print Date
  Serial.print("Time: ");
  Serial.println(time);  // Print Time
  String urlFinal = "https://script.google.com/macros/s/" +
GOOGLE_SCRIPT_ID + "/exec?" + "&date=" + month + "-" + dayYear + "-" +
Year + "&time=" + time + "&name=" + tName + "&studentID=" + tStudentID;
  Serial.print("POST data to spreadsheet:");
  Serial.println(urlFinal);
  HTTPClient http;
  http.begin(urlFinal.c_str());
  http.setFollowRedirects(HTTPC_STRICT_FOLLOW_REDIRECTS);
  int httpCode = http.GET();
  Serial.print("HTTP Status Code: ");
  Serial.println(httpCode);
String payload;
  if (httpCode > 0) {
    payload = http.getString();
    Serial.println("Payload: " + payload);
  }
  http.end();
}
```

```
uint8_t getFingerprintIDez() {
  uint8_t p = finger.getImage();
  switch (p) {
    case FINGERPRINT_OK:
      Serial.println("Image taken");
      found();
      break;
    case FINGERPRINT_NOFINGER:
      //Serial.println("No finger detected");
      scan();
      return p;
    case FINGERPRINT_PACKETRECIEVEERR:
      Serial.println("Communication error");
      return p;
    case FINGERPRINT_IMAGEFAIL:
      Serial.println("Imaging error");
      return p;
    default:
      Serial.println("Unknown error");
      return p;
  }

  // OK success!

  p = finger.image2Tz();
  switch (p) {
    case FINGERPRINT_OK:
      Serial.println("Image converted");
      break;
    case FINGERPRINT_IMAGEMESS:
      Serial.println("Image too messy");
      return p;
    case FINGERPRINT_PACKETRECIEVEERR:
      Serial.println("Communication error");
      return p;
    case FINGERPRINT_FEATUREFAIL:
      Serial.println("Could not find fingerprint features");
      return p;
    case FINGERPRINT_INVALIDIMAGE:
      Serial.println("Could not find fingerprint features");
      return p;
    default:
      Serial.println("Unknown error");
      return p;
  }
```

```
  // OK converted!
  p = finger.fingerFastSearch();
  if (p == FINGERPRINT_OK) {
    FingerprintDetails* details = getFingerprintDetails(finger.fingerID);
    Serial.println("Found a print match!");
    Serial.println("Fingerprint details:");
    Serial.print("Name: ");
    Serial.println(details->name);
    Serial.print("StudentID: ");
    Serial.println(details->studentID);

    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Success!");
    lcd.setCursor(0, 1);
    lcd.print("Name: ");
    lcd.print(details->name);
    digitalWrite(BUZZER_PIN, HIGH);
    delay(1000);
    digitalWrite(BUZZER_PIN, LOW);

    sendSheet(details->name, details->studentID);

    finger.fingerID = 0;
    lcd.clear();
  } else if (p == FINGERPRINT_PACKETRECIEVEERR) {
    Serial.println("Communication error");
    return p;
  } else if (p == FINGERPRINT_NOTFOUND) {
    Serial.println("Did not find a match");
    return p;
  } else {
    Serial.println("Unknown error");
    return p;
  }
  // found a match!
  Serial.print("Found ID #");
  Serial.print(finger.fingerID);
  Serial.print(" with confidence of ");
  Serial.println(finger.confidence);

  return finger.fingerID;
}
```

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```
  void found() {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Scanning...");
  delay(2000);
  lcd.clear();
}

void scan() {
  lcd.setCursor(0, 0);
  lcd.print("Please Scan...");
}

void notAuth() {
  lcd.setCursor(0, 0);
  lcd.print("Not Authorized!");
  delay(2000);
}

FingerprintDetails* get2fingerprintDatabase(byte tagId[4]) {
  for (int i = 0; i < 20; i++) {
    bool match = true;
    for (int j = 0; j < 4; j++) {
      if (tagId[j] != fingerprintDatabase[i].tagId[j]) {
        match = false;
        break;
      }
    }
    if (match) {
      return &fingerprintDatabase[i];
    }
  }
  return NULL;
}
```

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Appendix B1 Coding For RFID And Fingerprint Attendance Recording

```
#include <Adafruit_Fingerprint.h>

#define MODEM_RX 16
#define MODEM_TX 17
#define mySerial Serial2  // use for ESP32

Adafruit_Fingerprint finger = Adafruit_Fingerprint(&mySerial);

uint8_t id;

void setup()
{
  Serial.begin(9600);
  while (!Serial);  // For Yun/Leo/Micro/Zero/...
  delay(100);
  Serial.println("\n\nAdafruit Fingerprint sensor enrollment");

  // set the data rate for the sensor serial port
  finger.begin(57600);

  if (finger.verifyPassword()) {
    Serial.println("Found fingerprint sensor!");
  } else {
    Serial.println("Did not find fingerprint sensor :(");
    while (1) { delay(1); }
  }

  Serial.println(F("Reading sensor parameters"));
  finger.getParameters();
  Serial.print(F("Status: 0x")); Serial.println(finger.status_reg, HEX);
  Serial.print(F("Sys ID: 0x")); Serial.println(finger.system_id, HEX);
  Serial.print(F("Capacity: ")); Serial.println(finger.capacity);
  Serial.print(F("Security level: "));
Serial.println(finger.security_level);
  Serial.print(F("Device address: ")); Serial.println(finger.device_addr,
HEX);
  Serial.print(F("Packet len: ")); Serial.println(finger.packet_len);
  Serial.print(F("Baud rate: ")); Serial.println(finger.baud_rate);
}
```

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```
uint8_t readnumber(void) {
  uint8_t num = 0;

  while (num == 0) {
    while (! Serial.available());
    num = Serial.parseInt();
  }
  return num;
}

void loop()                       // run over and over again
{
  Serial.println("Ready to enroll a fingerprint!");
  Serial.println("Please type in the ID # (from 1 to 127) you want to save
this finger as...");
  id = readnumber();
  if (id == 0) {// ID #0 not allowed, try again!
     return;
  }
  Serial.print("Enrolling ID #");
  Serial.println(id);

  while (!  getFingerprintEnroll() );
}

uint8_t getFingerprintEnroll() {

  int p = -1;
  Serial.print("Waiting for valid finger to enroll as #");
Serial.println(id);
  while (p != FINGERPRINT_OK) {
    p = finger.getImage();
    switch (p) {
    case FINGERPRINT_OK:
      Serial.println("Image taken");
      break;
    case FINGERPRINT_NOFINGER:
      Serial.println(".");
      break;
    case FINGERPRINT_PACKETRECIEVEERR:
      Serial.println("Communication error");
      break;
```

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```
  case FINGERPRINT_IMAGEFAIL:
      Serial.println("Imaging error");
      break;
    default:
      Serial.println("Unknown error");
      break;
    }
  }

  // OK success!

  p = finger.image2Tz(1);
  switch (p) {
    case FINGERPRINT_OK:
      Serial.println("Image converted");
      break;
    case FINGERPRINT_IMAGEMESS:
      Serial.println("Image too messy");
      return p;
    case FINGERPRINT_PACKETRECIEVEERR:
      Serial.println("Communication error");
      return p;
    case FINGERPRINT_FEATUREFAIL:
      Serial.println("Could not find fingerprint features");
      return p;
    case FINGERPRINT_INVALIDIMAGE:
      Serial.println("Could not find fingerprint features");
      return p;
    default:
      Serial.println("Unknown error");
      return p;
  }

Serial.println("Remove finger");
  delay(2000);
  p = 0;
  while (p != FINGERPRINT_NOFINGER) {
    p = finger.getImage();
  }
```

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```
Serial.print("ID "); Serial.println(id);
  p = -1;
  Serial.println("Place same finger again");
  while (p != FINGERPRINT_OK) {
    p = finger.getImage();
    switch (p) {
    case FINGERPRINT_OK:
      Serial.println("Image taken");
      break;
    case FINGERPRINT_NOFINGER:
      Serial.print(".");
      break;
    case FINGERPRINT_PACKETRECIEVEERR:
      Serial.println("Communication error");
      break;
    case FINGERPRINT_IMAGEFAIL:
      Serial.println("Imaging error");
      break;
    default:
      Serial.println("Unknown error");
      break;
    }
  }

  p = finger.image2Tz(2);
  switch (p) {
    case FINGERPRINT_OK:
      Serial.println("Image converted");
      break;
    case FINGERPRINT_IMAGEMESS:
      Serial.println("Image too messy");
      return p;
    case FINGERPRINT_PACKETRECIEVEERR:
      Serial.println("Communication error");
      return p;
    case FINGERPRINT_FEATUREFAIL:
      Serial.println("Could not find fingerprint features");
      return p;
    case FINGERPRINT_INVALIDIMAGE:
      Serial.println("Could not find fingerprint features");
      return p;
    default:
      Serial.println("Unknown error");
      return p;
  }
```

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```
Serial.print("Creating model for #");  Serial.println(id);

  p = finger.createModel();
  if (p == FINGERPRINT_OK) {
    Serial.println("Prints matched!");
  } else if (p == FINGERPRINT_PACKETRECIEVEERR) {
    Serial.println("Communication error");
    return p;
  } else if (p == FINGERPRINT_ENROLLMISMATCH) {
    Serial.println("Fingerprints did not match");
    return p;
  } else {
    Serial.println("Unknown error");
    return p;
  }

  Serial.print("ID "); Serial.println(id);
  p = finger.storeModel(id);
  if (p == FINGERPRINT_OK) {
    Serial.println("Stored!");
  } else if (p == FINGERPRINT_PACKETRECIEVEERR) {
    Serial.println("Communication error");
    return p;
  } else if (p == FINGERPRINT_BADLOCATION) {
    Serial.println("Could not store in that location");
    return p;
  } else if (p == FINGERPRINT_FLASHERR) {
    Serial.println("Error writing to flash");
    return p;
  } else {
    Serial.println("Unknown error");
    return p;
  }

  return true;
}
```