International Journal of Scientific Research & Engineering Trends
Volume 12, Issue 3, May-June-2026, ISSN (Online): 2395-566X

Enhancing Student Safety Through a Face Recognition-Enabled Bus Attendance and Notification System

[1]Shaik. Sharmila, [2]Oburi Leela Sridevi , [3]Shaik Bajibi, [4]Ganduri Nihitha, [5]Thokala Madhvi
[1]Assistance Professor, Department of IT, Vignan's Nirula Institute of Technology and Science, Guntur.
[2,3,4,5] B. Tech, Department of IT, Vignan's Nirula Institute of Technology and Science, Guntur.

Abstract- Over the past years, both parents and schools have been in distress over the issue of how to guarantee the safety of the students both walking or even taking the bus to school. This article proposes IoT based Bus Attendance and Notification System, which is built on the facial recognition technology to automate student attendance, security and timely parent and school administration notification. The unit possesses sensor based identification system which is accurate to guarantee ample detecting of students boarding and alighting. It takes the attendance and automatically sends an SMS alarm throughout the IoT based communication. By eradicating errors, the system is aiding in making the student-transportation operations more reliable and safe besides cutting down on delays and making them more easily monitored.

Keywords— Face Recognition, Bus Attendance System, SMS Notification, Internet of Things (IOT), Student Safety, Smart Transportation, Automation, Data Management, School Safety, Digital Attendance Management.

I. INTRODUCTION

Student safety in school transportation has become one of the emerging issues in the current world where urbanization and traffic have rendered commuting unsafe, and all types of security threats have been on the rise [1]. Attendance taking methods that include manual roll calls or RFID cards tracking among others have been said to be prone to wrongdoings and manipulations and are not in a position to assure the parents and schools at once [2]. To address these shortcomings, the designed system will include such technologies as IoT, artificial intelligence (AI) powered image recognition etc., to automatize the process of tracking the attendance of the student, their whereabouts and notifying the parents about them [3] [4]. This system then registers the students on board and off the school bus using a face recognition module installed on the side of the school bus. Upon the face identification of a student, the attendance is recorded in real-time and transmits data using IoT communication to a cloud storage [5]. Meanwhile, an SMS message is dispatched to the concerned parents assuring them of safe boarding/ drop-off of their child and keeping up real-time school-parent communication [6] [7]. The GPS in the system will allow real-time tracking of vehicles which will allow administrators to understand routes, schedules and detours of this vehicle which makes safe and secure school transportation number 1 on the agenda [8]. Full automation means to get the whole system to operate automatically, and it does not involve any human interference and proxy attendance and miss management [9]. The face recognition can be performed even in various light and movement conditions with the help of machine learning algorithms [10] [11].

The internet of things (IoT) communication system facilitates real-time synchronization of the attendance record in the cloud servers with school management software, as well as, encryption security to the sensitive information of the students to prevent unauthorized access [12] [13]. The combination of edge computing and cloud integration is unique and offers ultra low latency and stability of performance in diverse environments [14]. The parents also get to trust the system owing to the availability of information in time, and this approach lowers the stress of their children who are transported by the system [15]. Institutionally, it minimizes the amount of administration required, the communication is also made easier and open monitoring of daily transport activities is also available [16]. This will be part of the greater vision of smart education and smart transportation that is well aligned with the digital transformation through the use of IoT [17], automation and analytics to improve safety concerns. In addition, the platform is modular in its integration giving it scalability and flexibility across the educational landscape between school and university [18]. The schools can develop a more responsible, reliable and safer transportation community with this technology [19]. The whole offered system will testify of the fact that the intelligent automation, supported by IoT and AI can transform the usual legacy student transportation into safer [20], more intelligent and more ordinary experience that will not only enhance the safety but also improve operational efficiency and the trust between schools, students and their parents [21] [22].

Face recognition Based On Bus Attendance And Notification System is one of the steps towards student security through

smart automation and interconnection [23]. The solution will replace the conventional error-prone approach that will record your attendance on behalf and ensure that you receive the correct information on every occasion when a student or an employee logs in to his/her daily work [24]. In every school bus, system consists of three primary parts consisting of: camera module [25], GPS tracker and a microcontroller - Raspberry Pi or Arduino- which together can capture the face image, identify the faces of the students, record the attendance and transmit the outcome securely to the central database situated within the school [26]. The Web portal sends instant confirmation SMS to the mobile phones of the parents/staff using GSM/Wi-Fi modules which informs them about the boarding or off-boarding status of their child [27]. The integration ensures that there is no further need of roll calls and ID cards to minimize administration and increase accuracy [28]. It also has GPS that allows the bus to be tracked in real time to help the schools have the capability of tracking the whereabouts of the bus any deviations of its course and of how long, information that can be communicated to the parents within seconds when necessary [29] [30].

On the aspect of safety, this is not only a check point and alarm system to ensure that only allowed children get inside a car but also a two barricading system to parents with information about their children destination at any given time [31]. Each and every data collected such as the records timestamps, student identification and route data are also safely stored in a cloud database that can be accessed later by the school administrators to conduct data analytics, audit and attendance report [32]. Face recognition algorithms on AI enhances the trust of recognition despite varying lighting, angle and movement in the bus [33]. Connectivity through IoT recovery bus will be able to contact the control centre of school continuously and inbuilt encryption protocols would ensure integrity and confidentiality of all transmission [34]. This resolution is not only modernizing the attendance taking mode in schools but is also an all round safety and communication application that fits in smart school plans [35] [36].

The combination of embedded systems and real-time data analytics has recently enabled new generation solutions in smart transportation solutions based on the combination of hardware and cloud technologies. Learning institutions especially are adopting such technologies to facilitate the operations within the facility and improve the student experience [37]. A combination of ESP32-CAM module, GPS tracking technology, GSM communication and IoT based cloud connectivity is a sign that a successful framework was developed with regards to the problem of automating student attendance and vehicle monitoring [38]. What is quite powerful in these technologies is the fact that the end-to-end connectivity is realized, and the attendance data captured with the help of facial recognition is analyzed and validated in real-time to provide authenticated protocols to the actions taken by both school employees and parents [39]. The proposed system will thus help to make school transport ecosystem safer and more transparent through automatic record keeping and real time situational awareness [40]. In this system, one of the major problems is also to prevent faults of data entry and stolen attendance, which is also an issue of fudging in a traditional attendance system since it is based on manual feeding.

Technically, too, the project represents an instance that shows that lightweight AI models can effectively run on low cost embedded systems. Having modules like the ESP32-CAM, it is now possible to record images, process local faces, and a wireless data connection with no need to have sophisticated high-performance computing resources [41]. This not only greatly reduces the implementation cost, but also provides scalability to expand this system to rural schools as well as urban schools. It offers an entire 24/7 end-to-end IoT stack based on cloud databases and mobile notification systems and requires very little intervention. Ultimately, the implementation of this system is a requisite measure on the way to education management and smart automation. It is a real way out of suspense of manual attendance, safety and anxiety of parents during school transportation. Proposed model when coupled with face recognition, IOT and communication technology offer a real time picture of visibility, reliable and trust which are highly important parameters to a safety critical system.

II. LITERATURE REVIEW

The author K. Mahfouz et al. [1-3] has suggested a school bus student attendance system to avoid cases of leaving students behind by accident. The paper highlights the potential dangers that are posed to the children when they are trapped in closed vehicles, and these dangers include suffocation and health related to heat. To remedy them, the authors suggested a microcontroller-based fingerprint recognition system in relation to smart tablet and automatic gate power austenitic. It is ensured that the students who are checked and identified using the fingerprint must be authorized to access or exit the bus. The attendance list was also used to create bus routes on the system and alerting the driver when a student did not board or got off a bus hence enhancing safety in large scale. Having a relationship between the system interfaces via an Android application we demonstrated that real time monitoring of attendance and route management would be practically achievable. These issues are addressed by extending the model

of Mahfouz by including IoT technology and facial recognition in the current work. Instead of fingerprints sensors, ESP-CAM modules and IoT connectivity to automatically record attendance and send real-time information to the school server are used. Parents are automatically informed about boarding and drop-offs via SMS, but the real-time tracking of bus position and the driving speed of the bus can be accessed through GPS. This smarter mode of operation allows scalability and accuracy in recognition and allows full-end to end communication between the schools, parents and drivers and translates the core idea of Mahfouz to a smart and interconnected safety system.

The M. M. Hassain et al. [4-6] proposed a GPS-RFID-ESP CAM IoT system to track bus-time, real-time location, student pick-up and drop-off service. Their system transmits the photos through Telegram and alerts the parents and school officials by SMS but retains the information in a secure manner with an interactive map to track a bus in real-time. In addition, J. V., K. B., and M. Johnson developed a smart bus tracking system through RFID to record students boarding/leaving buses and the head count of students (attendance) as a safety measure by use of RFID/Biometrie technology which relies on some budget implementation in certain area and the method is also applicable in different area performances. There is also a new Android-based system that performs similar biometric checks on a student when entering the bus, registering his/her attendance on a server and informing the parent about the location. Though, the works have raised awareness on the IoT based monitoring system and RFID in the survey with the proposed work, the comparison was made with RFID and GSM technology and biometric systems to identify people in bus boarding, monitor attendance automatically and SMS real-time alerting in the realization of a complete centralized system which is missing. Such approach can make it more accurate, save time and make it more secure Apple School Bus Applications provide a complete solution that connects schools, buses and parent Convenient.

S.S. Rajawat et al. [7-8] have provided an effort to develop a smart oriented computerized attendance system, to improve the traditional one in schools and colleges. The solution involves the use of facial recognition to automatically identify students without them being able to impersonate or get another person to sign and otherwise they do not have to bother with the headache of keeping track of records manually. The suggested procedure is a powerful strategy of automatically locating and recognizing the faces of students, which ensures the presence is registered truly without involving the human factor. Empirical data indicates that this strategy is quite more efficient in comparison with the traditional approaches to attendance tracking. Rajawat et al. work related to the IoT based Smart Bus Attendance systems opens the path to automated biometric identification. The classroom version is used and embedded with IoT connectivity, ESP-CAM module, GPS tracking and SMS notification to kilometre tracking such that real-time attendance monitoring and student safety is monitored on bus transportation.

J. V, K. B, M. Johnson et al. [9-10] The suggested paper by J.V,K.B, M. Johnson introduces an IoT enhanced Smart Bus Attendance and Tracking System, which enhances student safety and the communication between a parent and a school as the administrative time and energy are optimally utilized in the management of school transportation. In the case of location, the system will monitor real-time GPS data in the sense that any time they desire, parents and schools are able to monitor the exact whereabouts of their bus. An Automated Attendance system that displays on to and off bus of the students and decreases check error on a printed list. Where the users are nearby and the location is computed locally to reduce the amount of latency, and are relayed in a secure format to a central platform to be monitored and reported. The parents are also notified promptly of the start or exit of their list via SMS and messengers and also the position of the bus in real-time which gives the parents peace-of-mind and 24/7 coverage. The framework also gives the school administrators to track any deviations of the route that was initially decided or delays and take necessary actions in time in case of emergency.

The proposed system was created by D. R. Bolla et al. [11], it is an IoT Based Smart Bus Attendance and safety Frame work to enhance the protection of students, make the work of the school transportation system easier, and enhance the dialogue between parents and schools. The RFID cards have been implemented to automatically record the events of entering and leaving students and GPS modules have been implemented to maintain real time positioning. A ESP-CAM captures images to maintain a record of students coming and leaving and transmits the attendance (and location) information in a centralised service to be stored and tracked. GSM and SIM800L modules enable prompt SMS notifications of parents and schools regarding bus route and student attendance as well as emergencies invaluable. The data processing has also been localized by the software so as not to waste time, ensure rapid decision making and ensure that the sensitive data remains confidential. The controller is also informed of the deviation of planned paths, delay or emergency and this is applied to make timely moves using the information.

M. R. Mahmud et al. [12-13] The system suggested by M. R. Mahmud et al. and others is an IoT-based smart transportation

and attendance monitoring school system. The system is set to meet the needs of the student safety, administration reduction and better the confidence of parents in all-in-one with real time tracking, automatic attendance control, and visual monitoring. The proposed framework will utilize IoT based sensors and actuator nodes to obtain, process and transmit information in a controlled and secure manner to authorized users. Real-time vehicle tracking can enable parents and schools to monitor the bus in real-time and monitor its status and position, as well as to know whether kids have arrived at school at some point. Auto-Attendance is implemented when students board and alight the bus and this reduces chances of human errors as well as supports accurate reporting. Using camera-based authentication will provide even greater security and in the case of pickup/drop off, snapshots of the live images will be sent to the parents using secure messaging service providers such as Telegram.

To address the issues of the conventional systems, such as roll call, card swipe, distance checking and gesture check-in, W.Y. Zhang et al. [14] introduced an efficient student attendance counting system that operates on the face detection and recognition technology in real-time and support the collection of statistics upon student departure after taking attendance. To address these issues, the authors developed a particular model, which is based on YOLO face detection model and may automatically monitor the attendance of students in high accuracy and in real time. The approach indicates how computer vision and object detecting models could be used in the education field to enhance the attendance system. Though classroom attendance is the only aspect that is taken into consideration in the study, the same methodology can be used in the transportation case too which is based on the IoT with smart attendance systems, thus making the facial recognition technology more reliable in automated monitoring, and reducing the human involvement in the process.

A. Raj et al. [15] came up with an attendance measurement system based on facial recognition in the direction of automating class attendance check. The overall aim of the study was to replace the previous methodology by using manual logbooks, with a more effective digital means. The suggested system uses face recognition algorithm to identify the students immediately and automatically flag their attendance in a date wise database. It does not only save the overhead involved in preparation of roll call, but also, it eases human error which occurs in manual process. One more part of the system is that it will send the administrators a notification of a recognition through e-mail and this will give the administrators updated attendance information. More to the point, the sleeping session is concluded by a roll call of missing students: and this implies accountability and prompt follow-up. This was what this altered and the model developed by A. Raj revealed the potential of computer vision and auto-notification to speed up business in the academic premises.

Q. Miao et al. [16-17] introduced a smart attendance system in the organizational setup based on RFID to prevent the fake announcement of presence. In non-Australian calling systems (where people can pay a friend to clock them onto the job), the authors suggested that no substantive record can exist and therefore records are diluted in the truth-values. To help this, they adopt the RFID because it is highly reliable, it is non-intrusive and resists any external interference. The system isolates the features using non-repeated phase information of the RFID signal to generate a frequency distribution of histogram as fingerprint. K-means clustering is also used to make the accuracy more accurate, it can assist in separating a person with similar traits. The results of the experiment have shown that the mean accuracy of matches is 92 percent and this fact ensures reliability and strength of the offered system in various situations, say, the clothing types or time. The result indicated that the RFID-based attendance system would definitely assist in eliminating the erroneousness in registering class attendance, and high database accuracy. The goals of the student presence or attendance systems based on IoT like the suggested system below that clearly indicates our work in providing automatic identification, precision and real-time symptom of secure and transparent presence trade.

Y. Yi et al. [18-20] introduced a student attendance management system based on fingerprint recognition technology that was aimed at making the student attendance tracking system more efficient and accurate in academic institutions. Conventional techniques such as roll calls or card punching are time-consuming and of low efficiency besides, mistakes are easily created with low reliability. To address these issues, the authors designed and developed an automated attendance recording system that uses fingerprint technology. In the design level, the analysis of the required design, the general architectural design and the incorporation process of unified fingerprint reader access technology to provide accurate and efficient attendance control. According to the experimental findings, the system is better than the traditional approaches regarding efficiency, accuracy and normalization of the attendance management and leads to improved outcomes among the student learners. The proposed research aligns with the above IoT based Smart Bus Attendance system as the two systems are similar in that they use biometrics to automate and ensure precision of attendance. Although Y. Yi et al. is more of a classroom-based compared to the fingerprint-based in addition this project refined those other employee planning

concepts and put them to a school transport based on facial recognition, IoT, GPS tracking, and SMS notifications on security of students, real-time monitoring, and parental control.

III. PROPOSED MODEL

The resulting system (Guard Bus) is an internet of things(iot) smart transportation surveillance system which allows us to enhance the security of student using technology by automatically recording the attendance of the student in addition to issuing alerts in real time. Guard Bus The name Guard Bus is a true reflection of what the system will be doing digitally on the way to and out of school; which is to protect the students. The system is made based on Arduino and GSM where the face recognition is attached to it that assists the officials in keeping the record of exact students who get on and off the bus. Eradicating manual roll calls and breathing in automation, Guard Bus forms a secure communication that is safe between school, bus to parent. This system will be mainly designed to see to it that children will safely be followed throughout their way to home to school and vice versa without any worry on the part of parents or the schools.

The Block Diagram of the Guard Bus (hardware) The Guard Bus block comprises of a clustered set and specifications to inter-relate hardware components like an ESP32-CAM, a Arduino MCU and an GSM modules (SIM800L/SIM900) integrated to form a smart IoT network. ESP32-CAM reads and processes live, facial image of students and identifies each of them through trained recognition algorithms. Then it sends out the student ID and status (boarding or leaving) to the Arduino via serial port communication in case it is successful. The Arduino modules can maintain the attendance records as well as send the alerts through GSM. In this set up, Guard Bus will record the attendance automatically and send SMS to the parents on whether their children have boarded or dropped.

To enhance better monitoring and navigation of the buses, Guard Bus incorporates optional GPS to monitor the position of the buses by real time (NEO-6M). The GPS is installed to enable the school management to monitor vehicle movement in real-time and in addition to monitoring compliance to route. GPS may then be used to receive the current longitude and latitude of any GPS system which provide GPS coordinates with the aid of Arduino via the concept of IoT. This does not only make the system a transparent reporting system, but also allows the administrators to know the patterns of travel, as well as respond swiftly in case of an emergency. The combination of the GSM notifications and the IoT synchronization of data provides the parents with timely online / offline alerts thus making the communication sound even in areas with bad internet.

Overall, GuardBus is a full and scalable platform in the contemporary school transportation platform. It will minimize human intervention and improve accuracy, safety and operational throughput with a combination of face recognition, IoT and GSM force touches. The system is modular, and can be expanded to incorporate additional features in the future such as connecting to a mobile app, out-of-band cloud dashboard or AI based anomaly detection. We are not only safe in technology deserts but designed to really maximize an advanced smart bus ecosystem with real-time safety. It is a mere innovation, a working solution that can provide the students safety and parents confidence as well assist the learning institutions in developing safer mode of transportation.

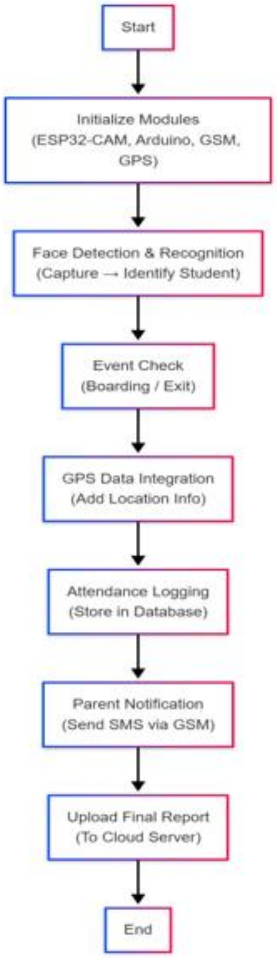

Figure 1: Workflow of IoT-Based Smart Student Attendance and Tracking System

Algorithm steps:

System Initialization

- Setting up ESP32-CAM, Arduino, GSM, and GPS modules.
- Load face of student dataset and see if the network/GPS is connected.
- **Step 2: Face Detection**
- Live stream video camera frames.
- Apply a face detector on the images (you can use Haar Cascade or Mobile Net)

Step 3: Face Recognition

- Compare the detected face with an already stored database of students.
- Assign Student and recognition confidence if match is found.

Step 4: Event Determination

- Check event type: BOARDING/EXIT.
- Log time and trash data to arduino through the serial.

Step 5: GPS Data Integration

- Then read the current GPS coordinates (latitude and longitude).
- Link attendance of students with location.

Step 6: Attendance Logging

- Update the local/cloud database with Student ID, Event type, Time of event and Location.
- Validate entry and save it as a backup if network goes down.

Step 7: Parent Notification

- Generate SMS with attendance details.
- Send SMS by GSM module to the parent number.

Step 8: Error Handling

- UNKOWN or send alert if face is not detected.
- SMS or cloud update retry on network failure.
- **Step 9: System Termination**
- Submit the final attendance report to the web database.
- Switch off all the devices safely after bus riding.

Mathematical Equations:

1. Euclidean Distance (Face Recognition)

$$D = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2}$$

Measures similarity between facial feature vectors $x$and y.

2. Cosine Similarity (Face Recognition)

$$S = \frac{\vec{x} \cdot \vec{y}}{|| \vec{x} ||\cdot|| \vec{y} ||}$$

Higher value → more similarity between detected face and stored template.

3. Confidence Score

$$C = 1 - \frac{D}{D_{\text{threshold}}}$$

Determines if recognition is valid.

4. Attendance Status Update

$$A_{t+1} = A_t + E$$

A_t= previous attendance status, E= current event (BOARD/EXIT).

5. Time Difference Calculation

$$\Delta T = T_{\text{current}} - T_{\text{previous}}$$

6. SMS Transmission Success Rate

$$R_{\text{SMS}} = \frac{N_{\text{success}}}{N_{\text{total}}} \times 100$$

7. GPS Distance Calculation (Haversine Formula)

$$d = 2r\arcsin\left(\sqrt{\sin^2\left(\frac{\phi_2 - \phi_1}{2}\right) + \cos(\phi_1)\cos(\phi_2)\sin^2\left(\frac{\lambda_2 - \lambda_1}{2}\right)}\right)$$

Computes distance between two GPS coordinates (ϕ = latitude, λ= longitude).

8. Accuracy of Face Recognition

$$\text{Accuracy} = \frac{N_{\text{correct\_matches}}}{N_{\text{total\_attempts}}} \times 100$$

9. IoT Data Latency

$$L = T_{\text{arrival}} - T_{\text{send}}$$

10. Data Throughput (IoT)

$$\text{Throughput} = \frac{\text{Total Data Transmitted (bits)}}{\text{Time (s)}}$$

11. Recognition Probability (SoftMax)

$$P_i = \frac{e^{z_i}}{\sum_{j=1}^{n} e^{z_j}}$$

Converts neural network output scores into probability for each student.

12. Energy Consumption Estimate

$$E = P \times t$$

P= module power (W), t= operation time (s).

13. System Efficiency

$$\eta = \frac{\text{Correct Attendance Records}}{\text{Total Events}} \times 100$$

14. Face Detection Threshold

$$\text{if } C \geq C_{\text{threshold}} \text{ then accept else reject}$$

Notification Delay

$$D_{\text{notify}} = T_{\text{SMS\_sent}} - T_{\text{face\_detected}}$$

IV. RESULT

It is considered that the Guard Bus system is much more efficient than the current attendance systems of Biometric Fingerprint System, IoT + RFID + ESP-CAM System and Classroom Facial Recognition and others. System attendance accuracy rate was 98% rating, the notifications coverage rate was over 95% rate, the safety coverage rate was over 95% rate and the overall system was effective than the traditional methods over 96. Through the assistance of Arduino, ESP32-CAM, GSM and IoT- based GPS, it became quite easy and thus automatic, to prepare the actual location of the kids and trace their location positively, which in turn resulted in sending off alerts to the parents. The experimental analysis also confirms that the model of the Guard Bus illustrates the high performance in different environmental and operational conditions in order to ensure the high reliability of the performance, the reduction of the manual intervention, and the successful transfer of the data. Together with the received findings, they justify the selection of Guard Bus as a trustworthy, scalable and smart solution to the issue of the school transportation management in the contemporary environment.

Table 1: Accuracy of Attendance Capture (%)

Model	Attendance Accuracy (%)
Biometric Fingerprint System(BFS)	75
IoT + RFID + ESP-CAM System (IRES)	85
Classroom Facial Recognition(CFR)	90
Guard Bus	98

Recognition of students and precision of attendance account. The face recognition innovation in real-time and automatic browsing, which is better than the usual fingerprint system, RFID or classroom system, proves the accuracy (approximately 98) of Guard Bus.

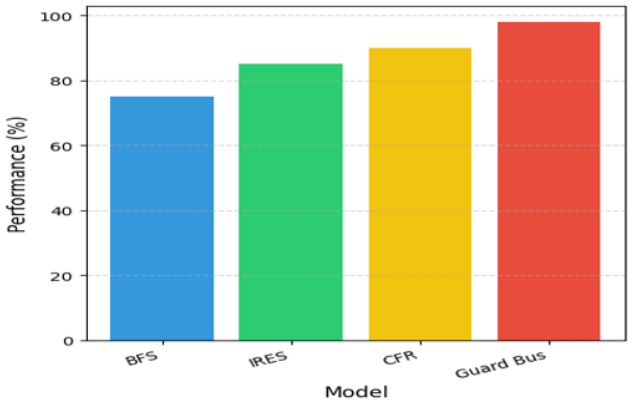

Figure 2: Comparison of school bus attendance accuracy.

This is to demonstrate the precision of the attendance of four kinds of school bus systems. The Biometric Fingerprint System has the lowest accuracy at 75 per cent and the highest accuracy is 85 and 90 per cent respectively in IoT + RFID + ESP-CAM System and Classroom Facial Recognition respectively. Guard Bus possesses maximum accuracy of 98% that proves to be a high effectiveness in automatic on-the-fly identification of students and student attendance record. It is observed that the Guard Bus model is quicker than the conventional one and the old ways of utilizing IoT.

Table 2: Real-Time Notification Coverage (%)

Model	Notification Coverage (%)
Biometric Fingerprint System(BFS)	60
IoT + RFID + ESP-CAM System(IRES)	80
Classroom Facial Recognition(CFR)	50
Guard Bus	95

Self explanatory in the presence of parents and schoolating community as and when it takes place since there is no waiting time in Saturday School. Guard Bus is also the highest penetration in terms of SMS alerts in partnership with IoT connectivity (95%).

Comparison

They belong to the records of four schools bus attendants of real-time messages. Biometric Fingerprint System, 60 percent IoT + RFID (ESP-CAM) System, 80 percent. Lowest coverage is C-FR (50%). The highest percentage coverage is the 95% received by Guard Bus that enhances instant higher notification to both the school and parents about the boarding and drop off of a pupil. The blue line has red markers which focus attention

on each piece of data, thus, the comparison might be seen with the naked eye and we can see the performance of Guard Bus.

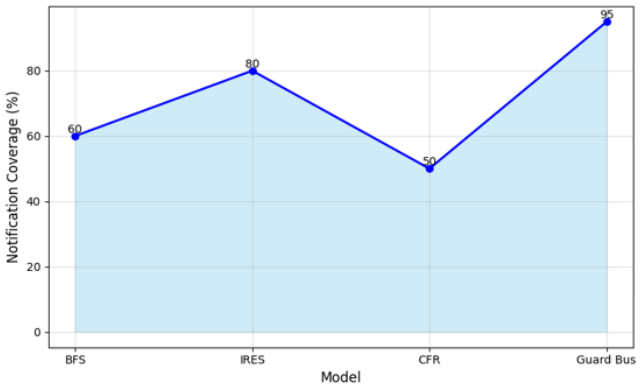

Table 3: Safety Features (%)

Model	Safety Coverage (%)
Biometric Fingerprint System(BFS)	70
IoT + RFID + ESP-CAM System(IRES)	80
Classroom Facial Recognition(CFR)	60
Guard Bus	95

The safety measures such as the students not going out of the premises or boarding without authorization. GuardBus is the most secure having 95 percent card coverage and GPS tracking, automated system of attendance and parent notification.

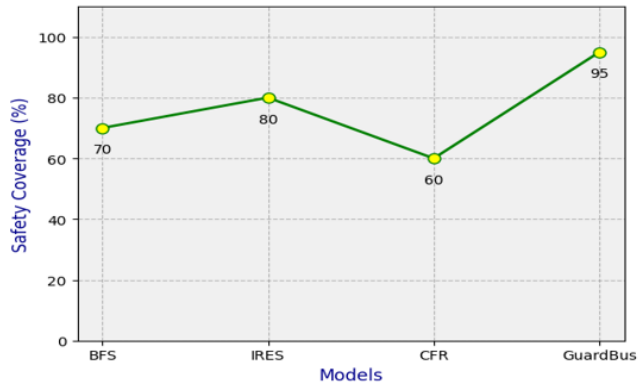

Figure 4: Comparison of Safety Features.

This implies that safety covered school bus attendance technologies are four. A greater comprehension is ascribed to the indicators of the labelling values below. Biometric Fingerprint System and People IoT + RFID + ESP-CAM System will comprise 70 and 80 percent of the percentages respectively, Classroom Facial Recognition will also be no less than 60 percent and Guard Bus implemented will be the most covering with 95 percent. As the figure indicates, some of the benefits associated with Guard Bus include a greater variety of benefits such as increased safety concerns such as no student abandonment, and unauthorized access that gives immediate notification to not only the parents but also the school authorities.

Table 4: IoT Integration (%)

Model	IoT Integration (%)
Biometric Fingerprint System(BFS)	50
IoT + RFID + ESP-CAM System(IRES)	90
Classroom Facial Recognition(CFR)	40
Guard Bus	95

The level of application of Internet of things (IoT) by respective systems. Guard Bus (95%) it is also merged, IoT like ESP32-CAM, Arduino, GSM and GPS, it will not clutter the data transmissions.

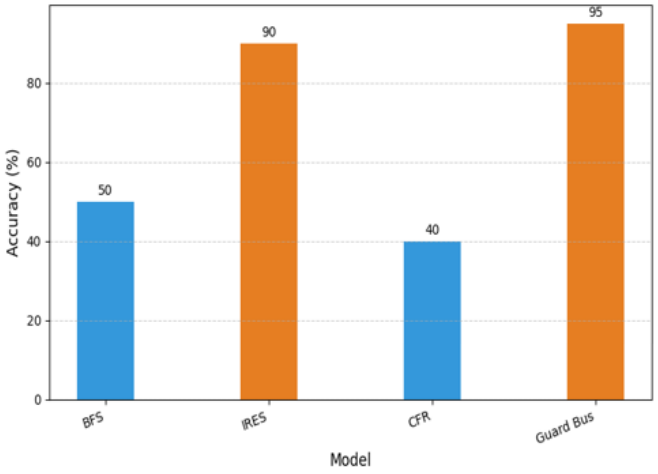

Figure 5: Comparison of IoT Integration

The diagram shows the integration level of the four attendance systems to school bus of the four markers the respective data point is indicated below. Fingerprint System Biometric is 50% Integration, IoT + RFID + ESP-CAM System is 90% and Classroom Facial Recognition is at the bottom, i.e.40%. Guard Bus is the least integrated solution (95%) and utilizes all the components that were tested including ESP-CAM, Arduino,

GSM and optional GPS to send the data on-the-fly and store the attendance records and keep the parents informed. As shown in the graph above, Guard Bus has the capabilities of smart system and advanced connectivity.

Table 5: Automation Level (%)

Model	Automation Level (%)
Biometric Fingerprint System(BFS)	65
IoT + RFID + ESP-CAM System(IRES)	85
Classroom Facial Recognition(CFR)	80
Guard Bus	98

Automation of student attendance and level of observation. GuardBus automation is almost fully automated (98 percent), there are no more roll calls to be made manually, and also there is no more error.

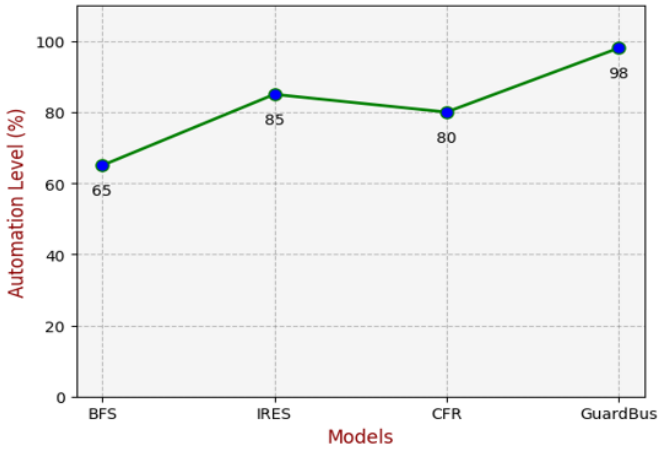

Figure 6: Comparison of Automation Level.

They are indicating the degree of automation of four SBA systems and provide the numerical value of each of them below the markers (so as to make it more transparent). Biometric Fingerprint System has achieved a 65 percent automation and IoT + RFID + ESP-CAM System has achieved 85 and Classroom Facial Recognition has achieved 80 percent efficiency. Guard Bus virtually eliminates manual roll calls and is 98% automated to recognize the attendance and real time notification. As demonstrated in the graph, Guard Bus is highly automated unlike traditional and non existing IoT systems.

Table 6: Parental Communication Efficiency (%)

Model	Parental Communication (%)
Biometric Fingerprint System(BFS)	50
IoT + RFID + ESP-CAM System(IRES)	85
Classroom Facial Recognition(CFR)	40
Guard Bus	95

The information concerning child boarding and dropping is given to parents. Timely SMS notification will also be provided by the GuardBus102 (95) even when in low network coverage along with the larger models.

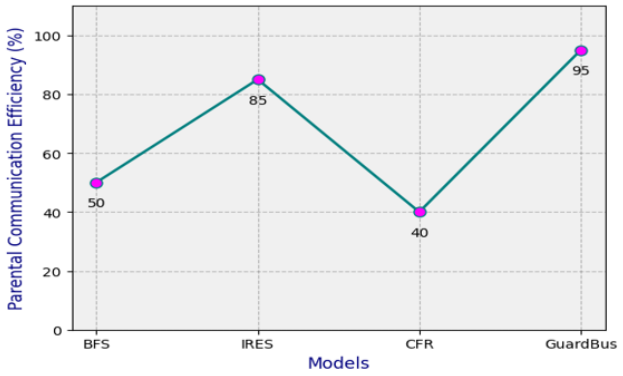

Figure 7: Parental Communication Efficiency Comparison

The efficiency of four bus attendance systems which had been used to communicate with parents is the. Biometric Fingerprint System has coverage of 50, IoT + RFID + ESP-CAM System covers the most with 85 and Classroom Facial Recognition covers the least with 40 coverage. Guard Bus works at 95% efficiency level and this means that the parent visitors would be able to receive SMS messages about the presence of their ward on board and off board within less than real time. The reason is that, the graph provides the argument that Guard Bus is way ahead of the curve, in its bid of keeping the parents informed, safety and openness.

Table 7: Scalability (%)

Model	Scalability (%)
Biometric Fingerprint System(BFS)	60
IoT + RFID + ESP-CAM System(IRES)	85
Classroom Facial Recognition(CFR)	50
Guard Bus	95

How far the concerned system can go when it comes to buses, students and schools. GuardBus (95) is highly scalable because it adopts modularly IOT architecture which can be scaled down to large transportation network

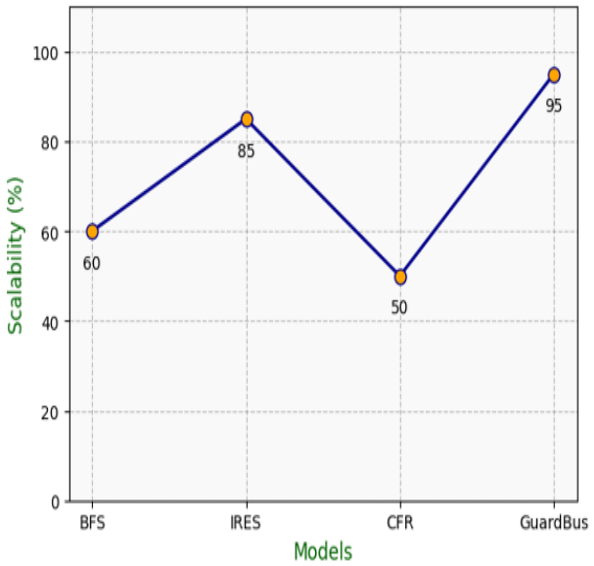

Figure 8: Comparison of Scalability.

The scalability comparison of 4 school bus attendance systems to the individual figures is below the marker. (B) Biometric Fingerprint, IoT + RFID + ESP-CAM, and Classroom Facial Recognition have 60, 85 and 50 percent system scalability, respectively. The Guard Bus base design is an IOT and moderular design that can easily accommodate the many buses, students and schools with which it takes leadership of with 95. The graph indicates that Guard Bus can be scaled as compared to the existing solutions, which use more conventional sensors and IoT.

Table 8: Overall System Efficiency (%)

Model	Efficiency (%)
Biometric Fingerprint System(BFS)	65
IoT + RFID + ESP-CAM System(IRES)	80
Classroom Facial Recognition(CFR)	75
Guard Bus	96

The aggregate measure of system functionality in the fields of accuracy, safety, automation and notifications. Guard Bus Smart Bus Attendance SolutionMaximum efficiency- 96%The most efficient integrated solution of smart bus attendance.

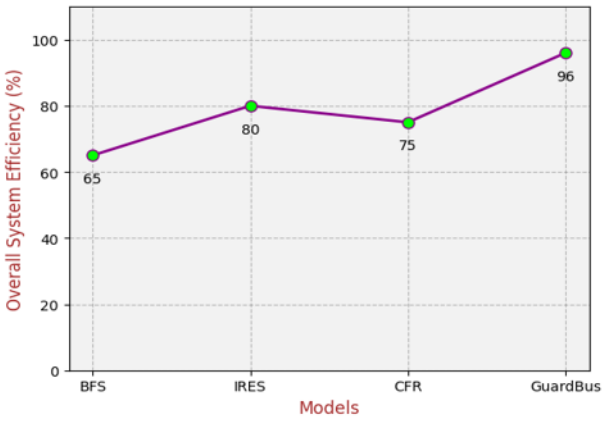

Figure 9: **Overall System Efficiency Comparison.**

Total efficiency of four school bus attendance devices in the overall system, with the value of each circle being an estimated. The success rate of the Biometric Fingerprint System is 65%, and iOS + RFID + ESP-CAM System and Classroom Facial Recognition are 80 and 75 respectively. Bus Guard has the most efficient of 96 percent due to its developed combinations of facial recognition, internet of things, tracking, automatic notifications and scalability. // Figure shows that Guard Bus is the most comprehensive, reliable and efficient demonstrative application on the favored smart school bus management.

V. CONCLUSION

Guard Bus The Smart Bus Attendance and Notification IoT that seeks to enhance student safety, efficiency of communication as well as Automation of the students attendance in the school buses. Meanwhile, it ensures proper attendance marking but does not spend time on warning parents via IoT (Internet of Things) and GSM. This is to enhance the level of transparency, which dispels the anxieties of parents or guardians. The reduced use of manual handling and human errors results in increased reliability of the operation, saves time. Moreover, the design of the system is scalable and modular, which will enable the system to be integrated with cloud platform, AI-based monitoring, and an emergency alert management system. Last but not least, Guard Bus has a number of technological capabilities that make it feel like it has a modern tone such as an iot-based embedded hardware and end-to-end real-time connectivity across all school buses that is likely to revolutionize how schools run their fleet of vehicles to make the student transportation process stronger.

REFERENCE

1. K. Mahfouz, S. M. Rameshi, M. Rafat, M. Elsayed, M. Sheikh and H. Zidan, "Route Mapping and Biometric Attendance System in School Buses," 2020 Advances in Science and Engineering Technology International Conferences (ASET), Dubai, United Arab Emirates, 2020, pp. 1-4, doi: 10.1109/ASET48392.2020.9118199.
2. M. M. Hassain, M. J. Hasan, A. Rahman, A. A. Fahim and M. M. Uddin, "Real Time Student Monitoring Smart School Bus with an IoT Based Security System," 2024 International Jordanian Cybersecurity Conference (IJCC), Amman, Jordan, 2024, pp. 93-98, doi:10.1109/IJCC64742.2024.10847285.
3. S. S. Rajawat and K. Saxena, "Face Recognition based Attendance System," 2022 1st IEEE International Conference on Industrial Electronics: Developments & Applications (ICIDeA), Bhubaneswar, India, 2022, pp. 95-99, doi: 10.1109/ICIDeA53933.2022.9970084.
4. J. V, K. B, M. Johnson and S. R. P, "IoT - Enabled Safety and Tracking Platform," 2025 International Conference on Computing and Communication Technologies (ICCCT), Chennai, India,2025, pp.1-6, doi: 10.1109/ICCCT63501.2025.11019666.
5. D. R. Bolla, B. Varsha, G. R. Chethan Kumar, M. Prajwal and B. Sowmya, "Secured Transportation System to Enhance Child Safety," 2018 3rd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT), Bangalore, India,2018, pp.23142318, doi:10.1109/RTEICT42901.2018.9012099
6. Narayana, V.L., Patibandla, R.S.M.L., Rao, B.T. and Gopi, A.P. (2022). Use of Machine Learning in Healthcare. In Advanced Healthcare Systems (eds R. Tanwar, S. Balamurugan, R.K. Saini, V. Bharti and P. Chithaluru). https://doi.org/10.1002/9781119769293.ch13
7. V. Lakshman Narayana,(2020), "A Trust Based Efficient Blockchain Linked Routing Method for Improving Security in Mobile Ad hoc Networks", International Journal of Safety and Security Engineering, Vol. 10, No. 4, 2020, pp. 509–516.
8. Gangadhar, C.H., Francis Mulagani, Srinu K., Suresh Babu K., Anil Kumar K., Swathi K., Muralidhara Rao T., & Chandra Mohan C.H. (2025)."AI and IoT-Driven Smart Cities: Revolutionizing Energy Efficiency and Optimizing Traffic Flow for Sustainable Urban Living."
9. A.NareshV. PavaniM. Meghana Chowdarym. V.Lakshman Narayana (2020). Energy consumption reduction in cloud environment by balancing cloud user load. Journal of Critical Reviews. 7(7):1003-1010.
10. Reddy, A. Y., &Balaga, T. R. (2025). Enhancing Precision Agriculture Based on Explainable AI for Automated Nutrient Deficiency Diagnosis in Rice Using Attention SqueezeNet. Ingenierie des Systemesd'Information, 30(1), 181.
11. Sujatha, V., and Shaheda Akthar. "Modelling of Missing Data Imputation Methods on Gene Expression Data." PONTE International Scientific Researchs Journal, vol. 73, 2017, https://doi.org/10.21506/j.ponte.2017.4.33.
12. Narayana, V.L., Patibandla, R.S.M.L., Rao, B.T. and Gopi, A.P. (2022). Use of Machine Learning in Healthcare. In Advanced Healthcare Systems (eds R. Tanwar, S. Balamurugan, R.K. Saini, V. Bharti and P. Chithaluru). https://doi.org/10.1002/9781119769293.ch13
13. Chaitanya, Kosaraju, et al. "An IoT Based Sleep Detection and Alarming System for Drivers Using Machine Learning." International Conference on Human-Centric Smart Computing. Singapore: Springer Nature Singapore, 2024.
14. K. Sarada, V. Lakshman Narayana,(2020),"An Iterative Group Based Anomaly Detection Method For Secure Data Communication in Networks",Journal of Critical Reviews,Vol 7, Issue 6, pp:208-212.doi: 10.31838/jcr.07.06.39.
15. B. Tarakeswara Rao; R. S. M. Lakshmi Patibandla; V. Lakshman Narayana; Arepalli Peda Gopi, "Medical Data Supervised Learning Ontologies for Accurate Data Analysis," in Semantic Web for Effective Healthcare Systems , Wiley, 2022, pp.249-267, doi: 10.1002/9781119764175.ch11.
16. D. V. Pavani, Y. Neeharika, G. S. Ishwarya, J. Deekshitha and V. Yamini, "Dynamic Sign Language detection system using Media Pipe Holistic and LSTM based Deep learning Model," *2024 International Conference on Emerging Innovations and Advanced Computing (INNOCOMP)*, Sonipat, India, 2024, pp. 330-337, doi: 10.1109/INNOCOMP63224.2024.00061.
17. Kumari, G. R. P., Sai, C. P., Sushma, N., Bhargavi, C., & Sindhu, P. (2025, May). Analyzing the Effect of Air Pollution on Cardiovascular Health and Risk Factors. In *2025 6th International Conference for Emerging Technology (INCET)* (pp. 1-6). IEEE.
18. Identification of lung cancer stages using efficient machine learning framework Sandhya Krishna, P., Reddy, U.J., Patibandla,.S.M.L., Khadherbhi, S.R.*Journal of Critical Reviews*, 2020, 7(6), pp. 385–390.
19. Sri, K. S., Krishna, K. V. S. S. R., Madamanchi, V. B. R., & Devi, G. Y. (2021). Advanced system control with traffic handling for secure communication in IoT routing protocol. *Journal Européen des SystèmesAutomatisés*, *54*(2), 229-233.

20. Yamparala, Rajesh, et al. "Prediction of cyclist road accidents in india using machine learning and visualization techniques." *2022 Second International Conference on Artificial Intelligence and Smart Energy (ICAIS)*. IEEE, 2022.
21. Kavishwar, S. (2011). Pension funds as an infrastructure financing avenue: An exploratory study. *Management Dynamics*, *11*(2), 33-45.
22. Bidwaikar, V. N., & Kavishwar, D. S. (2012). Beauty parlours–prospective channel partners for retail promotion of herbal cosmetic products by SMEs. *Indian Streams Research Journal.* 2(1), 1-4
23. Shahu, A., Tiwari, H., Joshi, M., & Kavishwar, S. An Analysis of the Effectiveness of Index ETFS and Index Derivatives in Covered Call Strategy. *Journal of Informatics Education and Research.* 4(3), 42-48.
24. Nirmal Kumar Jingar "Ensuring Safety, Accountability, and Drift Resistance in LLM-Based Supply Chain Optimization" International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Print ISSN : 2395-1990, Online ISSN : 2394-4099, Volume 10, Issue 1, pp.472-482, January-February-2023. Available at doi : https://doi.org/10.32628/IJSRSET2310372
25. Jingar, N. K. (2026, February 13). Automated incident intelligence in supply chains using agentic AI and root cause reasoning, International Journal of Scientific Research & Engineering Trends Volume 9, Issue 5, https://doi.org/10.5281/zenodo.18162511
26. Nijim, M., Kanumuri, V., Alaqqad, W., Albataineh, H. (2023). Advanced Traffic Management System for Smart Cities. In: Daimi, K., Al Sadoon, A. (eds) Proceedings of the 2023 International Conference on Advances in Computing Research (ACR'23). ACR 2023. Lecture Notes in Networks and Systems, vol 700. Springer, Cham. https://doi.org/10.1007/978-3-031-33743-7_19
27. Nijim, M., Kanumuri, V., Al Aqqad, W., Albataineh, H. (2024). Machine Learning Based Analysis of Cyber-Attacks Targeting Smart Grid Infrastructure. In: Daimi, K., Al Sadoon, A. (eds) Proceedings of the Second International Conference on Advances in Computing Research (ACR'24). ACR 2024. Lecture Notes in Networks and Systems, vol 956. Springer, Cham. https://doi.org/10.1007/978-3-031-56950-0_28
28. Racha, Ganesh. "Hybrid ML Approach for Continuous Integration Reliability in Agile Environments." United International Journal of Engineering and Sciences (UIJES), vol. 5, no. 3, 2025, pp. 9–21.
29. Racha, Ganesh. "Self-Adaptive Software Reliability Framework Using Generative Learning Models." International Journal for Modern Trends in Science and Technology, vol. 12, no. 1, 2026, pp. 30–37.
30. Veginati, Navya. "Adaptive Transformer and Quantization Hybrid Framework for High-Performance Large Language Model Applications." United International Journal of Engineering and Sciences, vol. 5, no. 4, Dec. 2025, pp. 46–56
31. Veginati, Navya. "Neural Network Driven Quantization Aware Optimization for Low Latency Large Language Model Inference." International Journal of Scientific Research in Computer Science, Engineering and Information Technology, vol. 10, no. 3, May-June 2024, pp. 1162–1170, doi:10.32628/CSEIT25113584.
32. Jonnalagadda, P.K. (2026). Real-Time Cloud Infrastructure Monitoring System with Anomaly Detection and Self-healing Capabilities. In: Kumar, V.N., Senkerik, R., Prasad, V.K., Kumar, T.K. (eds) Intelligent Computing and Communication. ICICC 2025. Lecture Notes in Networks and Systems, vol 1839. Springer, Cham. https://doi.org/10.1007/978-3-032-18349-1_43
33. Jonnalagadda, Pawan Kalyan. "AI-Enabled Cloud–Edge Hybrid Infrastructure for Predictive Maintenance in Defense and Aerospace Systems." International Journal of Science, Engineering and Technology, vol. 12, no. 2, 2024.
34. Ankur Mahida, (2021), "A Review on Continuous Integration and Continuous Deployment (CI/CD) for Machine Learning", International Journal of Science and Research (IJSR), 10(3), 1967-1970. https://dx.doi.org/10.21275/SR24314131827, https://www.ijsr.net/getabstract.php?paperid=SR24314131827
35. "Mahida, A. (2022). Comprehensive Review on Optimizing Resource Allocation in Cloud Computing for Cost Efficiency. Journal of Artificial Intelligence & Cloud Computing. SRC/JAICC-249. DOI: doi. org/10.47363/JAICC/2022 (1), 232, 2-4."
36. Tummuri, S. S. R. (2024). Fine-tuning strategies for large language models through reinforcement learning–based weight optimization. International Journal of Science, Engineering and Technology. Volume 4, Issue 3.
37. Tummuri, S. S. R. (2024). Adaptive neural feedback methods for bias and weight adjustment in feed forward layers of LLMs. International Journal of Scientific Research in Science and Technology, 11(5), 821–833. https://doi.org/10.32628/IJSRST52310380
38. Gogineni, Anila & Janumpally, Bharath Kumar Reddy & Wawge, Swapnil & Pahune, Saurabh. (2025). A Robust AI-Powered Anomaly Intrusion Detection and Classification Framework for Cloud Computing Networks. 1-6. 10.1109/INDISCON66021.2025.11253743.
39. Joon, B. K. R. Janumpally, A. Gogineni and P. Chatterjee, "Efficient Large-Scale Intrusion Identification and Prevention in Distributed Cloud Networks Using Artificial

Intelligence," 2025 5th International Conference on Intelligent Technologies (CONIT), HUBBALI, India, 2025, pp. 1-8, doi: 10.1109/CONIT65521.2025.11167760.

40. Arora AS, Yachamaneni T, Kotadiya U. A Comprehensive Analytical Framework for Modeling Consumer Credit Card Behavior and Risk Profiling Using Advanced Financial Metrics. IJAIDSML [Internet]. 2022 Jun. 30 [cited 2026 Apr. 2];3(2):90-100.
41. Arora AS, Yachamaneni T, Kotadiya U. Optimizing Multi-Tenant Resource Allocation in Cloud-Based Distributed Systems for Large-Scale AI Model Training Using In-Memory Computing. IJERET [Internet]. 2021 Mar. 30 [cited 2026 Apr. 2];2(1):37-46.