

# IoT – based Automatic Attendance Management System using Middleware

Hafiz Wahab Raza<sup>1</sup>

<sup>1</sup> Malaysian Institute of Information Technology (MIIT), Univerisiti Kuala Lumpur, Malaysia. Email: [hafizwahabraz@gmail.com](mailto:hafizwahabraz@gmail.com).

**Abstract** — The 21st century, where all things are depending upon technology, almost all the human tasks are being done with the help of technology to save a lot of time and make our life much more comfortable. The monitoring of students' attendance is a crucial task for faculty in today's world. There are more chances of errors while entering the students' attendance records in the primary system, primarily when the class was over. The main concern of this study is to build an IoT-based automated attendance management system for educational institutes by biometric recognition to incorporate fake/proxy attendance and errors of entry and to replace old manual methods of taking students' attendance by calling their names or roll numbers. The AAS will click the image of the classroom, and it will automatically detect the faces of students sitting in the lecture room and recognize them during lectures then mark their attendance daily to keep a record of their presence and also maintain and manage it for the management staff of the institution for future by using web services.

**Keywords**—AMS, Face Recognition, AAMS, Face Detector, Python, Monitoring, RFID, Arduino Uno, IoT

## I. INTRODUCTION

In the current era, where all the human tasks are performed by using various technologies. Internet of Things (IoT) is a vast domain where multiple sensor-based devices interact with each other to minimize human efforts and complexity[1][2]. IoT is implemented in various areas such as automation, manufacturing, healthcare, vehicle transportation, education, irrigation, agriculture, traffic management, and many more [3]. There are various applications of IoT in the education sector. One of them is the attendance management system which is used in educational institutions for the monitoring of the student's presence in the lecture as well as their progression in the academic year. Lack of appropriate and suitable AMS it is very difficult to tackle and keep a record of the students' records. In a manual attendance system, there are many cons which are loss of valuable time and energy, paper and proxies, etc. there are two types of attendances that can be taken manually. One is calling the names of the students by the lecturer and the second is giving the piece of paper to the students to fill and sign by their own but the main drawback of this is that students can mark the proxy of the absent students. To overcome these issues and challenges "Automatic Attendance System" is being used. There are various attendance management systems available for this purpose that used multiple techniques to mark the attendance of the students automatically such as Radio Frequency Identification (RFID), a biometric system through fingerprint, Iris scanning, face recognition, etc.

The attendance management system which is using RFID has various components which are an RFID tag, RFID reader, LCD, power supply unit, and Arduino Uno Microcontroller. RFID tag which contains the particulars of

the user encrypted form is read by the RFID reader who decrypts the information and shows it on the LCD. If this record matches with the database record, then verification will be done otherwise no entry will be made. RFID has also some drawbacks like time-consuming by which users have to wait for their turn when there are several users at a moment, fake entry issue is that anyone having an RFID card can mark the attendance without knowing that the person using her RFID using someone else identity[4].

Biometric technology is the evolution in information technology that aims to identify the identification of a person by using the physiological behavior of the user which remains the same and unchanged throughout his/her life. In biometric technology, multiple techniques are used which are: Fingerprint, Iris Recognition, Face Recognition, etc. In an attendance management system using fingerprints the following components are used: fingerprint sensor, Arduino Uno, PC, LCD, Node MCU, and database[5]. The user's thumb or finger is scanned by a fingerprint scanner which is connected with Arduino Uno which identifies the user identity by matching the record from the database that resides on the PC and displaying it using LCD while Node MCU is used to provide connectivity through Wi-Fi [6][7]. In Iris recognition, the user's eye's iris is captured at the time of registration by using image acquisition and iris segmentation then it is saved in the database for the recognition of the user's identity based on pre-set threshold [8].

This paper proposed an automatic attendance system using middleware.

## II. PROPOSED FRAMEWORK

The idea behind this work is to develop an efficient application called "Automatic Attendance System" to avoid the consequences of the manual attendance process where the lecturer has to take the attendance of each student manually and has to maintain the attendance sheets/records that take a lot of time, effort and also includes fake proxies. Now the automatic attendance system makes it easy for the lecturer and students both, the application handles the whole process of attendance by itself, it will automatically mark the attendance of the students present in the classroom using one of the human biometrics identification techniques. There are multiple biometric techniques with which we can identify a person i.e. Iris recognition, Fingerprint identification, Face recognition, RFID, and many other techniques but the technique that is implemented in this system is Face Recognition. This technique is much better than other techniques since it takes zero effort for the users, the users don't need to stand in front of the camera and wait for their identification, and also they don't need to put their thumb on the biometric machine for their identification, All they have to do is to enter in the classroom and sit on their chairs, the rest process will be done by the system automatically. A camera is supposed to be placed on the top center of the frontal wall or at any other location in the room from where the camera can capture the faces of all the students clearly,

The camera will capture an image of the students present in the classroom and the system will detect faces of the students by using the Computer Vision face detection algorithms and other techniques then it will recognize the students by matching their faces with the faces of the students enrolled in the face database and the end it will mark their attendance as “Present” or “Absent”. The database contains almost 300 to 400 pictures of one student in it. Not a single fake proxy will be approved by using this process. The main goal is to help the lecturer by improving the attendance process and moving it from manual to automatically computerized. The objectives of the study are given below: 1. Providing a valuable service to students and lecturers’. 2. Reduce the manual attendance process that includes many errors by providing an automatic attendance system. 3. Providing privacy and security, avoiding fake proxies. 4. Detection and recognition of faces to take attendance. 5. Automated update in database[9].

The proposed application will provide the facility of automatic attendance of lectures and will allow the students to check their daily attendance. It will also provide the facility of marking the attendance manually.

The application consists of the following main components:

Face Detector

The first main component is the Face Detector. Basically, it is a camera application that takes an image of the classroom and then detects the faces of the students that are sitting in the classroom, crops, and stores them in the database or a file. This component uses very strong face detection algorithms like Computer Vision and other techniques[10]

Face Identifier

The second main component is “Face Recognizer”. It's a desktop application that recognizes the students' faces by comparing them with the faces that are enrolled in the face database and mark them as present or absent. [4]

The application can be designed using various programming languages like Java, C#, C++, Python, etc. The language implemented in this study is Python.

III. SYSTEM ARCHITECTURE

Currently, many types of attendance management systems are being used to make a record of students’ attendance in institutions and universities. The basic purpose of taking this record is to cater for the performance of the student for the academic session. Each system must have some basic functional and non – functional requirements like ease of use, scalability, real-time, mobility, security, privacy, availability, cost-effectiveness, and reliability. These requirements can only be fulfilled and managed by IoT and the best IoT solution must support various heterogeneous devices, multiple networks, and applications to provide interoperability, security, scalability, and a user-friendly environment for the end-user and developers[1][7]. We proposed an IoT-based framework that fulfills all the above requirements and has a web application that can be controlled and operated anywhere easily. This framework consists of four layers named as perception layer, transport layer, middleware layer, and application layer as described below.

*Perception Layer:* This layer consists of various objects like sensors, transmitters, actuators, and controllers[11][12]. It defines the environment of the system. In our proposed framework camera, Raspberry Pi 3 with and transmitter are connected to perform their operations as per the requirements. The camera is used to take pictures of the student and Arduino UNO is used to collect the data and send it to the next layer using a transmitter.

*Network Layer:* This layer is used to forward the gathered data from multiple objects to the next layer for storage and operation purposes without any interpretation[13]. The transmission of data is handled by routing and transmitting it to other IoT devices which is the main function of this layer. Data filtering and data aggregation are performed on this layer. Internet gateways, switching, routing, and platform for cloud computing perform their functions using Bluetooth, 3G, Zigbee, LTE, Wi-Fi, etc.[14]

*Middleware Layer:* This layer is used for the storage of data collected from the various objects connected in the system on the perception layer. This layer contains a web server having a database that deals with all the queries generated by the authorized personnel using the web application. It also defines the operating system and the software which are used for the transfer of generated data between IoT devices and applications.

*Application Layer:* Data management and resource discovery are performed on this layer. It also provides interfaces to utilize the hardware resources[15][16]. Mostly in IoT, the transfer of data is performed by various IoT protocols like HTTP, CoAP, MQTT, and HTTPS. The proposed system uses a request/response method using Restful API due to which HTTP and HTTPS are used for the transfer of messages in the system.

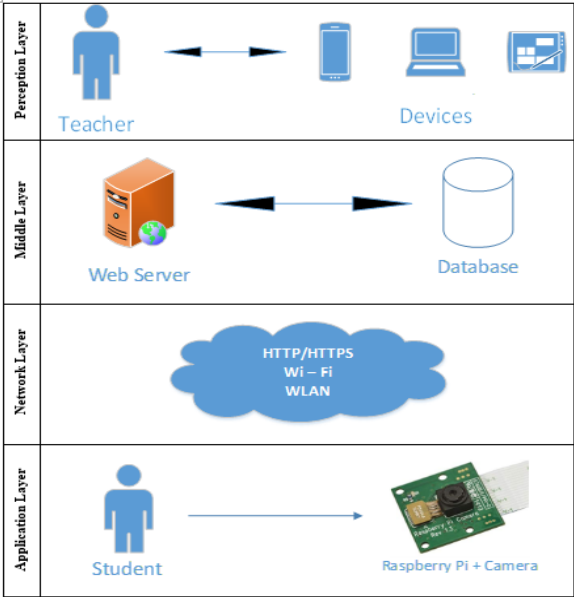
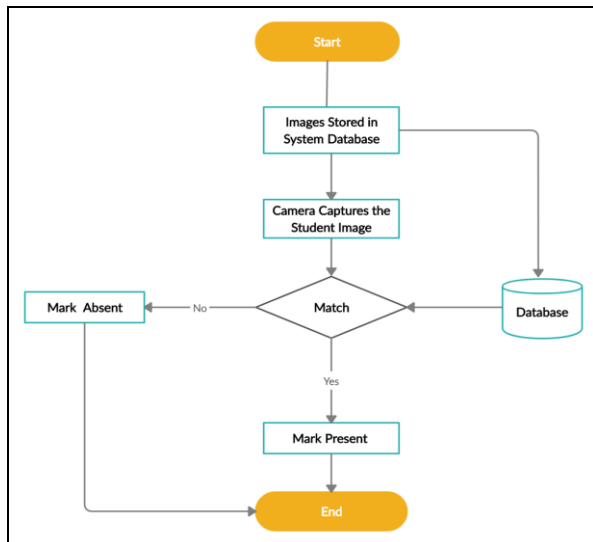


Fig. 1 Proposed Architecture

We catered for the performance of the system and it accepts or rejects users in seconds, after scanning. If it does not do it right then it should be handled to fix errors so our system will perform correctly. There should be a person to look out for the modifications required by the system and any mistake would be corrected quickly. Our system is secure and fully cares about saving students’ privacy that

why we have only allowed the System Admin for logging in to the system with his/her username and password. No one else could use it directly without any permission. We have designed the system easy to understand and simple to deal with for everyone so there is no such hard and fast training needed to use it. Users should take care of the software and system to give it proper maintenance from time to time to have a great and trouble free experience every time.



**Fig. 2 Flowchart of the proposed system**

The proposed system also provides some services which are registration service, Data visualization service, and Data Management.

**Registration Service:** This service is being handled by admin staff for the entry of every person in the system. With this service, the username and the password are created and allocated to the person. By using these credentials, they can access the system for ease of concern.

**Data Visualization:** By using this service every user can view the record which is permitted to view by the admin. Students can only view their attendance record while teachers/faculty staff can also update it by taking the attendance in their respective classes[17].

**Data Management:** The admin is responsible for the management of the data as there are many students and faculty members. So the record of every person is being handled by them and filtered accordingly.

#### IV. TECHNICAL DETAILS

The proposed system uses hardware and software which performs different functions by using tools that enable different techniques. The hardware used in this system is a Camera, Raspberry Pi, and different software. The purpose of using these is as follows.

##### • Raspberry Pi + Camera

It is a small digital camera linked with Raspberry Pi for remotely taking pictures of the students[18]. It arises with software that needs to be installed on the system. It is the main hardware used in this system. It detects and captures the faces of students that will be stored in a database.

##### • Python

Python is a programming language that enables the programmer to write a program. It is a high-level language that's why it is understandable by humans. It is interpreted and executes instructions directly without depending on the previous instructions[19]. We used this language in this system for coding purpose because it is simple and easy to understand, and have an extensive library to perform required tasks.

##### • Open CV

Open CV is a library of programming utilities based on the language C or C++. Open CV aims to visualize images at the time when the process occurs[19]. We are using it to recognize the faces of students at the actual time they entered the class also it requires low RAM and give fast and precise results and is compatible with any device.

##### • NumPy

It is the library that contains all mathematical functions. It supports a multi-dimensional array and performs all the operations based on numeric data[20]. We used it in python to store all the values with the same data type and indexed these values in sequence.

##### • SQLite 3

SQLite is a database engine that is very easy to use

SQLite3 is a library of programming language C that contains all the functions that help to implement a database management system. It is a lightweight database that doesn't necessitate a separate server[21]. So, we used SQLite3 to develop a database of our system where all the student details are stored. The database developed is fast, small, and reliable and managed all the student data, and generates the record of attendance accurately.

##### • PyQt5

It has a broad binding with python having many modules to enable python for being used for application development rather than C language on all supported platforms [22]. It was used to make the GUI of the system. It is very flexible.

#### V. SYSTEM IMPLEMENTATION

Every software system required some kind of functional assistance to let it perform smoothly. We designed our system in a way that it could easily do it on its own. The system captures the face images via a camera and saves them to the database for distinguishing between people.

The architecture of the proposed system contains a different set of modules that performs specific functions. The first module is the instructions set manager in which the camera activates and the system starts to take images then the process of face detection and extraction starts[23]. The system detects and extracts the faces from the class and updates the faces with student data updated into the database and training of data starts. The second module is the face recognizer where the input is recognized and then extracts the recognized input and matched with the trained data. The third and last module is the Attendance update. In this module attendance record is updated. If the data is matched with the trained data system update attendance as Present. If data is not matched attendance update as absent.



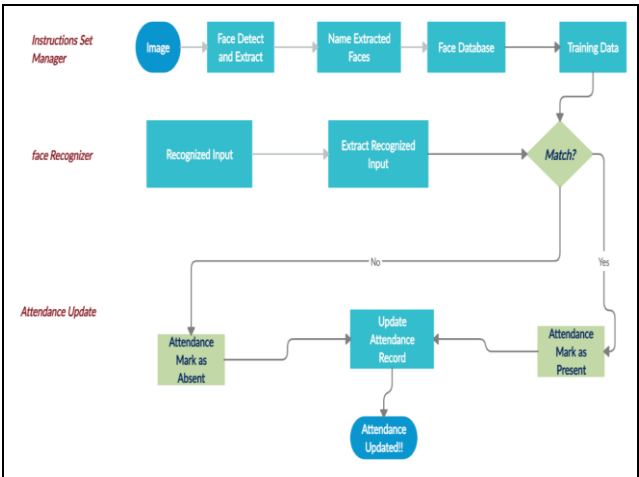


Fig. 3 System Architecture

The system uses a combination of different methods, such as face detection and recognition. Face detection is performed on real-time images without any application domain in mind. The methods utilized in the system are skin-like region segmentation, white balance correction, face image extraction on a face candidate, and facial feature extraction. The system then uses a face classification method where the Open CV library is integrated with the system. The tested system has the smooth and acceptable performance to recognize faces bonded within its limits. The system is also capable of checking and recognizing multiple faces in real-time images.

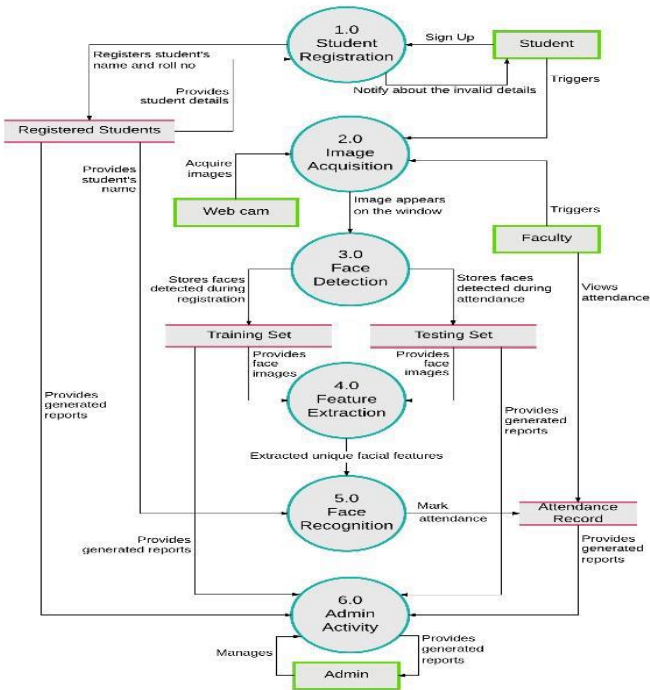


Fig. 4 Data Flow Diagram of the system

The first stage of the system is the registration of the student by his/her name or roll number/registration number which will be unique by signing up a registration form and notified if some information is invalid. The next stages are image acquisition and face detection where the images of the student were taken and stored in the database. In this way, around 300 pictures of each student were taken by the

camera. The time taken by capturing the student's pictures is almost 18 seconds.



Fig. 5 Capturing Student's Image

The next stage is face recognition where the face is being recognized by its unique features. Facial recognition [24] software is a technology that is capable of identifying or verifying an object from an image or a video frame by a video source. There are several methods in which facial recognition systems perform tasks, but in general, these systems work through comparing selected facial identifications from a given image with all images saved within a database. A face recognition system is also known as a Facial Biometric Artificial Intelligence-based software that can uniquely judge a person by analyzing several patterns based on object facial textures and shape.

After the facial recognition of the student's image, the next phase is marking the attendance of the student and update it in the database. This attendance is now available for the admin and faculty staff for their concerns. The required specifications for the system are described below.

Table 1 : System Specifications

CATEGORY	REQUIRED SPECIFICATIONS
Operating System	Windows 7 (SP1), Windows 8, Windows 10
Processor	Intel Core i3-2100 2nd generation
RAM	4GB-8GB
DISK	128GB
Database	My SQL 5.5.2

VI. RESULTS AND FINDINGS

The proposed system was implemented and tested using the developed application on multiple students while sitting in a classroom and checking the accuracy of the system. The results provide two main contributions to the system which are automatic attendance management of the students and comparative analysis of the proposed system with the existing other methods of attendance systems.

Initially, the data set of each student's images were created by taking the pictures of each student in different postures, expressions, and distance. For this purpose, almost 300 pictures of each student were taken, and it took around 18 seconds. All images were saved in RGB colors and the format for these was. JPEG. then after saving the images into the database some other details were entered. Through each student's data set the system will recognize it easily. Then the system starts training the data set. After that, the system was tested by taking input from the camera installed on the frontal wall of the room. It captured images and detected the students' faces and recognized them by comparing the data sets from the database and updating the attendance of the recognized students in the database.

S_NO	S_NAME	S_ID	S_EMAIL	C_CODE	Field6
1 0	Rohan Kumar	BBE-1484	Rohankram...	CS306	NULL
2 1	Kapil Kumar	BBE-1485	kapil.ratnan...	CS306	NULL
3 2	Nadia Shahid	BBE-1445	nadiashahid...	CS306	NULL
4 3	Qurrat	BBE-1510	qurratulain...	CS306	NULL
5 4	Azhaer	BBE-1020	Azharali@g...	CS306	NULL
6 5	Sir Aftab	BB-10200	Aftabahmed...	CS306	NULL
7 6	Junaid	BBE-1002	Junaidali@g...	CS306	NULL
8 7	Yousaf	22	YousafKhan...	CS306	NULL

Fig. 6 Students Record before taking Attendance



Fig. 7 Students detected faces

S_NO	S_NAME	S_ID	S_EMAIL	C_CODE	Field6
1 0	Rohan Kumar	BBE-1484	Rohankram...	CS306	Present
2 1	Kapil Kumar	BBE-1485	kapil.ratnan...	CS306	Present
3 2	Nadia Shahid	BBE-1445	nadiashahid...	CS306	Present
4 3	Qurrat	BBE-1510	qurratulain...	CS306	Present
5 4	Azhaer	BBE-1020	Azharali@g...	CS306	Present
6 5	Sir Aftab	BB-10200	Aftabahmed...	CS306	Present
7 6	Junaid	BBE-1002	Junaidali@g...	CS306	Present
8 7	Yousaf	22	YousafKhan...	CS306	Present

Fig. 8 Students Record after taking Attendance

The obtained results were quite satisfactory as the main objective of the system is to update the attendance of the students by using facial recognition but still, there were some issues faced by the camera due to the low light of the room and the distance of the student from the camera. In this condition, if a student is present and his/her attendance could not be marked as a present then the teacher can also mark the attendance manually on the system by using own ID. The results were accurate, the application recognized and marked the attendance of students in the classroom correctly, but because of the classroom environment (low lighting) issue and the camera quality, the application faced some problems to recognize the students' faces while sitting too far from the camera. This issue can be resolved if the lighting in the classroom would be good and the camera quality would have high resolution. Table 2 shows the comparative analysis of the proposed system with the other kinds of traditional systems having different parameters.

Table 2: Comparative Analysis with Traditional Systems

Parameters	Traditional Systems	IoT - AAS
Human efforts	Needed	No Need
Attendance Time Taken	More than 10 Mins	Less than 4 Mins
Security	Vulnerable	Authentication
Management	Difficult	Easy
Speed	Slow	High
Accuracy	Low	High
Storage	Papers, Files	Database, Cloud

## VII. CONCLUSION

This system provides facilities to the different institute staff to take attendance easily without the need for any hard copy. It saves time and manages all the records of students, it also detects an unknown person. This system provides a camera that is fitted to the classroom wall which can easily recognize the face of every student. It takes the attendance of students automatically when a lecturer will come into the class and at the time of attendance he will log in a system to take attendance by biometrical identification techniques which has a lot of types but in this system, we will use face recognition. In this system, data will be trained by taking approx. 200 pictures of every enrolled student. The data of every student will be saved in the database. After the login of the lecturer, a camera will start recognizing the face of students and mark their attendance automatically. Every lecturer has his login id and has a record of all enrolled students. The system is reliable, secure, and speedy and replaces the conniving and manual structure. It moreover decreases the proportion of work of the association and besides replaces the stationary things.

## REFERENCES

- [1] A. Čolaković and M. Hadžialić, "Internet of Things (IoT): A review of enabling technologies, challenges, and open research issues," *Comput. Networks*, vol. 144, pp. 17–39, 2018, DOI:

- 10.1016/j.comnet.2018.07.017.
- [2] M. A. Kamal, M. K. Kamal, M. Alam, and M. M. Su'ud, "Context-Aware Perspective Analysis working of RFID Anti-Collision Protocols," *J. Indep. Stud. Res. - Comput.*, vol. 2, no. 16, pp. 19–32, 2018, DOI: 10.31645/jisrc/(2018).16.2.02.
  - [3] M. A. Razzaque, M. Milojevic-Jevric, A. Palade, and S. Cla, "Middleware for internet of things: A survey," *IEEE Internet Things J.*, vol. 3, no. 1, pp. 70–95, 2016, DOI: 10.1109/JIOT.2015.2498900.
  - [4] S. N. Shah and A. Abuzneid, "IoT Based Smart Attendance System (SAS) Using RFID," *2019 IEEE Long Isl. Syst. Appl. Technol. Conf. LISAT 2019*, pp. 1–6, 2019, DOI: 10.1109/LISAT.2019.8817339.
  - [5] M. A. Kamal, M. M. Alam, H. Khawar, and M. S. Mazliham, "Play and Learn Case Study on Learning Abilities through Effective Computing in Games," *MACS 2019 - 13th Int. Conf. Math. Actuar. Sci. Comput. Sci. Stat. Proc.*, pp. 1–6, 2019, DOI: 10.1109/MACS48846.2019.9024771.
  - [6] Yu Maw Win | Saw Aung Nyein Oo, "Wireless Student Attendance System using Fingerprint Sensor," *Int. J. Trend Sci. Res. Dev.*, vol. 3, no. 3, pp. 1664–1668, 2019, DOI: <https://doi.org/10.31142/ijtsrd25157>.
  - [7] H. W. Raza, M. A. Kamal, M. Alam, and M. S. M. Su'ud, "A Review Of Middleware Platforms In Internet Of Things: A Non – Functional Requirements Approach," *J. Indep. Stud. Res. Comput.*, 2020, DOI: 10.31645/18.
  - [8] K. O. Okokpujie, E. Noma-Osaghae, O. J. Okesola, S. N. John, and O. Robert, "Design and Implementation of a Student Attendance System Using Iris Biometric Recognition," *Proc. - 2017 Int. Conf. Comput. Sci. Comput. Intell. CSCI 2017*, pp. 563–567, 2018, DOI: 10.1109/CSCI.2017.96.
  - [9] M. A. Kamal, M. M. Alam, A. Bakar, and M. Mohd, "Impact of LoRA and 5G on Smart Manufacturing from Automation Perspective," vol. 18, pp. 1355–1378, 2022, DOI: 10.13052/jmm1550-4646.1852.
  - [10] "Real Time Face Recognition Using OpenCV and MATLAB."
  - [11] T. Aziz and E. Haq, "Security Challenges Facing IoT Layers and its Protective Measures," *Int. J. Comput. Appl.*, vol. 179, no. 27, pp. 31–35, 2018, DOI: 10.5120/ijca2018916607.
  - [12] M. A. Kamal, H. W. Raza, M. M. Alam, and M. Mohd, "Highlight the Features of AWS, GCP and Microsoft Azure that Have an Impact when Choosing a Cloud Service Provider," *Int. J. Recent Technol. Eng.*, vol. 8, no. 5, pp. 4124–4232, 2020, doi: 10.35940/ijrte.d8573.018520.
  - [13] M. A. Kamal, M. M. Alam, and M. S. Mazliham, "Routers Perspective Simulation-Based Analysis of EIGRP and OSPF Routing Protocol for an Organizational Model," *Int. J. Innov. Technol. Explor. Eng.*, vol. 9, no. 4, pp. 2013–2019, 2020, DOI: 10.35940/ijitee.b6509.029420.
  - [14] S. N. Swamy, D. Jadhav, and N. Kulkarni, "Security threats in the application layer in IoT applications," *Proc. Int. Conf. IoT Soc. Mobile, Anal. Cloud, I-SMAC 2017*, pp. 477–480, 2017, DOI: 10.1109/I-SMAC.2017.8058395.
  - [15] X. Sun and N. Ansari, "Dynamic Resource Caching in the IoT Application Layer for Smart Cities," *IEEE Internet Things J.*, vol. 5, no. 2, pp. 606–613, 2018, DOI: 10.1109/JIOT.2017.2764418.
  - [16] M. A. Kamal, H. W. Raza, M. M. Alam, M. M. Su'ud, and A. B. A. B. Sajak, "Resource allocation schemes for 5G network: A systematic review," *Sensors*, vol. 21, no. 19, 2021, DOI: 10.3390/s21196588.
  - [17] A. Waqar, S. K. Hamid, and M. A. Kamal, "Madadgar ( Anti theft-SOS ) Android App," vol. 9, no. 2, pp. 119–135, 2021.
  - [18] P. Pasumarti and P. P. Sekhar, "Classroom Attendance Using Face Detection and Raspberry-Pi," *Int. Res. J. Eng. Technol.*, vol. 5, no. 1, pp. 167–171, 2018.
  - [19] K. Yamini, S. M. Kumar, S. Sonia, P. V. Yugandhar, and T. Bharath, "Class Attendance Using Face Detection and Recognition with OPENCV," pp. 3822–3826, 2019.
  - [20] S. Van Der Walt, S. C. Colbert, and G. Varoquaux, "The NumPy array: A structure for efficient numerical computation," *Comput. Sci. Eng.*, 2011, DOI: 10.1109/MCSE.2011.37.
  - [21] "sqlite3 — DB-API 2."
  - [22] Riverbank Computing Limited, "PyQt5 · PyPI," *Python Software Foundation*. 2019.
  - [23] M. A. Kamal, M. Shahid, and H. Khawar, "The Mathematical Model for searching the Shortest Route for TB Patients with the help of Dijkstra's Algorithm," *Sukkur IBA J. Comput. Math. Sci.*, vol. 5, no. 2, pp. 41–48, 2021, DOI: 10.30537/sjcms.v5i2.772.
  - [24] F. Application and P. Data, "( 12 ) United States Patent," vol. 2, no. 12, 2008.