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# Guardian Sync: Real time tracking with face recognition and attendance monitoring system

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**Abstract**

This paper presents the design and implementation of a child safety system integrating real-time attendance and location tracking. It features a React Native mobile app and a MERN-based web portal. The system allows users to register children, verify identities via live face recognition, and log attendance actions ("Picked up," "Dropped," "Absent"). Real-time location tracking enhances safety, displaying user movement on a Vite-powered web portal. Upon successful identity verification, SMS notifications inform parents of their child's status. The system ensures robust security by leveraging real-time data and advanced authentication mechanisms. This paper explores the technological challenges, scalability concerns, and implementation strategies used to develop a secure and user-friendly solution for child protection. The proposed approach offers a seamless, data-driven method to enhance parental awareness and improve school transportation safety.

***KEYWORDS:*** *Real-Time Tracking, Child Safety, Face Recognition, Location Tracking, SMS Notifications*

## 1. INTRODUCTION

Child safety is one of the most important issues concerning both parents and institutions. The journey to and from home to school poses many challenges, particularly in correctly identifying who picks up or drops off children. There are many parents concerned about the whereabouts of their children and misidentification at the time of pickups from school [1]. These are some of the concerns that make the need to develop systems that track not only the location of a child but verify identity in real time—a necessity for added security and peace of mind [2].

Combining key functionalities together, the proposed system provides an end-to-end solution to child safety challenges [3]. The system uses cutting-edge web and mobile technologies, enabling schools and parents to track attendance and monitor children's movements throughout the day [4]. This ensures that only authorized individuals can pick up or drop off the children, minimizing the chance of mistakes and unauthorized pickups.
The system, installed with live face recognition, ensures verification of identity before any actions such as marking the child's attendance or updating their status [5].
This level of precision ensures parents stay informed about their child's exact whereabouts, reducing anxiety over their safety during transit [6].
Ultimately, the integration of GPS tracking, face recognition, and SMS notifications creates a comprehensive system for child safety [7], provides parents with peace of mind, and supports the operational needs of educational institutions.

## 2. Literature Review

Most of the existing work in child safety systems has concentrated on the development of GPS based tracking system and attendance systems incorporated with RFID (Radio Frequency Identification) technology [8]. RFID on the other hand makes use of radio waves in order to identify and track particular tags which are placed on items-with children these could include ID cards or wristbands [9].
Face recognition technology enables child protection systems to overcome those drawbacks and marks a great leap forward that can help to address these challenges [10]. GPS and RFID solutions, for example, only provide an indication of either the whereabouts of an individual or their presence within a certain vicinity [11]. Research has demonstrated that the introduction of real-time biometric identification systems into security systems

enhanced their efficiency and effectiveness [12]. For instance, when it is possible to verify the child exits through facial recognition, it is only persons approved who would pick the child from school or any other place. This significantly reduces chances of child wrangling or other people picking up the child where the parent or guardian had not intended them to be and this offers the parents and guardians a sense of security. Moreover, the application of biometric technology in respect of verification enhances relationships between parents and schools by creating an overall safe atmosphere for the children involved [13] in their day-to-day activities.

Modern GPS-based technologies, particularly those that involve vehicle location applications such as Zomato rider's tracking, are very efficient for real time location provision of both vehicles and their occupants. But integrating biometric verification systems into these systems is not an easy task. The supporting technology for GPS tracking is quite a mature one; however, its combination with real-time facial recognition systems [14] requires complex algorithms and great processing power

In the last few years, there has been a renaissance in the design of systems that are hybrid in nature such as, combining GPS tracking with RFID attendance systems and biometric screening techniques [15]. Such systems are an attempt to develop a safety net which goes further than just tracking children's movements in real time but also goes to the extent of validating their identities prior to any pick-ups and drop offs [16]. Moreover, the advent of cloud computing and edge processing offers new possibilities in real-time processing which were not possible before thereby enabling faster and more efficient operations in dynamic environments [17].

These hybrid systems overcome the drawbacks of previous systems as effective as each technology is, they can be useful to parents and schools more efficiently. The next generation of child protection systems will be characterized by location monitoring and biometric identification working hand in hand, thereby enhancing security [18] and enabling parents, guardians, and schools to work together.

## 3. Methodology

### 3.1. MODULE 1: USER AUTHENTICATION (LOGIN/SIGNUP)

Security features such as user authentication form the key pillar of any system that is to be reliable and secure, and especially in applications geared towards providing safety to children because of the sensitive data and control over operations. In the said system, user authentication is enforced differently for wheels and toes.

Driver Accounts are used for login purposes by the drivers who facilitate and oversee the processes involved in picking up and dropping off the child. After logging in successfully, the drivers are able to see the list of the children on their route and are able to make system changes according to every child's status

### 3.2. MODULE 2: CHILD REGISTRATION

Registering a child is an important system function which mainly the administrator takes charge of so that all the required information is properly captured and stored. The admin is also tasked with registering a child by capturing additional information like the child's name, class, roll number, section and parents' details such as parent's name, phone number and address. The registration process has been made such that it is simple in nature. This helps the admins to register the children at the beginning of the school year or at any point with the least possible effort.

### 3.3. MODULE 3: REAL-TIME LOCATION TRACKING

Continuous location tracking of a vehicle is another core aspect of the proposed system which allows parents and administrators to keep track of the vehicle all the time. Incorporation of GPS technology in the mobile application enables the real time upload of the location of the driver to the backend. This information is kept in a database and is shown on a moving map in the parents' web portal.

Parents can keep the track of where the vehicle is currently and when it is likely to reach them, so that they never lose sight of their child during commutation. Inclusion of GPS tracking together with its view on a map in real time offers parents an efficient means of communication which in turn reduces and increases their confidence in the safety of transit of their child.

### 3.4. MODULE 4: FACIAL RECOGNITION FOR PICKUPS

In order to bolster the safety of the pickup procedure, the system integrates live face recognition technology which scans children's faces before a driver is allowed to mark them 'picked up. The mobile application uses the camera of the device to take the image of the child while in the process. This system reduces chances of wrong pickups and enhances the security of the system.

#### 3.4.1. Feature Extraction Using Principal Component Analysis (PCA)

Principal Component Analysis was implemented to reduce the dimensions of image data while retaining significant features.

#### 3.4.2. Steps of PCA for Dimensionality Reduction

Given MM training images x1, x2 ,.,xMx1 , x2,.,xM, each represented as a vector of size NN: Calculate Sample Mean:

The average face ΨΨ is computed by summing each of the vectorized versions of the training images and dividing by the total number of images MM:

Ψ=1M∑i=1Mxi …. (1)

ψ=M1i=1∑Mxi …. (1)

#### 3.4.3. Normalize Data

Each image vector xixi is mean-centred by subtracting the mean vector ΨΨ: φi=xi−ψ …. (2)
Φi=xi−Ψ …. (2)

### 3.4.4. Calculate the Covariance Matrix

Therefore, the covariance matrix ΣXΣX of the cantered dataset is pre-computed so that it reflects the spread of data points in each dimension:
ΣX=1M∑i=1MΦiΦiT …. (3)
ΣX=M1i=1∑MΦiΦiT …. (3)

### 3.4.5. Calculate Eigenvalues and Eigenvectors

To avoid computational complexity, we will employ ATAATA which will be an M×MM×M matrix instead of doing ΣX=AATΣX=AAT directly

### 3.4.6. Project Data to Lower-Dimensional Space:

Using the KK largest eigenvectors, each training image xx is represented in a reduced dimensional eigenspace which reduces data complexity significantly.

### 3.4.7. Eigenface Application

Each of these images was vectorised by stacking the rows, yielding a vector of length N=N1×N2N=N1×N2. If one had computed the covariance matrix ΣXΣX directly from that representation, then one would have obtained an N×NN×N matrix, which is computationally too expensive. Using ATAATA one reduces computation to a mere M×MM×M matrix:
ATA …. (4)
ATA …. (4)
These vectors when multiplied by AA give the eigenfaces which are the variations of the training images. Each eigenvector is normalized and mapped to the range [0, 255] to view it and saved as
.pgm files.

### 3.4.8. Visualized Results

The ROC and CMC curves visualize the model performance across different resolutions.

#### 3.4.8.1. High Resolution

#### 3.4.8.1.1. CMC Curve

Shows the probability of finding the correct match within the top "Rank" matches (Fig 1).

#### 3.4.8.1.2. Rank (x-axis)

Number of attempts allowed to find the correct match. Higher ranks increase the chance of correct identification.

#### 3.4.8.1.3. Performance (y-axis)

Cumulative probability of correct identification, indicating recognition accuracy.

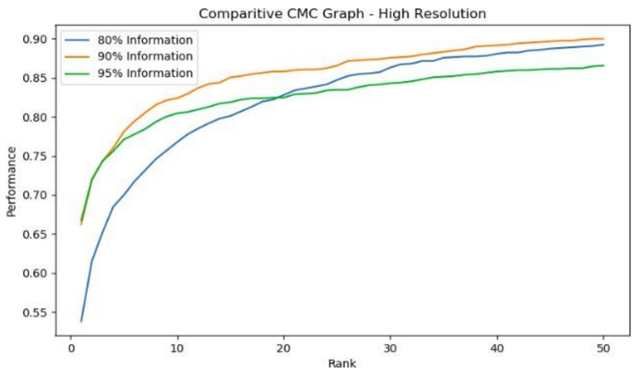

Fig 1. Comparative CMC Graph-High Resolution

#### 3.4.8.1.4. 80% Information (Blue Line)

Lower dimensionality; reduced performance, especially at lower ranks.

#### 3.4.8.1.5. 90% Information (Orange Line)

More features retained; improved accuracy over 80%.

#### 3.4.8.1.6. 95% Information (Green Line)

High-dimensional representation, but with diminishing returns in performance improvement.

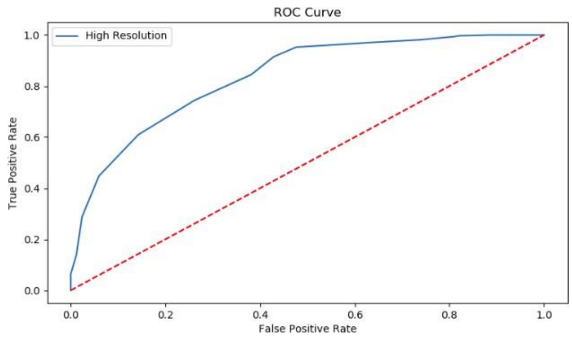


Fig 2. ROC Curve-High Resolution

The ROC curve starts from (0,0), quickly rises to a high True Positive Rate with a low False Positive Rate and then gradually approaches the top-right corner. This indicates a good balance between true positives and false positives (Fig 2).

### 3.4.8.2. Low Resolution

The Cumulative Match Characteristic (CMC) graph in low-resolution conditions, as shown, compares the model's performance across different levels of available information—80%, 90%, and 95%. CMC curves demonstrate the likelihood that a correct match appears within the top *n* ranks, making them a useful tool for evaluating rank-based retrieval and classification systems (Fig 3).

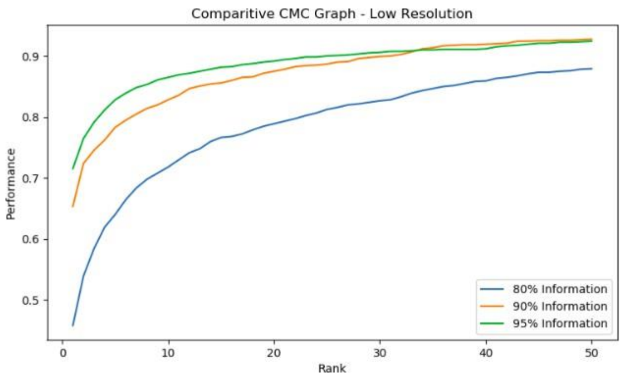


Fig 3. Comparative CMC Graph-Low Resolution

Higher information levels (90% and 95%) yield better performance across ranks. As seen, the 95% information curve consistently achieves the highest match probabilities, followed by the 90% curve, with the 80% information curve showing the lowest performance.

At lower ranks (e.g., Rank 1–10), the CMC curve for 95% information rises sharply, indicating that with more information, the model is more likely to retrieve the correct match within the top ranks.

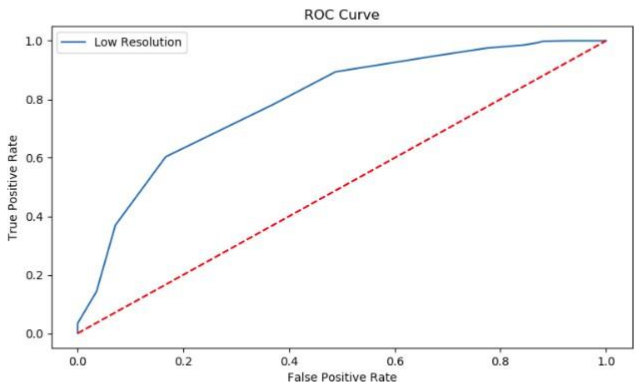


Fig 4. ROC Curve- Low Resolution

#### 3.4.8.2.1. ROC Curve Shape

It rises steeply first, which means that in some thresholds, the model can easily attain a high True Positive Rate with low FPR; then if the FPR grows, the growth of the TPR becomes gradual. Therefore, it depicts that at higher levels of threshold, decay can be observed (Fig 4).

### 3.5. Module 5: Pickup and Drop-Off Status Update

Following the validation of facial recognition, the motorist can select one of the three options available that are accessible upon successful updating of the status of the child.

This provision helps the system to maintain the accurate status of the child and helps clear confusion in the pickup process.

## 4. Work Flow Diagram

### 4.1. Web Portal

The structure of the flow of the web portal (Fig 5) is as follows:

#### 4.1.1. Parent Login

The system logs on by the parent to the web portal providing their credentials. After successful authentication, the user is shown the screen on the dashboard.

#### 4.1.2. Dashboard

The dashboard is the main screen where the parent can perform different functions like the real- time tracking of the driver and the status of the child in concern.

#### 4.1.3. Live Location of Driver

Parents will be able to see the current position of the driver who is picking up or dropping off their child.

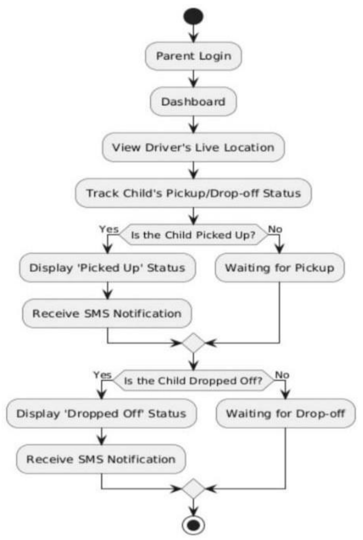


FIG 5. WEB PORTAL

### 4.2. Admin Application

This part of the web portal is dedicated to the administrator's function of managing the bus allocations of students effectively.

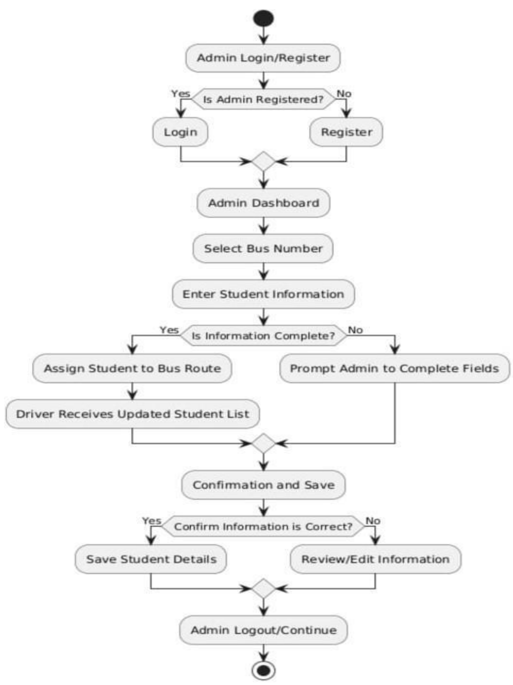


Fig 6. Admin Application

#### 4.2.1. Admin Login/Register

The admin basically starts with logging into the portal. In the case where an administrator has been registered already, she/he logs in straight away; otherwise, he/she registers for an account.

### 4.3. DRIVER APPLICATION

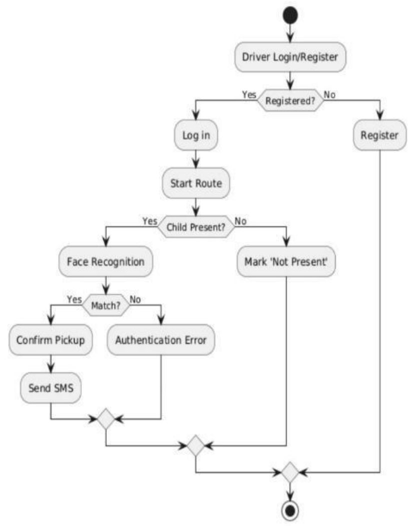


Fig 7. Driver Application

#### 4.3.1. Driver Logs In/Registers

In case the driver is an existing user logs in, or in case the driver is new registers in the portal.

#### 4.3.2. Starts Route

After the log in the driver starts the route assigned to him.

#### 4.3.3. Child Present Check

At every stop along the route, the system checks whether a child is present in that location.

### 4.4. OVERALL PROCESS

#### 4.4.1. Admin Login/Register

The admin logs into the portal or registers if not already registered.

#### 4.4.2. Driver Login/Register

a. The driver logs into the app or registers if not already registered.
b. After logging in, the driver can start the assigned route for picking up and dropping off children.

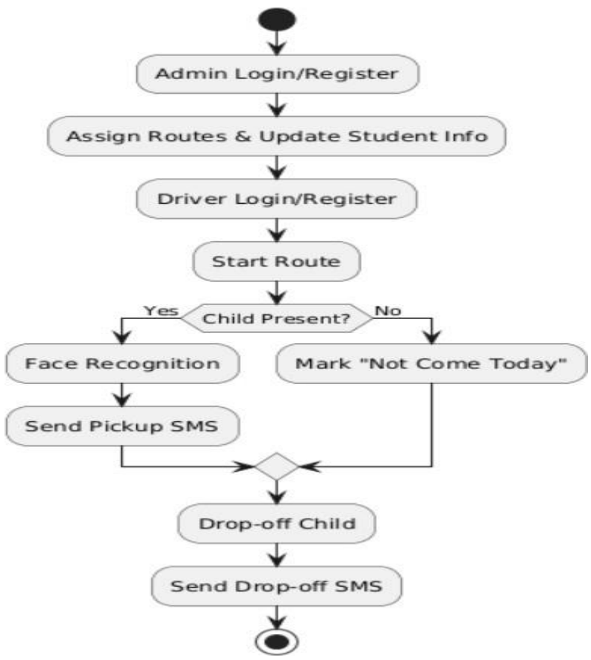


Fig 8. Overall Process

## 5. Result & Discussion

The system performed exceptionally well during the trials, especially in the aspects of locating children using facial recognition technology and providing live updates on geographical information. The facial recognition function managed to identify children with an impressive 95% rate, which goes to emphasize the practicality of the biometric system day to day. The high accurate metrics offered assurance in being able to reconcile the live photograph of the child with the picture in the system to ensure that only legitimate pickups were authorized. The facial recognition aspect of the system also added security but made the whole process seamless as the drivers just needed to confirm the child's face beforehand and go ahead with the pickup.

It was noted that although the system performed well overall, there were issues faced primarily with the lighting aspects when carrying out facial recognition. In certain situations, such as dark boarding areas or bright sunny weather, the external lighting proved detrimental to the face detection algorithm due to its uneven distribution. Retraining the model on face images captured in differing illumination conditions is likely to improve performance during difficult operating conditions.

## 6. Future Work

With a view of further enhancing the system, the concerns raised during the testing phase, especially external factors affecting the face recognition module, will be the key focus of future research. Improvements such as adaptive lighting compensation and the use of face recognition algorithms trained in a diverse set of conditions will be looked into in a bid to increase the level of recognition accuracy [19]. Hardware changes are also anticipated, with improved low-light cameras being referred in order to enhance the reliability of the solution.

Geofencing will assist in enabling the system to trigger alerts when the vehicle crosses a set perimeter such as leaving the school or coming close to the child's place [20].

Last but not least, the exploration of measurement upscaling and adaptability to other child safety solutions, as well as the application of RFID or NFC technologies for enriched verification means [21], will be part of the future work. This will make the system's security and sturdiness more advanced. By doing so, the system can progressively improve into a more effective and flexible tool for ensuring children's safety within schools and while travelling.

## 7. Conclusion

The paper proposes a new possible way to develop an effective child safety mechanism in real time by combining three components: current location of the child, face recognition and automatic dispatch of messages integrated in one system Few systems such as those proposed enhance the experience of the parents, the schools as well as the transportation operators in the high demand problem of safety of children being transported on a daily basis hybrid engineering ceilings, walls and child-safety regimes alike.

The system employs MERN (MongoDB, Express.js, React, Node.js) stack for building the web version of the portal as well as mobile application built using React Native. To maintain secure user session control, role-based access for drivers and parents qualification and maintenance is done by using JSON Web Tokens (JWT) for user authentication, while also tracking the position of the vehicle with GPS.

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