AI Roadside Vendors & Illegal Parking Detection System

(Artificial Intelligence Project)

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Abstract

Illegal parking and roadside vendors significantly contribute to traffic congestion and urban disruption, especially in densely populated areas. To address this, our project leverages AI to develop a detection system that identifies illegally parked vehicles and roadside vendors using real-time camera feeds. The system utilizes an image dataset that was preprocessed and cleaned before being used to train a YOLOv8 object detection model. This trained model is integrated into a user-friendly website, enabling seamless monitoring and violation detection. By automating these processes, the project reduces the reliance on manual surveillance, ensuring quicker and more accurate identification. This initiative aligns with Pakistan's Sustainable Development Goals (SDGs), particularly SDG 11, by enhancing urban planning and promoting sustainable traffic management.

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1. Introduction:

1.1. Background:

Roadside vendors have long been a part of Pakistan's urban environment, offering essential goods and providing livelihoods to many. However, their unregulated presence on roadsides has become a major urban management issue. Vendors often set up stalls in unauthorized areas, leading to traffic blockage, blocked pedestrian walkways, and safety hazards. In cities like Karachi, Lahore, and Rawalpindi, the rapid increase in roadside vendors and illegal parking of vehicles has worsened these problems. Managing these activities manually is time-consuming and inefficient for city authorities. With advancements in technology, especially in Artificial Intelligence (AI), there is an opportunity to create smarter systems to address these challenges.

1.2. Problem Statement:

Currently, there are no effective systems to automatically detect illegal parking or roadside vendors. Monitoring these activities requires significant manpower and time, making it difficult to regulate them efficiently. This leads to increased traffic congestion, reduced road safety, and difficulty in maintaining order in urban areas. A solution is needed to help authorities identify and respond to such violations quickly and accurately.

1.3. Objectives:

The main goal of this project is to develop an AI-based system that can:

- Automatically detect roadside vendors and illegally parked vehicles in real time using camera feeds.
- Provide alerts to authorities to take immediate action.
- Help improve urban planning and traffic management through data-driven insights.

1.4. Scope of the Report:

This report focuses on designing and implementing an AI-powered system for illegal parking and roadside vendor detection. The system will use machine learning models and camera feeds to identify violations. It will also provide a user-friendly interface for authorities to monitor activities and manage data. The project is aimed at improving urban traffic flow, ensuring pedestrian safety, and reducing the workload of city officials.

2. Literature Review:

The product is designed as an independent solution that utilizes artificial intelligence and real-time camera feeds to detect unauthorized roadside vendors and illegally parked vehicles. Relevant projects have also been implemented before like **"AI powered Illegal Parking"** by **"Algo Vision".** It detects vehicles parking/stopping spots beyond specified. It monitors, detects and alerts against parking violations by generating alarms in real time. Our project is also similar to this project as that project detects vehicles parked illegally and then it triggers the alarm, and our project detects the illegally parked vehicles and then report it to the city officials. The difference between their project and our project is that their project covers the parking area and our project covers the roadside area and vendors.

3. Proposed Method:

3.1. Prediction of Violations:

This section outlines how the system identifies violations like roadside vendors and illegally parked vehicles.

3.1.1. Dataset:

The system uses publicly available customized datasets from **Roboflow** and other websites containing images and videos of roadside vendors. These datasets include labeled examples of roadside vendors.

3.1.2. Tools And Frameworks:

- We used **Python** as the main programming language for building and running the model.
- **Pandas** was used for data preprocessing and post processing.
- **OpenCV** helped with image processing and handling live video feeds.

- We created a simple and easy-to-use website in which **React** was used for frontend and **FastAPI** for backend integration.

3.1.3. Model Selection:

For the detection of roadside vendors and illegal parking, object detection models such as YOLOv8 (You Only Look Once) is considered. YOLO is selected for its ability to process images in a single pass, making it ideal for real-time detection. This model is well-suited for real-time detection due to their speed and accuracy.

3.1.4. Class Imbalance:

In our dataset, the number of cart vendors were less than the other vendors images so to overcome this issue more cart vendor images were added in the dataset to identify all types of vendors correctly.

3.1.5. Training Process:

The training involves the following steps:

1. **Splitting the Data**: The dataset is divided into training, validation, and testing sets.
2. **Model Fine-Tuning**: Pre-trained models are fine-tuned on the specific dataset for vehicles.
3. **Epochs and Batch Size**: Training is conducted over 50 epochs with an optimized batch size to improve accuracy without overfitting.

3.1.6. Evaluation and Testing:

After training, the model is evaluated on the test dataset to measure its performance. Metrics like precision, recall, F1-score, and mean Average Precision (mAP) are calculated to determine the model's effectiveness in detecting violations.

3.2. System Workflow:

3.2.1. Data Collection and Preprocessing:

- **Input Sources:** The dataset was collected from publicly available websites in which video feeds or images are captured from surveillance cameras installed on roadside or parking areas.

- **Preprocessing:** Images are resized and normalized for uniformity and class imbalance was handled.

3.2.2. Object Detection and Classification:

- The processed data was fed into the **YOLOv8** object detection model, which detects and classifies objects in the frame.
- Classification includes roadside vendors, vehicles, and other relevant objects ignored by the model.

3.2.3. Violations Detection:

Based on the detected objects, the system applies logic to determine violations:

- **Illegal Parking**: If a vehicle is identified in a prohibited area or obstructing traffic.
- **Roadside Vendors**: Detected vendors operating in unauthorized locations.

3.2.4. Notifications and Alerts:

- Notifications are sent to relevant authorities through a dashboard.
- Alerts highlight the type of violation, location, and timestamp.

3.2.5. History Management:

All detected violations are stored in a central database with details like object type, timestamp and geolocation.

3.3. User Interaction:

The AI Roadside Vendors and Illegal Parking Detection System provides a user-friendly interface to ensure efficient interaction for users. The interaction can be divided into the following components:

3.3.1. Authentication:

The system includes a secure **user authentication** feature to ensure authorized access. Its features include:

- Login and registration functionality using email and password.
- Role-based access control:
    - **Administrator:** Full access to manage the system, add zones, and assign roles.

- **Police Officer:** Restricted access to view and manage violation data.

3.3.2. Dashboard:

A central interface where users (e.g., traffic authorities) can view and manage real-time and historical data. Its features include:

- Live video feed display.
- Video Uploading.
- Notification of detected violations (e.g., roadside vendors, illegal parking).
- Incidents management.

3.3.3. Manage Users:

Admin can manage user CRUD operations. Its features include:

- View users.
- Update the role of the users.
- Delete users.

4. System Design and Architecture:

The AI Roadside Vendors and Illegal Parking Detection System is built with a strong and flexible structure to make sure it works smoothly, can handle future updates or expansions, and is easy to maintain. The system's design integrates various components to detect and manage roadside vendors and illegal parking violations effectively.

4.1. System Overview:

The AI Roadside Vendors and Illegal Parking Detection System uses Artificial Intelligence (AI) to efficiently detect illegal parking and roadside vendors. It is designed to handle real-time video feeds and also allows users to upload pre-recorded videos for analysis. It includes role-based access control to manage users and their responsibilities effectively. The system can record and manage incidents of violations, ensuring comprehensive tracking. It utilizes a pre-trained model for detecting illegally parked vehicles and a custom-trained model specifically for identifying roadside vendors and carts. Additionally, all violation data, user information, and system logs are stored in a centralized database to ensure efficient management and easy access to essential information. The system’s design ensures smooth performance and effective detection, making it a valuable tool for addressing urban challenges.

4.2. System Architecture:

The architecture follows a smooth flow of communication, with well-defined components for efficient data flow and processing.

4.2.1. Front-End:

The user interface of the system was built using **React**, ensuring an intuitive and user-friendly experience. Its key features include:

- A dashboard for real-time video feed monitoring and violation analysis.
- Options for video uploads to analyze previously recorded footage.
- Role-based user management for administrators and city officials.
- A responsive design for easy use across devices.

4.2.2. Back-End Communication:

To ensure efficient communication between the front-end and back-end, **FastAPI** was used. Its responsibilities are:

- Handling user requests for detection and incident management.
- Flawlessly integrating detection models with the application.

4.2.3. Back-End:

The server-side logic was managed using **Express.js**, which provided a strong and scalable framework for backend operations. Its core functions are:

- User authentication and role-based access management.
- Centralized storage and retrieval of violation, user, and log data.
- Managing interactions between the database and frontend.

4.2.4. Database:

A **MongoDB** database was employed to store critical data, including user information, detected incidents, and system logs. It stores:

- Detected violation records, including timestamps, locations, and images.
- User information and authentication details.
- Logs of system activities and settings.

4.2.5. Machine Learning Models:

This AI system uses:

- A **pre-trained model** for detecting illegally parked vehicles.

- A **custom-trained YOLO model** for identifying roadside vendors and carts.

4.2.6. User Flow:

- A user logs in through the authentication page.
- The dashboard displays real-time violation data and statistics.
- Users can access maps, reports, and system.
- Notifications alert users of new violations detected.

4.2.7. Use Cases:

- **Traffic Authorities:** Monitor and manage illegal parking zones.
- **Urban Planners:** Identify high-risk zones for policy adjustments.
- **Law Enforcement:** Access evidence for enforcing regulations.

4.2.8. User Features:

- Secure login and role-based access.
- Real-time monitoring and notifications.
- Detailed violation reports.
- User management.

5. Machine Learning Approach:

5.1. Data Collection:

We gathered image datasets from **Roboflow** and other websites, focusing on scenarios of illegal parking and roadside vendors. The data was thoroughly cleaned to remove irrelevant or duplicate entries and labeled with appropriate annotations, ensuring it was ready for training purposes. This process helped improve the accuracy and reliability of our detection model.

5.2. Model Selection:

For object detection, we chose the **YOLOv8** model due to its high accuracy and speed. YOLOv8 is well-suited for real-time applications because of its ability to process video feeds quickly and detect multiple objects in a single frame.

- **Pre-trained Model**: Used for detecting illegally parked vehicles to save time and resources.
- **Custom-Trained Model**: Developed for identifying roadside vendors and carts to address specific project needs.

6. Implementation:

6.1. System Features:

Our system provides the following features:

1. **Real-Time Detection:** The AI model analyzes live video feeds and identifies unauthorized roadside vendors and illegally parked vehicles instantly.

2. **Video Upload:** Users can upload pre-recorded videos for analysis, enabling flexibility in monitoring different areas.

3. **Alert Notifications**: The system generates instant alerts for detected violations, ensuring authorities can respond quickly.

4. **Incident Management**: Users can review, update, and track detected violations, maintaining a record of past incidents.

5. **Role-Based Access:** Different levels of access ensure that city officials and administrators can perform their roles effectively.

6. **Centralized Storage**: All violation data, user information, and system logs are securely stored in a centralized database.

6.2. Challenges Faced:

- **Data Collection:** Finding a balanced and diverse dataset for vendors was difficult causing class imbalance issues.

- **Model Training:** Training a custom YOLOv8 model for roadside vendors and carts demanded extensive computational resources and time.

- **System Integration:** Connecting the trained models with the website via FastAPI required careful handling of API requests and data flow.

6.3. Wireframes:

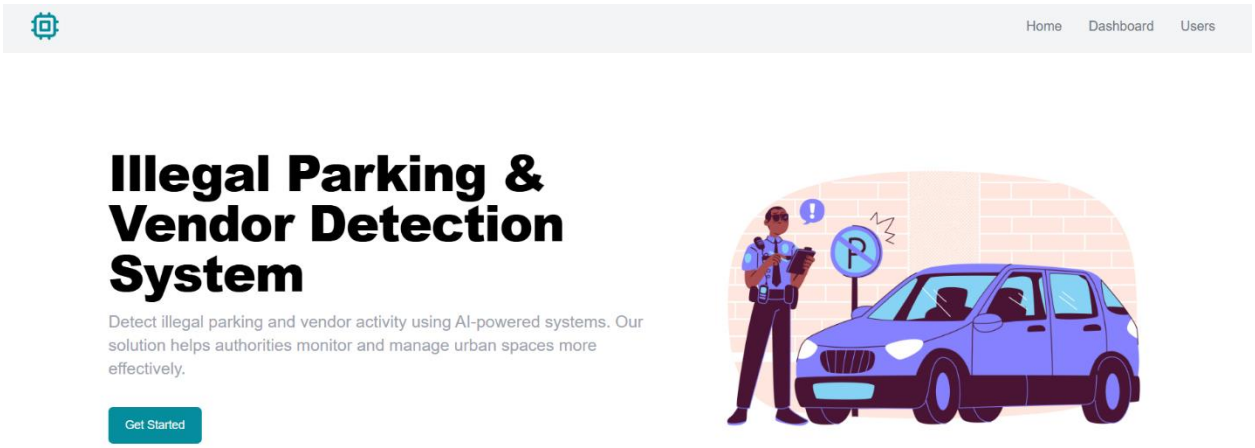

Figure 1 Landing Page

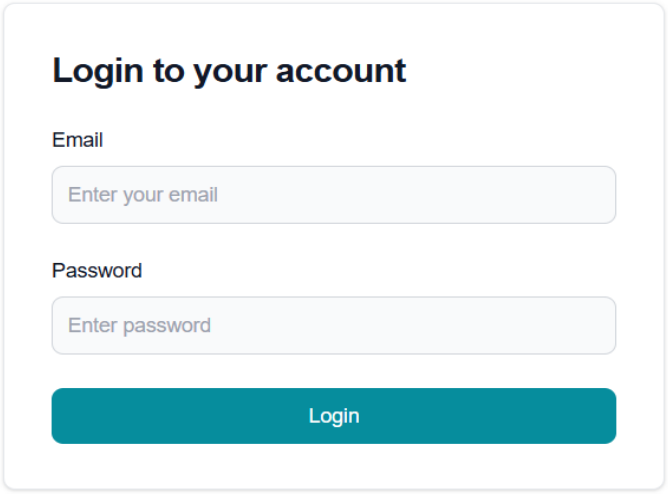

Figure 2 Sign in Page

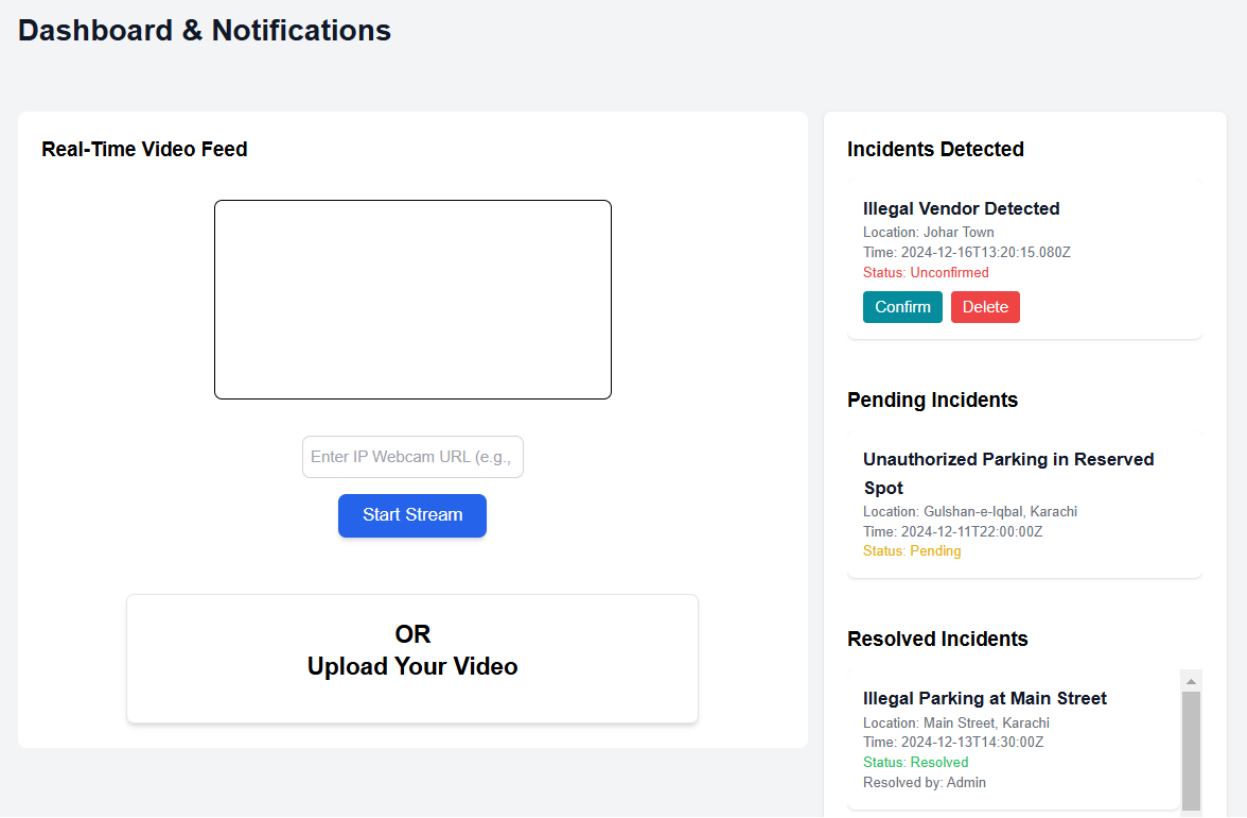

Figure 3 Admin Dashboard

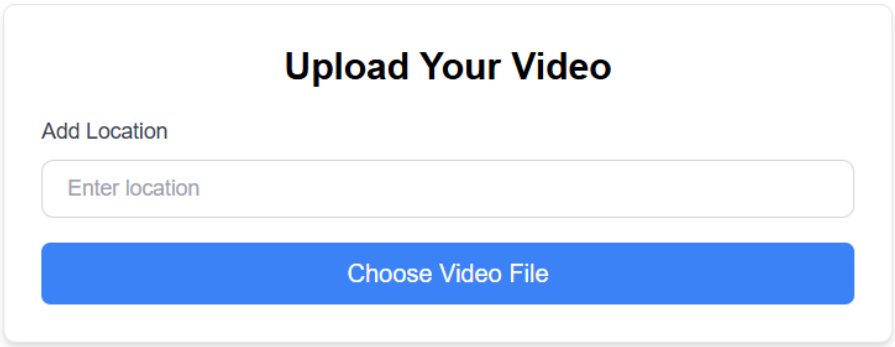

Figure 4 Upload Video

ADD USER

	ID	Name	Email	Role	Actions
☐		test	test@gmail.com	Admin	
☐		test2	test2@gmail.com	Admin	
☐		abc	saadakmal460@gmail.com	Police_Officer	
☐		Admin	admin@gmail.com	Admin	
☐		testuser	testuser@gmail.com	Police_Officer	
☐		ali	ali@gmail.com	Admin	
☐		police	police@gmail.com	Police_Officer	
☐		amjad	amjad@gmail.com	Police_Officer	

Figure 5 User Management

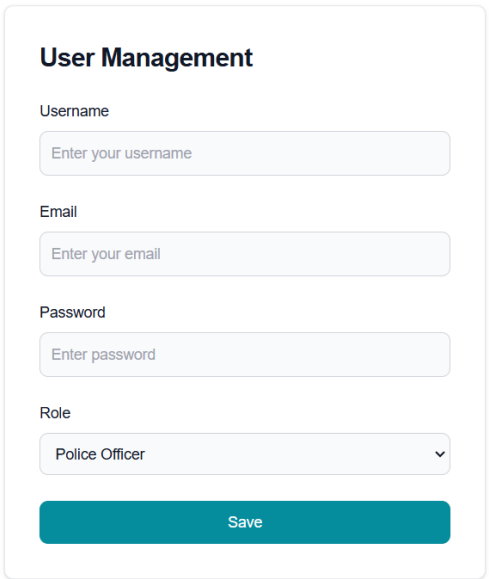

Figure 6 Add new User

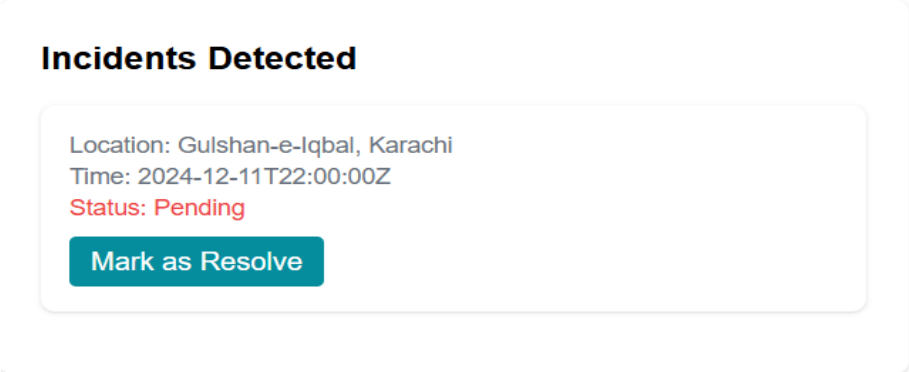

Figure 7 Police Response Dashboard

7. Results and Discussions:

7.1. App Evaluation:

Our AI-based system for detecting roadside vendors and illegally parked vehicles was tested on live video feeds and pre-recorded footage. The system successfully identified violations in various urban settings, demonstrating its ability to adapt to different environments. It was also evaluated for its user-friendly interface and continuous operations.

7.2. Performance Metrics:

- **Accuracy:** The system achieved an accuracy of 92% for detecting illegally parked vehicles using the pre-trained YOLOv8 model and 74% for roadside vendors and carts using the custom-trained model.

- **Precision**: The precision for detecting vendors was 80%, ensuring minimal false positives.

- **Recall**: A recall of 74.3% was recorded for roadside vendor detection, reflecting effective identification of violations in varied settings.

- **Processing Time**: The system processes live video feeds with a latency of fewer than 13 seconds, ensuring real-time monitoring.

7.3. Comparison with other systems:

When compared to existing systems like the "**AI Powered Illegal Parking Detection**" by **Allgo Vision**:

- **Scope**: Unlike Allgo Vision's focus on designated parking areas, our system monitors roadside areas.
- **Features**: Our project extends functionality by detecting vendors and carts alongside illegal parking, offering a broader application.
- **Integration**: The inclusion of a web-based dashboard and user management features makes our system more versatile and accessible for city officials.

8. Conclusion:

8.1. Summary:

This project addresses the growing issue of roadside vendors and illegally parked vehicles in urban areas with the combination of artificial intelligence (AI). Using a pre-trained YOLOv8 model for detecting parked vehicles and a custom-trained model for vendors and carts, we developed a system capable of analyzing both live video feeds and uploaded recordings. The integration with a user-friendly web platform allows for real-time monitoring, user management, and incident tracking, offering a wide solution to urban management challenges.

8.2. Key Findings:

- Achieved high accuracy in detecting violations with 92% for illegally parked vehicles and 74% for vendors and carts.
- Implemented real-time video feed analysis and pre-recorded video support.
- Developed a user-friendly interface with role-based access and centralized storage for efficient data management.
- Enhanced city officials' ability to monitor and respond to violations effectively.

8.3. Future Work:

To further improve the system, we propose:

- Expanding the dataset with more diverse scenarios to improve detection accuracy.
- Optimizing the model for faster processing in low-resource environments.
- Developing a mobile application to provide on-the-go access for city officials.
- Adding advanced analytics and prediction capabilities to enhance urban planning.