Sheffield Hallam University College of Business, Technology and Engineering

MSc Dissertation Report

Face Recognition-Based Mobile Attendance Register Application For Higher Educational Institutions

A dissertation submitted in partial fulfilment of the requirements of Sheffield Hallam University for the degree of Master of Science in **Computing**

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Date of Submission	23/08/2024

STATEMENT 1:

This dissertation does NOT contain confidential material and thus can be made available to staff and students via the library.

ACKNOWLEDGEMENTS

I would like to convey my sincere gratitude to the tutors of Sheffield Hallam University, especially my supervisor Dr.Samuele Vinanzi who guided me throughout this project. Special thanks to all the students and faculties who took part in the survey as a part of this project. Their contribution was an essential part of this study. Furthermore, my sincere gratitude to my family and friends for their constant source of motivation.

ABSTRACT

The traditional methods of marking attendance in educational institutions are often time-consuming, prone to errors or having high implementation and maintenance cost. To address these issues, this project describes the design and implementation of a face recognition-based prototype mobile attendance application that can be used in higher educational institutions. Face recognition is a type of biometric authentication system in which an individual is identified using their facial features. The prototype application identifies a student by comparing their face image with the previously enrolled faces in the system. If a matching face is found and the student has a class scheduled, the system automatically marks the attendance. This proposed system is developed using recent technologies like .Net MAUI and OpenCV computer vision library.

The research begins with a review of existing attendance systems followed by a discussion about face recognition technology. Various face recognition algorithms are evaluated to select the most efficient one. A prototype application is then developed using OpenCV face recognition library with the chosen algorithm. The system is trained with a diverse dataset using images of individuals. The results shows that the prototype application is more efficient and accurate even under different conditions. The report concludes with a discussion on the limitations and future enhancements.

Keywords:

Face recognition, Attendance register system, Image processing, Biometric verification, OpenCV, .Net MAUI

CONTENTS

1. INTRODUCTION

1.1 Project Rationale

Attendance is crucial for academic success and personal development. However, Sittampalam and Ratnarajah (2019) observed that in academic institutions in most developing countries, paper-based attendance systems are used to manage the attendance of students. There are a few drawbacks to this system. High time-consuming, manual errors, loss or damage of paper, inefficiency, inconvenience, acting as proxies to mark attendance, etc. are few of them. In a study conducted by Shoewu et al. (2014) with 80 students, it was found that the average time taken to mark attendance per student is 17.83 seconds which implies that manual methods are significantly time-consuming compared to automated systems.

As per Patil et al. (2022), with the evolution of technology, new systems were developed like RFID (Radio Frequency Identification), biometrics, barcode etc. which are more expensive and complex. Even though these technologies are more efficient and convenient compared to traditional paper-based systems, Gohel (2018) argues that a significant reason that institutions are not using these technologies is due to security concerns and high implementation and maintenance costs. This project will research how facial recognition can be integrated into a mobile app to create a smart attendance register system that can be implemented in higher educational institutions which could overcome the disadvantages of traditional systems.

1.2 Project Aims

This project aims to create a face recognition-based automated attendance register prototype mobile application using OpenCV computer vision library that could be implemented in higher educational institutions. This application helps institutions to implement an efficient and more accurate system that can reduce the time required to mark attendance as it performs quickly by identifying students using facial recognition. The deliverables of this project are a mobile application with the face recognition capability, a web API for the backend service and a web application portal for managing the master data of the application.

1.3 Research Objectives

The main objectives of this project are as follows:

1.Conduct a literature review on existing attendance register systems.
2. Get feedback from students and teachers about the current attendance register systems and proposed system.

3. Identify the suitable research philosophy, approach, strategies, data gathering tools and development tools to implement the proposed system.

4. Design and implement a prototype mobile application using facial recognition to mark attendance.

5. Test the mobile app with different users, various scenarios etc. and verify the functionality, performance and its accuracy.

6. Evaluate the results and analyse if the project aims and objectives are met.

7. Suggestions for future enhancements of the applications.

8. Write a dissertation report on the project

1.4 Research Questions

1. What are the current challenges with existing attendance systems in higher educational institutions, and how do students and faculty perceive the adoption of face recognition-based attendance solutions?
2. How face recognition technology can be integrated into a mobile application to develop an attendance register application that could be used in higher educational institutions?

1.5 Significance of the research

This research is done to develop a new attendance register system to overcome the limitations of the existing ones. Jha et al. (2023) supports the idea that of integrating facial recognition technology into attendance system presents numerous benefits, including the elimination of manual check-ins, which significantly saves time and minimizes administrative workload. Kortli et al. (2020) also agree to this idea and highlights the fact that due to its versatility and effectiveness, facial recognition has recently emerged as one of the most widely adopted biometric authentication systems, with applications spanning home security, border control, surveillance and many more. This project will help educational institutions to implement an

effective attendance register system using facial recognition in the form of a mobile app. This system is simple and does not require any complicated hardware other than a mobile or a tablet and it is easy to maintain as well. This was possible using recent technologies like OpenCV and .Net MAUI. Teachers will have much benefit from this system as attendance registration takes very less time and that too without their interference and they can focus on their teaching without wasting much time. It is also helpful for students as this process is much simpler and easy to use. A similar system using face recognition was implemented by Syamala et al. (2020). They found that the system offered significant advantages, including being less intrusive, cost-effective, and more efficient, ultimately reducing the manual workload for users. This highlight's that face recognition is more reliable and much more accurate than other traditional methods. Considering all these advantages of this system, this kind of system has much significance in the modern world to enhance the attendance tracking process.

2. LITERATURE REVIEW

There have been significant improvements in the attendance register process over time. With the evolution of modern technology, new methods were implemented to make the system more efficient and secure. Few research papers relevant to existing systems are reviewed in this paper.

2.1 Existing systems

2.1.1 Paper Based System

Acasamoso et al. (2021) mentioned in their conference paper that the Polytechnic University of the Philippines in Ragay has been following the traditional way of paper-based marking system for about 26 years. Subbiah et al. (2022) highlights that manual attendance systems can be problematic due to potential errors, such as teachers missing students, students marking attendance for absent peers, or students leaving class for personal reasons. Additionally, there is a risk of misuse where teachers might mark students absent out of bias. Understanding the limitations of paper based manual systems, GOV.UK (2022) suggested that to enhance accuracy and streamline the sharing and analysis of attendance data, schools are encouraged to utilize electronic management information systems for maintaining attendance and admission records. This implies even the government is promoting digital solutions to overcome the limitations and inefficiencies of traditional paper-based systems.

2.1.2 RFID System

Shah and Abuzneid (2019), proposed a Smart Attendance System that uses Radio Frequency Identification (RFID) technology for marking attendance. Ahmad and Nababa (2021) supports the idea that RFID technology significantly enhances the accuracy and performance of attendance systems over traditional paper-based methods. Students will use RFID cards in which a unique identification number like student ID will be embedded in it. Even though this system improves the efficiency of the attendance system in terms of reducing the time and minimizing errors, it has few limitations. While RFID systems can be cost-effective in the longer run, the initial installation and setup cost of such device are high. A power outage will

interrupt the working of the device. If a student lost his card, a new card needs to be provided. As stated by Tamilkodi (2021), this system does not solve the issue of proper authentication because there may be chances that other students can use someone else's card and mark the attendance.

2.1.3 Fingerprint based Attendance System

Biometric Smart Attendance System was proposed by Jayakumar et al. (2022) in which the fingerprint is used to uniquely identify an individual. They claim that this system will be more secure since fingerprints are used for identification. Each student's fingerprint is analysed and saved using a process called enrolment. The fingerprint reader extracts key features of fingerprint using the sensor and compares them with the ones saved in the database and the attendance marking can be done. The need for students to carry a separate RFID card is no longer required. However, Budi et al. (2018) argues that this system has high investment cost and is inaccurate. This system may not be efficient at times as the scanner may not be able to detect the fingerprint at the first attempt. Also, if the finger is wet or dirty, this might affect the device reader's performance. Since the covid –19 pandemic, the issue of hygiene and the spread of virus also became a concern as all students are touching the device.

2.1.4 QR Code-Based Student Attendance System

Liew and Tan (2021) proposed an android application which can detect and verify attendance using Quick Response (QR) code which is a type of code that can be used to store information and read by machines. Teachers can generate a unique QR code and share it with the students. Students will scan the QR code using their phones to mark the attendance. Similar system in the form of a mobile application with QR code scanner integrated with it was developed by Stupina et al. (2021). They confirm that generation and scanning of a QR code takes less than a minute which makes the attendance registration process save much time. However, a key concern highlighted by Mohammed and Zidan (2023) with QR code-based attendance systems is the risk of fraud, as students might share or create fake QR codes, leading to inaccuracies and compromising the system's integrity.

2.1.5 Web Based Attendance System

Recent advancements in attendance management have introduced web-based systems that significantly enhance the efficiency and security of recording student attendance. A notable example is the implementation of a web-based attendance system developed by Al-Mesbahi, Juremi, and Hamza (2021). This system allows staff to manage student attendance through a secure, online platform where each user has a unique username and password. This system is digital version of the traditional paper-based system. A key feature is the two-factor authentication (2FA) process, which integrates one time password (OTP) to protect the login function, addressing vulnerabilities associated with traditional login methods. By using modern technology such as bootstrap for responsive design, the system ensures user-friendly interfaces across various devices.

2.1.6 Other systems

Rahman et al. (2022) developed an IoT- based attendance register system which is integrated with an RFID card reader and MySQL database. This system is using atmega328P microcontroller integrated with the Arduino uno and ESP8266 Wi-Fi module. This is similar to the RFID system mentioned earlier, but with the use of IoT sensors, this system offers real-time synchronisation and improved performance. However, the use of Internet of Things (IoT) sensors can make such systems expensive.

2.1.7 Face Recognition Technology and Its Potential Benefits

Face recognition technology, a subset of biometric systems, has gained significant attention due to its advancements in security and user identification. This technology uses algorithms to analyse and match facial features captured through cameras or sensors, offering a contactless and automated method of verifying identities. Jayaraman et al. (2020) note that the biometric system distinguishes users based on unique facial features such as the mouth, nose, eyes and forehead or by examining spatial geometry characteristics to distinguish between individuals. Facial recognition can be conducted through two primary methods: identification and verification. In identification, the system detects if there is any human face in the input image. In verification, the system compares the detected face in the input image against previously trained images to confirm a match.

The primary advantage of face recognition technology lies in its ability to enhance security and convenience. Unlike traditional authentication methods that rely on passwords or physical tokens, face recognition provides a seamless, user-friendly experience that reduces the risk of unauthorized access. There are various algorithms available to implement the face recognition technology which are pointed out by Dirin, Delbiaggio, and Kauttonen (2020). They are the Eigenface, Fisherfaces, and Local Binary Patterns Histogram (LBPH) algorithms. Among these various algorithms, Budiman et al. (2023) suggest that Local Binary Patterns Histograms (LBPH) are well-regarded for their high performance and accuracy in facial recognition, capable of identifying individuals from both frontal and lateral viewpoints. In an experiment conducted by Shetty et al. (2021), using LBP classifier algorithm, 5 faces in an image were identified in 0.04 seconds and the accuracy rate was 100 %. This indicates the efficiency of the LBP algorithm is really good and this can be selected for the prototype application.

3.0 RESEARCH METHODOLOGY

3.1 Introduction

This chapter aims to describe the methodology used in this project for the development of a prototype application. This project follows the Research Onion Framework by Saunders et al. (2019) containing various aspects like research philosophy, research approach, strategy, techniques, data analysis, ethical considerations and limitations are discussed in this chapter.

3.2 Research Philosophy

Research philosophy is a set of assumptions and beliefs for conducting research on a topic. Since this research is focused on developing an attendance marking system using face recognition which can be measured and observed, pragmatism research philosophy has been selected for this study due to its focus on practicality and problem-solving feature. Pragmatism offers a flexible approach, integrating both qualitative and quantitative methods to efficiently address complex problems which is the most important strength of this method. In terms of developing the face recognition app, the accuracy and performance of face recognition model is crucial, being a measurable value. Additionally, user feedback and suggestions are vital to enhance the application's user-friendliness and adoption rate. Considering these factors, pragmatism was deemed the most suitable philosophy for this research. On the other hand, another philosophy that could have been used is Positivism. However, it was not considered due to its potential limitation in exploring subjective experiences and solely focusing on the accuracy of face recognition. Interpretivism may not be the best approach for addressing the technical challenges and objectives of this research project. Moreover, this project involves computational processes in face recognition rather than understanding human behaviour through subjective interpretations. However, the flexibility of this method might lead to complex design of the project and requires more effort which is a limitation that needs to be addressed. This limitation can be managed by carefully organizing the research process and maintaining a focused approach throughout the study. Therefore, pragmatism seems to be the most suitable research philosophy that offers a balanced approach to addressing the challenges and aligns to the objectives of this project.

3.3 Research approach

This research employs a combination of both quantitative and qualitative approaches in various stages. The decision to use a mixed-methods approach is driven by the need to explore both the technical performance of the system and the user experiences and perceptions associated with its implementation. The quantitative aspect involves measuring the accuracy and performance of the face recognition process, whereas the qualitative aspect focuses on to gather insights into user experiences, concerns, and expectations, offering a deeper understanding of the system's impact and usability. If only a quantitative approach was selected, then this research may lack user expectations. On the other hand, if only a qualitative approach were selected, then this application might not be accurate and could cause incorrect results. In the requirement analysis stage, using qualitative methods, requirements and suggestions from students and teachers were collected. Quantitative data results from the manual testing, system logs and unit testing of the application were used to find the accuracy and performance of the application. However, the use of mixed methods can lead to a more complex research design. Also, data collection and analysis using survey can be time-consuming and may require additional resources. These limitations of using this approach can be managed by careful planning and coordination.

3.4 Research Strategy

Research strategies guide the overall direction of the research. Some of the most used strategies includes experiments, surveys, case studies, action research, ethnography, grounded theory, and archival research. Main strategies used in this research are experiments and surveys to address both the technical and user expectation aspects. The primary goal of this experiment is to evaluate the system's performance in terms of accuracy, performance and reliability. By conducting controlled experiments, the study measures key metrics such as accuracy, and execution time. A controlled environment was setup to test different conditions and factors that might affect the face recognition, like skin colour, facial features, background light. The quantitative data collected because of these experiments were used for data analysis.

Survey research strategy was used to gather data from a group of students and teachers about their perceptions of the face recognition-based attendance register system. Using surveys, qualitative data on user satisfaction levels of current attendance systems, familiarity of the face recognition technology and concerns about its implementation will be gathered. This data will provide insights into user attitudes and expectations, which are critical for assessing the

system's practical viability. As this project aims to develop a system for a broad area of audience rather than focusing on a specific area or case, case studies are less suitable for this research project. As ethnography strategy seems to be time-consuming and focus more on social and cultural contexts, which are not the primary focus of this research project. Therefore, it seems to be less suitable for this project. Grounded theory is more suitable to develop new theories based on the collected qualitative data, which is not the case with this project. This project aims developing and evaluating a new solution, archival research which involves analysing historical data to answer research question is not appropriate in this context

3.5 Research Choice

A mixed method is followed in this research project as both the qualitative factors like user expectations and quantitative aspects like accuracy and performance are primary focus of this research. By combining quantitative and qualitative methods, the study can explore both the measurable outcomes of the system's performance and the contextual factors influencing user acceptance which is the major strength of using this method. The Mono method on the other hand focus only on either qualitative or quantitative aspects. So, either the accuracy or user expectation will have to be compromised if mono method is used as only one type of data could be collected and analysed. However, if multi method was used, the only advantage is that it could enhance the depth of understanding within the same paradigm. However, using this mixed method choice can be complex and time-consuming, requiring careful planning and execution. The mixed-methods approach aligns with the research objectives by allowing for a detailed investigation of both the technical performance of the face recognition system and the user's perception and concerns about its adoption. This implies that mixed-methods approach is a good fit for the success of this project.

3.6 Time Horizons

A cross-sectional approach is followed in this project as this is a prototype application and developed in a short time frame. Cross-sectional studies are efficient for collecting data from a large sample within a limited timeframe, making it possible to complete the study within the required deadlines. This approach is appropriate given the constraints of the research timeline and the nature of the data required to answer the research questions. A longitudinal method was not chosen because it requires data to be collected over a long period of time and observe its changes and trends on that period which is not necessary in the context of this project.

3.7 Techniques And Procedures

3.7.1 Participants/Data Source

For the survey, students and faculties of Sheffield Hallam university were considered. Students at other universities were also considered because different universities may be using different attendance systems. Surveys were distributed to 25 participants and 18 of them completed the survey. The participants' ages were distributed as follows: 10 participants were between 18-30 years old, 7 were between 31-50 years old, and 1 participant was 51 years or older. The median age of the participants is 18 years, and the standard deviation of the ages is approximately 9.13 years. For training the face recognition model, this study utilized the MUCT Face Database developed by Milborrow, Morkel, and Nicolls (2008) database, which is a publicly available dataset designed for facial recognition research. The MUCT database includes images of individuals under varying lighting conditions, expressions and skin tones providing a comprehensive collection of facial data.

3.7.2 Sampling technique

The findings in this project can be used to generalize to the entire population of students in the university. Due to this fact, probability sampling was applied to this project. Among the various probability sampling techniques, a stratified probability sampling techniques has been chosen over other methods to ensure the target population is divided into subgroups that share same characteristics. The entire population was divided into 3 subgroups: images with low or too much lighting, with normal lighting and images with facial expressions. The sample included both males and females ensuring that this study has most accuracy and minimize the bias between gender. A sample size of 30 individuals were selected from the MUCT image database. This sample size was deemed adequate to train and validate the face recognition model effectively. These sample images were used to train the face recognition model. Individuals from this sample were then randomly selected to verify the face recognition process.

Non-probability sampling methods were not considered because they do not guarantee that each member of the population has a known or equal chance of selection.. This increases the risk of selection bias, where certain groups or characteristics may be incorrectly represented. Due to the potential for bias, findings from non-probability sampling may not be generalizable to the

broader population. For face recognition models, which require a diverse and representative dataset, this lack of generalizability can significantly impact the model's performance and accuracy.

3.8 Data Collection Process

Qualitative and quantitative data were collected as a part of this research project. Qualitative data collected includes survey data collected from the participants. Using Qualtrics platform, survey was designed carefully with relevant questions. Survey link along with the participant consent form and participant information sheet were distributed mostly to students and faculties of Sheffield Hallam university through WhatsApp and emails. Students at other universities were also invited to participate in the survey. The response was collected over a period of 2 weeks. Out of 25 surveys distributed, 18 responses were received achieving a 72% of response rate. These data were essential to understand the user expectations about the implementation of face recognition technology in the prototype application.

For training the face recognition model during the development phase, quantitative data in the form of images of individuals were required. Considering the difficulty of using real participants, it was planned to use any publicly available database of images. MUCT database was found which meets the requirements of this project. One of the authors of this database were contacted by email to confirm there are no restrictions or copyright issues for using the database for this research project. So, this database was considered as the primary data source for the training and testing process of the prototype application. Details like name, age, address, etc where required to register users in the prototype application.

Instead of using real user's details, a third-party C# library called Bogus was used to generate fake data and assign it to users. Other quantitative data collected includes data from database records like accuracy rate and processing time obtained using manual testing. Using structured query language (SQL), queries were run against database records to get quantitative data required for analysis. Execution time of the recognition process was noted using a timer during manual testing. Results from the unit testing were also used in the analysis process.

3.9 Ethics

Strict ethical guidelines were followed throughout this research project to ensure the integrity and well-being of all participants and their personal data. Proper ethical approval was obtained

from the university before starting the research project. None of the participants were forced to take part in the research project; instead, proper consent from all participants was obtained in this research project, and the assurance of confidentiality was maintained throughout the project. A publicly available image database was used in the development of this prototype application and the author was contacted to ensure there are no copyright issues in using the database. To further minimise ethical risks, a fake data generator is used to generate details like name, address, age etc. ensuring no real individuals' data is involved. This approach aligns with the principles non-maleficence, as the system aims to improve attendance tracking accuracy without causing harm to any participants. Since recent technologies are used to build this system, which improves accuracy and efficiency of attendance tracking process, the ethical principle of beneficence is addressed by ensuring the system provides benefits to students, teachers and the managements.

Survey was designed and stored using the Qualtrics platform which is associated with the university. The results and summary of this research will be shared with participants upon request to ensure transparency. The system will be designed to avoid bias towards any group of individuals, including age, gender, religion, and race. This was achieved by thorough testing of the application using images of individuals having different sex, skin tone etc. The system will be transparent, giving individuals the right to understand how it works and how their data is used, as clearly outlined in the participant information sheet. This research project uses a popular open-source library called OpenCV for the face recognition.

4.0 SURVEY RESULTS AND ANALYSIS

This research project follows a mix of qualitative and quantitative data analysis processes. As part of qualitative data collection, around 25 respondents were invited for the survey. Among these respondents, 18 responses were collected, including 17 students and 1 teacher. This section analyses the results of the survey data recorded by the participants.

4.1 Question 1

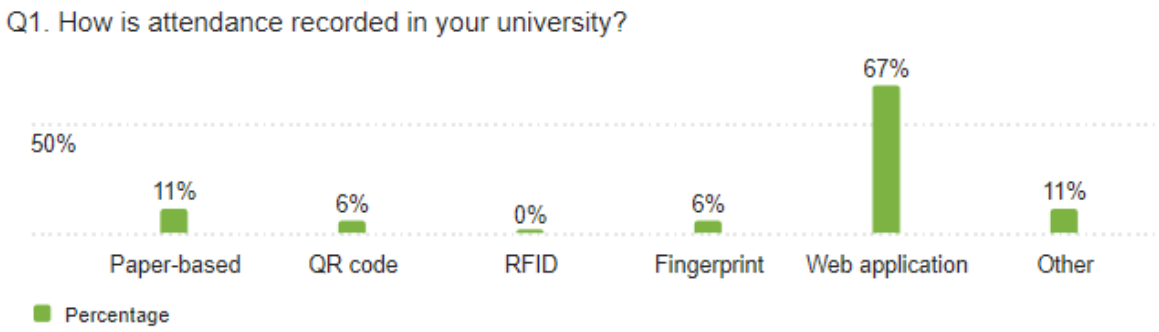


Figure 4.1: Percentage of responses on attendance recording methods.

Analysis: The analysis shows 67% of respondents are using web-based systems for attendance marking at their university. This preference for web-based systems for attendance marking highlights the shift towards digital solutions in educational institutions. Even though the technology has improved a lot, a notable proportion of respondents (11%) mentioned their university still uses paper-based systems. This may be due to budget constraints or the lack of knowledge of the advanced systems or a resistance to change to the digital methods. The small proportion of usage of QR code (6%) and fingerprint systems (6%) shows the growing interest in adopting new technologies for attendance systems. None of the respondents mentioned the use of the RFID-based systems which indicates it is not a preferred system anymore and many advancements are required in this area. The high cost of implementation and the complexity of maintaining the system and its associated devices may be an important factor that makes it less popular. The 'Other' category has 11 % of responses which suggests the existence of other less popular methods. These results highlight the preference of digital systems using recent technologies.

4.2 Question 2

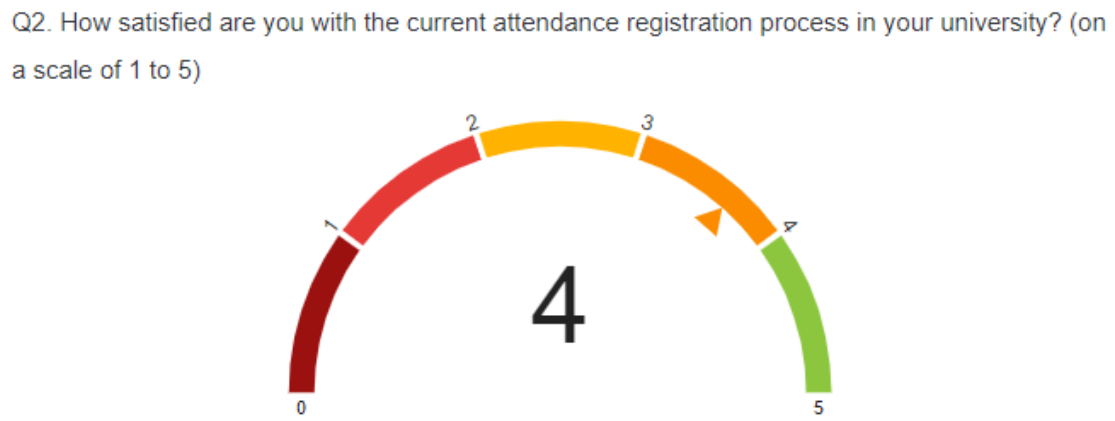


Figure 4.2: Mean satisfaction level with the current attendance system.

Analysis: The average satisfaction score by the respondents is 4 indicating an above average satisfaction among the respondents with the existing attendance system used in their university. Majority of the respondents selected values 4 and 3 which may be those who are using the web-based application that was discussed related to Question 1. It is notable that only very few respondents were fully satisfied with the system indicating the possibility of improvements and enhancements. This data shows the satisfaction levels can be improved by considering the suggestions and expectations of users and introducing a new system that could overcome the disadvantages of existing systems.

4.3 Question 3

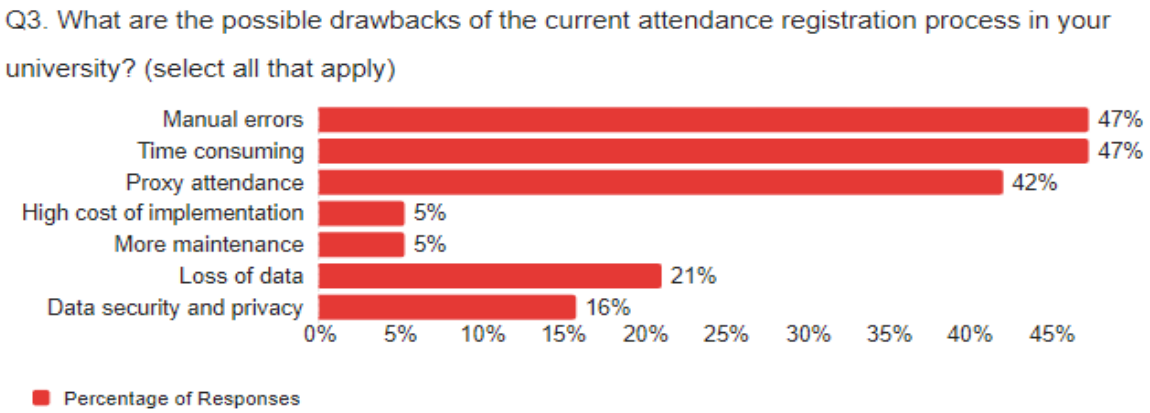


Figure 4.3: Drawbacks in the current attendance systems.

Analysis: The analysis reveals that the most critical drawbacks of the current attendance registration process identified by the respondents are manual errors and the time-consuming nature of the process, each affecting nearly half of the respondents. Both these options were selected by 47% of the respondents. Proxy attendance is also a significant concern, reported by 42% of respondents which shows the concerns over the reliability of attendance records. Other issues, such as loss of data and data security/privacy concerns, are noted by 21% and 16% of respondents respectively, indicating that participants are less concerned about it. However, it is worth considering this for the prototype application development to enhance system robustness and trustworthiness. High cost of implementation and maintenance issues are the least cited, each by 5% of respondents. This concern, while not widespread among the general user base, is particularly relevant to university management, who must balance the budget constraints with technological advancements.

4.4 Question 4

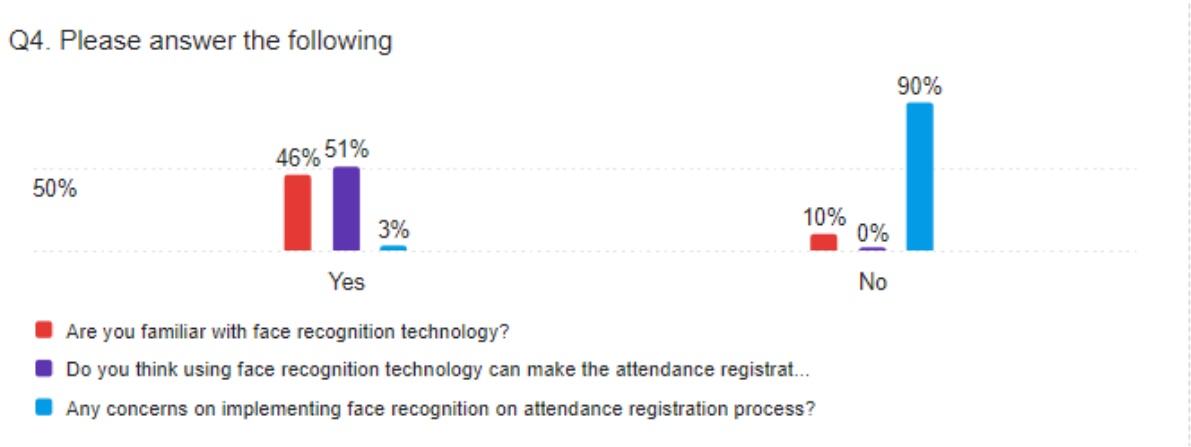


Figure 4.4: Concerns and perceptions about implementing face recognition technology

Analysis: This survey question was aimed to assess the familiarity of face recognition technology, its benefits in the attendance registration process and concerns related to its implementation in universities. Understanding user perceptions about these is crucial for the adoption of face recognition in the prototype application. Nearly half of the respondents (46%) are familiar with face recognition technology, indicating a decent level of awareness among the respondents. However, the fact that 10% are unfamiliar suggests that there may be a knowledge gap which needs to be filled by making them aware about the potential benefits of the face recognition technology. Due to this knowledge gap, only a half or the respondents (51%) say they think the face recognition technology can make the attendance registration process even

better. This again shows the knowledge gap among the respondents. But this positive response among the respondents indicates that they are aware about the potential benefits of the face recognition technology in terms of improving the accuracy, effectiveness and ease of the attendance registration process. An overwhelming majority (90 %) of the respondents do not have concerns in the implementation of face recognition for the attendance registration process which indicates a high level of trust in the technology. However, the concerns of 3 % of the respondents are to be addressed which might be due to the security and privacy concerns.

4.5 Question 5

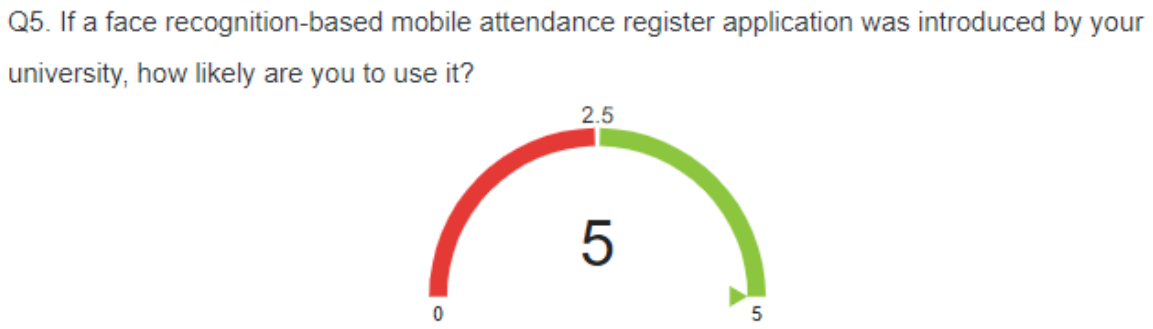


Figure 4.5: Mean likelihood of using face recognition technology

Analysis: The mean score of 5 suggests an exceptionally high willingness among students and faculties to use the face recognition-based mobile attendance application if implemented by their university. A mean score at the maximum value on the scale indicates that nearly all respondents are highly inclined to use the app if introduced. The high mean score reflects strong confidence in the technology and its perceived benefits, such as convenience, ease of use, and efficiency. This finding aligns with earlier survey question results, where most respondents believe that face recognition technology would make the attendance process easier and more efficient, and few expressed concerns about its implementation.

4.6 Question 6

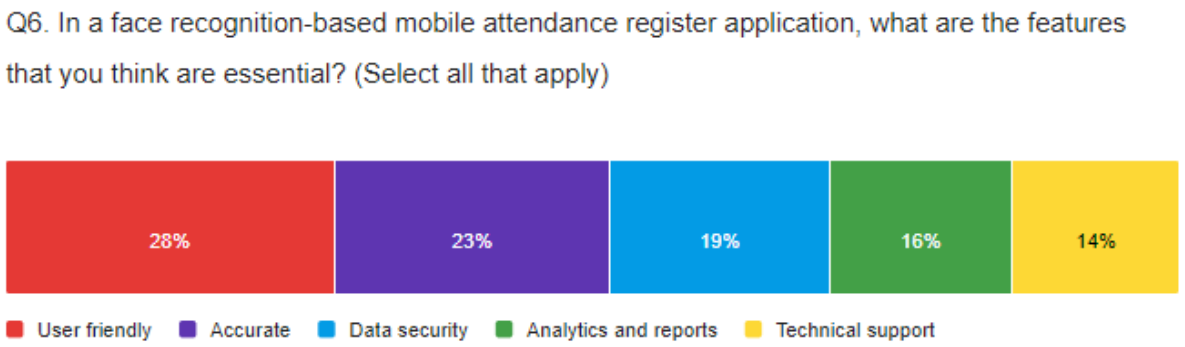


Figure 4.6: Percentage distribution of essential features in face recognition-based application.

Analysis: The purpose of this survey question was to identify the features that students and faculties consider essential in a face recognition-based mobile attendance register application. The highest percentage of respondents (28%) identified a user-friendly interface as the most essential feature. This emphasises the importance of ease of use in ensuring the application's usability. Students prioritise applications that are easy to navigate and require minimal effort to operate. Accuracy is the second most essential feature, cited by 23% of respondents. Given the nature of the application, which involves recording attendance, accuracy is crucial to ensure that the system correctly identifies students and records their presence without errors. The application must employ advanced face recognition algorithms that are reliable and have a low error rate to maintain the trust of users and the integrity of attendance records. Testing and validation of the technology should be rigorous to avoid misidentification or false positives/negatives. Data security is identified as an essential feature by 19% of respondents. Since the application will manage sensitive biometric data, implementing strong data protection measures is crucial to prevent breaches, unauthorized access or misuse of personal information. Analytics and reports and technical support were mentioned by 16 % and 14 % of the respondents respectively which are also the important features to be considered. These findings underscore the importance of designing an application that is easy to use, reliable, secure, and supportive. Understanding these preferences helps in the design and development of a system that meets user needs and ensures high satisfaction and adoption rates.

4.7 Question 7

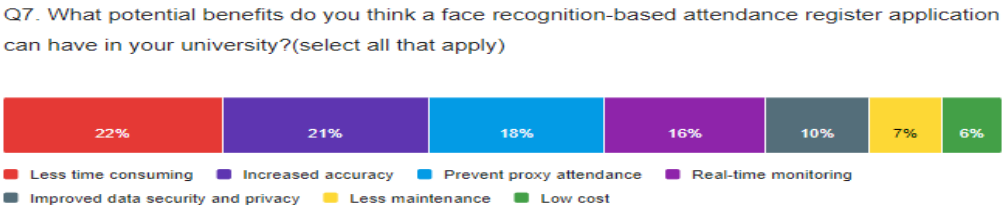


Figure 4.7: Percentage distribution of benefits of face recognition-based application.

Analysis: The survey results highlight that the most anticipated benefits of implementing a face recognition-based attendance system are reduced time consumption (22%) and increased accuracy (21%). This implies the current systems are having the issues of more time consuming and less accuracy. Preventing proxy attendance (18%) is also a significant perceived benefit, indicating concerns about integrity in the current system. 16% of respondents consider real-time monitoring is a potential benefit that would make the application more efficient and responsive. Improved data security and privacy (10%) is an important concern, reflecting a desire for secure handling of personal data. However, fewer respondents see low cost (6%) and less maintenance (7%) as primary benefits, suggesting that while these are advantages, they are not as critical as the operational efficiencies and accuracy improvements. The cost and maintenance is not a concern for students or faculties but in the viewpoint of the management of the university it is one of the most important factors to be considered.

4.8 Question 8

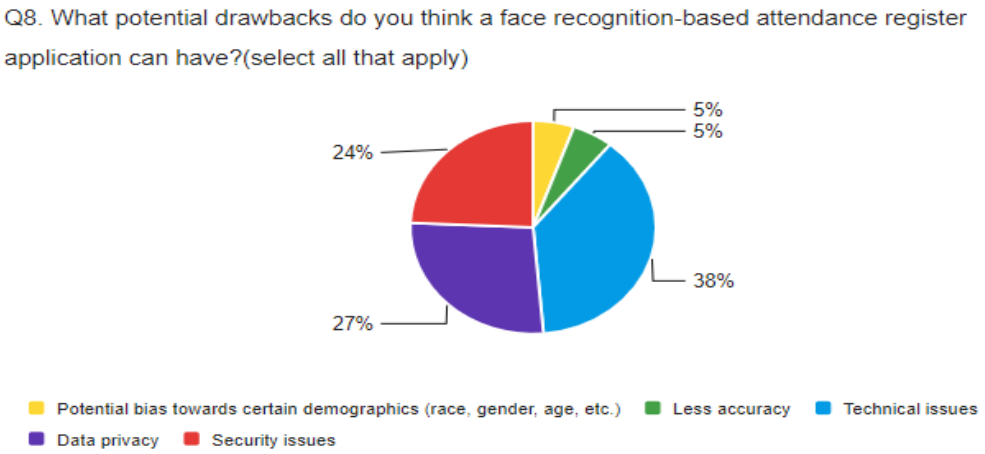


Figure 4.8: Percentage distribution of drawbacks of face recognition-based application.

Analysis: The results indicate that the primary concern regarding the implementation of a face recognition-based attendance application is related to technical issues (38%). This indicates the respondents have concerns regarding the reliability of face recognition which implies the prototype application should be designed and tested thoroughly to make the application more reliable. Data privacy concerns (27%) are also significant, reflecting worries about how biometric data will be handled, stored, and protected. Given the sensitive nature of facial recognition data, there is a strong need for security measures to prevent unauthorised access and ensure compliance with privacy regulations. Security issues (24%) are closely related to data privacy, focusing on the risks of data breaches or hacking attempts that could compromise the system and expose personal data. By implementing proper authentication, authorization techniques and various other measures, data privacy and security could be implemented in the prototype application to keep the user's data secure and anonymous. Interestingly, only 5% of respondents are concerned about less accuracy and potential bias towards certain demographics (race, gender, age, etc.). This may be because the respondents trust the accuracy levels of face recognition technology. However, the low percentages in these areas should not be overlooked, as even a small incidence of inaccuracy or bias could have serious implications for the fairness and reliability of the system.

5.0 SYSTEM DESIGN AND DEVELOPMENT

5.1 System Architecture

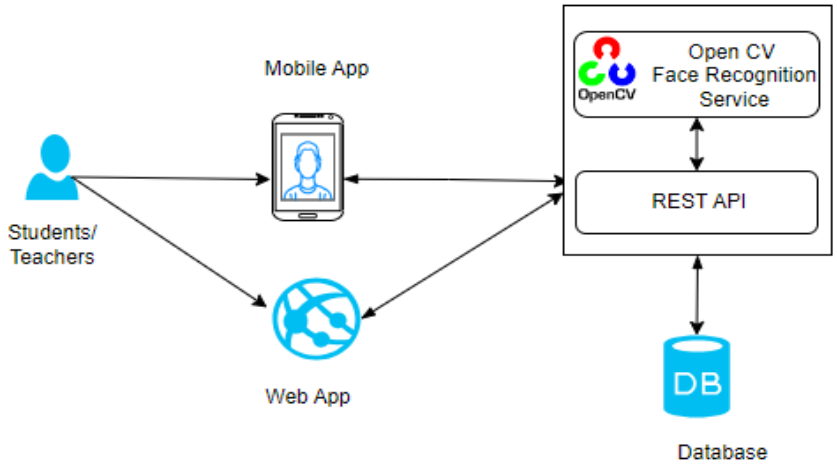


Figure 5.1.1: High level architecture diagram

The main components of the proposed system are an android mobile app, web application, REST API integrated with face recognition service and the database as mentioned in the figure 5.1.1. The mobile app is an android application that can be installed on android devices using an apk installation file. Once installed, students can register and enrol in the application by providing their basic details and images. The REST API component acts as the backend service for the mobile app. This API provides the necessary endpoints for all the functionalities such as enrolment, marking attendance, get attendance history etc. The face recognition service is another important part of this proposed system which is integrated with the API. The face recognition module has 2 main functionalities like training the face recognition model and recognizing students for attendance marking. The application data including the user details, and attendance records are stored in Microsoft SQL server database. The web application component of this system serves as the portal for teachers or admin to manage this system. Using this portal departments, courses, modules and schedules can be created.

The mobile app has the option to register students into the system using the enrolment process where their basic details are entered along with their face image. The face recognition model processes the image and use it to train the recognition model which is then saved into the database. During the attendance marking process the application detects students face after preprocessing the image. If a match is found with the previously trained faces, the model will

fetch the student's details and checks for the timetable schedule from the database. If a valid class is found, the attendance is automatically marked, else a warning message will be displayed and will be redirected to the profile page where we can see the attendance history and upcoming class schedules. The flowchart for student enrolment and attendance marking process is shown in the figure 5.1.2 below.

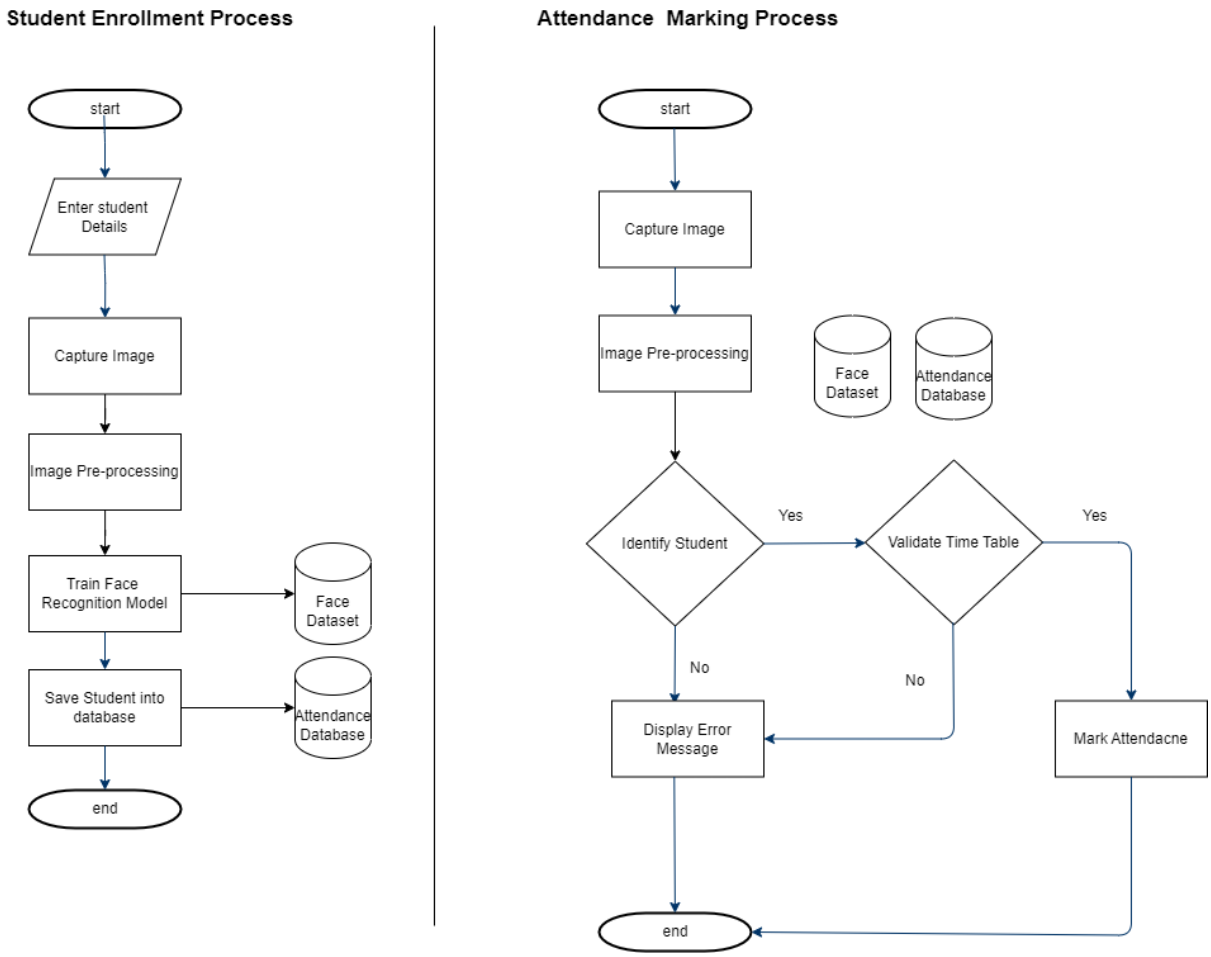


Figure 5.1.2 Flowchart for student enrolment and attendance marking process

5.2 Development Frameworks and Tools

Mobile App: .Net MAUI app development framework

Web Application: .Net 6 (MVC architecture)

Web API: .Net 6 Framework

Programming Language: C#

Database: Microsoft SQL Server

Data Access Technology: Entity Framework Core
Face Recognition: OpenCV
Code Version Control Tool: GitHub
Integrated Development Environment (IDE): Visual Studio

Various .Net technologies are used in the development of this project. The Android app is developed using .NET MAUI which is a multi-platform app development framework. While there are other alternatives such as React Native, Flutter etc, .Net MAUI was chosen due to its cross-platform support, seamless integration with the .NET ecosystem, unified UI design, performance improvements and strong community support. The web application was developed using the .Net 6 framework and MVC (model view controller) architecture. The web API was developed using .Net 6 framework and it was configured with swagger UI to visually display the endpoints to the users. C# programming language is used in mobile, web and API development. Application data is stored in a Microsoft SQL Server database. Visual studio development platform is used to develop all these projects as all these projects are .Net technologies. For efficient and flexible data access, the popular ORM (object relational mapping) tool entity framework core is used. For developing the face recognition model, OpenCV is used, which is an open-source library that provides face recognition services. All the three solutions were uploaded to GitHub account as a backup.

5.3 Face Recognition Model

The face recognition module is an important part of this project which is responsible for the identification and verification of individuals. OpenCV is an open-source machine learning and computer vision-based software library that has various algorithms that can be used in the face recognition process. The popular algorithm LBPH is one among them and due its accuracy and simplicity and efficiency, this algorithm was selected for this project. There are 2 stages involved in the development of a face recognition model. Model training and model verification.

5.3.1 Model Training:

Using the Haar Cascade classifier, the faces in the image are detected. The detected face in the image is cropped and converted into grayscale and normalised. The detected face is then

divided into a grid of cells normally 8x8 pixels each. LBPH Face Recognizer internally uses Local Binary Patterns (LBP) for face recognition. Each pixel in the image is compared with its adjacent pixels and is converted into a binary number which is called LBP. For each cell in the image, a histogram of the LBP is created which represents the frequency of each pattern. Histograms of all the cells are then combined into a single histogram which represents the detected face. Figure 5.3.1.1 given below illustrates this conversion process, based on the methodology described by Abuzneid and Mahmood (2018). The histogram is saved in the file storage with the student ID. The detected image is also saved as a .bmp file format with the unique student id as its label. A separate text file is also maintained to keep a record of these images with its label. Figure 5.3.1.2 shows the code implementation of model training process in the API solution.

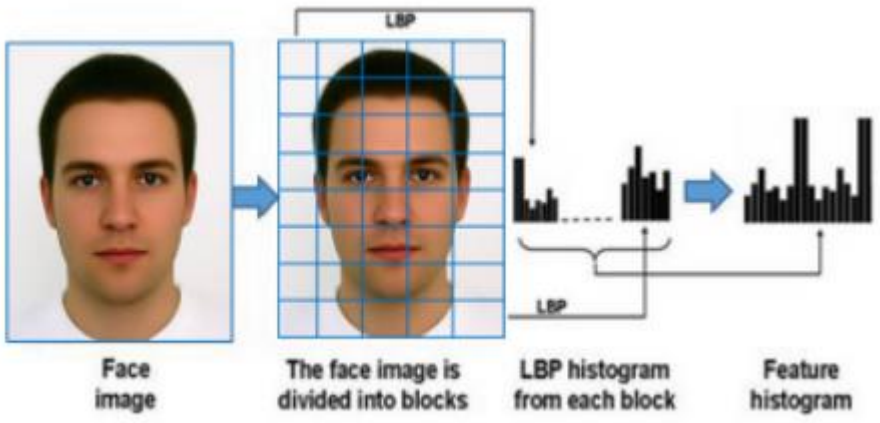


Figure 5.3.1.1: Face representation using local binary patterns

```
2 references
public void TrainModel(string studentId, Image<Bgr, byte> bgrFrame)
{
    try
    {
        var grayFrame = bgrFrame.Convert<Gray, byte>();
        var faces = haarCascade.DetectMultiScale(grayFrame, 1.1, 5, new Size(30, 30));

        foreach (var face in faces)
        {
            var detectedFace = grayFrame.Copy(face).Resize(200, 200, Inter.Cubic);
            detectedFace._EqualizeHist(); // Normalize the image
            detectedFace.Save(facePhotosPath + "face_" + studentId + "_"+(trainingImages.Count + 1)+ CConfig.ImageFileExtension);
            using (StreamWriter writer = new StreamWriter(faceListTextFile, true))
            {
                writer.WriteLine($"face{trainingImages.Count + 1}:{studentId}");
            }
            trainingImages.Add(detectedFace);
            labels.Add(int.Parse(studentId));
        }
        if (trainingImages.Count > 0)
        {
            using (var imagesVector = new VectorOfMat())
            using (var labelsVector = new VectorOfInt(labels.ToArray()))
            {
                foreach (var img in trainingImages)
                {
                    imagesVector.Push(new Mat[] { img.Mat });
                }
                recognizer.Train(imagesVector, labelsVector);
                recognizer.Write(modelPath); // Use Write method to save the model
                SaveHistogramImage(grayFrame.Mat, studentId);
            }
        }
    }
    catch (Exception ex)
    {
        throw ex;
    }
}
```

Figure 5.3.1.2: Code implementation of model training.

Images from the sample dataset of images selected from the MUCT database were used as input to train the face recognition model. Figure 5.3.1.3 shows a sample dataset having 30 images including 3 images of each individual.

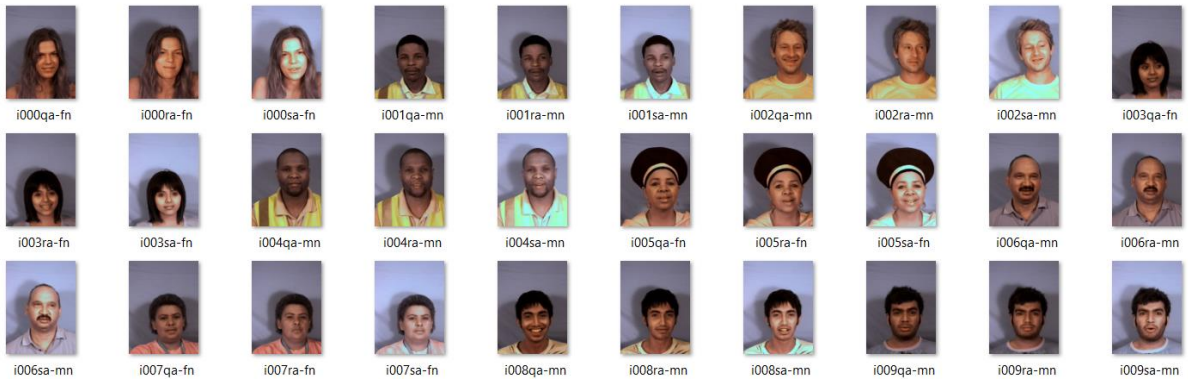


Figure 5.3.1.3 Sample dataset of images used for training the model.

The trained images are shown in the figure 5.3.1.4 and their corresponding histogram image in figure 5.3.1.5 respectively.

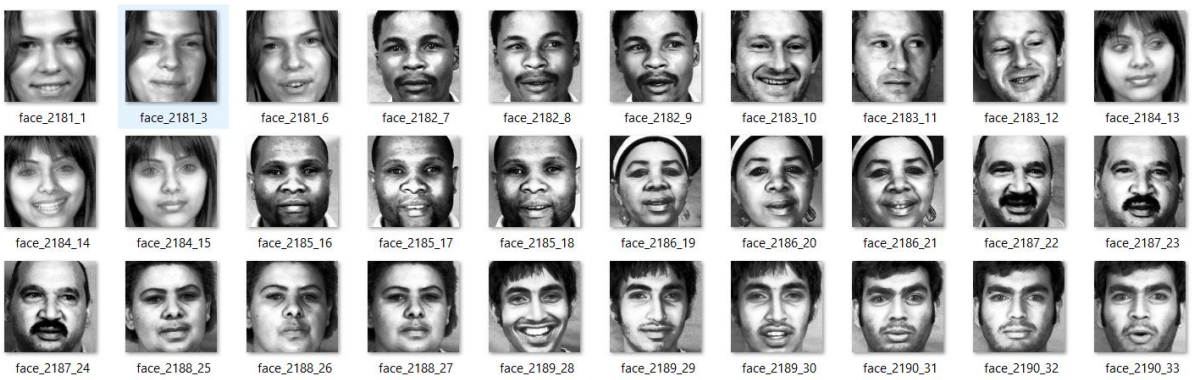


Figure 5.3.1.4 Trained images.

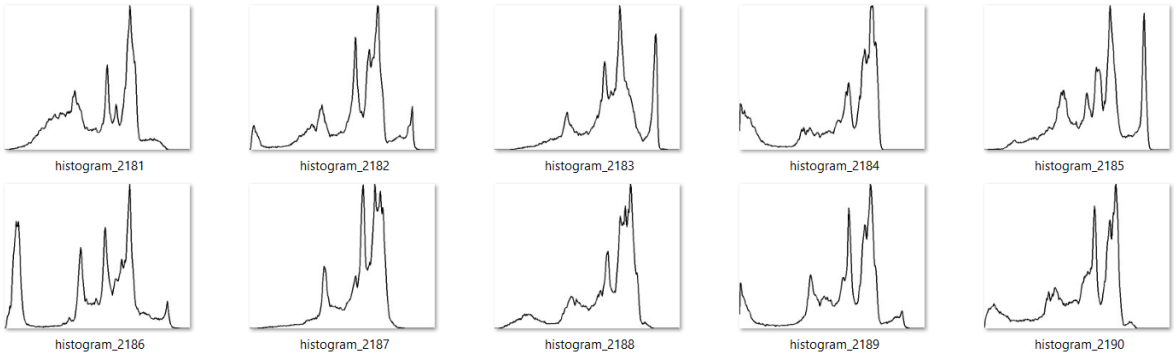


Figure 5.3.1.5: Histogram image of trained images.

The recognition model is then trained with all the images that are pre-processed and saved. After the training, the model is generated in the form of an xml file called trainedModel.xml which will be used during the recognition process. Figure 5.3.1.5 shows the flow chart of the training process.

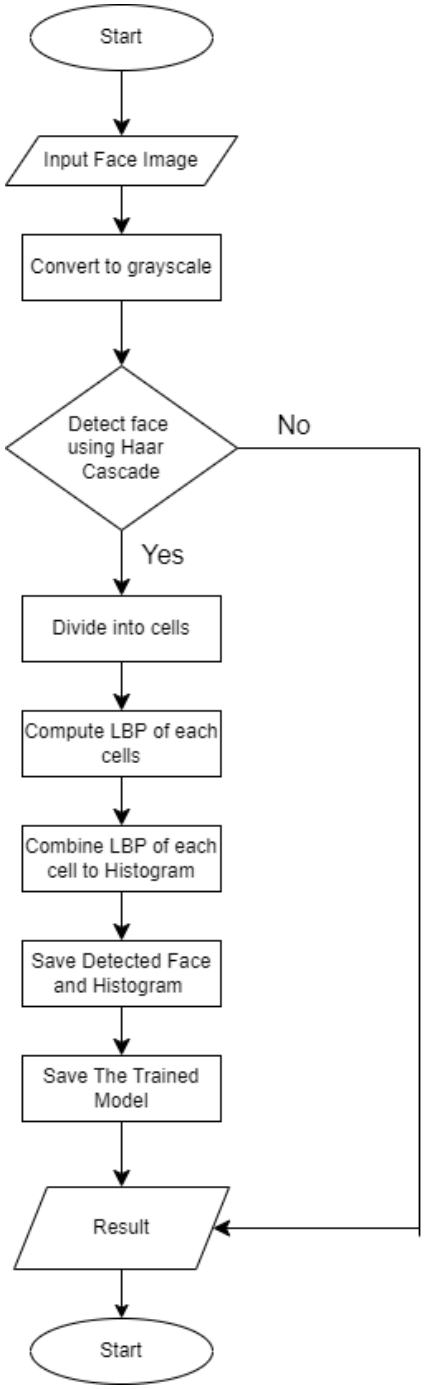


Figure 5.3.1.5: Face recognition model training algorithm flow chart

5.3.2 Model Verification

The image is converted to grayscale and normalised. The face in the grayscale is detected using Haar cascades classifier similar to the process done in the training process. The detected face is the cropped and resized to the specified dimensions. The LBPH recognizer is then used to generate histogram of the detected face and compare it with the stored histograms and using the distance metric Euclidean distance, its prediction is determined. Based on the distance

value, the label of the recognized face is returned, which is the student Id. Using the student ID, the details are then fetched from the database along with the timetable details to mark the attendance. Figure 5.3.2.1 shows the code implementation of model verification in the API solution.

```
1 reference
public string RecognizeFace(Image<Bgr, byte> bgrFrame)
{
    try
    {
        var grayFrame = bgrFrame.Convert<Gray, byte>();
        var faces = haarCascade.DetectMultiScale(grayFrame, 1.1, 5, new Size(30, 30));

        foreach (var face in faces)
        {
            var detectedFace = grayFrame.Copy(face).Resize(200, 200, Inter.Cubic);
            detectedFace._EqualizeHist(); // Normalize the image

            var result = recognizer.Predict(detectedFace);

            if (result.Label != -1 && result.Distance < 45)// Adjust distance threshold
            {
                return result.Label.ToString();
            }
            else
            {
                return "0";
            }
        }

        return "-1";
    }
    catch (Exception ex)
    {
        throw ex;
    }
}
```

Figure 5.3.2.1: Code implementation of model verification.

5.4 Functional Requirements

- Students should be able to register in the mobile app by providing basic details like name, email, phone etc.
- Students should be able to enrol into the system using their face image.
- Students should be able to login using 4-digit Pin
- App should have feature to identify and mark attendance using face.
- Students should be able to view their attendance history.

- Admin should be able to login into the backend portal using credentials.
- Admin should be able to manage departments, courses and modules.
- Admin should be able to manage timetables.
- Admin should be able to view reports based on attendance data.

5.5 Non-Functional Requirements

- App should be user friendly and attractive.
- App should have proper authentication and authorization mechanisms.
- Face recognition should complete on an average of 1 seconds.
- The error rate of face recognition should be less than 0.1%.
- App should be compatible with multiple devices and multiple platforms.
- App should be responsive in different screen size.

5.6 Use Case Diagrams

5.6.1 Actors:

- Student
- Faculty
- Administrator

5.6.2: Use Cases

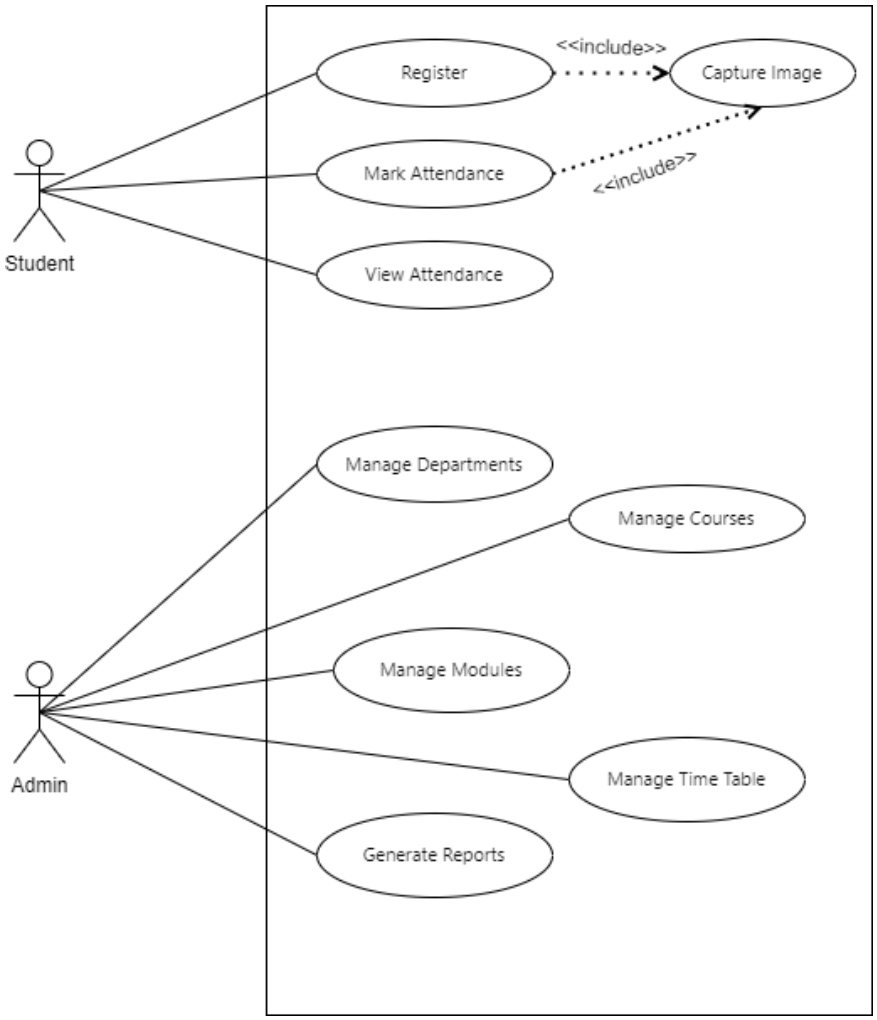


Figure 5.6.2: Use case diagram

5.7 User Interface Design

The user interface for the mobile application was developed using an online tool called Miro. The figure 5.7 given below shows all the mock up screens which was used as a reference for the actual development process.

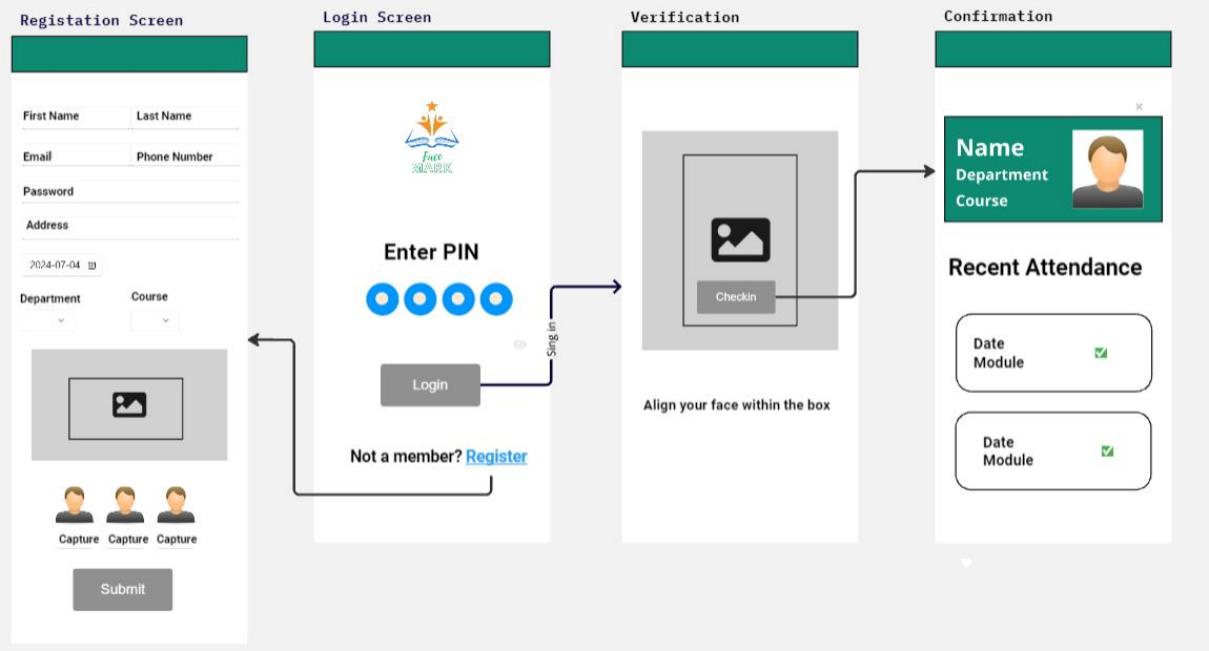


Figure 5.7: UI mock-up Screens developed using Miro.

5.8 Database Design

The figure 5.8 given below shows the design of database structure in Microsoft SQL server database which is used to store the application data of the prototype application.

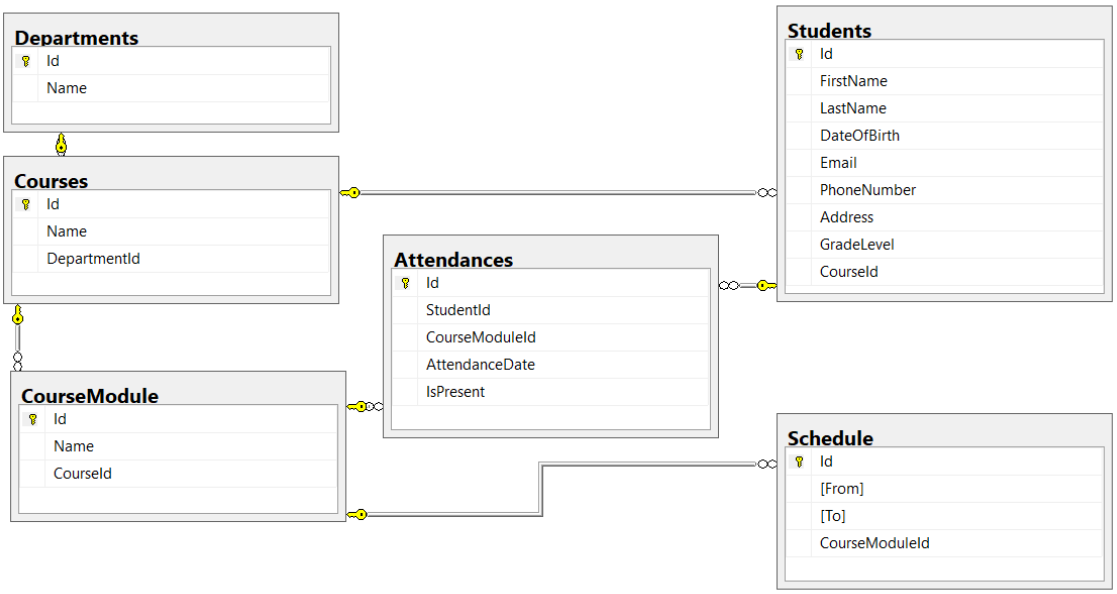


Figure 5.8: Database diagram

6.0 IMPLEMENTATION

6.1 Mobile Application

The mobile app was developed using .Net MAUI framework using Visual studio application. The complete solution structure is shown in the figure 6.1 below.

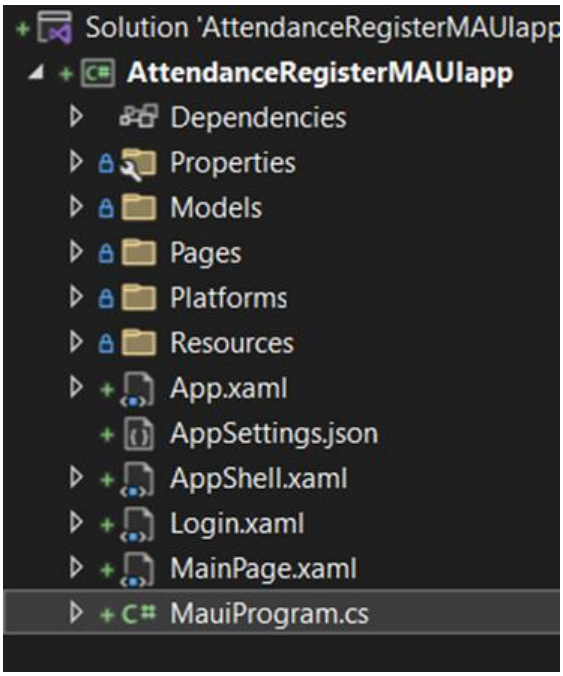


Figure 6.1: Mobile app solution structure

Simple model-based architecture is used in this project. The model folder contains all the domain models which represent application data. There are 4 screens in this application including login, register, main and attendance confirm pages. The user interface is designed using XAML files and each XAML file has its own code behind file which is a class file having extension .cs. All the application logic are in the code-behind file. By keeping model, UI and application logic in separate files, it is easier to maintain the code and easily modify the application. The AppSettings.json file contains all the important configuration data such as backend API URL, folder paths etc. The authentication method used is a simple pin number-based verification. This application requires a few permissions like ACCESS_NETWORK_STATE, CAMERA and INTERNET which are configured in the platform specific files. This application is connected to a database using the backend API. The application can be compiled into an apk file and installed into an android device to test the

functionalities. Testing can also be done using the emulators available in Visual Studio. The application contains the following functionalities:

- User authentication.
- Student registration
- Attendance marking using face recognition
- View profile details
- View attendance history

6.2 API

The API acts as the backend service for the mobile application. Data is passed in the form of JavaScript Object Notation (JSON) format. It provides endpoints for operations such as student registration, login, face recognition model training, face verification, marking the attendance, etc. A repository pattern is followed in developing this API. The API is configured with Swagger UI which can be used to visually view the endpoints and test it in real time. The web API is connected to SQL server database for the data storage and retrieval. The solution structure is shown in figure 6.2.1 and the Swagger UI implementation is shown in figure 6.2.2 respectively.

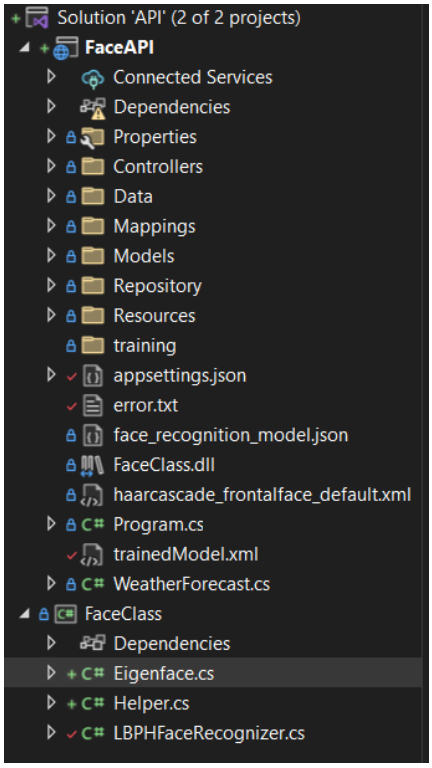


Figure 6.2.1: Web Api Solution Structure

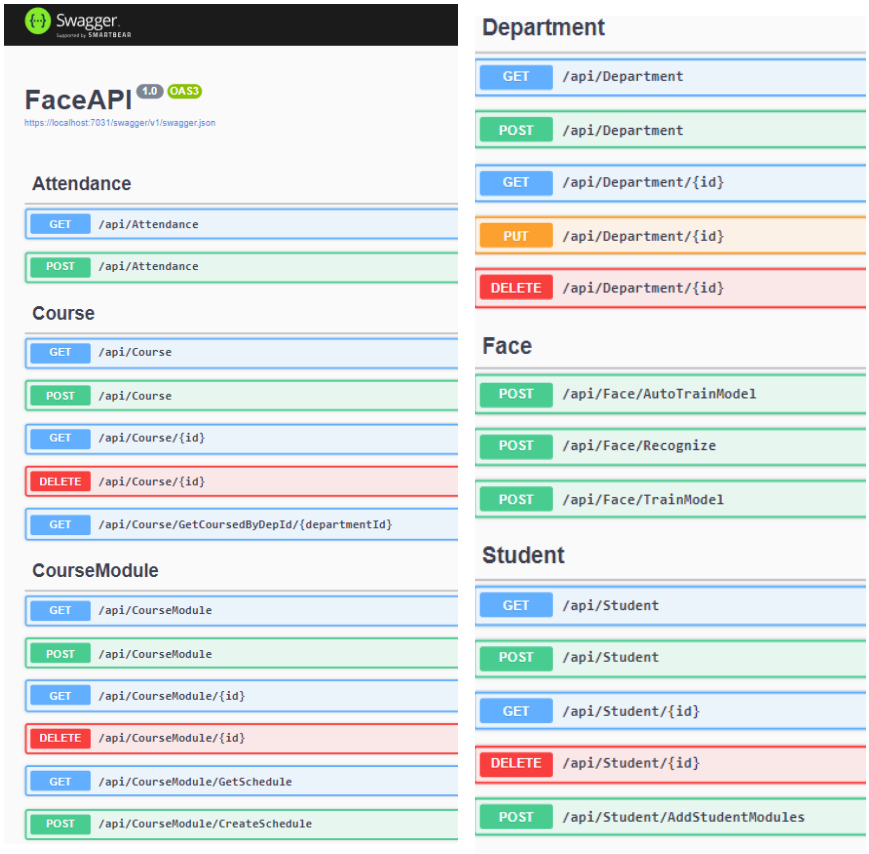


Figure 6.2.2: Swagger UI of the API

6.3 Web Application

The web application acts as the backend portal that can be used by the admin to manage the system. Using this portal, admin can manage departments, courses, modules and course schedules. The user interface of the application is shown in the Figure 6.3.1, Figure 6.3.2, Figure 6.3.3 and 6.3.4.

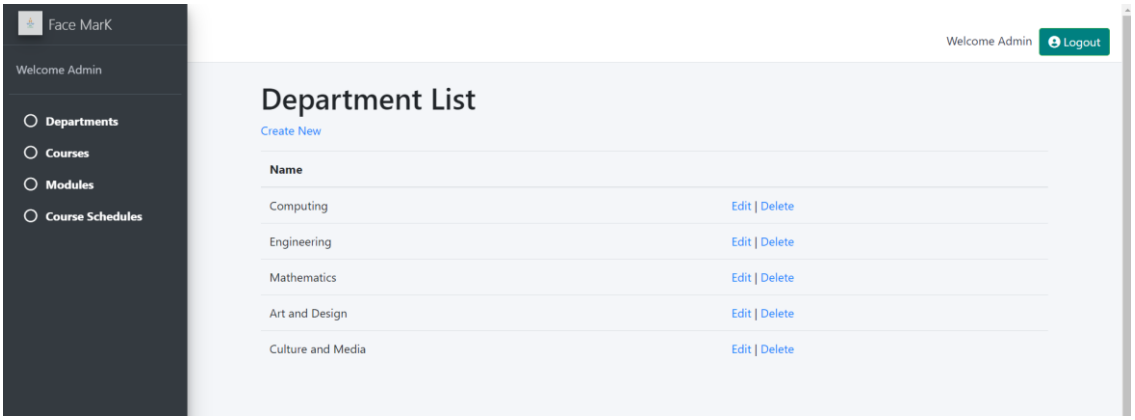


Figure 6.3.1 Department List Screen

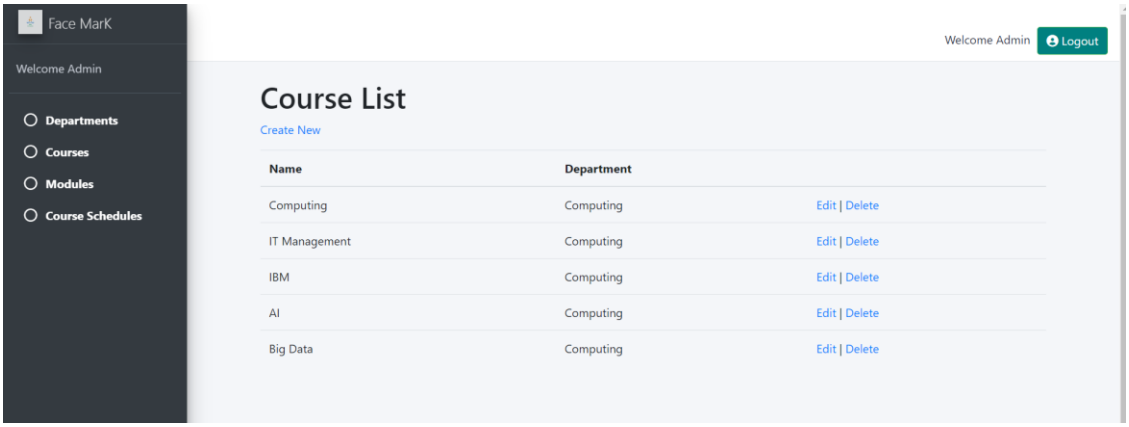


Figure 6.3.2 Course List Screen

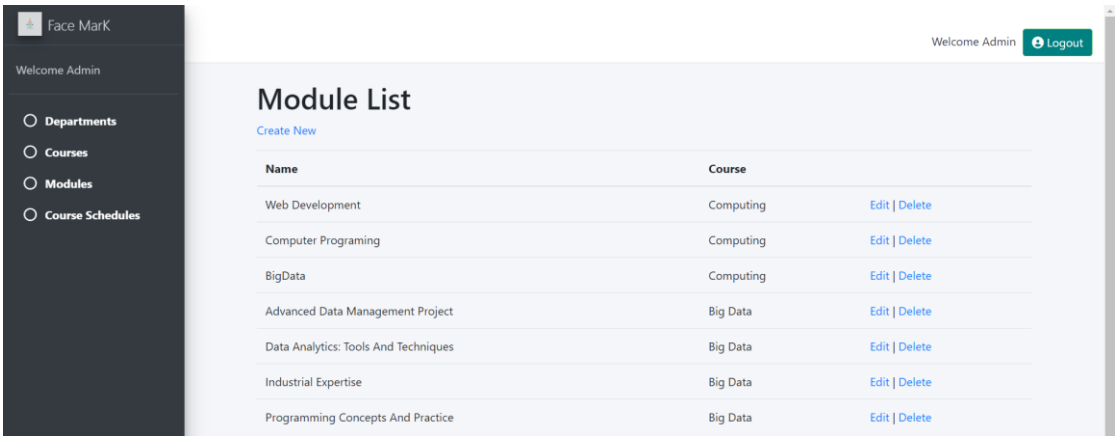


Figure 6.3.3 Modules List Screen

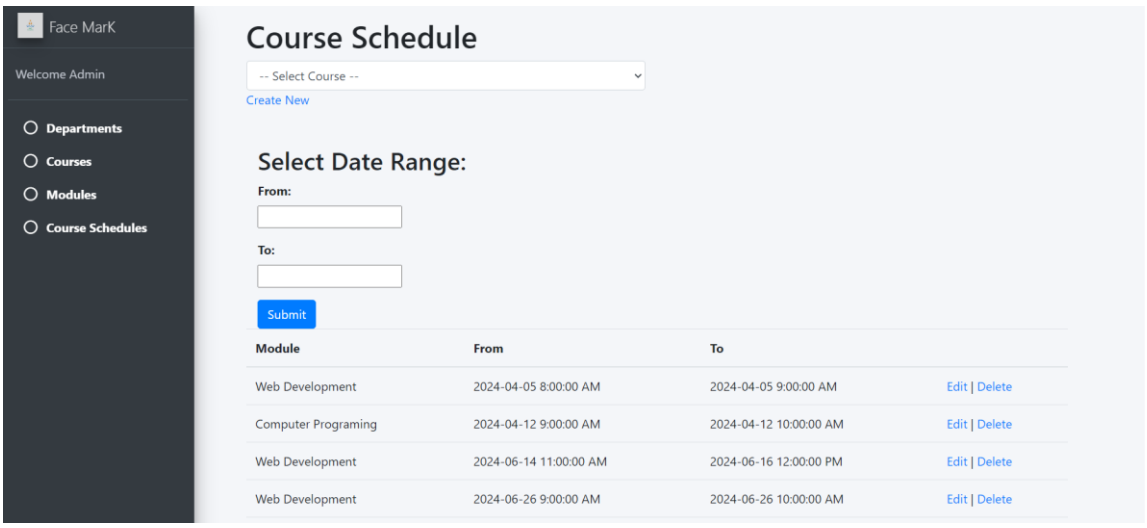


Figure 6.3.4 Course Schedule

7.0 TESTING AND EVALUATION

This section outlines the testing process conducted to find the accuracy and performance of the prototype application. The results of face recognition under various testing scenarios are also described. Few challenges and limitations faced during the testing phase are also discussed.

7.1 Testing Environment

The entire testing process was done in a laptop with windows 11 operating system. The application was tested using the Visual studio application. Master data such as departments, courses, modules and module schedules were created using the web application. The endpoint available in the Rest API 'AutoTrainModel' was used to train the face recognition model which will use the sample dataset of images taken from the MUCT image database. The accuracy of the face recognition was measured using a confusion matrix. Tiwari (2022) describes confusion matrix as a representation of predictions in a matrix format that shows correct and incorrect predictions. Figure 7.1.1 and 7.1.2 describes the confusion matrix and its parameters respectively.

	Positive	Negative
Positive	TP	FP
Negative	FN	TN

Figure 7.1.1 Confusion matrix

Metric/Scenario	Description
True Positives (TP)	Correctly recognized faces from the database.
False Positives (FP)	Incorrectly recognized faces as someone from the database.
True Negatives (TN)	Correctly identified non-matches or unknown faces.
False Negatives (FN)	Fails to recognize faces that are in the database.

Figure 7.1.2 Confusion matrix parameters

Singh et al. (2021) utilised performance metrics such as accuracy, precision, recall, and F1 score to evaluate the effectiveness of their algorithm. The same metrics are used in this scenario. Hicks et al. (2022) define accuracy as a metric that measures the ratio of correctly classified samples to the total number of samples. Recall, or sensitivity indicates the percentage of true positive samples correctly identified. Precision reflects the proportion of relevant samples among those retrieved and the F1 score balances precision and recall by taking their harmonic mean. The formula for each of these metrics are shown below in the Figure 7.1.3.

$$Accuracy = \frac{(TP + TN)}{(TP + FP + FN + TN)}$$

$$Precision = \frac{TP}{TP + FP}$$

$$Recall = \frac{TP}{TP + FN}$$

$$F1Score = \frac{2*precision*recall}{precision + recall}$$

Figure 7.1.3: Formulas for accuracy, precision, recall, and F1 Score

7.2 Test Cases

4 scenarios were tested with respect to the number of images of an individual that were used to train the model. In the first three scenarios, 30 images of users from the MUCT database were selected which includes images with too low or too high lighting, normal lighting and images with facial expressions.

7.2.1 Test case 1

Threshold value: 45
Trained images per Individual: 1
Total number of images: 30

In the test case 1, 30 images were used to train the model consisting of single image per person. The sample dataset is shown in the Figure 7.2.1.1. The images after training are shown in the Figure 7.2.1.2. The performance metrics of this test case are shown in Figure 7.2.1.3. From the results, it is clear that incorrect lighting and different facial expressions are a major factor that result in lower accuracy levels. The result of using images with normal lighting conditions and without facial expressions are effective but it can be improved more.

Figure 7.2.1.1: Image dataset for test case 1

Figure 7.2.1.2: Images saved after training the model for test case 1

Metric/Scenario	Total Images	True Positives (TP)	False Positives (FP)	True Negatives (TN)	False Negatives (FN)	Precision	Recall (TPR)	F1 Score	Accuracy
Scenario 1: low or too high Lighting	10	4	3	1	2	0.57	0.67	0.62	0.50
Scenario 2: normal lighting	10	6	2	2	0	0.75	1	0.80	0.80
Scenario 3: Expressions	10	4	2	1	2	0.67	0.67	0.67	0.56
								Average	0.62

Figure 7.2.1.3: Performance metrics for test case 1

7.2.2 Test case 2

Threshold value: 45
Trained images per Individual: 2
Total number of images: 30

In the test case 2, 30 images were used to train the model consisting of 2 images per person. The sample dataset is shown in the Figure 7.2.2.1. The images after training is shown in the Figure 7.2.2.2. The performance metrics of this test case are shown in Figure 7.2.2.3. From the results, it is clear that incorrect lighting and different facial expressions are still a major factor that result in lower accuracy levels even after using 2 images per individual. However, the

accuracy levels have improved compared to test case 1, which indicates the more the number of images per single person is used to train the model, more will be the accuracy.

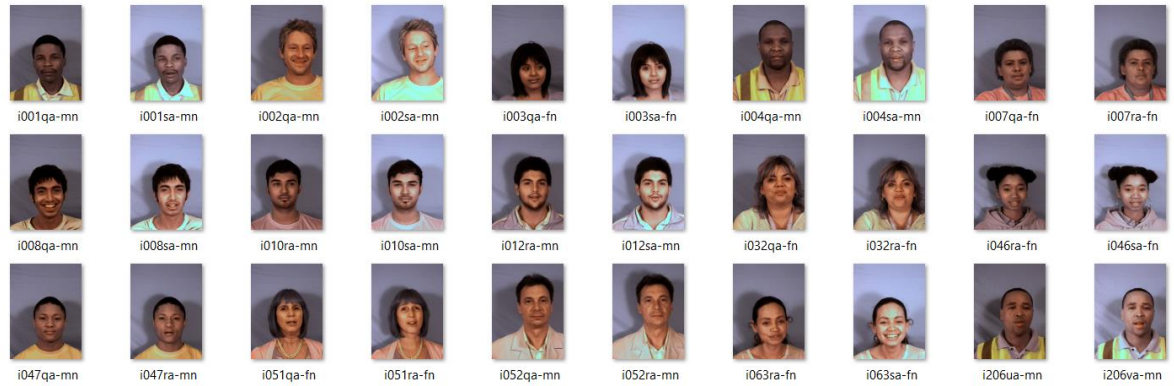


Figure 7.2.2.1: Image dataset for test case 2

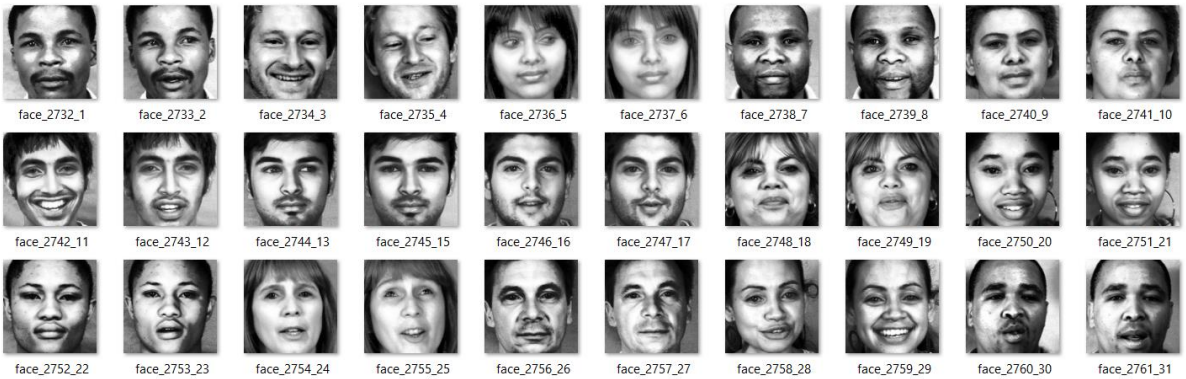


Figure 7.2.2.2: Images saved after training the model for test case 2

Metric/Scenario	Total Images	True Positives (TP)	False Positives (FP)	True Negatives (TN)	False Negatives (FN)	Precision	Recall (TPR)	F1 Score	Accuracy
Scenario 1: low or too high Lighting	10	4	3	2	1	0.57	0.8	0.67	0.60
Scenario 2: normal lighting	10	6	1	3	0	0.86	1	0.92	0.90
Scenario 3: Expressions	10	5	2	3	0	0.71	1	0.83	0.80
								Average	0.77

Figure 7.2.2.3: Performance metrics for test case 2

7.2.3 Test case 3

Threshold value: 45
Trained images per Individual: 3
Total number of images: 30

In the test case 3, 30 images were used to train the model consisting of 3 images per person. The sample dataset is shown in the Figure 7.2.3.1. The image after training is shown in the Figure 7.2.3.2. The performance metrics of this test case are shown in Figure 7.2.3.3. The average accuracy rate is increased to 0.97 which seems to be an ideal condition. This result shows the assumption during the test case 2 about using more images per single person to train the model seems to be correct. With this setup the incorrect lighting conditions and facial expressions seems to be less of a problem in the face recognition process.

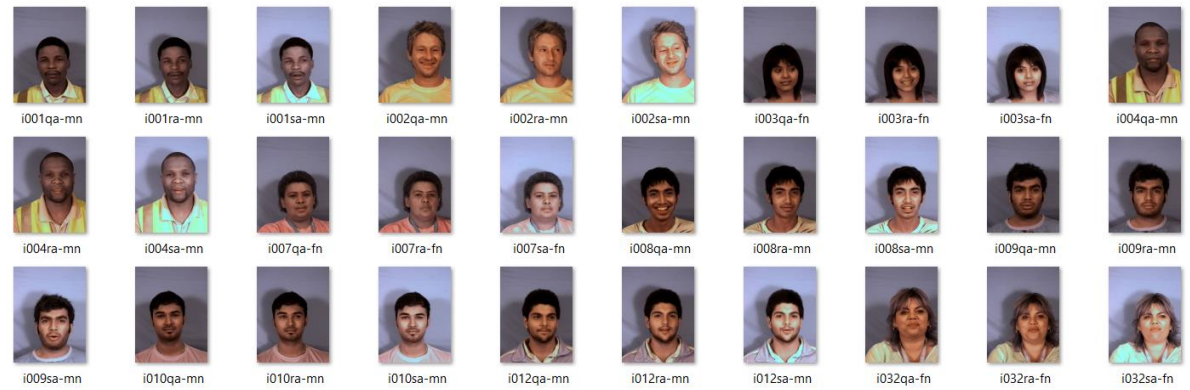


Figure 7.2.3.1: Image dataset for test case 3

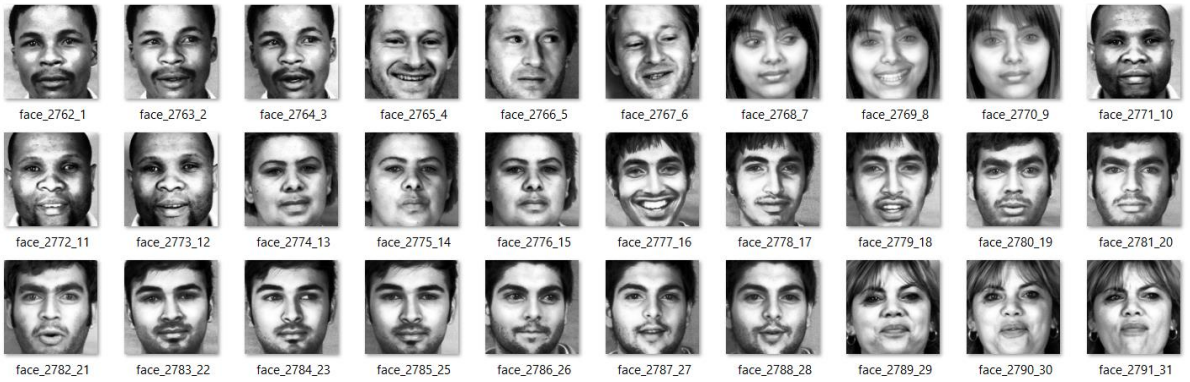


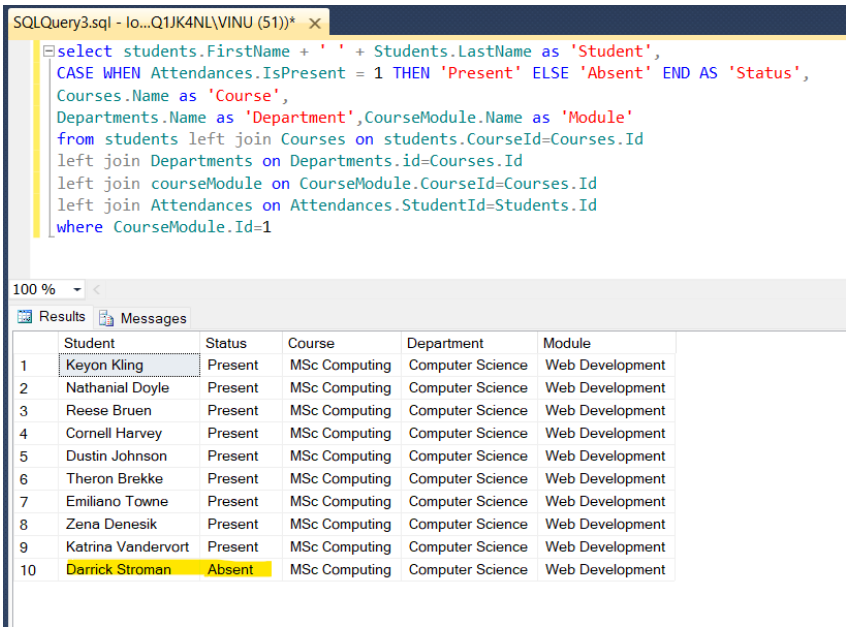
Figure 7.2.3.2: Images saved after training the model for test case 3

Metric/Scenario	Total Images	True Positives (TP)	False Positives (FP)	True Negatives (TN)	False Negatives (FN)	Precision	Recall (TPR)	F1 Score	Accuracy
Scenario 1: low or too high Lighting	10	5	0	4	1	1	0.83	0.91	0.90
Scenario 2: normal lighting	10	5	0	5	0	1	1.00	1.00	1.00
Scenario 3: Expressions	10	4	0	5	0	1	1.00	1.00	1.00
								Average :	0.97

Figure 7.2.3.3: Performance metrics for test case 3

7.2.4 Test case 4

A setup was done to simulate the classroom environment to mark the student attendance. 10 students were registered in the application in the MSc Computing course. A schedule was created for various modules in this course. Images of 9 Students were used to mark the attendance on the scheduled time and the other 1 student was considered as absent for the session. Figure 7.2.11 shows the summary of the attendance for the MSc Computing course. All the students who marked the attendance using the mobile application using face recognition were marked as present. The student who was not present for the session is marked as absent. Figure 7.2.12 shows the sample screenshot from the mobile app indicating a student who was present and absent. This indicates that the automatic attendance marking is working as expected without any errors.



	Student	Status	Course	Department	Module
1	Keyon Kling	Present	MSc Computing	Computer Science	Web Development
2	Nathanial Doyle	Present	MSc Computing	Computer Science	Web Development
3	Reese Bruen	Present	MSc Computing	Computer Science	Web Development
4	Cornell Harvey	Present	MSc Computing	Computer Science	Web Development
5	Dustin Johnson	Present	MSc Computing	Computer Science	Web Development
6	Theron Brekke	Present	MSc Computing	Computer Science	Web Development
7	Emiliano Towne	Present	MSc Computing	Computer Science	Web Development
8	Zena Denesik	Present	MSc Computing	Computer Science	Web Development
9	Katrina Vandervort	Present	MSc Computing	Computer Science	Web Development
10	Darrick Stroman	Absent	MSc Computing	Computer Science	Web Development

Figure 7.2.11: Database log for test case 4.

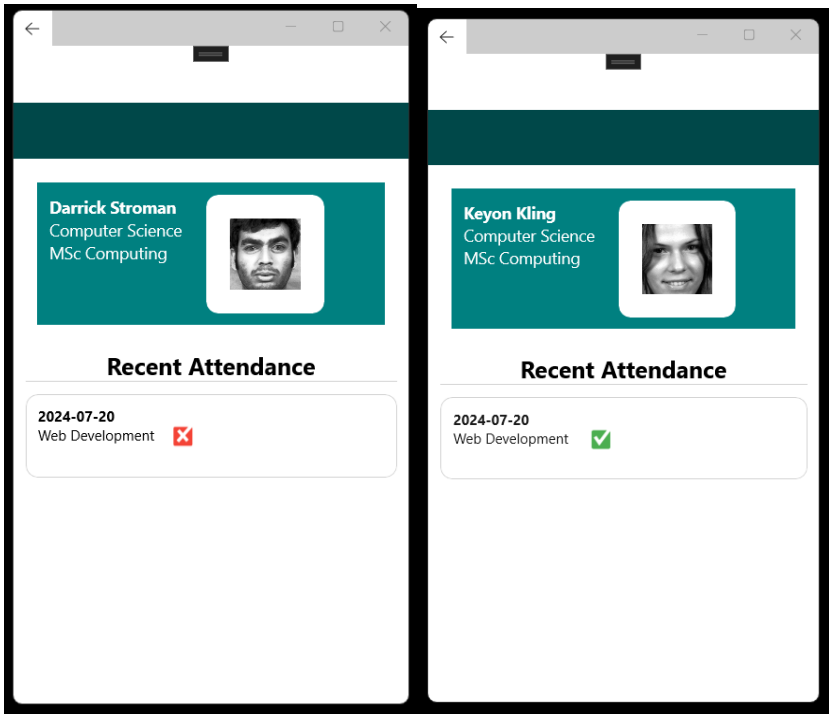


Figure 7.2.12: Mobile App Attendance History Screen

7.3 Performance Testing

To verify the performance of the prototype application, logs from system output were collected, which shows the time taken to complete the enrolment and recognition process. Below are the results of the observations:

Register a new student including face enrolment: **2.39 seconds (Figure 7.3.1)**
Recognize and mark attendance of student: **0.36 seconds (Figure 7.3.2)**
Auto train the face recognition model with 30 images: **5.87 seconds (Figure 7.3.3)**

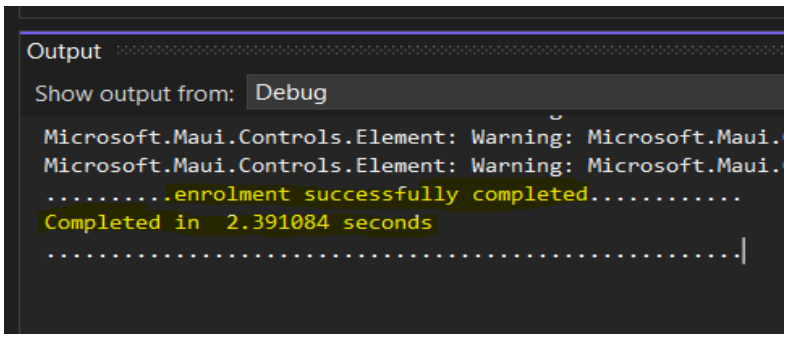


Figure 7.3.1: Student enrolment system log.

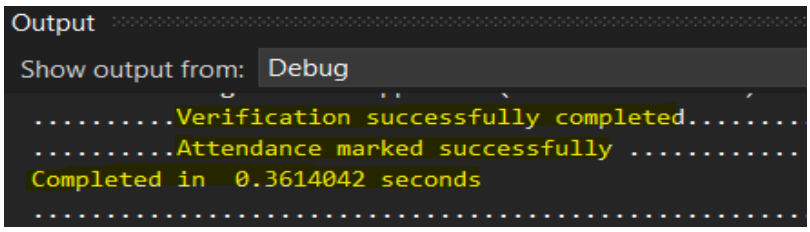


Figure 7.3.2: Student verification and attendance marking system log.

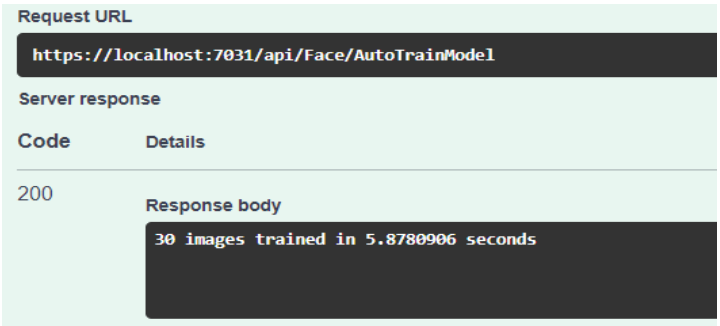


Figure 7.3.3: Auto train images API request output

7.4 Unit Testing

In addition to manual testing, unit testing was also performed to ensure the reliability and accuracy of the system's components. Manual testing allows for real-world scenario simulation and user experience evaluation, which are crucial for verifying the functionalities. However, unit testing offers a more systematic approach by allowing the isolation and verification of individual components, ensuring that each part of the system functions correctly in various conditions. Unit tests were written to validate the core components of the system, including face detection, recognition, and the attendance recording process. The testing framework utilized for this purpose was NUnit, with Moq framework used to mock dependencies. Figure 7.4 shows the results of unit test executed. All the unit tests are passed which implies the functionalities are working as expected.

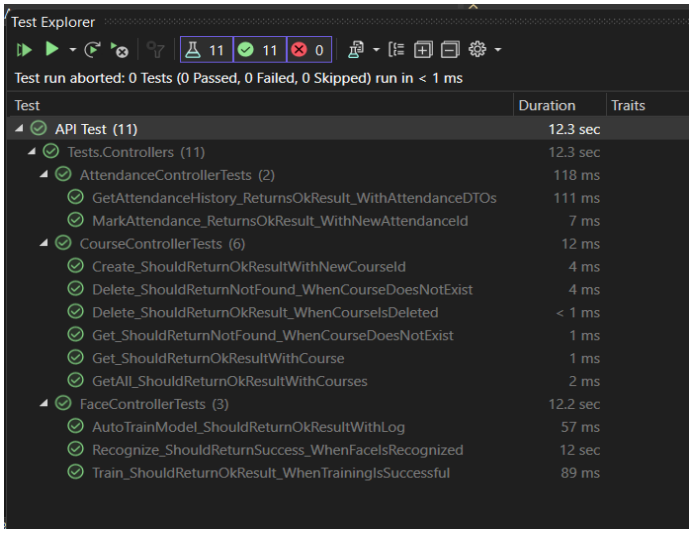


Figure 7.4: Unit test output results.

7.5 Evaluation of Results

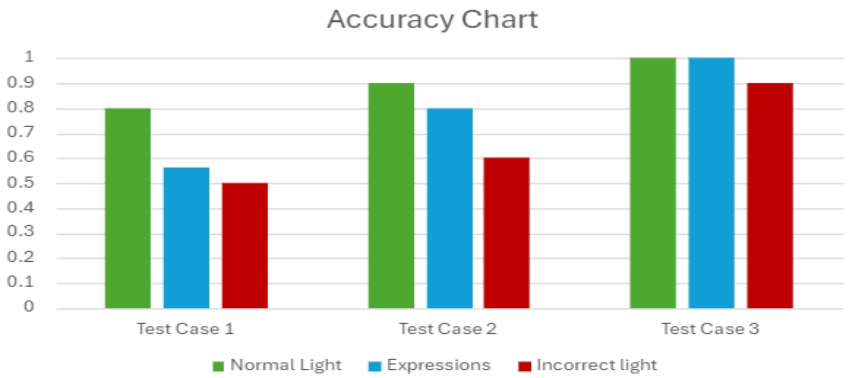


Figure 7.5: Accuracy chart for 3 test cases.

The analysis of the face recognition model's performance, as presented in Figure 7.5, reveals the understanding of the factors influencing the accuracy levels. The results show that accuracy tends to increase with the number of images used to train the face recognition model. The results of the first three test cases, yielding average accuracy levels of 0.62, 0.77, and 0.97 respectively, underscore the importance of training the model with an adequate number of images per individual. This aligns with the observations from the experiments conducted by Dunn, Kemp, and White (2018) that using multiple images resulted in faster and more accurate results in face recognition process. The increase in accuracy from 0.62 to 0.97 across the test cases highlights the model's potential to improve significantly with sufficient training data. Furthermore, the analysis emphasizes the impact of external factors such as facial expressions and lighting conditions on the model's performance. So, it is recommended that an ambient lighting and face

with normal expressions is required to get the better results. It is also worth investigating whether more than three images could further enhance accuracy.

The threshold value set for the face recognition is another important factor. The model demonstrates impressive efficiency, requiring only 0.36 seconds to recognize and mark attendance. This rapid processing time highlights its potential for real-time application, ensuring minimal disruption during class sessions.

8.0 CONCLUSION

The following section provides a comprehensive overview of the research project, reflecting on the primary objectives, summarizing key findings, addressing encountered challenges, and outlining the study's limitations. Additionally, this section offers recommendations for future work, emphasizing the potential for further improvements in face recognition technology.

8.1 Summary

This project began with a discussion of the importance of attendance in educational institutions and the drawbacks of traditional methods. A systematic literature review of existing attendance registration systems was conducted, and their limitations were evaluated. The literature review underscored the need for a faster and more accurate system, such as one based on face recognition. This led to the development of a prototype application capable of marking attendance using face recognition technology. A thorough research methodology was adopted, selecting the appropriate research philosophy, approach, strategy, and methods. Initial data collection using survey was done among students and faculties. Following the research methodology, the development of the prototype application was initiated. The project included the design of a mobile application, a web API, a web application, and a database. It utilized various techniques, such as defining functional and non-functional requirements, creating use case diagrams, designing user interfaces, developing database diagrams, and constructing architecture diagrams. The OpenCV face recognition technology was implemented to develop the face recognition model using the haarcascade classifier for the face detection and Local binary pattern histogram (LBPH) algorithm for face recognition. During the testing phase, MUCT image database was used to test various scenarios to evaluate and assess the accuracy and performance of the application. The project's limitations and potential future enhancements were also discussed.

8.2 Outcomes of Objectives

The primary aim of this project was achieved successfully by implementing face recognition technology in a mobile application that has the capability to mark student attendance. All the

objectives of this projective were met successfully. Through the systematic literature review, insights about existing attendance systems were evaluated. A survey was conducted among the students and faculties. Using proper research methodology, the proposed system was developed, implemented and tested properly. The prototype application was tested with various scenarios to make sure the accuracy level is high enough and the performance of the system is good. Future enhancements that could make the application more efficient were also discussed.

8.3 Key Findings

The proposed application of face recognition-based attendance register system exhibited several advantages over traditional systems. The time taken to mark the attendance using this new system is .36 seconds which is significantly much faster than traditional systems. Moreover, it minimized the error by showing the high accuracy rate which is 97% when 3 images per individual is used to train the model. The face recognition model can recognize individuals even in the various lighting conditions, gender, skin tones and facial expressions. However, it is recommended to use face images with normal lighting conditions and without much facial expressions for better results. The accuracy can be even increased if a greater number of images per single individual is used. The simple user interface makes it even more user friendly. The whole system architecture is easy to maintain as it requires only an android phone with internet connectivity. Integration of OpenCV with the implementation of haarcascade classifier and local binary pattern algorithm seems to be an efficient way to build a scalable and accurate face recognition model for the attendance marking process.

8.4 Challenges

Integrating the OpenCV computer vision library directly into the .NET MAUI cross-platform framework had a challenge, as OpenCV primarily supports languages like C++, Python, Java, and MATLAB. This limitation initially hindered the development process as the programming language of this prototype application is C#. However, the challenge was effectively overcome by using EmguCV, a C# wrapper library for OpenCV. This allowed for seamless integration of OpenCV face recognition functionalities within the .NET MAUI framework.

For testing the prototype application, using images from a publicly available database was preferred than using real participants which is less convenient considering the time frame for

the development. Finding a database of images with different lighting conditions, facial expressions, age, gender, and skin tone was essential to test various scenarios to ensure the accuracy of the application. It was challenging to find a database with these features. Most of them were paid or having copyright issues. But after constant search, a database called MUCT database was found which had enough images that satisfy this project requirements. The author of the database was contacted by email to make sure it does not have any usage restrictions or copyright issues.

During testing, the local binary patterns histogram (LBPH) algorithm initially produced inaccurate results when images taken under poor lighting or with varied facial expressions were used. To improve accuracy, the system was adjusted from using a single image per individual to using multiple images. Significant improvements were observed when three images per individual were used, which allowed the model to better handle variations in real-world conditions.

8.5 Limitations

As the prototype application is a mobile application, it requires a backend API to perform various functionalities. Testing the application on an actual mobile requires the API and database to be deployed in an actual server. Deploying on a server is costly and needs more configurations and setup. This was a limitation faced in testing process since this is a short duration project. But this limitation was overcome by using the Visual studio android emulator feature which was used to simulate the testing process the same as on a mobile.

8.6 Recommendations and Future Scope

To ensure the robustness and scalability of the system, deploying the entire system on cloud platforms such as Microsoft Azure or Amazon AWS is recommended. For instance, deploying the Web API on Azure Web Services and the database on Azure SQL Server can significantly improve availability, performance, and security due to the advanced features provided by Azure Cloud. Improving the code quality through best practices like code refactoring and modularization can enhance the performance and scalability of the application. These practices make the application easier to maintain and update over time. The testing phase has revealed that different lighting conditions affect the accuracy of face recognition. To address this, the

current implementation can be enhanced by incorporating image preprocessing techniques. These techniques can enhance the image quality before it is used for training and recognition, leading to better accuracy.

To improve the security of the application, user details and credentials can be encrypted and saved in database. Popular authentication method called JSON Web Tokens (JWT) or any other methods can be used in the API to make it even more secure. Also implementing a role-based authorization will also add an extra layer of security. Making the application more accessible to people with disabilities can be also considered. This could be like adding voice command features, screen reader capability etc. Conducting cross-platform testing ensures that the application functions as expected on various operating systems such as iOS, Windows, and macOS. This helps in identifying and fixing any platform-specific issues, ensuring a seamless user experience across different devices.

Implementation of artificial intelligence (AI) can further enhance the application to analyse historical attendance data to forecast trends, helping institutions identify potential issues. Additionally, AI can enhance user experience by enabling personalized features. For example, the system could learn individual user behaviours and preferences, adapting the interface and notifications accordingly. Voice recognition and natural language processing (NLP) can further streamline the user interaction, making the system more intuitive and accessible.

9.0 REFERENCES

1. Acasamoso, D., Avila, E., & Vargas, S. (2021). Development and acceptability of a student daily attendance monitoring system. *Proceedings of the 2021 IEEE 13th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM)*. https://doi.org/10.1109/HNICEM54116.2021.9731963
2. Abuzneid, M., & Mahmood, A. (2018). Enhanced Human Face Recognition Using LBPH Descriptor, Multi-KNN, and Back-Propagation Neural Network. *IEEE Access, PP*, 1. 10.1109/ACCESS.2018.2825310
3. Ahmad, M. B., & Nababa, F. A. (2021). The need of using a Radio Frequency Identification (RFID) system. *International Journal of New Computer Architectures and their Applications (IJNCAA)*, 11(2), 22-29.
4. Al-Mesbahi, L. A. H., Juremi, J., & Hamza, M. S. (2021). Web-based attendance system with OTP implementation. *Journal of Applied Technology and Innovation, 5*(2). https://jati.sites.apiit.edu.my/files/2021/03/Volume5_Issue2_Paper12_2021.pdf
5. Budiman, A., Yaputera, R. A., Achmad, S., & Kurniawan, A. (2023). Student attendance with face recognition (LBPH or CNN): Systematic literature review. *Procedia Computer Science, 216*, 31-38.
6. Dirin, A., Delbiaggio, N., & Kauttonen, J. (2020). Comparisons of facial recognition algorithms through a case study application. *International Association of Online Engineering*. Retrieved August 1, 2024, from https://www.learntechlib.org/p/217823/
7. Dunn, J. D., Kemp, R. I., & White, D. (2018). Search templates that incorporate within-face variation improve visual search for faces. *Cognitive Research: Principles and Implications, 3*, 37. https://doi.org/10.1186/s41235-018-0128-1
8. GOV.UK. (2022, May). Working together to improve school attendance: Guidance for maintained schools, academies, independent schools, and local authorities. https://assets.publishing.service.gov.uk/media/63049617e90e0729e63d3953/Working_together_to_improve_school_attendance.pdf
9. Gohel, S. (2018). Bluetooth attendance system with Android application for ERP. *Proceedings of the 2018 International Conference on Computing, Power and*

Communication Technologies (GUCON), 481-484. https://doi.org/10.1109/GUCON.2018.8674898

10. Hicks, S. A., Strümke, I., Thambawita, V., Hammou, M., Riegler, M. A., Halvorsen, P., & Parasa, S. (2022). On evaluation metrics for medical applications of artificial intelligence. *Scientific Reports, 12*(1), 5979. https://doi.org/10.1038/s41598-022-09954-8
11. Jayaraman, U., Gupta, P., Gupta, S., Arora, G., & Tiwari, K. (2020). Recent development in face recognition. *Neurocomputing, 408*, 231-245. https://doi.org/10.1016/j.neucom.2019.08.110
12. Jayakumar, K., Surendar, V., Sheela, A., Javagar, P., Riyas, K. A., & Dhanush, K. (2022). Internet of Things based biometric smart attendance system. *Proceedings of the 2022 International Conference on Sustainable Computing and Data Communication Systems (ICSCDS)*, 1492-1497. https://doi.org/10.1109/ICSCDS53736.2022.9761045
13. Jha, P. B., Basnet, A., Pokhrel, B., Pokhrel, B., Thakur, G. K., & Chhetri, S. (2023). An automated attendance system using facial detection and recognition technology. *Apex Journal of Business and Management, 1*(1), 103-120. https://nepjol.info/index.php/ajbm/article/view/61984
14. Kortli, Y., Jridi, M., Al Falou, A., & Atri, M. (2020). Face recognition systems: A survey. *Sensors, 20*(2), 342. https://doi.org/10.3390/s20020342
15. Liew, K. J., & Tan, T. H. (2021). QR code-based student attendance system. *Proceedings of the 2021 2nd Asia Conference on Computers and Communications (ACCC)*, 10-14. https://doi.org/10.1109/ACCC54619.2021.00009
16. Milborrow, S., Morkel, J., & Nicolls, F. (2008). The MUCT face database. University of Cape Town. http://www.milbo.org/muct/
17. Mohammed, M., & Zidan, K. (2023). Enhancing attendance tracking using animated QR codes: A case study. *Indonesian Journal of Electrical Engineering and Computer Science, 31*, 1716. https://doi.org/10.11591/ijeecs.v31.i3.pp1716-1723
18. Patil, M. A., Parane, K., Sivaprasad, D. D., Poojara, S., & Lamani, M. R. (2022). Smart attendance management system using IoT. *Proceedings of the 2022 Second International Conference on Computer Science, Engineering and Applications (ICCSEA)*, 1-6. https://doi.org/10.1109/ICCSEA54677.2022.9936433
19. Rahman, T., Saputra, A., & Anggara, E. (2022). Attendance monitoring system based on IoT. *Multitek Indonesia, 15*, 33-43. https://doi.org/10.24269/mtkind.v15i2.3758

20. Saunders, M., Lewis, P., Thornhill, A., & Bristow, A. (2019). "Research Methods for Business Students" Chapter 4: Understanding research philosophy and approaches to theory development. (pp. 128–171)
21. Shah, S. N., & Abuzneid, A. (2019). IoT based smart attendance system (SAS) using RFID. *Proceedings of the 2019 IEEE Long Island Systems, Applications and Technology Conference (LISAT)*, 1-6. https://doi.org/10.1109/LISAT.2019.8817339
22. Shetty, A. B., Bhoomika, Deeksha, Rebeiro, J., & Ramyashree. (2021). Facial recognition using Haar cascade and LBP classifiers. *Global Transitions Proceedings*, *2*(2), 330-335. https://doi.org/10.1016/j.gltp.2021.08.044
23. Shoewu, E. D. O., Makanjuola, N., & Olatinwo, S. (2014). Biometric-based attendance system: LASU Epe Campus as case study. *American Journal of Computing Research Repository*, *2*(1), 8-14. https://doi.org/10.12691/ajcrr-2-1-2
24. Sittampalam, G., & Ratnarajah, N. (2019). SAMS: An IoT solution for attendance management in universities. *Proceedings of the 2019 IEEE Region 10 Conference (TENCON)*, 251-256. https://doi.org/10.1109/TENCON.2019.8929616
25. Singh, P., Singh, N., Singh, K. K., & Singh, A. (2021). Diagnosing of disease using machine learning. In K. K. Singh, M. Elhoseny, A. Singh, & A. A. Elngar (Eds.), *Machine Learning and the Internet of Medical Things in Healthcare* (pp. 89-111). Academic Press. https://doi.org/10.1016/B978-0-12-821229-5.00003-3
26. Stupina, M. V., Anistratenko, K. V., & Pazina, L. O. (2021). Using the QR code as a means of automating the process of accounting for attendance at educational classes. Journal of Physics.Conference Series; J.Phys.: Conf.Ser, 2131(2), 22077. 10.1088/1742-6596/2131/2/022077
27. Subbiah, D., Devi, V., Sankara, N. S., V., P., S, H., & Rajasekaran, S. (2022). A smart digital attendance monitoring system for academic institution using machine learning techniques. *Webology*, *19*, 3109-3118. https://doi.org/10.14704/WEB/V19I1/WEB19205
28. Syamala, B., Nikhila, A., Balaji, G. T., Sagar, G. V., & Sagar, K. A. (2020). Attendance management system using face recognition. *International Journal for Research in Applied Science and Engineering Technology*, *8*(7), 1684–1688.
29. Tamilkodi, R. (2021). Automation System Software Assisting Educational Institutes for Attendance, Fee Dues, Report Generation Through Email and Mobile Phone Using Face Recognition. Wireless Personal Communications, 119(2), 1093-1110. 10.1007/s11277-021-08252-2

30. Tiwari, A. (2022). Supervised learning: From theory to applications. In R. Pandey, S. K. Khatri, N. K. Singh, & P. Verma (Eds.), *Artificial Intelligence and Machine Learning for EDGE Computing* (pp. 23-32). Academic Press. https://doi.org/10.1016/B978-0-12-824054-0.00026-5

Appendix A - Research project plan

Research Proposal

Face Recognition Based Attendance Register System

Vinu Davis

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INTRODUCTION AND JUSTIFICATION

Attendance is crucial for academic success and personal development. According to Sittampalam & Ratnarajah (2019), In academic institutions in most developing countries, paper-based attendance systems are used to manage the attendance of students. There are a few drawbacks to this system. High time-consuming, manual errors, loss or damage of paper, inefficiency, inconvenience, acting as proxies to mark attendance, etc. are few of them. As per Patil et al. (2022), with the evolution of technology, new systems were developed like RFID (Radio Frequency Identification), biometrics, barcode etc. which are more expensive and complex. Even though these technologies are more efficient and convenient compared to traditional paper-based systems, Gohel (2018) stated that a significant reason that institutions are not using these technologies is due to security concerns and high implementation and maintenance costs. This project will research how facial recognition can be used in mobile app to create a smart attendance register system that can be implemented in higher educational institutions which could overcome the disadvantages of traditional systems.

RESEARCH QUESTION, AIMS & OBJECTIVES

This project aims to create a face recognition-based automated attendance register prototype mobile application using OpenCV computer vision library that could be implemented in higher educational institutions. This application helps institutions to implement an efficient system that can overcome the drawbacks of attendance register systems used currently.

RESEARCH QUESTION

How can face recognition technology be integrated into a mobile application to develop an attendance register application that could be used in higher educational institutions?

OBJECTIVES

1. Conduct a literature review on existing attendance register systems.

2. Get feedback from students and teachers about the current attendance register systems and proposed system.

3. Identify the suitable research philosophy, approach, strategies, data gathering tools and development tools to implement the proposed system.

4. Design and implement a prototype mobile application using facial recognition.

5. Test the mobile app with different users and verify the functionality and its accuracy.

6. Get feedback from users regarding the application.

7. Evaluate the result and analyse if the project aims and objectives are met.

8. Suggestions for future enhancements of the applications.

9. Write a dissertation report on the project.

DELIVERABLES

A mobile application(android) and a web application will be developed as part of this project. The mobile app will have the feature to enrol, identify and mark the attendance of students using facial recognition. Web application can be used as a configuration and management portal which contains features like creating timetables, managing departments, courses, modules and generating reports.

LITERATURE REVIEW

There have been significant improvements in the attendance register process over time. With the evolution of modern technology, new methods were implemented to make the system more efficient and secure. Few research papers relevant to existing systems are reviewed in this paper.

EXISTING SYSTEMS

RFID System

Shah and Abuzneid (2019) proposed a Smart Attendance System that uses Radio Frequency Identification (RFID) technology for marking attendance. Students will use RFID cards in which a unique identification number like student ID will be embedded in it. Even though this system improves the efficiency of the attendance system in terms of reducing the

time and minimizing errors, it has few limitations. While RFID systems can be cost-effective in the longer run, the initial installation and setup cost of such a device are high. A power outage will interrupt the working of the device. If a student lost his card, a new card needs to be provided. As stated by Tamilkodi (2021) this system does not solve the issue of proper authentication because there may be chances that other students can use someone else's card and mark the attendance.

Fingerprint based Attendance System

Biometric Smart Attendance System was proposed by Jayakumar et al. (2022) in which the fingerprint is used to uniquely identify an individual. They claim that this system will be more secure since fingerprints are used for identification. Each student's fingerprint is analysed and saved using a process called enrolment. The fingerprint reader extracts key features of fingerprint using the sensor and compares them with the ones saved in the database and the attendance marking can be done. The need for students to carry a separate RFID card is no longer required. Budi et al. (2018) argues that this system has high investment cost and is inaccurate. This system may not be efficient at times as the scanner may not be able to detect the fingerprint at the first attempt. Also, if the finger is wet or dirty, this might affect the device reader's performance. Since the covid –19 pandemic, the issue of hygiene and the spread of virus also became a concern as all students are touching the device.

QR Code-Based Student Attendance System

Liew & Tan (2021) proposed an android application which can detect and verify attendance using QR which is a type of code that can be used to store information and read by machines. Teachers can generate a unique QR code and share it with the students. Students will scan the QR code using their phones to mark the attendance. A similar system in the form of a mobile application with QR code scanner integrated with it was developed by Stupina et al. (2021). They stated that generation and scanning of a QR code takes less than a minute which makes the attendance registration process save much time. As this system is developed only in android, the need of iOS app is important as there will be students with iPhone, but it will be hard to maintain 2 separate application and dedicated skilled resource in both technologies will be required.

PROPOSED SYSTEM

The proposed system is an android mobile application that can automatically mark attendance by recognizing students using their face. This system uses OpenCV and .NET MAUI technology. According to Zhu & Cheng (2020), OpenCV is an open-source library which offers face recognition services using algorithms that can detect, recognize, and analyse faces in images. A wrapper library called Emgu CV will be used in this proposed system which can be used to invoke OpenCV functions from .NET project. The mobile application can be developed using .NET MAUI technology which is a cross-platform app development framework. According to Microsoft (2023), using this technology, applications that can run on android, iOS, macOS and windows could be created using a single shared code base. The only hardware resources required for this proposed system are an android or iOS phone or a tablet with a camera. The mobile app will have a backend REST Api developed using .NET Core framework which will have the endpoints required for the enrolment and attendance marking process. Face detection and recognition will be integrated within the web API. The application data will be stored in Microsoft Azure database. A high-level overview of the architecture and flow chart are shown in Appendix B and C respectively.

RESEARCH PHILOSOPHY

Since this research is focused on developing an attendance marking system using face recognition which can be measured and observed, pragmatism research philosophy will be used for this study due to its focus on practicality and problem-solving. Pragmatism offers a flexible approach, integrating both qualitative and quantitative methods to efficiently address complex problems. In terms of developing the face recognition app, the accuracy of face recognition is crucial, being a measurable value. Additionally, user feedback and suggestions are vital to enhance the application's user-friendliness and effectiveness. Considering these factors, pragmatism will be deemed the most suitable philosophy for this research.

RESEARCH APPROACH

This research follows a combination of both quantitative and qualitative approaches in the various stages. This research project considers both technical aspects and user experience. Therefore, combining both qualitative and quantitative methods will be used. The quantitative aspect involves measuring the accuracy of the face recognition process, whereas the qualitative

aspect focuses on getting feedback from students and staff to improve the effectiveness and usability of the application, making it more user-friendly. In the requirement analysis stage, qualitative approach will be used to collect requirements and suggestions from students and teachers. During the design Phase, a quantitative approach will be followed to collect data from students for enrolment into the system. This data can be used to train the face recognition model and to verify the face. During the testing stage quantitative data available in the system will be used to test the system's functionality, accuracy and performance. In the final stage, qualitative approach will be used to gather feedback from participants on the system's effectiveness and suggestions on improving the application.

RESEARCH STRATEGY

Main strategies used in this research are experiments and surveys to address both the technical and user experience aspects. By conducting different experiments, the accuracy of the face recognition process will be determined. The quantitative data collected from these experiments will be used to analyse the face recognition model's accuracy. Survey research strategy will be used to gather data from a group of students and teachers about their perceptions of the face recognition-based attendance register system. Surveys will be designed carefully with relevant questions to collect feedback about their experience with the prototype application. Using surveys, qualitative data on usability, user satisfaction, system's ease of use, accuracy, and overall effectiveness and issues will be collected.

PARTICIPANTS/DATA SOURCE

Participants of this research project include students and faculties of Sheffield Hallam university. Surveys will be completed by them to get their feedback on implementing face recognition in the attendance registration process. Experiments will be conducted on them to test the application accuracy and performance.

LIMITATIONS

There are several limitations for this research project. Technological aspects like device specifications may affect the performance of the application. The internet speed is also a major

factor as the mobile app relates to backend Api service. Environmental factors like the low light or too much light of the area may affect the accuracy of the face recognition. These factors highlight the importance of testing the application in diverse environments and different devices with different specifications.

ETHICAL CONSIDERATIONS

Strict ethical guidelines will be followed throughout this research project to ensure the integrity and well-being of all participants and their personal data. Proper ethical approval will be obtained from the university before starting the research project. None of the participants will be forced to take part in the research project, instead proper consent from all participants will be obtained in this research project, and the assurance of confidentiality will be maintained throughout the project. To maintain the confidentiality of the data, proxy names will be used to represent the participants. Data collected will be stored securely on the university server. The results and summary of this research will be shared with the participants if needed.

Since recent technology is used to build this system which improves efficiency, ethical principle, beneficence is addressed as this system and ensures does good and ensures non-Malfeasance as nobody is harmed in the process. The system will be designed so that it does not show bias towards any group of individuals, including race, gender, age, and religion. The system will be transparent, and individuals will have the right to know how the system works and how their data is being used. As this research project handles sensitive data, legal issues also will be considered, and the system will comply with regulations like general data protection regulation (GDPR). UK da data protection act can be followed by storing the data in a server in Europe. This research project uses a popular open-source library called OpenCV for face recognition. OpenCV (n.d) highlighted that in terms of security, they are ISO 27001 certified and SOC 2 compliant, in terms of privacy they are GDPR certified which ensures the security and privacy of users in this proposed system.

DEVELOPMENT AND IMPLEMENTATION DECISIONS

The proposed system will utilize OpenCV, an open-source library that provides face recognition services using computer vision. OpenCV will be used to train the model with data and identify individuals using their face. The Android app will be developed using .NET

MAUI, a multi-app framework, and the C# programming language. Application data will be stored in an Azure SQL Server cloud database. The mobile app will communicate with the database using a .NET Core Web API. Visual studio development platform will be used to develop both mobile app and Api projects. The system will be installed on an android phone for testing purposes. Version control for both mobile and API solutions will be managed using GitHub. Project management tool called Monday will be used to manage the task. GitHub Actions will be used for CI/CD operations. The Web API will be deployed using Microsoft Azure Web Services.

PROJECT MANAGEMENT METHODOLOGY

This project will be developed using the waterfall model which is a traditional software development model. In this model each stage of the process will be done one after the other like a waterfall. Project management tool called Monday will be used to follow the process. Other alternatives considered were the Agile model which is the most recent and widely used methodology. But since this is a short project done by a single person to make things simple and easy. Each stage in the process is mentioned in Figure 1. Gantt chart of time plan section.

REQUIREMENTS

Functional requirements

- Users should be able to register using the mobile app.
- Staff should be able to manage courses.
- Staff should be able to manage the timetable.
- Students should be able to enrol into the system using their face image.
- App should have a feature to identify and mark attendance.
- Staff should be able to view reports based on attendance data.
- Email notifications must be generated to notify staff and parents with the attendance reports.

Non-functional requirements

- App should have proper authentication and authorization mechanisms.
- App should be user friendly and attractive.
- App should be compatible with multiple devices and multiple platforms.

RISKS AND ISSUES

Requirements: If the project requirements and goals are not clearly defined, it may affect the project's overall progress, resulting in a waste of time and resources. To avoid that, project goals and objectives are to be clearly defined and followed.

Planning: If the proper time plan is not defined and followed, the project may not be completed within the expected deadline. Using a project management tool called Monday can be useful to track the project's progress.

Compatibility: Mobile app may not be supported in different mobile versions. Defining a less API target level can be helpful to support the app in most of the devices.

Security: Threats like SQL injection, unauthorized access etc. may occur. Using proper authentication and authorization methods security can be ensured.

Data and code loss: Loss of data collected from users may result in testing of the application. Loss of solution code may result in restarting or reworking of the entire application. To avoid this risk, data can be stored in google drive folder and GitHub can be used to manage solution code.

Financial risk: There may arise a need to purchase a paid subscription plan from Microsoft Azure to deploy web API and use SQL server database. Using a free student trial subscription, the cost of purchasing a paid plan can be avoided.

Time Plan

This project is scheduled to be completed in 18 weeks from May 14 to September 7. The main task is as follows

- Research initiation
- Research design
- Data collection
- Design
- Development and implementation
- Testing and deployment
- Evaluation and analysis
- Reflection on result
- Dissertation

The full schedule of the task is shown in the Gantt chart below.

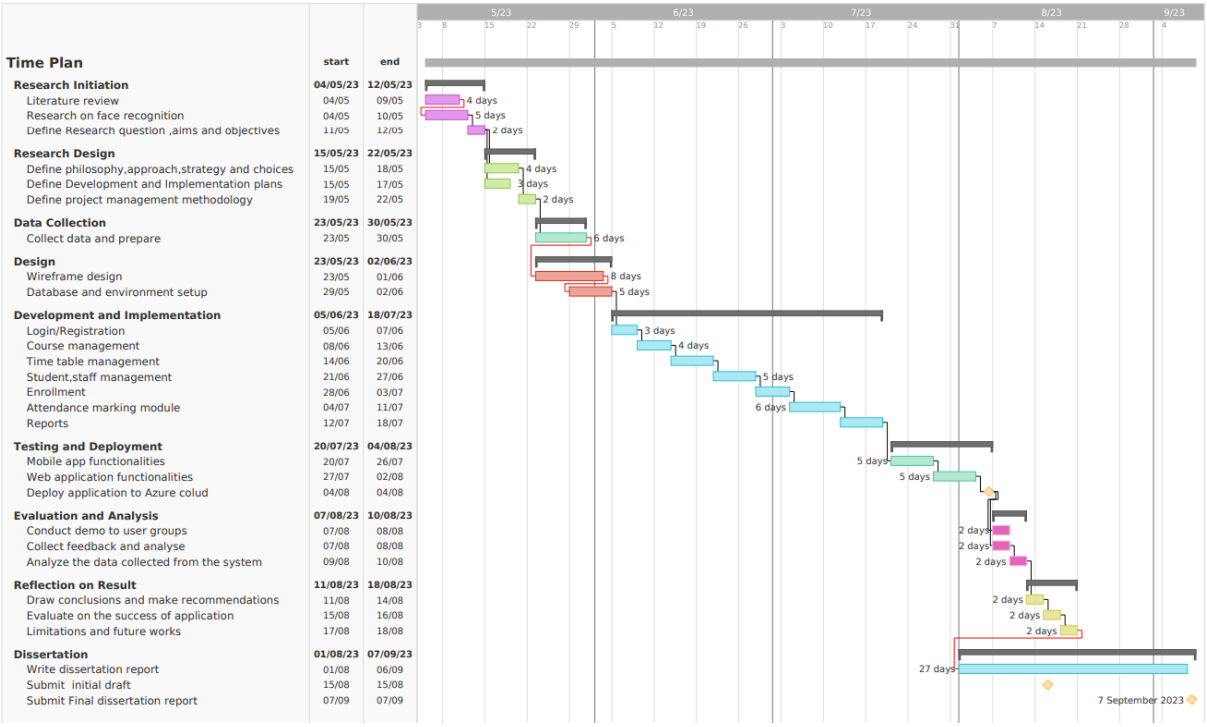


Figure 1. Gantt chart

REFERENCES

1. Budi, S., Karnalim, O., Handoyo, E. D., Santoso, S., Toba, H., Nguyen, H., & Malhotra, V. (2018). IBAtS - Image Based Attendance System: A Low Cost Solution to Record Student Attendance in a Classroom. Paper presented at the 259-266. 10.1109/ISM.2018.00037
2. Gohel,S. (2018). Bluetooth Attendance System with Android Application for ERP. Paper presented at the - 2018 International Conference on Computing, Power and Communication Technologies (GUCON), 481-484. 10.1109/GUCON.2018.8674898

3. Jayakumar, K., Surendar, V., Sheela, A., Javagar, P., Riyas, K. A., & Dhanush, K. (2022). Internet of Things based Biometric Smart Attendance System. Paper presented at the - 2022 International Conference on Sustainable Computing and

Data Communication Systems (ICSCDS), 1492-1497. 10.1109/ICSCDS53736.2022.9761045

4. Liew, K. J., & Tan, T. H. (2021). QR Code-Based Student Attendance System. Paper presented at the - 2021 2nd Asia Conference on Computers and Communications (ACCC), 10-14. 10.1109/ACCC54619.2021.00009

5. Microsoft. (2023, January 30). What is .NET MAUI?. https://learn.microsoft.com/en-us/dotnet/maui/what-is-maui?view=net-maui-7.0

6. OpenCV. (n.d). OpenCV Face Recognition. opencv. Retrieved May 1, 2023, from https://opencv.org/opencv-face-recognition/

7. Patil, M. A., Parane, K., Sivaprasad, D. D., Poojara, S., & Lamani, M. R. (2022). Smart Attendance Management System using IoT. Paper presented at the - 2022 Second International Conference on Computer Science, Engineering and Applications (ICCSEA), 1-6. 10.1109/ICCSEA54677.2022.9936433

8. Shah, S.N., & Abuzneid, A. (2019). IoT Based Smart Attendance System (SAS) Using RFID. Paper presented at the - 2019 IEEE Long Island Systems, Applications and Technology Conference (LISAT), 1-6. 10.1109/LISAT.2019.8817339

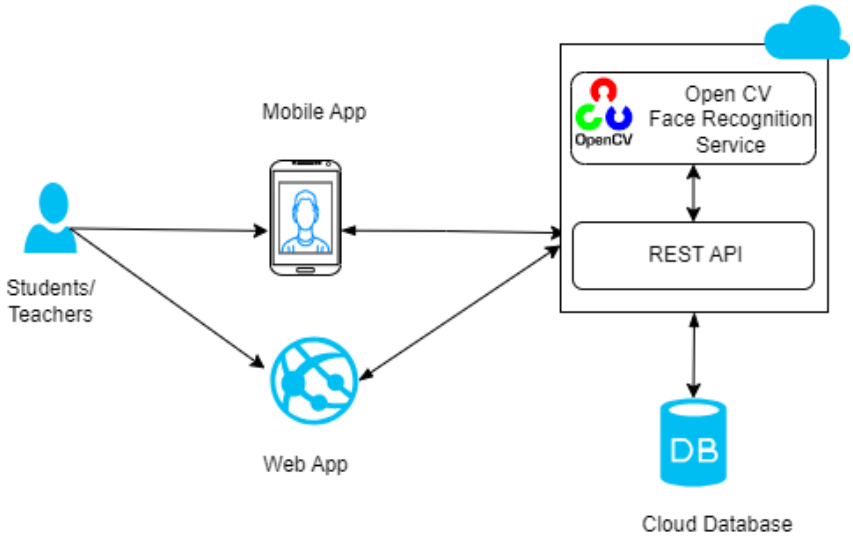
9. Sittampalam, Gopinath & Ratnarajah, Nagulan. (2019). SAMS: An IoT Solution for Attendance Management in Universities. Paper presented at the - TENCON 2019 - 2019 IEEE Region 10 Conference (TENCON), 251-256. 10.1109/TENCON.2019.8929616

10. Stupina, M. V., Anistratenko, K. V., & Pazina, L. O. (2021). Using the QR code as a means of automating the process of accounting for attendance at educational classes. Journal of Physics.Conference Series; J.Phys.: Conf.Ser, 2131(2), 22077. 10.1088/1742-6596/2131/2/022077

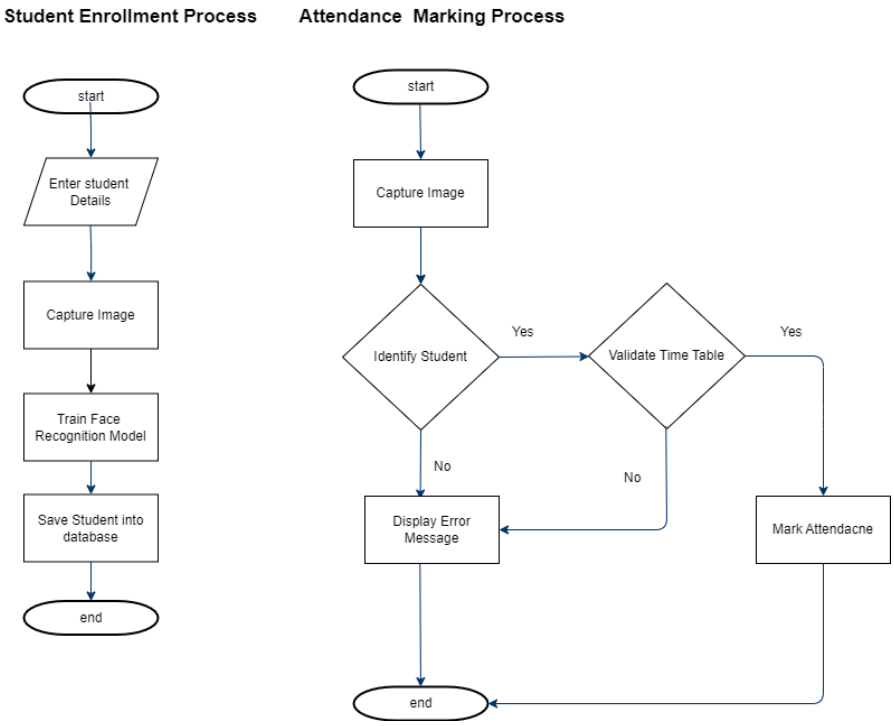
11. Tamilkodi, R. (2021). Automation System Software Assisting Educational Institutes for Attendance, Fee Dues, Report Generation Through Email and Mobile Phone Using Face Recognition. Wireless Personal Communications, 119(2), 1093-1110. 10.1007/s11277-021-08252-2

12. Zhu, Z., & Cheng, Y. (2020). Application of attitude tracking algorithm for face recognition based on OpenCV in the intelligent door lock. Computer Communications, 154, 390-397. 10.1016/j.comcom.2020.02.003

Appendix A: Project Architecture



Appendix B: Flow chart



Appendix B - Ethics Form

UREC2 RESEARCH ETHICS PROFORMA FOR STUDENTS UNDERTAKING LOW RISK PROJECTS WITH HUMAN PARTICIPANTS

This form is designed to help students and their supervisors to complete an ethical scrutiny of proposed research. The University Research Ethics Policy (www.shu.ac.uk/research/excellence/ethics-and-integrity/policies) should be consulted before completing this form. The initial questions are there to check that completion of the UREC 2 is appropriate for this study. The final responsibility for ensuring that ethical research practices are followed rests with the supervisor for student research.

Note that students and staff are responsible for making suitable arrangements to ensure compliance with the General Data Protection Act (GDPR). This involves informing participants about the legal basis for the research, including a link to the University research data privacy statement and providing details of who to complain to if participants have issues about how their data was handled or how they were treated (full details in module handbooks). In addition, the act requires data to be kept securely and the identity of participants to be anonymised. They are also responsible for following SHU guidelines about data encryption and research data management. Guidance can be found on the SHU Ethics Website www.shu.ac.uk/research/excellence/ethics-and-integrity

Please note that it is mandatory for all students to only store data on their allotted networked F drive space and not on individual hard drives or memory sticks etc.

The present form also enables the University and College to keep a record confirming that research conducted has been subjected to ethical scrutiny.

The form must be completed by the student and the supervisor and independently reviewed by a second reviewer or module leader (additional guidance can be obtained from your College Research Ethics Chair[1]). In all cases, it should be counter-signed and kept as a record showing that ethical scrutiny has occurred. Some courses may require additional scrutiny. Students should retain a copy for inclusion in their research project, and a copy should be uploaded to the relevant module Blackboard site.

Please note that it may be necessary to conduct a health and safety risk assessment for the proposed research. Further information can be obtained from the University's Health and Safety Website https://sheffieldhallam.sharepoint.com/sites/3069/SitePages/Risk-Assessment.aspx

SECTION A

1. **Checklist questions to ensure that this is the correct form:**

Health Related Research within the NHS, or His Majesty's Prison and Probation Service (HMPPS), or with participants unable to provide informed consent check list.

Question	Yes/No
Does the research involve? • Patients recruited because of their past or present use of the NHS	No
• Relatives/carers of patients recruited because of their past or present use of the NHS	No
• Access to NHS staff, premises, or resources	No
• Access to data, organs, or other bodily material of past or present NHS patients	No
• Foetal material and IVF involving NHS patients	No
• The recently dead in NHS premises	No
• Prisoners or others within the criminal justice system recruited for health-related research	No
• Police, court officials, prisoners, or others within the criminal justice system	No
• Participants who are unable to provide informed consent due to their incapacity even if the project is not health related	No
• Is this an NHS research project, service evaluation or audit? *For NHS definitions please see the following website* http://www.hra.nhs.uk/documents/2013/09/defining-research.pdf	No

If you have answered **YES** to any of the above questions, then you **MUST consult with your supervisor** to obtain research ethics from the appropriate institution outside the university. This could be from the NHS or Her Majesty's Prison and Probation Service (HMPPS) under their independent Research Governance schemes. Further information is provided below. https://www.myresearchproject.org.uk/

2. **Checks for Research with Human Participants**

Question	Yes/No
1. Will any of the participants be vulnerable? *Note: Vulnerable people include children and young people, people with learning disabilities, people who may be limited by age or sickness, pregnancy, people researched because of a condition they have, etc. See full definition on ethics website in the document* ***Code of Practice for Researchers Working with Vulnerable Populations*** *(under the Supplementary University Polices and Good Research Practice Guidance)*	No
2. Are drugs, placebos, or other substances (e.g., food substances, vitamins) to be administered to the study participants or will the study involve invasive, intrusive, or potentially harmful procedures of any kind?	No
3. Will tissue samples (including blood) be obtained from participants?	No
4. Is pain or more than mild discomfort likely to result from the study?	No
5. Will the study involve prolonged or repetitive testing?	No
6. Is there any reasonable and foreseeable risk of physical or emotional harm to any of the participants? *Note: Harm may be caused by distressing or intrusive interview questions, uncomfortable procedures involving the participant, invasion of privacy, topics relating to highly personal information, topics relating to illegal activity, or topics that are anxiety provoking, etc.*	No
7. Will anyone be taking part without giving their informed consent?	No
8. Is the research covert? *Note: 'Covert research' refers to research that is conducted without the knowledge of participants.*	No
9. Will the research output allow identification of any individual who has not given their express consent to be identified?	No

If you have answered **YES** to any of these questions you are **REQUIRED** to complete and submit a UREC3 or UREC4 form. Your supervisor will advise. If you have answered **NO** to all these questions, then proceed with this form (UREC2).

3. **General Project Details**

Details	
Name of student	Vinu Davis
SHU email address	C1056386@hallam.shu.ac.uk
Department/College	MSc Computing
Name of supervisor	Vinanzi, Samuele
Supervisor's email address	s.vinanzi@shu.ac.uk
Title of proposed research	Face Recognition-Based Mobile Attendance Register Application for Higher Educational Institutions
Proposed start date	01/06/2024
Proposed end date	25/08/2024

Background to the study and the rationale (reasons) for undertaking the research (500 words)	Attendance is crucial for academic success and personal development. Academic institutions in most developing countries uses paper-based attendance systems to manage the attendance of students. There are a few drawbacks to this system. High time-consuming, manual errors, loss or damage of paper, inefficiency, inconvenience, acting as proxies to mark attendance, etc. are few of them. With the evolution of technology, new systems were developed like RFID (Radio Frequency Identification), biometrics, barcode, web applications etc. which are more expensive and complex. Even though these technologies are more efficient and convenient compared to traditional paper-based systems, due to security concerns, high implementation and maintenance costs are few drawbacks of these systems. Recently, there is a rapid increase in the use of face recognition technology with the help of computer vision and machine learning. These technology can be used to provide innovative solutions to attendance marking process which offers accuracy and reliability, scalability, efficiency, low cost, less maintenance and enhanced security. OpenCV is one of the largest and popular open-source computer vision based library that provide face recognition service. This project will research how facial recognition using OpenCV can be integrated into a mobile application to create a simple and efficient attendance register system that could be implemented in educational institutions.

Aims & research question(s)	Aim This project aims to create a face recognition-based automated attendance register prototype mobile application using OpenCV computer vision library that could be implemented in higher educational institutions. Research Question How face recognition technology can be integrated into a mobile application to develop an attendance register application that could be used in higher educational institutions?
Methods to be used for: 1. Recruitment of participants 2. Data collection 3. Data analysis	1. Recruitment of participants: Postgraduate students of Sheffield Hallam university will be contacted by email to request their participation in Surveys. 2 Data collection: Surveys will be used in the initial stage to get feedback from participants on implementing face recognition in the attendance register process. Data from the face recognition mobile app like the result of the face recognition, accuracy values etc will be collected for the analysis purpose. Observations will be done during the testing of the prototype application to understand the usability and effectiveness of the application 3.Data analysis: both thematic and statistical analysis will be followed in the data analysis process.
Outline the nature of the data held, details of anonymisation, storage and disposal procedures as required.	Survey data collected will be stored in the university server using the Qualtrics platform. Data collected in the mobile app includes images from a database of images, details like name, department and course. Proxy names and addresses will be generated and will be assigned to users. Data will be stored in a database in Microsoft SQL server database with a restricted access. All the data collected as part of this project will be disposed after a predefined

	retention period which will be clearly communicated to the participants.

4. Research in External Organisations

Question	**Yes/No**
1. Will the research involve working with/within an external organisation (e.g., school, business, charity, museum, government department, international agency, etc.)?	No
2. If you answered YES to question 1, do you have granted access to conduct the research from the external organisation? *If YES, students please show evidence to your supervisor. You should retain this evidence safely.*	N/A
3. If you do not have permission for access is this because: A. you have not yet asked B. you have asked and not yet received an answer C. you have asked and been refused access *Note: You will only be able to start the research when you have been granted access.*	N/A

5. **Research with Products and Artefacts**

Question	**Yes/No**
1. Will the research involve working with copyrighted documents, films, broadcasts, photographs, artworks, designs, products, programs, databases, networks, processes, existing datasets, or secure data?	No

2. If you answered YES to question 1, are the materials you intend to use in the public domain? *Notes: 'In the public domain' does not mean the same thing as 'publicly accessible'.* • *Information which is 'in the public domain' is no longer protected by copyright (i.e., copyright has either expired or been waived) and can be used without permission.* • *Information which is 'publicly accessible' (e.g., TV broadcasts, websites, artworks, newspapers) is available for anyone to consult/view. It is still protected by copyright even if there is no copyright notice. In UK law, copyright protection is automatic and does not require a copyright statement, although it is always good practice to provide one. It is necessary to check the terms and conditions of use to find out exactly how the material may be reused etc.* *If you answered YES to question 1, be aware that you may need to consider other ethics codes. For example, when conducting Internet research, consult the code of the Association of Internet Researchers; for educational research, consult the Code of Ethics of the British Educational Research Association.*	N/A
3. If you answered NO to question 2, do you have explicit permission to use these materials as data? *If YES, please show evidence to your supervisor.*	N/A
4. If you answered NO to question 3, is it because: A. you have not yet asked permission B. you have asked and not yet received and answer C. you have asked and been refused access. *Note: You will only be able to start the research when you have been granted permission to use the specified material.*	**N/A**

SECTION B

HEALTH AND SAFETY RISK ASSESSMENT FOR THE RESEARCHER

1. **Does this research project require a health and safety risk assessment for the procedures to be used?** (Discuss this with your supervisor)

☐ Yes

☐✓ No

If **YES** the completed Health and Safety Risk Assessment form should be attached. A standard risk assessment form can be generated through the Awaken system (https://shu.awaken-be.com). Alternatively if you require more specific risk assessment, e.g. a COSHH, attach that instead.

2. **Will the data be collected fully online (no face-to-face contact with participants)?**

□✓ Yes (See the safety guidance for online research[2] and **go to question 7b**)

☐ No (Go to question 3)

3. **Will the proposed data collection take place on campus?**

☐ Yes (Please answer questions 5 to 8)

□✓ No (Please complete all questions and consult with your supervisor))

4. **Where will the data collection take place?**

(Tick as many as apply if data collection will take place in multiple venues)

	Location	**Please specify**
☐	Researcher's Residence	
□	Participant's Residence	
✓		
☐	Education Establishment	
☐	Other e.g., business/voluntary organisation, public venue	
☐	Outside UK	

5. **How will you travel to and from the data collection venue?**

☐ On foot

☐ By car

☐ Public Transport

☐ Other (Please specify)

Please outline how you will ensure your personal safety when travelling to and from the data collection venue.

no travel required
…….

6. **How will you ensure your own personal safety whilst at the research venue?**

……..

7. **Are there any potential risks to your health and wellbeing associated with either (a) the venue where the research will take place and/or (b) the research topic itself?**

□✓ None that I am aware of

☐ Yes (Please outline below including steps taken to minimise risk)

8. **If you are carrying out research off-campus, you must ensure that each time you go out to collect data you ensure that someone you trust knows where you are going (without breaching the confidentiality of your participants), how you are getting there (preferably including your travel route), when you expect to get back, and what to do should you not return at the specified time.**

   Please outline here the procedure you propose using to do this.

……

Insurance Check

The University's standard insurance cover will not automatically cover research involving any of the following:

i) Participants under 5 years old
ii) Pregnant women
iii) 5000 or more participants
iv) Research being conducted in an overseas country
v) Research involving aircraft and offshore oil rigs
vi) Nuclear research

vii) Any trials/medical research into Covid 19

If your proposals do involve any of the above, please contact the Insurance Manager directly (fin-insurancequeries-mb@exchange.shu.ac.uk) to discuss this element of your project.

Adherence to SHU Policy and Procedures

Ethics sign-off	
Personal statement	
I can confirm that: • ..... have read the Sheffield Hallam University Research Ethics Policy and Procedures • ..... agree to abide by its principles.	
Student	
Name: Vinu Davis	Date: 02/06/2024
Signature: 	
Supervisor ethical sign-off	
I can confirm that completion of this form has not identified the need for ethical approval by the TPREC/CREC or an NHS, Social Care, or other external REC. The research will not commence until any approvals required under Sections 4 & 5 have been received and any necessary health and safety measures are in place.	
Name: Dr Samuele Vinanzi	Date: 17/07/2024
Signature: 	
Independent Reviewer ethical sign off	
Name:	Date:
Signature:	

Please ensure that you have attached all relevant documents. Your supervisor must approve them before you start data collection:

Documents	Yes	No	N/A
Research proposal if prepared previously	☐✓	☐	☐
Any recruitment materials (e.g., posters, letters, emails, etc.)	☐	☐	☐✓
Participant information sheet[3]	☐✓	☐	☐
Participant consent form[4]	☐✓	☐	☐
Details of measures to be used (e.g., questionnaires, etc.)	☐✓	☐	☐
Outline interview schedule / focus group schedule	☐	☐	☐✓
Debriefing materials	☐	☐	☐✓
Health and Safety Risk Assessment Form	☐	☐	☐✓

Appendix C - Participant Information Sheet

Sheffield Hallam University

Participant Information Sheet

Face Recognition-Based Mobile Attendance Register Application For Higher Educational Institutions

The University undertakes research as part of its function for the community under its legal status. Data protection allows us to use personal data for research with appropriate safeguards in place under the legal basis of **public tasks that are in the public interest.** A full statement of your rights can be found at:www.shu.ac.uk/about-this-website/privacy-policy/privacy-notices/privacy-notice-for-research. However, all University research is reviewed to ensure that participants are treated appropriately and their rights respected. This study was approved by the University's Research Ethics Committee. Further information at:www.shu.ac.uk/research/excellence/ethics-and-integrity. Please download a copy of the **participant information sheet** here (Participant Information Sheet_SHU 1.docx) and retain this for your records before starting the survey.

You are invited to take part in a study about the use of face recognition technology in attendance registration process in higher educational institutions. You have been requested to take part because you are a student or staff of Sheffield Hallam University. By taking part in the survey, you will be contributing to the development of a prototype application using face recognition to mark the attendance of students.

Your participation is requested for an online survey to help me understand your understandings about current attendance register systems and possibility of using face recognition in the attendance registration process. You can take part in this survey at your own convenience. There will be questions based on traditional attendance registration systems and your experiences, suggestions, and their drawbacks. The survey will be administered and completed via the online survey platform Qualtrics. The survey should take no longer than 5 minutes to complete. Participation is voluntary and it is up to you to decide if you want to take part in it. A copy of the information provided here is yours to keep, along with the consent form if you do decide to take part. You can still decide to withdraw at any time without giving a reason, or you can decide not to answer a particular question. There are no possible risks or disadvantages in taking part in this project. By taking part in this project, you can have some possible benefits like understanding about traditional and latest attendance register systems and getting hands on experience with the face recognition technology.

Your Confidentiality is most important to me. Data collected during the survey will be stored on a university server. Proxy names will be used instead of your real name during the

analysis of this project. Access to the information will be available only to myself as I am doing this research project.

This project is expected to be completed by the end of August 2024. All the data collected through surveys and through the application will not be used for any other purpose other than this project and will be removed completely after the completion of this project. The findings of this research project will be summarized in a dissertation report, which can be shared with you upon request.

You can contact me using the information below if you have any questions or concerns about this research project.

Details of whom to contact if you have any concerns or if adverse effects occur after the study are given below.

Researcher Details:

Vinu Davis (email: c1056386@shu.ac.uk, telephone: +4407768310704)

You should contact the Data Protection Officer if:	**You should contact the Head of Research Ethics (Dr Mayur Ranchordas) if:**
• ou have a query about how your data is used by the University • ou would like to report a data security breach (e.g. if you think your personal data has been lost or disclosed inappropriately) • ou would like to complain about how the University has used your personal data DPO@shu.ac.uk	• ou have concerns with how the research was undertaken or how you were treated ethicssupport@shu.ac.uk

Postal address: Sheffield Hallam University, Howard Street, Sheffield S1 1WBT Telephone: 0114 225 5555

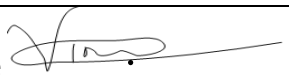
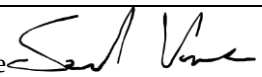
Appendix D - Publication Procedure Form

Sheffield Hallam University | College of Business, Technology and Engineering

Dissertation for Computing (55-708541).

PUBLICATION PROCEDURE FORM

In this module, while you create your own research question or topic area, your supervisor makes a significant intellectual contribution to this work as the research progresses. Your supervisor will make the decision on whether your work merits publication based on the quality of the work you have produced. Your supervisor will co-author the paper for publication with you and your supervisor will both be listed as authors. You are required to sign the declaration below to confirm that you understand and will follow this procedure.
Declaration:

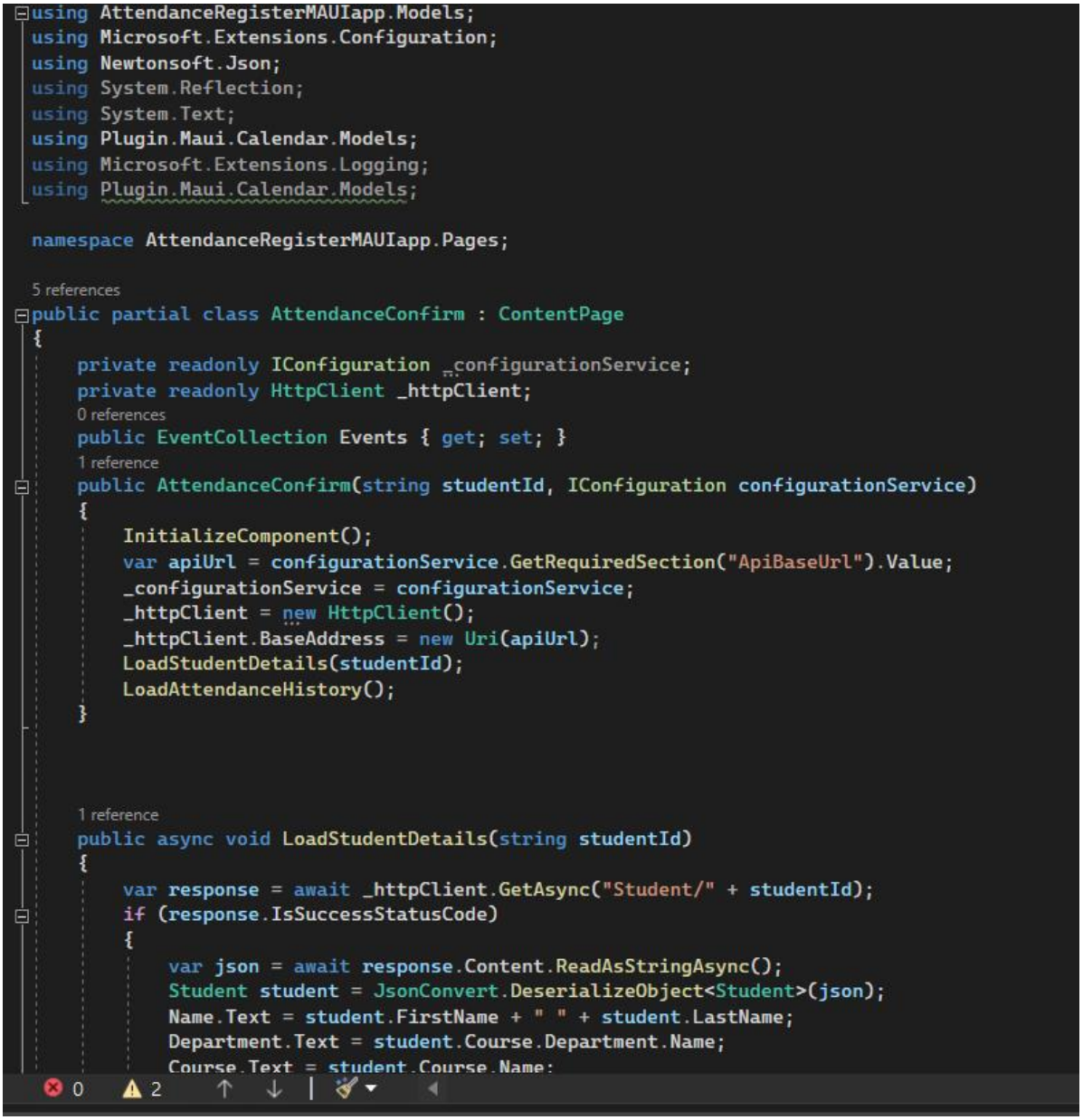
I …Vinu Davis… confirm that I understand will comply with the Publication Procedure outlined in the Module Handbook and the Blackboard Site.		
Student:	Signature 	Date 15/08/2024
Supervisor:	Signature 	Date 04/09/2024

Appendix E - Software Code

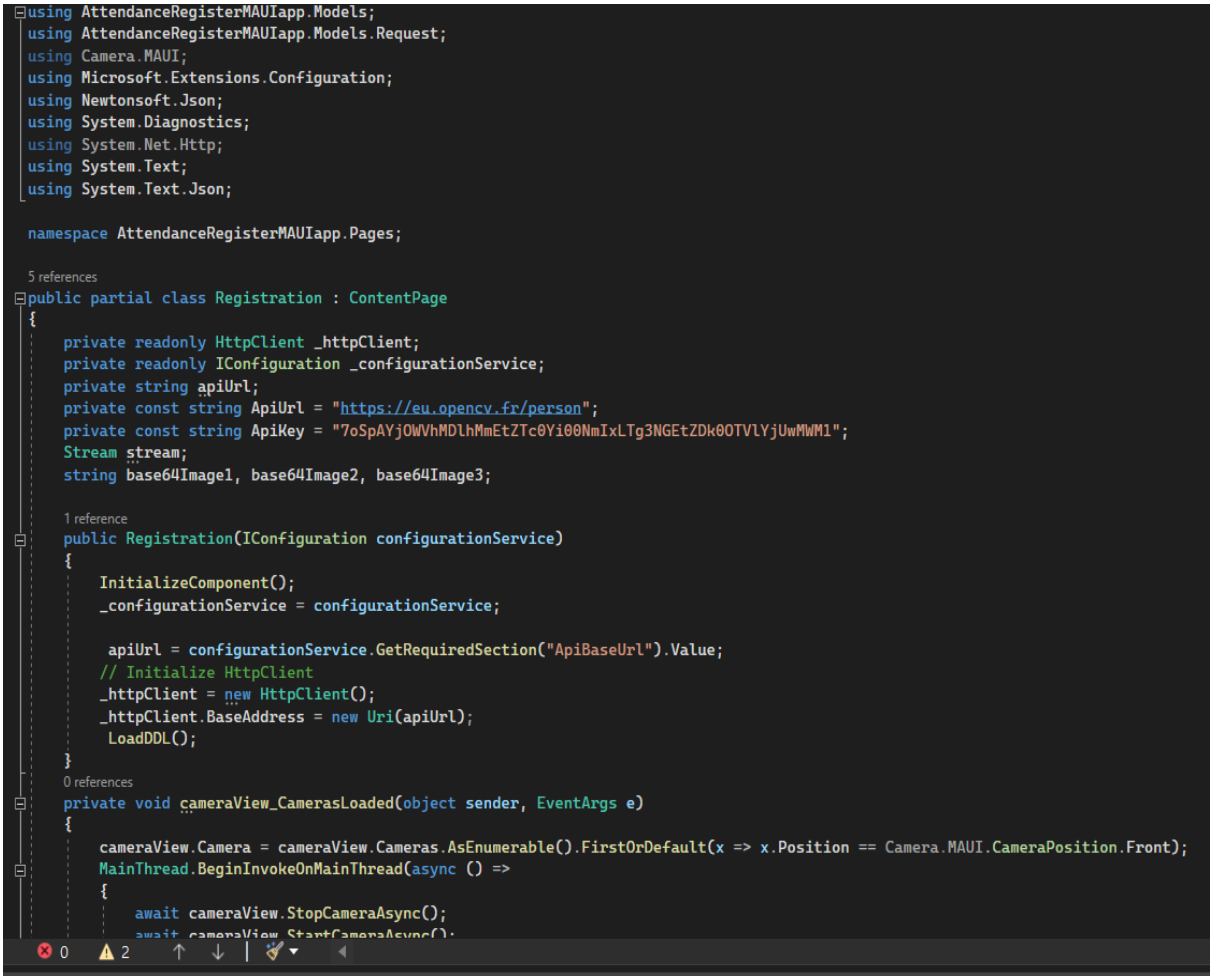
```
<?xml version="1.0" encoding="utf-8" ?>
<ContentPage xmlns="http://schemas.microsoft.com/dotnet/2021/maui"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             xmlns:cv="clr-namespace:Camera.MAUI;assembly=Camera.MAUI"
             x:Class="AttendanceRegisterMAUIapp.MainPage">
    <StackLayout >
<StackLayout BackgroundColor="#004849" >
    <Label Text="" FontSize="20" HorizontalOptions="Center" VerticalOptions="CenterAndExpand" />
</StackLayout>
        <Grid>
            <!-- Camera Feed -->
            <cv:CameraView
            x:Name="cameraView"
            HorizontalOptions="FillAndExpand"
            VerticalOptions="FillAndExpand"
            CamerasLoaded="cameraView_CamerasLoaded" />
            <!-- Overlay for face guide -->
            <Grid x:Name="OverlayGrid"
              HorizontalOptions="FillAndExpand"
              VerticalOptions="FillAndExpand"
              BackgroundColor="Transparent">
                <!-- Transparent rectangle with border -->
                <Frame
                BackgroundColor="Transparent"
                BorderColor="Teal"
                HasShadow="False"
                HorizontalOptions="Center"
                VerticalOptions="Center"
                WidthRequest="300"
                HeightRequest="400" />
                <!-- Optional: Text instructions -->
                <Label
                Text="Align your face within the box"
                TextColor="White"
                HorizontalOptions="Center"
                VerticalOptions="End"
                Margin="0,0,0,20"
                FontAttributes="Bold"
                BackgroundColor="Black"
                Opacity="0.7" />
            </Grid>
            <!-- Bottom controls -->
        <StackLayout Orientation="Vertical"
                     HorizontalOptions="Center"
                     VerticalOptions="End"
                     Padding="10"
                     Spacing="10"
                     Margin="0,0,0,20">
            <Button
                x:Name="BtnSubmit"
                Text="Checkin"
                HorizontalOptions="Center"
                Clicked="BtnSubmit_Clicked" />
                <Button
    x:Name="BtnSubmitBrowse"
    Text="Load Image"
    HorizontalOptions="Center"
    Clicked="BtnSubmitBrowse_Clicked" />
                <Image
                x:Name="myImage"
                WidthRequest="100"
                HeightRequest="100"
                HorizontalOptions="Center" />
        </StackLayout>
    </Grid>
    </StackLayout>
</ContentPage>
```

```
<ContentPage xmlns="http://schemas.microsoft.com/dotnet/2021/maui"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             x:Class="AttendanceRegisterMAUIapp.Pages.Registration"
             xmlns:cv="clr-namespace:Camera.MAUI;assembly=Camera.MAUI"
             Title="">
    <ScrollView>

        <StackLayout Padding="20" Spacing="20">
            <!-- Personal Information -->
            <StackLayout Orientation="Horizontal" HorizontalOptions="FillAndExpand">
                <Entry Placeholder="First Name" x:Name="FirstNameEntry" HorizontalOptions="FillAndExpand" />
                <Entry Placeholder="Last Name" x:Name="LastNameEntry" HorizontalOptions="FillAndExpand" />
            </StackLayout>

            <!-- Contact Information -->
            <StackLayout Orientation="Horizontal" HorizontalOptions="FillAndExpand">
                <Entry Placeholder="Email" x:Name="EmailEntry" HorizontalOptions="FillAndExpand" />
                <Entry Placeholder="Phone Number" x:Name="PhoneNumberEntry" HorizontalOptions="FillAndExpand" />
            </StackLayout>

            <!-- Email and Password -->
            <Entry Placeholder="Password" IsPassword="True" x:Name="PasswordEntry" HorizontalOptions="FillAndExpand" /

            <!-- Address -->
            <Entry Placeholder="Address" x:Name="AddressEntry" HorizontalOptions="FillAndExpand" />
            <DatePicker x:Name="DateOfBirthPicker" />
            <!-- Academic Information -->
            <StackLayout Orientation="Horizontal" HorizontalOptions="FillAndExpand">
                <Picker x:Name="DepartmentPicker" Title="Department" SelectedIndexChanged="DepartmentPicker_SelectedIn
                <Picker x:Name="CoursePicker" Title="Course" HorizontalOptions="FillAndExpand" />
            </StackLayout>

            <!-- Camera and Image -->
            <cv:CameraView x:Name="cameraView" HeightRequest="200" CamerasLoaded="cameraView_CamerasLoaded" Horizontal
            <StackLayout Orientation="Horizontal" HorizontalOptions="CenterAndExpand" Padding="20" Spacing="20">
                <!-- First Image and Button -->
                <StackLayout Orientation="Vertical" HorizontalOptions="FillAndExpand">
                    <Image x:Name="myImage1" Source="user.png" HeightRequest="100" HorizontalOptions="FillAndExpand" /
                    <Button Text="Capture" Clicked="ButtonImage1_Clicked" HorizontalOptions="Center" />
                </StackLayout>

                <!-- Second Image and Button -->
```

```
2 references
private async void FaceApi(Stream imageStream)
{
    using (System.Net.Http.HttpClient client = new System.Net.Http.HttpClient())
    {
        client.DefaultRequestHeaders.Add("accept", "application/json");
        byte[] imageBytes;
        using (MemoryStream memoryStream = new MemoryStream())
        {
            await imageStream.CopyToAsync(memoryStream);
            memoryStream.Position = 0;
            imageBytes = memoryStream.ToArray();
        }

        string base64Image = Convert.ToBase64String(imageBytes);
        myImage.Source = ImageSource.FromStream(() => new MemoryStream(imageBytes));
        var api = _configurationService.GetRequiredSection("ApiBaseUrl").Value;
        System.Net.Http.HttpClient _httpClient = new System.Net.Http.HttpClient();
        _httpClient.BaseAddress = new Uri(api);
        string jsonRequest = JsonConvert.SerializeObject(base64Image);
        var content = new StringContent(jsonRequest, Encoding.UTF8, "application/json");
        var response = await _httpClient.PostAsync("Face/Recognize", content);

        if (response.IsSuccessStatusCode)
        {
            string responseContent = await response.Content.ReadAsStringAsync();
            var verificationResponse = JsonConvert.DeserializeObject<VerificationResponseAPI>(responseContent);
            if (verificationResponse.Id <= 0)
            {
                await DisplayAlert("Error", verificationResponse.Message, "OK");

            }
            else
            {
                AppSession.UserId = verificationResponse.Id.ToString();
                AppSession.Image = verificationResponse.Image;
                await DisplayAlert("Success", verificationResponse.Message, "OK");
                await Navigation.PushAsync(new AttendanceConfirm(AppSession.UserId, _configurationService));
            }
        }
    }
}
```



```
using AttendanceRegisterMAUIapp.Models;
using Microsoft.Extensions.Configuration;
using Newtonsoft.Json;
using System.Reflection;
using System.Text;
using Plugin.Maui.Calendar.Models;
using Microsoft.Extensions.Logging;
using Plugin.Maui.Calendar.Models;

namespace AttendanceRegisterMAUIapp.Pages;

5 references
public partial class AttendanceConfirm : ContentPage
{
    private readonly IConfiguration _configurationService;
    private readonly HttpClient _httpClient;
    0 references
    public EventCollection Events { get; set; }
    1 reference
    public AttendanceConfirm(string studentId, IConfiguration configurationService)
    {
        InitializeComponent();
        var apiUrl = configurationService.GetRequiredSection("ApiBaseUrl").Value;
        _configurationService = configurationService;
        _httpClient = new HttpClient();
        _httpClient.BaseAddress = new Uri(apiUrl);
        LoadStudentDetails(studentId);
        LoadAttendanceHistory();
    }



    1 reference
    public async void LoadStudentDetails(string studentId)
    {
        var response = await _httpClient.GetAsync("Student/" + studentId);
        if (response.IsSuccessStatusCode)
        {
            var json = await response.Content.ReadAsStringAsync();
            Student student = JsonConvert.DeserializeObject<Student>(json);
            Name.Text = student.FirstName + " " + student.LastName;
            Department.Text = student.Course.Department.Name;
            Course.Text = student.Course.Name;
```



```
using AttendanceRegisterMAUIapp.Models;
using AttendanceRegisterMAUIapp.Models.Request;
using Camera.MAUI;
using Microsoft.Extensions.Configuration;
using Newtonsoft.Json;
using System.Diagnostics;
using System.Net.Http;
using System.Text;
using System.Text.Json;

namespace AttendanceRegisterMAUIapp.Pages;

5 references
public partial class Registration : ContentPage
{
    private readonly HttpClient _httpClient;
    private readonly IConfiguration _configurationService;
    private string apiUrl;
    private const string ApiUrl = "https://eu.opencv.fr/person";
    private const string ApiKey = "7oSpAYjOWVhMDlhMmEtZTc0Yi00NmIxLTg3NGEtZDk0OTVlYjUwMWM1";
    Stream stream;
    string base64Image1, base64Image2, base64Image3;

    1 reference
    public Registration(IConfiguration configurationService)
    {
        InitializeComponent();
        _configurationService = configurationService;

         apiUrl = configurationService.GetRequiredSection("ApiBaseUrl").Value;
        // Initialize HttpClient
        _httpClient = new HttpClient();
        _httpClient.BaseAddress = new Uri(apiUrl);
         LoadDDL();
    }
    0 references
    private void cameraView_CamerasLoaded(object sender, EventArgs e)
    {
        cameraView.Camera = cameraView.Cameras.AsEnumerable().FirstOrDefault(x => x.Position == Camera.MAUI.CameraPosition.Front);
        MainThread.BeginInvokeOnMainThread(async () =>
        {
            await cameraView.StopCameraAsync();
            await cameraView.StartCameraAsync();
```

```
using AttendanceApi.Models.Domain;
using AttendanceApi.Models.DTO;
using AttendanceApi.Models.DTO.Request;
using AttendanceApi.Repository;
using AutoMapper;
using Microsoft.AspNetCore.Http;
using Microsoft.AspNetCore.Mvc;

namespace AttendanceApi.Controllers
{
    [Route("api/[controller]")]
    [ApiController]
    3 references
    public class AttendanceController : ControllerBase
    {
        private readonly IMapper mapper;
        private readonly IAttendanceRepository attendanceRepository;

        1 reference
        public AttendanceController(IAttendanceRepository attendanceRepository, IMapper mapper)
        {
            this.mapper = mapper;
            this.attendanceRepository = attendanceRepository;
        }
        [HttpGet]
        1 reference
        public async Task<IActionResult> GetAttendanceHistory(int studentId)
        {
            var attendance = await attendanceRepository.GetAllAsync(studentId);
            var attendanceDTO = mapper.Map<List<AttendanceDTO>>(attendance);
            return Ok(attendanceDTO);
        }
        [HttpPost]
        1 reference
        public async Task<IActionResult> MarkAttendance([FromBody] AddAttendanceRequestDTO addAttendanceRequestDTO)
        {
            addAttendanceRequestDTO.AttendanceDate = DateTime.Now;
            var attendance = mapper.Map<Attendance>(addAttendanceRequestDTO);
            var result = await attendanceRepository.CreateAsync(attendance);
            return Ok(attendance.Id);
        }
    }
}
```

Appendix F - Survey Invitation.