Design and Development of Real-Time Automated Facial Recognition Attendance Management System for Staff of FUTIA.

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Abstract- ***Attendance taken is one of the most important tasks that must be performed daily in every educational institution like universities, colleges, and schools, as well as organizations. In developing countries like Nigeria, majority of university attendance markings are done manually. The main goal of this project is to develop a real-time automated Facial Recognition-based attendance system that will eliminate the use of the manual management system. Face Recognition is a method of using various face recognition algorithms to identify or verify the identity of individuals via their face. This project utilized computer vision techniques to create face databases to load data into the recognition algorithm for implementation of this real-time automated attendance management system that accurately identified and track individual faces of university staff for attendance purposes. Some of the hardware and software tools utilize are USB camera, Personal Computer, OpenCV, developer kit, face detection and facial recognition algorithms, utilizing machine learning for recognition capabilities. This developed system that tracks attendance automatically is installed to reduce attendance administrative burdens, prevent proxy attendance, and enhance security at the school entrance gates. This system offers an efficient solution for attendance management, due to its enhanced functionalities, because it provides real-time notification, reports, and its capacity to integrate with existing infrastructure. The system is trained with university staff information, such as name, staff number, carder, and facial photographs. These facial images captured with camera are extracted using OpenCV, and the system compare the pictures taken and creates dataset using developer kit. Every moment recognition is concluded, the developed Excel sheet for staff attendance marking information is updated.***

Index Terms- ***Facial Recognition, Personal Computer, USB camera, Computer Vision, Face Databases.***

I. INTRODUCTION

Attendance taken and record keeping in tertiary institutions is very important for both university's staff and student. Hence, the main purpose of this work is to build a real-time automated face recognition-based attendance monitoring system for educational institution to enhance and upgrade the current attendance system into more efficient and effective one when compared to the current manual system. The current conventional manual method of staff attendance taking in Federal University of Technology, Ikot-Abasi (FUTIA) is by writing names, time of arrival, and signing on logbook, this method is time consuming and has a lot of ambiguity that introduces inaccurate and inefficient staff attendance records. This method of staff attendance monitoring is also labor intensive; hence, valuable university time that could have been used for other official university activities are dedicated to attendance taken. Since staff attendance in tertiary institutions is very vital for purpose of staff performance evaluation analysis and prediction, there is need therefore to provide solution to the attendance problems associated with manual attendance systems. In the bid of getting rid of this manual attendance

methods its problem of inflexibility in generating statistical data for analysis, various researchers have proposed different methods and technologies such as RFID attendance system, barcode-based attendance system and fingerprint identification. However, these various proposed systems suffer from one deficiency or the other also, hence, the need to replacing the current manual attendance system with this real-time automated face recognition-based attendance monitoring system that is more efficient and effective,

Therefore, this project has designed and implemented a real-time automated staff attendance monitoring and management system based on face recognition using machine learning technique for educational institution to enhance and upgrade the current FUTIA staff attendance system into more efficient and effective system, hence, eliminating the deficiencies associated with the legendry manual attendance systems. This system is a contactless involuntary attendance marking system is devoid of every kind of interference with the normal university working activities. It eliminated all the short falls of the conventional manual systems, such as interference with normal institutional work activities, as well as been stressful to staff during attendance marking. Additionally, staff were registered in the database through the system enrolment user friendly interface with facial recognition algorithm to detect face segment from the camera frame, extract useful facial features, classify the features and store these features in the database created.

Finally, this developed attendance systems uses facial detection and recognition algorithms to streamline and intelligently perform attendance management in the university environment. The system detects face segments from the camera frame, extract facial features, classify the features, and compare the face to database faces created during system training phase, to recognize the face detected, record the attendance of the identified staff, and filter, update and save the report of attendance details of a particular staff and generate monthly report on every staff.

II. LITERATURE REVIEW

The author in (Ritika Andhare, et. al., 2021) proposed to develop a working prototype of a system that will facilitate class control for BVCOEW lecturers in a classroom by detecting student faces for them. In this project, the authors studied various algorithms for the implementation of face recognition systems in mobile phones, and discovered that Eigenfaces machine-learning algorithm that recognizes faces at real-time was the engine of training the system after applying some filters on the image.

The authors in (Omkar Biradar, and Anurag Bhave, 2019 and Ayush Atul Sathe, 2019) developed a face detection, recognition and image normalization system that marks attendance of users (students/employees), with the help of Raspberry pi and Open-cv software by using a system attached camera which captures users, and detect the faces in images and compare with the detected faces in the user's database and mark their attendance. Then the system automatically updated the attendance on the web page which they have created by using face detection and face recognition.

The researchers in (Tippavajhala Sundar Srinivas, et al., 2022) developed a face recognition based smart attendance system using IoT features, which is time-saving, more efficient, real-time, precise, and it gives automatic report in spreadsheet. They realized their system with Raspberry Pi, Webcam, OpenCV, Haar cascade and python. Their implemented system, which was designed to address many of the problems of existing manual systems and finger print based biometric system, works automatically once the registration of individual student is completed and dataset is createdIn the paper titled Automated Attendance System Using Face Recognition, the researchers (Akshara Jadhav, et al, 2017) based their work on face recognition techniques that proved to be time saving and secured. They discovered that in real time scenarios PCA perform better than other algorithms with better recognition rate and low false positive rate. They recommended that future work should be towards improvement on the recognition rate of algorithms when there are changes in a person like tonsuring head, their developed system only recognizes face up to 30 degrees angle variations.

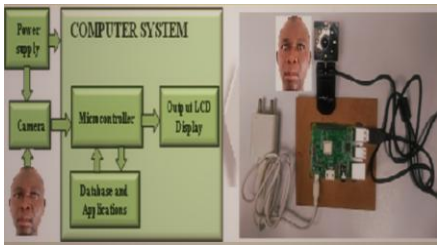
The authors in (Amit Dubey, et al., 2021) proposed the implementation of RFID technology in educational/Industrial domain to solve the problems of manual attendance method. Their implemented system provides facilities for both students and staff by reducing time to take the attendance as well as providing a database system that holds all the student's and staff's information. The two objectives of their system are- the first is to register, record and maintain attendance of students using RFID tag and Website and the second is to monitor a student's location by installing RFID readers at different locations within the campus such as in the canteen, classroom doors, library, college gates and so on (Ononiwu G. Chiagozie and Okorafor G. Nwaji, 2012) The RFID based system provides an effective and efficient method to record students attendance with real time data for example student's entry time and leaving time can be recorded instantly as the students enters or leaves the classroom and also helps in finding locations of students in the campus in case they are not present in the class as the readers installed at different locations within the campus can sense the RFID tags embedded in student's ID card and determine their locations. (Okorafor G. Nwaji., et al. 2013), Amit Dubey, et al., 2021)(Shreya Prabhulkar, et al., 2024) proposed computerized attendance management system using face recognition that would have advantage over the current manual attendance system. Their developed face recognition attendance system possessed advanced features over manual attendance systems including improved accuracy, security, and adaptability to diverse scenarios, and robustness.

The authors in (Mathana Gopala Krishnan, and Balaji Shyam Babu, 2015) proposed automated face recognition attendance system for schools and colleges for attendance taking within specific time period, that is before the time expiration. Their system recognizes students faces using eigenface approach for face recognition and automatically saves the details regarding attendance in database, and create a summary list of students who are absent in a particular day.

III. METHODOLOGY

This section presents the materials and methods that have been used to realize the objectives of this research work. The project materials comprise of both the hardware and software tools, which include Personal Computer (PC), USB Camera, Secondary Memory, OpenCV (Open-Source Computer Vision), and Python. The project method is the step-by-step processes used to achieve the overall system hardware and software design and the implementation of this real-time automated facial recognition attendance management system. In the design and implementation of this real-time automated attendance monitoring and management system based facial recognition for staff of FUTIA, a bottom-up approach technique was used to realize this project methods. This started from data collection through review of previous researches on attendance systems, and perform analytical method that included systems design, modeling, simulation, calculations and analysis of the simulation test results by means of computational software. Figure 1 is the block diagram of the implemented face recognition attendance system

Figure 1: Block Diagram of The Conceptual System.



The hardware and software technical requirements of the conceptual system block diagram of figure 1 includes- (i) a camera with optimum resolution of 512 by 512 pixels that was strategically positioned to capture/snapshots staff pictures. (ii) a secondary memory that stored all the staff images and database, (iii) a standalone personal computer (PC) installed with necessary software for attendance management and display, (iv) open-source computer vision library (OpenCV) and machine learning software library, which plays a major role in real-time operation, deployed here for images and videos processes to identify staff faces. These hardware and software devices acquire and extract multiple shots of the staff

faces, and the algorithms detect facial features that were used to create multiple templates of staff facial dataset. These templates are stored in database along with staff ID.

A. System Design

The Project design consist of hardware and software designs, which form the system design architecture. The hardware modules are for image capturing, while the software modules are for face detection and recognition, and a web-based interface for management and visualization. In this project designed, a real-time automated attendance management system through face recognition technology was achieved to replace the current manual and biometric methods. The hardware design focuses on the physical components necessary for the implementation of a real-time face recognition-based attendance system. The hardware setup is generally modular as shown in figure 2 and includes devices for capturing still or mobile images, processing units for running face detection and recognitionalgorithms, and memory unit for datasets storage as databases. However, the system software design integrates multiple modules that facilitate image acquisition, face detection, face recognition, database management, and user interaction via web applications. The design follows a modular architecture, emphasizing algorithms for face detection and recognition, data handling, and system interfaces.

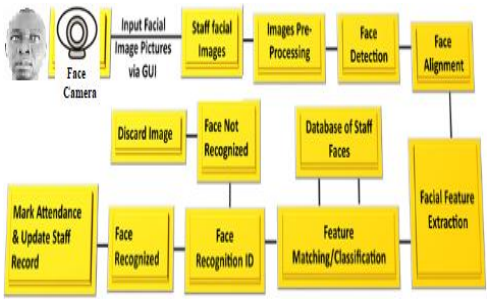


Figure 2: System Architecture Diagram

The architectural design focuses on accuracy, efficiency, and ease of deployment, and employs a multi-layered architecture comprising distinct modules that handle data acquisition, processing, storage, and presentation, as shown. These layers and their functionalities include: Input/Physical Layer- This where several images or videos of individual staff are captured using a camera device, and the captured files uploaded to the server via a web application interface. Processing Layer- This module is where face detection and recognition are performed on the uploaded files to the server using a robust and efficient detection method known as the Viola and Jones algorithm that scans the input staff images or video frames to identify faces with the underly OpenCV, cropping the detected face regions for recognition processing. Data Layer- This module is the centralized database that stores staff profiles and attendance records. Once recognition is successful, the system searches the identified staff in the database and marks their attendance accordingly. This process updates the attendance records in real-time and generates a visual sheet accessible via the web application. Presentation Layer- This module is the web application interface is for real-time viewing, managing, and reporting of staff attendance, and periodic display of updated staff attendance records in real-time and generate a printable summery visual sheet accessible via the web.

B. System Implementation

The system implementation involves machine training and machine testing in achieving this real-time automated facial recognition attendance management system. this is structured into two clear stages to ensure accurate detection and recognition of faces to facilitate reliable attendance marking. The machine training and testing is shown in Figures 3a & 3b respectively, and the process involves data preparation, model training, and validation, as detailed below.

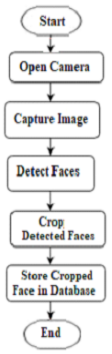


Figure 3a: Flowchart for Face Detection and Machine Training Phase

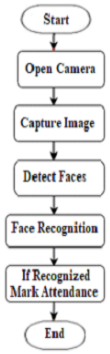


Figure 3b: Flowchart Face Recognition and Attendance Marking Phase

System Training Phase: The data collection for this system begins by capturing multiple images of each individual (staff) using a camera. These images are cropped to remove the background and focus solely on human faces using a face detection algorithm. The cropped facial images are stored in a database, each linked with relevant identifiers (e.g., staff ID or name). This dataset serves as the training data template for face recognition. The images are processed to standardize size, lighting, and orientation to enhance recognition accuracy. The detected faces obtained within the captured images using Viola and Jones algorithm are cropped and saved as training samples, finally these samples are used to build a reference template in the database for subsequent recognition tasks.

System Testing Phase: This is facial recognition phase where new images or videos are uploaded during attendance sessions, and the system performs face detection on these inputs using the same Viola and Jones method. The detected faces are then compared against the trained dataset using correlation techniques. This involves computing similarity scores between detected faces and stored face images, and a high correlation score indicates a match, confirming the identity of the individual.

The system software design integrates multiple modules that facilitate image acquisition, face detection, face recognition, database management, and user interaction via web applications. The design follows a modular architecture, emphasizing algorithms for face detection and recognition, data handling, and system interfacing. The system operational technique involves (i) Data generation for training because the system first trains on a dataset of pre-cropped images of staff faces. These images are saved into a database and processed for detection and recognition, forming the basis for matching during attendance. (ii) Capturing users' images/videos using camera device equipped and upload the image files to the server through a web application interface to enable remote and flexible data collection. (iii) Perform face detection on the uploaded files using the Viola and Jones algorithm, to scan the input images or video frames to identify faces, and crop the detected face regions for further processing. (iv) Perform face recognition by comparing the cropped face images with the trained database entries using a correlation technique. The identities of staff are authenticated in this stage by matching the detected faces against stored profiles. (v) Finally, once recognition is successful, the identity of the staff is searched by the system in the database and the attendance is marked accordingly. This process updates the attendance records in real-time and generates a visual sheet accessible via the web application. Figure 4 showed the detailed diagram of flowchart explanation of this system operation.

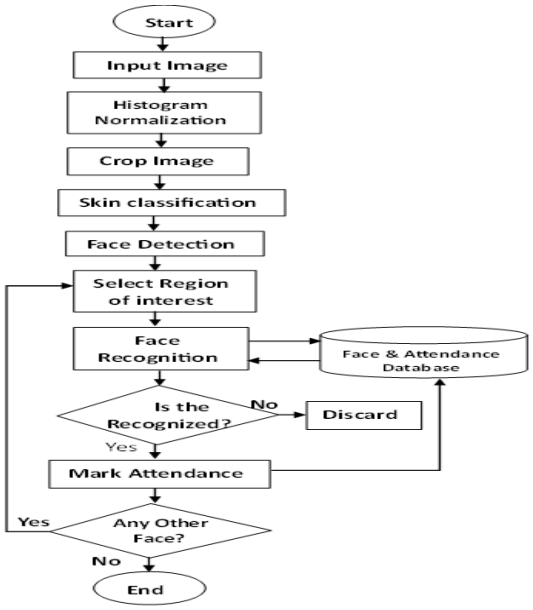


Figure 4: The System Flowchart Diagram

Figure 4 demonstrated the sequential flow of operation of the system image capturing, detection and recognition, which involves image inputting, processing, matching, and attendance marking, ensuring an efficient automated process of face recognition during attendance marking.

C. System Testing

This section discussed some of the various experimental tests conducted during the course of achieving the objective of this research. The experimental test commenced immediately after the images of the university staff beneficiaries were captured into the system by the camera, through the processes known as system trainings phases. The summary of these tests that were carried out after the

system trainings to ascertain this system`s high recognition accuracy is illustrated in Table 1.

Table 1. summary of the system tests and the results

TESTING METHODS	TESTING FACTORS	DEVICE RESPONSE	OUTPUT ACCURACY
Recognition Accuracy	Measured % of correctly identified faces from a set of registered profiles under every condition.	Passes on 5 Images per file of every Staff	95%
		Failures	5%
Processing Time	Assessed the time taken from capturing an image to recognizing the face and marking attendance, ensuring real-time functionality	% Fast (< 2 Seconds)	97%
		%Delay (> 5 Seconds)	3%
Environmental Conditions	% response when tested under different lighting environments (bright, dim, and backlit conditions) to evaluate robustness against lighting variations	Bright,	98%
		Dim, and	75%
		Backlit conditions	25%
Face Orientation and Pose Variation	Evaluated system performance with faces at different angles and poses to determine recognition versatility	Passes	94%
		Failure	6%
Distance from Camera	Varied the distance between the subject and the camera to determine the effective operational range	Lesser distance 2 Meters	100%
		Greater Distance 5 Meters	90%
Number of Registered Faces	Tested scalability by increasing the size of the dataset to assess system performance as the number of profiles grows	% passes on 550 Profiles	95%
False Recognition Rate	Monitored the percentage of incorrect face matches to evaluate system specificity	% failure on 550 Profiles	5%
Unregistered Face Handling	Checked the system's ability to identify non-registered individuals and appropriately reject them	Passed	98%
		Failed	2%
System Stability and Reliability	Conducted prolonged operational testing to verify consistent performance over time without crashes or errors		96%

These parameters in Table 1 collectively provided a comprehensive assessment of the system's accuracy, efficiency, robustness, and scalability in practical scenarios.

IV. RESULTS AND DISCUSSIONS

This section presents both the summary of some of the results of various experiments conducted during the course of achieving the objective of this research and the discussions are based on the interpretations of the results obtained from the test factors. Some of these results and the discussion summary based on the factors tested are shown in Table 2. Also, figure 5 illustrated the graphical representation of the average summery of the successful system response result analysis based on the factors tested

Table 2. Summary of the Results and Discussion

SYSTEM RESPONSES BASED FACTOR TESTED	DISSCUSIONS BASED ON THE RESULTS
Recognition Accuracy	The result showed that the system achieved an overall accuracy of 95%, aligning with the targeted precision, even under varied lighting and pose conditions.
The system response on level of Processing Time	The result showed that the system processed each face recognition and attendance marking within approximately 1-2 seconds, facilitating real-time operation suitable for practical deployment
The system response on Environmental Conditions	The result showed that the system maintained high recognition rates in diverse ambient lighting conditions, confirming the robustness of the underlying algorithms like LBPH and method
The system response on Face Poses Orientation and Variation	The result showed that the system performance is versatile in recognition of faces at different angles and poses
The system response on Distance from Camera	The result showed that the system effective operational distance between the subject and the camera is about 10 meters range
The system response on Number of Registered Faces	The result showed that the system effectively handled datasets with up to 200 profiles without significant degradation in performance, indicating suitability for medium-sized institutions
The system response on False Recognition Rate	The result showed that the system maintained a false acceptance rate below 5%, ensuring dependable identification and minimal incorrect attendance markings
The system response on Unregistered Face Handling	The result showed that correctly identified and rejected unregistered individuals, preventing false attendance entries and ensuring security
The system response on level of System Stability and Reliability	The result showed that operated reliably over extended periods without crashes or errors, confirming stability suitable for daily usage contexts

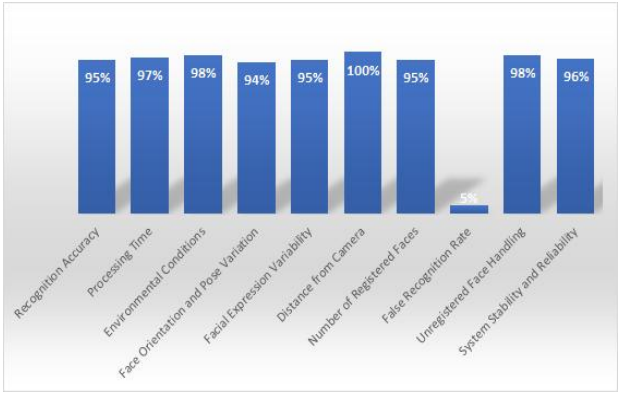


Figure 5: The Average Percentage successful response

Finally, various results obtained showed that the implemented system not only achieved a high recognition accuracy but also demonstrated robustness, speed, and stability, making it a viable solution for real-time automated facial recognition attendance management system for staff of Federal University of Technology Ikot-Abasi.

The comparison between the developed face recognition based real-time automated attendance management system and the manual attendance system is shown in Table 3. Hence, it can be seen

from this table 3 that the average execution time for forty (40) staff is approximately 30.13 seconds for the manual attendance as against 1.78 seconds for the real-time automated facial recognition attendance management system. Figure 6 shows the graphical comparison between the real-time automated facial recognition attendance and manual attendance systems.

Table 3: Tabular comparison between manual and Real-Time Automated Facial Recognition System.

Staff	Manual System	Real-Time Automated Facial Recognition System
1	22.71	1.01
2	12.80	1.03
3	19.61	1.00
4	31.48	1.04
5	12.65	1.05
6	36.34	1.19
7	44.66	1.07
8	25.28	1.05
9	35.13	1.01
10	26.31	1.02
11	24.99	2.03
12	15.26	2.08
13	35.19	2.00
14	26.54	2.00
15	26.58	1.23
16	36.90	2.05
17	36.97	2.14
18	37.65	5.00
19	47.77	2.36
20	57.72	2.07
21	42.75	1.06
22	32.82	1.02
23	29.67	1.01
24	21.45	1.07
25	12.68	1.04
26	26.36	1.18
27	24.64	1.03
28	35.25	1.07
29	25.23	3.05
30	36.32	1.01
31	34.97	2.03
32	25.27	2.08
33	35.20	4.03
34	16.56	2.01
35	26.59	1.25
36	36.93	2.07
37	16.98	2.29
38	47.63	5.00
39	37.79	2.32
40	27.71	2.05

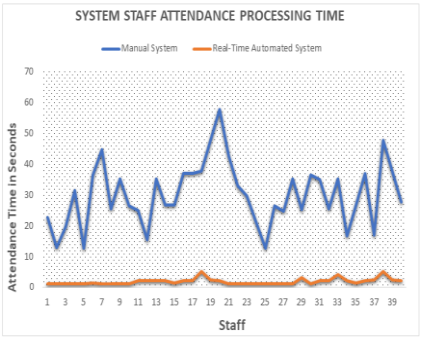


Figure 6: Comparison between the Developed Real-Time Automated Facial Recognition and Manual Attendance Systems

CONCLUSION

The Design and Implementation of a Design and Development of Real-Time Automated Facial Recognition Attendance Management System for Staff of FUTIA which is the aim and objective of this work was successfully implanted. This system provides an effective and more convenient method of taking attendance when compared to the manual method and biometric systems. Data are more organized, the system more friendly, the data manipulation and retrieval are done by an authorized user through the graphical user interface. The face-recognition provides high security performance. The system update notifications provide staff real-time information on the time the time the arrive to the university. This system can also be implemented in any private and public universities in Nigeria and organizations

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REFERENCES

[1] Akshara Jadhav, Akshay Jadhav, Tushar Ladhe, Krishna Yeolekar, 2017. "Automated Attendance System Using Face Recognition" International journal of advanced research in science, engineering and technology.

[2] Amit Dubey, Anjali Dubey, Abhimanyu Kumar Singh, Basanta Mahato, and Priyanshu Singh, (2021). "RFID Based Attendance & Monitoring

System" International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE) Vol 7, Issue 9, ISSN (Online) 2395-2717

[3] Ayush Atul Sathe, (2019). "Face recognition attendance system" international journal of innovative technology and exploring engineering (IJITEE).

[4] Mathana Gopala Krishnan, Balaji, Shyam Babu, (2015). "Implementation of Automated Attendance System Using Face Recognition", International journal of scientific and engineering research

[5] Okorafor G. Nwaji., Nosiri C. Onyebuchi., Opara, F. Kelechi. (2013). "Automatic Door Unit Radio Frequency Identification (RFID) Based Attendance System" Int. J Sci. Emerging Tech Vol-5 No.6.

[6] Omkar Balaji Biradar, and Anurag Shakshank Bhave, (2019). "A Face Recognition-Based Attendance Monitoring System Using Raspberry-Pi and Open-Cv," IJITEE

[7] Ononiwu G. Chiagozie and Okorafor G. Nwaji, (2012). "RADIO FREQUENCY IDENTIFICATION (RFID) BASED ATTENDANCE SYSTEM WITH AUTOMATIC DOOR UNIT" Academic Research International ISSN-L: 2223-9553, ISSN: 2223-9944. Vol. 2, No. 2.

[8] Ritika Andhare, Akanksha Baghele, Ankita Tiwari, Prof. K.D. Yesugade, (2021), "Vision Face Recognition Attendance Monitoring System Using Deep Learning and Computer Vision" International Journal of Scientific Research & Engineering Trends. Volume 7, Issue 3, ISSN (Online): 2395-566X.

[9] Shreya Prabhulkar, Sayali Angre, Akshata Dhale, and Mayuresh Mahale, (2024). "Face Recognition Attendance System for Employees" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056. Volume: 11 Issue: 04 www.irjet.net p-ISSN: 2395-0072

[10] Tippavajhala Sundar Srinivas, Thota Goutham, and Dr. M. Senthil Kumaran, (2022). "Face Recognition based Smart Attendance System Using IoT" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056. Volume: 09 Issue: 03 | Mar 2022 www.irjet.net p-ISSN: 2395-0072