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AI Powered Traffic Violation Detection

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Abstract: The number of two-wheelers is rapidly increasing. The number of traffic violations and accidents are also becoming substantially higher due to unsafe riding like riding without helmet, triple riding and using mobile phone while riding. The current system for monitoring traffic mainly involves manual monitoring or analog cctvs which affects efficiency and human error, a tedious and time taking the process. To tackle these challenges, the project proposes an AI-Powered Traffic Management System that automatically detects and penalizes traffic violations by two-wheelers, employing the live feed of a webcam or CCTV camera. The YOLOv8 deep learning-based object detection model will be used in the system for quickly detecting helmet absence, triple riding, mobile phone usage while riding, etc. The EasyOCR technique is employed to detect a vehicle's number plate and then the details of the violation, the details of the rider, date and time, and the fine amount to be charged are all stored in one central location. After the fine is imposed, a system-generated email notification is sent to the vehicle owner containing details of the violation and the amount for which the fine is imposed. All fined records are maintained in the system for monitoring and reporting and for further analysis in the future. The whole system has been developed using Python, OpenCV, Decision Tree and EasyOCR implementing in Visual Studio Code. Moreover, the experimental result shows high accurate, real-time, high accuracy, and reliable detection in practical traffic. The system reduces human interference, automates the traffic rule compliance monitoring, enhances transparency and scalability which boosts road safety and facilitates intelligent and smart traffic management systems (TMS).

Keywords: AI-Powered Traffic Management System, Traffic Violation Detection, YOLOv8, Computer Vision, Helmet and Rider Safety, License Plate Recognition, EasyOCR, Real-Time Video Analysis.

I. INTRODUCTION

Road safety gets lots of attention these days in cities. That's mostly because vehicle numbers have shot up - especially motorbikes, which make up a big part of road users in poorer nations. Riders on two- wheelers face high risks when crashes happen. On top of that, breaking rules such as skipping helmets, carrying three people, or texting while driving makes bad outcomes way more likely. Even though laws exist and cameras watch streets, enforcing them stays tough since human tracking can't handle the growing number of vehicles.

The way old-school traffic control works depends mainly on cops being there. These days, they usually use regular surveillance cameras. Officers have to spot rule-breaking by hand. That process takes ages while needing lots of effort - and mistakes can happen easily - so staying alert nonstop becomes tricky. On top of that, today's auto systems spot things like red-light jumps or speeding -but miss key two-wheeler issues. Because of these gaps, we need a smarter, self-running setup that can grow easily.

Nowadays, progress in how computers see things, smart machines, and advanced pattern recognition lets us build cameras that understand what's happening right away. Models like YOLO can spot many items in a scene quickly while staying precise - no delays or mistakes. Because of this tech, catching drivers who break road rules happens on its own, making it easier for police to take action when needed.

A smart traffic setup's introduced here to catch common bike violations- like three people riding together, no helmets, or texting while driving. Instead of just recording footage, it actively spots rule-breaking using YOLOv8 on video feeds from regular cameras. Once something happens, the tool switches gears and pulls out plate numbers through EasyOCR tech. After grabbing that data, it logs the offense type, date, penalty cost, plus rider info into a digital log. Then - without any human push - a message gets sent by email to the bike's registered user.

With quick, accurate spotting of traffic violations, this setup aims to cut down on manual work while boosting how well rules are enforced - making roads safer at the same time. It fits into the vision of smarter urban areas, pushing forward smart transit tech through live monitoring, digital data sharing, along with auto-created reports.

II. RELATED WORK

Smart transport tech now uses image analysis plus machine learning to track traffic and spot rule breakers. One key part - reading license plates automatically - gets lots of attention in road safety tools. Mufti's team looked at many plate-reading approaches, pointing out problems like poor lighting, blurry movement, or messy surroundings. Singh with Gupta checked how these systems work outside labs, showing why strong, reliable models are essential for actual use

Because deep learning came up, YOLO-style object detectors got popular - thanks to fast results on the fly. Early versions like YOLOv4 [8], along with YOLOv7 [7], brought design upgrades that boosted both precision and response time, fitting well into monitoring road activity. Those builds set the stage for newer iterations running live in traffic systems.

Some research zeroed in on catching bike riders without helmets - using smart algorithms that learn patterns. Nie [2], along with Chen et al. [3], used a tool called YOLOv5 to spot helmet use instantly, showing strong results when testing was done neatly. Over time, Nouman et al. [4] upgraded this method by tweaking how details are pulled from images, making their version run smoother than before. More lately, work led by Aboah et al. [9] plus Agorku et al. [10] made progress by blending tricks like training models with very little data while also combining multiple models - to handle gaps where examples were missing or uneven.

Beyond spotting helmets, studies have looked into wider traffic monitoring and rule-breaking detection. Patel and Chawla [5] built an AI-powered setup with YOLOv8 that catches various offenses, showing auto-tracking can actually work. Aboah and team [11], instead, introduced a camera-driven method combining deep learning with decision trees to flag odd behaviors - proving smart processing helps tackle tricky road situations.

E-challan automation's been getting noticed as a way to go digital with traffic checks. Instead of manual work, Mishra and Sahu [12] used OCR through an ANPR setup to issue fines online. Building on that, Kumar et al. [13] brought in deep learning tools - boosting how well violations are spotted. On another track, Nair and Raj [14] mixed YOLO detection with OCR methods, making it possible to catch offenses and report them without human help. Detection of phone use during driving's mostly looked at four- wheeled vehicles. Rekkila [16] used a CNN method to spot when drivers handle phones, showing how deep learning can catch signs of distraction. While the study centered on cars, it still offers helpful insights for applying such methods to motorbikes instead.

At the same time, smart helmets using IoT tech aim to boost rider protection by tracking data with sensors. Shakil and team [17] reviewed how connected helmets can keep riders safer. On another note, Kamdi's group [18] built a smart helmet powered by Arduino. Even though these ideas help avoid accidents, they need extra gear and depend on users actually wearing them right - making it tough to roll out across whole cities.

Even though there's been big improvements in spotting helmets, reading number plates, and auto-generating fines, many current projects only tackle one piece at a time. Some tools look at just one kind of rule-breaking or depend on custom gear; very few tie everything together - like catching various bike offenses, grabbing plate info, storing data centrally, then alerting riders without delay. To fix this gap, our approach combines YOLOv8 for spotting several violations, OCR to pull out license numbers, along with a Python– SQL system running the backend, creating a full package that grows easily and works smarter for traffic control.

III. METHODOLOGY

The suggested approach introduces a smart traffic control setup that catches two-wheeler rule breaks live through video feeds. It zeroes in on serious offenses - like no helmets, three riders at once, or using phones while driving. Instead of humans watching, it uses advanced image analysis powered by deep learning to spot bikes and riders. After detecting vehicles, it reads their number plates, processes data behind the scenes, then sends alerts without delay. This whole process cuts down human effort, makes checking rules faster, also helps keep roads safer.

1. System Architecture

The setup of the new system appears in Figure 1. It works in sections - one part grabs data, another handles smart analysis, while the last manages background tasks. Video feeds come nonstop from street cameras, sent straight to a brain-like

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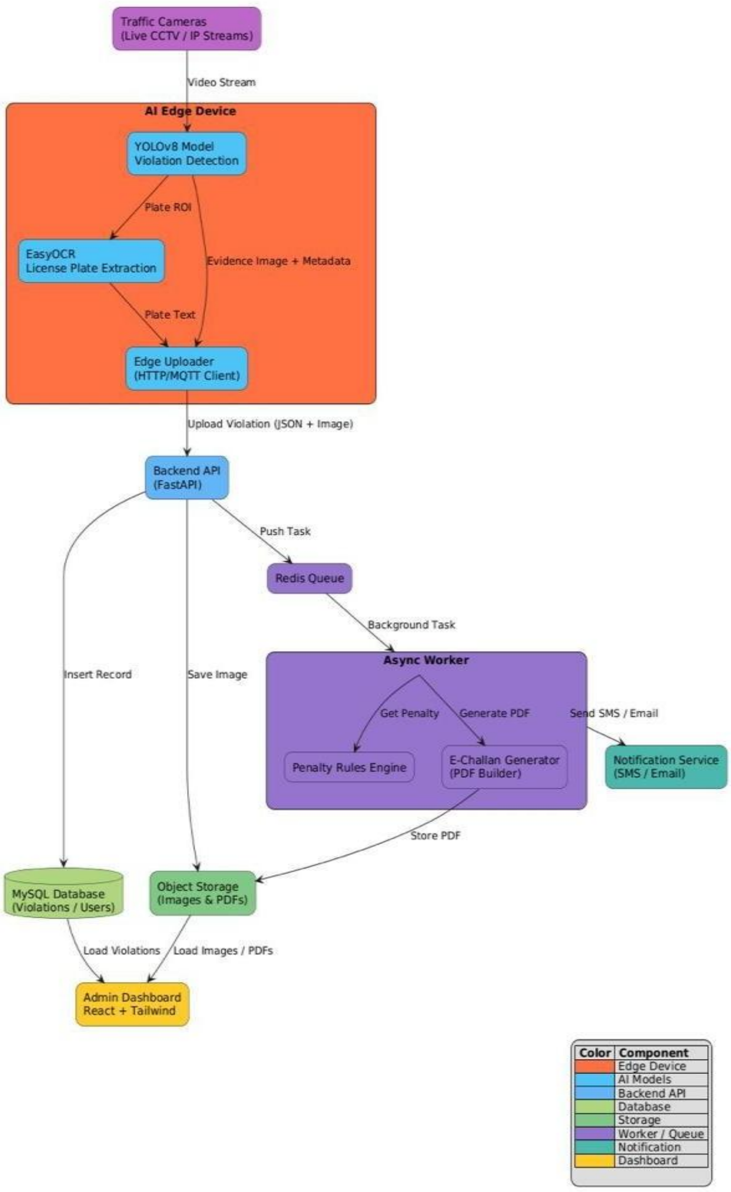
processing block. Each image gets scanned by a tool built on YOLOv8 that spots rule breaks plus reads car tags. The data gets sent to the backend server - there, violations are logged, proof is created, also alerts go out. This setup helps it grow easily, keeps things running fast, plus makes upkeep simpler.

Fig 1: System Architecture: AI-Powered Traffic Violation Detection



2. Functional Block Description

The setup's layout shows up in Figure 2. Instead of a regular cam, a traffic camera grabs live video clips. An on-site AI unit handles those clips using YOLOv8 software. That detection part spots bikes, headgear, handheld devices, overcrowded riders, or number tags. If a violation shows up, the system sends the license area to OCR so it can pull out the text. While that happens, the server handles storing info, creating proof, also sending alerts - on top of this, admins get a live view through a dashboard showing tracked offenses.

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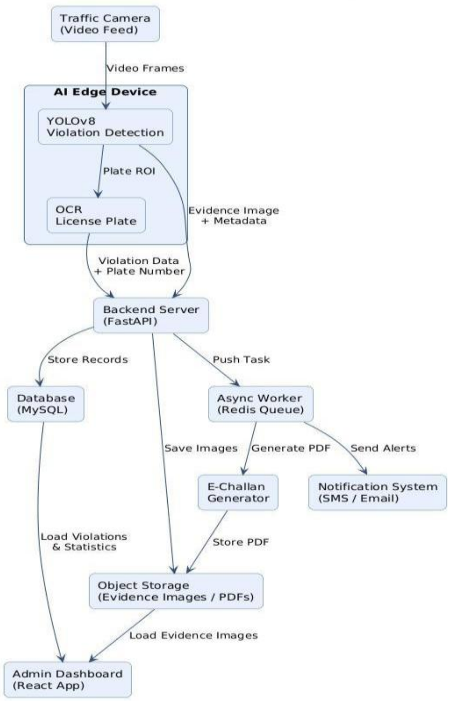
Fig 2: Traffic Violation Detection - Block Diagram



3. Dataset Collection and Preparation

The dataset for training and also testing comes from actual traffic scenes showing different two-wheel vehicle situations. It covers people on bikes with helmets, without them, using phones while driving, carrying three riders, motorbikes themselves, plus number plates. Images were gathered during varied light levels, from multiple camera views, and across diverse road settings to help the system work better in real life. Every photo got adjusted in size and scaled evenly so it fits what YOLOv8 needs at input.

4. Dataset Annotation and Distribution Analysis

All dataset pictures got hand-labeled with boxes around six types of objects - helmet, no-helmet, motorcycle, phone use, three people on a bike, and license plate. Labels were saved in YOLO style so they'd work smoothly during model training. We checked how often each category showed up to see if some were rare or overrepresented. Where labels were scarce, we used tricks like mirror flips, resizing, and light tweaks to boost their numbers. That helped the system spot less common cases better without missing details.

5. Traffic Violation Detection Using YOLOv8

YOLOv8 got picked because it's fast and spots objects well on the fly. Instead of multiple steps, it finds different things - like helmets or bikes - in one go. No anchors are used here; that helps speed things up during live monitoring. Its built-in structure has been fine-tuned to handle video feeds without lag. To keep results reliable, only predictions above a certain score stay through filtering.

Fig. 4. Sample annotated images and class-wise dataset distribution.

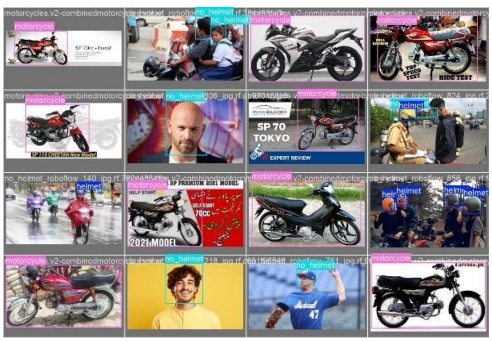


Fig. 4. Sample annotated images and class-wise dataset distribution.

Fig. 5. YOLOv8-based detection of multiple traffic violations

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5 Performance Evaluation Metrics

The trained model's results were checked with common object detection measures like precision, recall, F1-score, or mAP. To look at how accurate predictions were per class - along with where mistakes happened - a confusion matrix was analyzed. Instead of just one view, Precision–Recall checks showed how well precision and recall balanced out at various confidence levels, which highlights that the system works consistently.

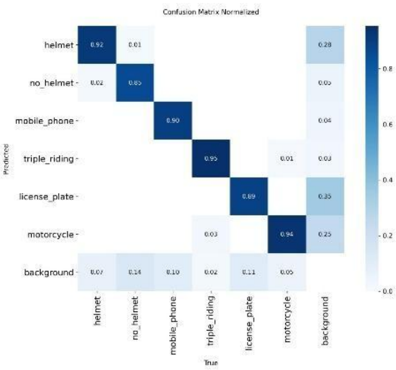

Fig. 8. Normalized confusion matrix

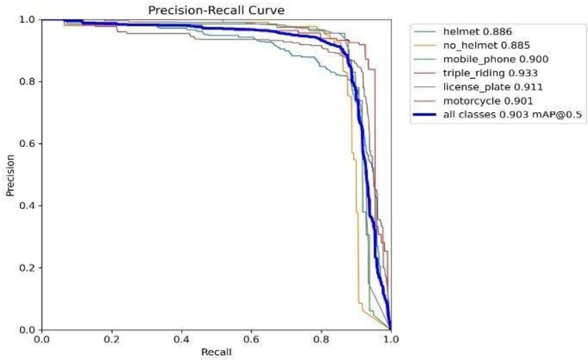

Fig. Precision–Recall curve

6. Backend Integration and Automation

The backend runs on Python, linking to a SQL database that safely holds traffic offense info. When a breach happens and the plate's grabbed, it saves key facts - like car ID, violation kind, moment of incident, along with penalty sum - straight into storage via Python- driven commands. Instead of just saving data, it fires off an automatic message to the driver's known email, spelling out what went wrong, how it unfolded, plus the fee due. Thanks to this self-running setup, entries stay correct, alerts go out fast, human steps drop away, making enforcement smoother from end to end.

7. Methodology Summary

The backend setup uses Python along with a SQL database to safely store and share traffic violation info. Instead of manual entry, it logs each incident - like car plate, offense kind, time, and fee - all in order. Once saved, the system sends an email straight to the driver, including full details about the ticket. Thanks to this flow, handling records gets faster, updates are clear, effort drops significantly, making road rule enforcement smoother overall.

IV. CONCLUSIONS AND FUTURE WORK

This project introduced a smart traffic tool that spots bike rule breaks - like three people on one scooter or texting while driving - using advanced image analysis instead of old-school methods. It combines a powerful object detector (built on YOLOv8) with live video streams or user-uploaded pictures to catch offenses reliably, along with certainty levels for each result. Fines get calculated without hands-on help; all records are managed from one control panel. Data stays safe in MongoDB, while alerts go out via email - making every step digital and smooth. Tests showed it works well in everyday settings, needing almost no person-in-the-loop action, beating conventional ways by being more precise and easier to scale up. Overall, this setup gives cities a solid starting point for smarter road oversight.

The suggested setup could get better if it checks more road rules - like spotting missing helmets, ignoring signals, speeding, or wrong lanes. Linking up with official car records might let it pull driver info fast, making fines easier to issue. Running this on local hardware helps cut delays and handles live tracking across big areas. Down the line, tools like smart overview screens could map out traffic trends. Officers and regular folks might use phone apps tied into the network. Tracking vehicles using several cameras at once can manage crowded roads where views get blocked. Tweak the AI smarter and train models together without sharing raw data - it keeps results sharp, private, and ready to grow.

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