SMART TICKET: An Intelligent Public Transport System with Fraud Detection and Loyalty Program

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Abstract -**This research explores the development and implementation of a user-friendly, secure, and scalable web-based system designed for seamless user identification and verification. Built on the Flask framework, the system integrates user registration, QR code generation, and facial recognition functionalities, offering a comprehensive solution for various use cases such as public transportation, access control, and digital ticketing. By combining Flask's flexibility with MongoDB's robust data storage capabilities, the application is designed to handle large-scale user data securely while maintaining high performance.**

The face recognition component of the system is integrated to enhance security and streamline the user experience, making it faster and more convenient compared to traditional manual verification methods. In addition, the use of QR codes for automated ticketing and penalty management aims to reduce human error and operational overhead, while rewarding loyal users with a loyalty program.

The proposed solution also ensures multi-language support, catering to diverse user needs, and is designed with accessibility in mind to accommodate those with varying levels of technological literacy. Our system's architecture and design prioritize both security and user-friendliness, ensuring a positive user experience across multiple domains.

In the future, the system can be expanded to include advanced encryption for enhanced data protection, real-time monitoring features, and machine learning capabilities to further optimize face recognition accuracy and system performance. The work presented in this paper demonstrates the potential for integrating cutting-edge web and biometric technologies to improve efficiency, reliability, and user experience across multiple industries.

Index Terms: **Smart Ticketing, Public Transport, Fraud Detection, QR Code, Face Recognition, Loyalty Program, Scalability, Security**

I. INTRODUCTION

In the era of rapid urbanization, public transport systems have become a lifeline for millions, providing cost-effective and sustainable mobility solutions. However, with the rise of conductor-less public transport systems, several challenges have emerged, including fare evasion, inefficient ticketing processes, and limited accessibility for diverse user groups. These issues, if left unaddressed, can lead to financial losses for transport authorities and deter the widespread adoption of public transportation.

This research proposes an innovative solution to revolutionize the ticketing process in conductor-less public transport systems by introducing a smart, automated, and user-friendly system. At the core of this system is a QR code-based ticketing mechanism that ensures secure validation of tickets while offering features like dynamic fare calculation based on travel distance, reward points for frequent users, and penalties for non-compliance. The system is designed to be inclusive, with support for multiple languages and provisions for users with varying literacy levels.

A key focus of this project is its alignment with the principles of sustainability. By encouraging the use of public transport through loyalty rewards and simplified ticketing processes, the proposed system aims to reduce the dependency on private vehicles, thereby decreasing greenhouse gas emissions and contributing to the fight against climate change. Additionally, the system's data-driven design enhances transparency, operational efficiency, and user trust.

The proposed solution also maps directly to several Sustainable Development Goals (SDGs), including Goal 11: Sustainable Cities and Communities, which advocates for inclusive, safe, resilient, and sustainable cities, and Goal 13: Climate Action, which emphasizes the need for urgent action to

combat climate change and its impacts. By addressing these global priorities, this research not only contributes to technological innovation but also underscores the role of public transport in creating a sustainable future.

This paper explores the design, implementation, and outcomes of this smart ticketing system, shedding light on its potential to transform public transport into a more accessible, efficient, and environmentally friendly mode of travel.

II. RESEARCH GAP OR EXISTING METHODS

1.Existing Methods:

The ticketing mechanisms in public transport have evolved over the years, with various systems being implemented to cater to the growing demands of urban mobility. Traditional paper-based ticketing systems have been the foundation of fare collection in many regions due to their simplicity and widespread acceptance. However, these systems are labor-intensive, environmentally unsustainable, and prone to issues like ticket fraud and loss.

In recent years, smart cards and contactless payment systems have gained popularity. These systems allow passengers to pre-load funds and make quick, seamless payments. While these methods reduce the reliance on cash transactions, they often require significant initial investments in infrastructure and card distribution. Mobile ticketing applications represent another innovative step, enabling users to purchase and validate tickets digitally via smartphones. These apps often include QR codes or NFC technology for validation, offering increased convenience.

However, while conductor-less systems aim to improve operational efficiency, they struggle with challenges such as fare evasion, lack of real-time ticket monitoring, and inadequate enforcement mechanisms. Some regions have attempted to integrate machine-readable passes and automated fare collection gates, but these systems often fail to address inclusivity and scalability issues.

2.Research Gap:

Despite the advancements in ticketing technologies, several limitations and challenges persist. One major research gap lies in addressing fare evasion in conductor-less systems. Current methods often depend on random inspections or basic QR code scans, which can be bypassed by users. These gaps suggest the need for a more robust validation system that combines advanced technologies such as machine learning and real-time data verification.

Another significant gap is the lack of a user-friendly interface for individuals with varying levels of technological literacy. Many existing systems assume that users are adept at operating smartphones or smart cards, which excludes certain populations, such as the elderly or individuals in rural areas. Multi-language support and accessibility features are often missing in current implementations, limiting their inclusivity.

Sustainability is another area where existing systems fall short. While the use of public transport inherently aligns with Sustainable Development Goals (SDGs) related to climate action, most ticketing solutions do not actively incentivize eco-friendly behavior. Systems that reward passengers for frequent usage or promote the use of sustainable transport modes are underdeveloped.

Moreover, the integration of data-driven insights into public transport systems remains limited. Most systems do not leverage real-time data to provide insights into travel patterns, optimize route planning, or identify and mitigate fraudulent activities. Additionally, there is little research on combining loyalty programs with fare management to encourage consistent use of public transport.

Addressing these gaps requires a multi-faceted approach that integrates advanced technology, inclusivity, and sustainability into the design and implementation of public transport ticketing systems. By doing so, future systems can ensure greater efficiency, accessibility, and alignment with global sustainability objectives.

III. PROPOSED METHODOLOGY

The Flask application is designed to manage user registration, QR code generation, face recognition, and other related features for a user management system. It integrates MongoDB as its database to store user details and performs various operations to facilitate user interactions.

User Registration and Management

The application provides a registration feature where users can submit their name, mobile number, Aadhar number, and photo through a form. The photo is saved locally, and its base64-encoded version is stored in the MongoDB database for efficient retrieval. During registration, the system ensures the uniqueness of Aadhar numbers to prevent duplicate entries. Additionally, each user starts with an initial balance of 150 and placeholders for their travel-related information, such as source, destination, fare, and trip count.

QR Code Generation and Viewing

Users can generate a unique QR code linked to their Aadhar number. The system checks if a QR code already exists for the user; if not, it generates one using the qrcode library. The QR code is saved as a base64-encoded string in the database for future use. The application also allows users to view or download their QR codes directly.

Face Recognition Integration

The application supports face recognition to identify registered users. Photos uploaded during registration are processed to extract face encodings, which are stored in memory. A live webcam feed is used to detect and recognize faces, drawing rectangles around detected faces and labeling them with recognized names. The recognized names are stored in a set, ensuring no duplicates, and are matched with the database records for verification.

Recognized Names and Validation

Recognized names can be validated against the database, and matched names are saved to a file (recognized_names.txt). This file can be downloaded or queried to check if any recognized names match those in the system. The application ensures that only valid names corresponding to registered users are saved or displayed.

Templates and User Interaction

The application uses HTML templates for a seamless user experience. Features like registration, QR code generation, face recognition, and QR code scanning have dedicated templates, allowing users to interact easily with the system. The face recognition feature streams live video and updates the recognized names dynamically.

Security and Scalability

The application employs essential security measures, such as verifying unique Aadhar numbers and preventing duplicate QR code generation. The use of MongoDB ensures scalable storage and efficient retrieval of user data, while base64 encoding simplifies image handling and storage.

Overall, this Flask-based application integrates multiple technologies, such as face recognition, QR code generation, and MongoDB, to provide a comprehensive user management solution for systems requiring secure identity management and travel-related functionalities.

IV. OBJECTIVES

1. Seamless User Registration
   Facilitate a straightforward registration process where users can input personal details, upload photos, and ensure data is securely stored in a database.
2. Unique Identification System
   Implement a system that ensures the uniqueness of user records by validating key identifiers such as Aadhar numbers, preventing duplication.
3. QR Code Generation and Management
   Generate personalized QR codes for users, storing them efficiently in the database, and enabling easy retrieval and download for future use.
4. Face Recognition Integration
   Leverage facial recognition technology to identify registered users through live webcam feeds, ensuring accurate and secure user verification.
5. Dynamic User Interaction
   Provide a user-friendly interface with templates to handle registration, QR code generation, face recognition, and other functionalities, ensuring smooth user interaction.
6. Data Storage and Security
   Utilize MongoDB for scalable and secure storage of user data, including personal details, images, and generated QR codes, while employing base64 encoding for efficient handling of image data.
7. Real-Time Recognition
   Enable real-time face detection and recognition using webcam streams, ensuring recognized users are accurately identified and verified against the database.

8. Comprehensive Travel Management
   Maintain user-related travel data, such as source, destination, fare, trip counts, and balances, to support future system expansions related to travel and ticketing.
9. Scalability and Expandability
   Design the application to support the integration of additional features in the future, such as advanced security measures, travel management systems, or reward-based programs.
10. Accessibility and Usability
    Ensure the application is accessible and usable for a diverse audience, providing simple navigation and clear instructions for all functionalities.

These objectives aim to deliver a robust and secure application while prioritizing user convenience and technological efficiency.

V. SYSTEM DESIGN AND IMPLEMENTATION

System Overview:

The *Smart Ticketing* system combines QR code-based ticketing, facial recognition, and a loyalty program. Passengers will scan QR codes at entry points, and their identity will be authenticated using facial recognition. Data from Wireless Access Points (WAPs) will be used for real-time monitoring.

Figure 1. Smart Ticketing Framework

System Architecture:

The system architecture consists of the following components:

- Frontend: A mobile app for passengers to manage tickets, access rewards, and interact with the system.
- Backend: A secure database and server infrastructure to manage user data, transactions, and system analytics.
- API Integration: APIs will connect different system components, including the facial recognition module, ticketing system, and rewards program.
- Network Layer: A robust network layer will ensure real-time communication between transport stations, vehicles, and central servers.

System Implementation Process:

The implementation will follow the following steps:

1. Deployment of WAPs and integration with existing transport infrastructure.
2. Development and integration of the facial recognition module.
3. Deployment of QR code-based ticketing and user authentication system.
4. Integration of the rewards program and administrative portal.
5. Testing and fine-tuning of the system, followed by large-scale deployment.

VI. OUTCOMES

The outcomes of implementing the *Smart Ticketing* system include:

- Improved Fare Integrity: Enhanced fraud detection and real-time monitoring ensure that only authorized users access transport services.
- Increased Commuter Engagement: The loyalty program successfully incentivizes regular use of public transport, increasing ridership.
- Scalable Solution: The system can be scaled to different transport networks and accommodate large volumes of passengers.
- Enhanced Security: Integration of dynamic content filtering and firewalls ensures that user data remains secure.

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VII.CONCLUSION AND FUTURE WORK

This research presents a robust and innovative Flask-based application that integrates user registration, QR

code generation, and face recognition to enhance user identification and verification processes. By leveraging MongoDB for secure and scalable data storage and employing advanced face recognition algorithms, the system ensures reliability and efficiency. The seamless integration of various functionalities demonstrates the potential of such applications in domains like public transport systems, security protocols, and user management solutions. This research contributes to developing user-centric systems that are efficient, secure, and scalable.

Future Work:

1. Enhanced Security Features: Incorporate advanced encryption methods to protect sensitive user data and ensure secure transmission of information between components.
2. Multi-Language Support: Expand the application's usability by introducing multi-language support to cater to diverse user demographics.
3. Mobile Integration: Develop mobile-friendly versions or dedicated apps to enhance accessibility and ease of use for end-users.
4. Real-Time Monitoring: Implement real-time monitoring and reporting features for administrative oversight, such as detecting anomalies or unauthorized access attempts.
5. Integration with IoT Devices: Extend the system to integrate with Internet of Things (IoT) devices for applications like automatic boarding verification in public transport or secure entry systems in buildings.
6. Machine Learning Enhancement: Employ machine learning algorithms to improve the accuracy and speed of face recognition, particularly in challenging conditions such as low light or diverse user demographics.
7. Reward and Loyalty Systems: Introduce reward systems to encourage application usage, such as loyalty points or bonuses for frequent users in a public transport scenario.
8. Scalability for Large-Scale Deployments: Optimize the system for deployment in large-scale scenarios, such as city-wide public transport systems or national-level identification projects.
9. Integration with Payment Systems: Enhance the application by integrating digital payment solutions, allowing users to perform seamless transactions for ticketing or service charges.
10. User Feedback Mechanism: Incorporate a feedback system to gather user insights and improve the application based on user experiences and suggestions.

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