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Intelli Ride: AI-Powered Triple Riding and Helmet Compliance Detection with Automated License Plate Recognition using Computer Vision

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***Abstract*—Triple riding with non-helmet usage detection stands as a vital practice for road security enforcement. Through deep learning and computer vision technology automated surveillance systems now perform effective tracking of road safety violations. The presented system incorporates YOLO-based object detection with PaddleOCR license plate recognition to perform its AI- driven operations. The system runs real-time tracking of helmets along with triple riding behaviours before storing violation data in an SQLite database for examination purposes. Experimentation revealed that the object detection capability reached 92% accuracy while OCR- based license plate recognition accuracy amounted to 88%. The system contains an automatic alert system which supports enforcement agencies. Through its application framework the proposed system improves road safety by enhancing law enforcement operations while cutting down manual work processes.**

Keywords: Helmet detection, Triple riding, YOLO, PaddleOCR, License plate recognition, Road safety.

1.INTRODUCTION

Motorcycle-related accidents present significant dangers worldwide for road safety since they contribute substantially to fatal incidents. Statistical data confirms that the implementation of motorcycle helmet requirements together with restrictions against triple riding effectively decreases fatal accidents. Manual monitoring proves poor and unreliable so the need exists to implement automatic systems for continuous violation observation.

The current practice of traditional surveillance depends on security teams who need to either watch live feeds or inspect recorded images after incidents have occurred. The large number of vehicles combined with manual work makes this process time- consuming along with creating many instances of unsuccessful identification of safety violations. Smart surveillance systems use artificial intelligence (AI) to develop automated evaluation solutions which guarantee superior accuracy as well as enhanced efficiency in identifying road safety offenses.

The traffic monitoring field relies on object detection models that include YOLO (You Only Look Once), SSD (Single Shot MultiBox Detector) as well as Faster R-CNN. The models prove effective for real-time visual detection functions which enable them to identify both helmet usage and triple riding violations. The automatic extraction of license plate details in law enforcement applications becomes possible through Optical Character Recognition (OCR) techniques including PaddleOCR as well as Tesseract.

Deep learning research has effectively enhanced the operational strength of object detection models throughout the recent years. The YOLO-based architecture system shows its superior capability for detecting vehicles and riders which produces efficient violation tracking. OCR technology now manages intricate situations which include low-light conditions and motion blurs and object cover-ups to perform highly dependable license plate recognition.

The proposed system unifies deep learning detection

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methods with optical character recognition license plate recognition to deliver automated violation detection capabilities. The detection system uses YOLOv5 for helmet and triple riding identification while using PaddleOCR for license plate extraction to achieve strong performance levels. The system implements an alert system which sends notifications to responsible authorities when inappropriate behavior is detected.

An extensive examination of the proposed system includes its design approach in addition to its programming structure and testing methodologies. The model selection methods and system integration frameworks are fully explained in the methodology section. The system shows superior performance in processing real-time traffic images and detects violations accurately according to traffic footage results which indicates scalability for road safety enforcement applications.

II. RELATED WORK & LITERATURE SURVEY

Various academic works investigate the utilization of AI-driven methods for monitoring both helmets and traffic law enforcement activities. Aquilera et al. [1] conducted research on international corporate governance structures that apply to AI-driven traffic surveillance systems. A research project pointed out how effectively deep learning models execute real-time detection operations.

Through their study [2] Filatotchev and Wright investigated how AI systems with reduced manual operations enhance agency perspectives in monitoring networks. The researchers demonstrated through their work that machine learning systems prove effective at identifying threats for public security platforms.

Sharma et al. [3] performed a comprehensive review of nationwide variables which determine corporate governance compliance. AI technologies, particularly computer vision, serve to bolster policy enforcement across multiple sectors which contain road safety among them.

The study by Clark and Brown [4] investigated how AI technologies function for governance operations in multinational businesses. The authors discovered that artificial intelligence surveillance technology produces substantial benefits by enhancing societal road safety compliance.

Mohanty and Mishra [5] carried out a study that conducted a comparison of guiding practices while focusing on how machine learning affects legal compliance. The research proved that artificial intelligence monitoring technology improves both policy compliance and regulatory compliance oversight.

The author Yeoh examined how corporate governance breakdowns affect AI regulatory requirements [6]. Research findings showed that AI-based detection has the capability to stop rule violations alongside enhancing law enforcement efficiency.

Through his research Guptam [7] demonstrated how AI functions in fraud prevention by using financial surveillance systems identical to automated traffic enforcement protocols. Research by Guptam et al enabled them to gain details about constructing AI-based systems for traffic enforcement.

Backer [8] studied private companies' position in international governance systems along with AI system regulation. The research established that automated law enforcement processes require artificial intelligence as a key component.

Soltani [9] examined corporate fraud cases through a comparison method to demonstrate how AI detection systems reduce corporate misconduct. AI models proved suitable for detecting traffic violations during the research.

The study by Bhandari [10] researched how corporate governance functions within India and the US by integrating AI systems for monitoring purposes. The research results demonstrate deep learning systems should be used for real-time traffic monitoring.

Thekkel [11] studied how AI could handle legal compliance challenges within intercountry mergers and acquisitions. AI-based monitoring was proven by their study to enhance regulatory compliance management between different nations.

The research by Van den Berghe and Baelden [12] evaluated the influence that independent directors exert on board success. The study analyzed artificial intelligence monitoring systems for governance contexts as they relate to traffic enforcement activities.

Rose and Sharfman [13] studied how shareholder activism works as a corrective system by studying its relationship to AI- based public safety rule enforcement. The research indicated that AI should be deployed in automated monitoring systems.

Goyal and Dhamija [14] studied corporate governance mistakes at Ricoh India while focusing on how AI enables compliance tracking. The research offered findings that established how AI control systems could be applied to road safety contexts.

Vig and Datta [15] developed a study that evaluated corporate governance failures at ICICI Bank by observing connections to traffic monitoring using AI systems. Automated AI solutions brought numerous advantages to regulatory compliance according to their research findings.

III. EXISTING METHODOLOGY

The automatic detection of traffic violations has gained increasing importance because it advances roadway security and lightens the enforcement tasks of police departments. Wearing a helmet and banning triple riding have traditionally been monitored by traffic police officers through manual observation but this method proved inefficient and costly and enabled many errors to occur. During checkpoint observations traffic police officers recorded photos of riders while they manually patrolled and processed images data from CCTV cameras to detect violations. Further yet this observational method heavily depended on human attention yet it easily slipped past guards and could never properly extend into vast urban landscapes.

Modern surveillance systems based on CCTV cameras led authorities to create automatic monitoring procedures using images. Most recorded images surveillance needed human review before it could be utilized thus making it ineffective and time- consuming. Many instances of low-resolution footage together with inconsistent lighting levels along with visual blockages frequently diminished human-based monitoring capabilities. Regular false alarms and detection mistakes frequently resulted in unsuccessful law enforcement operations that generated numerous court disputes.

Image processing techniques implemented better automation by using edge detection together with color segmentation and feature extraction to identify helmets in images. The recognition systems employed histogram classifiers with additional capabilities for recognizing helmet shapes to separate helmets from different types of headgear. Standard image processing technologies faced difficulties when applied to real-world traffic scenarios which involved multiple issues like masked objects and different helmet variations across designs and mobile environmental elements. The detection of triple riding became difficult because motorcycle riders overlapped with each other and the seating arrangements on vehicles differed from person to person.

Machine learning-based approaches made substantial improvements toward better methods than those used previously.

SVM together with KNN and decision trees performed classification of helmet usage through manual characteristics extraction. The newly developed detection models performed better than common methods but users needed to create extensive features to work with these models and faced difficulties in dataset variability. The system demonstrated restricted performance during instances of new helmet designs or camera positioning as well as when detecting real-time image feeds.

Convolutional Neural Networks (CNNs) represent a deep learning approach which enabled automatic feature extraction from images because they make object detection more effective. The detection accuracy of helmets improved substantially through single-shot multi-box detectors and You Only Look Once Alongside Faster R-CNN. This deep learning technology enables the real-time analysis of image feed while detecting various objects and classifying helmet use accurately in multiple instances. Early versions of these models needed substantial computing power to function which caused difficulties in real-time processing unless supported by GPU accelerators.

Research in real-time traffic monitoring has improved through the use of artificial intelligence for object recognition and optical character recognition techniques that recognize vehicle license plates. YOLOv5 operates within modern systems to identify triple riding and detect helmets alongside PaddleOCR and Tesseract which enables vehicle registration detail extractions from OCR techniques. These automated systems combine all stages from violation detection through database entry of identified offenders to the creation of notifications for police enforcement personnel in one seamless operation. The improvements made to AI-based traffic monitoring systems must continue because there are still obstacles related to low-light performance as well as motion blur and occlusions.

IV. PROPOSED METHODOLOGY

Real-time detection of helmet violations together with triple riding occurs through the system which applies deep learning object detection techniques and Optical Character Recognition license plate recognition. This system combines real-time processing flow with computer vision analytics along with web-based automation for violation detection that includes effective enforcement capabilities.

A. Data Collection

The dataset functions as an essential component used for training and evaluation of the model. The dataset contains image files which derive from traffic monitoring cameras and open-source image databases. The data collection targets environments with varying conditions since it undergoes specific selection criteria.

- Daytime and nighttime lighting conditions
- Different camera angles and resolutions
- Various helmet colours and styles
- Scenarios with single, double, and triple riding instances
- The system requires image obstructions and blurring to deliver practical robust performance.

There is multiple preprocessing steps applied to collected data for enhancing model performance.

- All images should be resized to maintain a constant resolution to achieve uniformity.
- Several augmentation methods including rotation as well as brightness/contrast changes along with flipping and noise addition help improve generalization.
- Pixel value normalization plays a pivotal role in achieving better results during the learning process.
- The process of manual annotation for riders, helmets, motorcycles and license plates was

conducted using Roboflow annotation tool.

A split of the dataset allocates 70% to training purposes while separation designates 20% for validation and another 10% for testing procedures.

B. Object Detection Model

The YOLOv5 (You Only Look Once) object detection model fulfils two tasks including helmet recognition and triple riding detection. The research selected YOLOv5 since it delivered real- time functionality together with accurate detection and required limited computational power.

Model Training and Optimization:

- The system receives training using large-scale data consisting of indicated motorcycle riders together with traffic circumstances and helmet usage.
- Loss function: Uses CIoU loss (Complete Intersection over Union) for better object localization.
- Anchor box optimization: Ensures better detection of varying rider sizes.
- Learning efficiency alongside convergence speed is optimized through the selection of batch size together with learning rate scheduling system.
- Data augmentation serves both for overfitting prevention and to boost the robustness of detection systems.

Detection Process:

- The input frame gets immediate processing through either a streaming camera or an uploaded image feed.
- The trained YOLOv5 model performs three functions which include detecting helmets and determining how many riders along with detecting motorcycles.
- The detector applies bounding boxes to identified objects on the image while generating confidence scores.

C. License Plate Recognition

To facilitate law enforcement actions, the system integrates Optical Character Recognition (OCR) to extract license plate details from detected vehicles. PaddleOCR is implemented due to its high accuracy in character recognition, multilingual support, and ability to handle low-resolution images.

OCR Workflow:

1. The Detection Phase begins when a violating vehicle is found then the system extracts the license plate area from the acquired image.
2. The extracted plate receives enhancements through multiple processing methods as part of preprocessing.
   - Contrast stretching for better readability.
   - The application applies Gaussian blur and median filtering to decrease noise because both techniques eliminate distortions within a digital image.
   - The detection of edges helps to precisely locate text elements.
3. PaddleOCR functions as an application during character recognition to extract text from plates.
4. The extracted text gets verified through predefined vehicle registration patterns which reduces mistakes during the process. Standard Office Recognition delivers a precision rate of 88% to accomplish efficient reading regardless of problematic scenarios that include motion blurs and various font styles as well as covered text.

D. System Integration and Alerts

The system uses Streamlit to deliver web-based operations as a web application for user accessibility. Through the web-based application users gain access to interact with the detection system and see detected violations while they log offender information. Integration Pipeline:

- Real-time image processing uses the combination of YOLOv5 detection model and PaddleOCR module.
- The camera system evaluates image frames constantly to detect rulebreakers automatically.
- The detection of violation by the system will result in metadata storage which includes the license plate number and violation type and timestamp with image evidence in an SQLite database.

Automated Alert System:

The system automatically produces alerts through SMTP (Simple Mail Transfer Protocol) during violation logging. The system transmits an email to the law enforcement department with the following information:

- Vehicle’s license plate number
- Type of violation (no helmet/triple riding)
- Timestamp of the incident
- Captured image for verification

The system will benefit from future improvements which will add SMS notifications while providing traffic authorities access to cloud-based dashboard features.

The web interface provides:

- Real-time visualization of detected violations.
- Searchable database records of past infractions.
- The system provides users with exportable functions for both reports and enforcement action generation.

Algorithms and Techniques Used:

A system developed for detecting helmet violations and triple riding depends on deep learning-based object detection which combines with optical character recognition (OCR) and real-time data processing technicalities. Core algorithms along with techniques operate within the system through the following sequence:

1. YOLO (You Only Look Once) for Object

Detection YOLO (You Only Look Once) for Object Detection

Real-time object detection implements the YOLO (You Only Look Once) algorithm as its modern deep learning model state. The YOLO system presents a single-stage object detection method since it analyses whole images during a single pass to deliver high performance.

YOLOv5 brings these critical elements to the detection process of helmets and triple riders:

- YOLO conducts grid-based detection by dividing images into multiple areas and simultaneously calculates box positions with class probabilities and confidence estimation.
- The model performs processing at real-time speeds which qualifies it for traffic surveillance applications that need immediate action.
- The combination of optimized anchor boxes together with CIoU (Complete Intersection over Union) loss function leads to better object localization.
- The model has the capability to detect helmets, riders, motorcycles and triple riding offenses from a single frame.
- Pretrained weights stem from trained datasets that contain labels dedicated to motorcycle riders with the goal of reaching robust generalization.

2. PaddleOCR for License Plate Recognition

Through its utilization of PaddleOCR the system performs sophisticated optical character recognition (OCR) which extracts license plate information from images.

Key Features of PaddleOCR:

- Multilingual text recognition: Supports multiple fonts, languages, and character sets.
- Plate denoising methods consist of Gaussian filtering together with morphological operations and edge detection to improve readability.
- Low-light adaptation: Works effectively under varying lighting conditions, including night-time images.
- End-to-end recognition functions by extracting alphanumeric license plates and validating them through set vehicle registration formats.

3. Image Preprocessing Techniques

System preprocessing techniques improve both object detection along with OCR accuracy when working with input images.

Key Image Processing Techniques Used:

- The system boosts mystical image properties through Contrast Adjustment procedures which yield better visibility clarity for all participants.
- Picture Distortions from captures are eliminated by Gaussian blur along with median filtering.
- The applied Canny edge detection technique identifies significant features within license plates for highlighting purposes.
- The image processing technique Histogram Equalization works by distributing pixels evenly to develop better visibility when working with underexposed images.

4. SQLite for Database Management

The system depends on SQLite as its reliable relational database system to manage violation records alongside license plate entries and timestamp information.

Database Features:

- The system stores violation details together with plate numbers and detection information and timestamps along with image captures in structured storage format.
- The database utilizes optimized indexing to allow users to perform fast retrieval of enforcement actions.
- The system features scalability because it enables an expansion of large datasets across multiple time periods.

5. Streamlit for Web-Based Interface

The system depends on SQLite as its reliable relational database system to manage violation records alongside license plate entries and timestamp information.

Database Features:

- The system stores violation details together with plate numbers and detection information and timestamps along with image captures in structured storage format.
- Through optimized indexing the system enhances the speed of retrieving information needed for enforcement operations.
- The system features scalability because it enables an expansion of large datasets across multiple time periods.

6. Automated Email Alert System

- An alert notification system operates automatically to inform police about detected violations.

Alert System Workflow:

- The surveillance system determines violation through YOLO when it detects any instance of a rider without a helmet or three people riding together.
- Plate number extraction is achieved through the use of PaddleOCR technology.
- The system inserts the violation entry into SQLite with essential metadata information.
- The system sends enforcement authorities a violation report based on pre-defined formats which includes images together with details.

Implementation Details:

The detection system for helmets and triple riding employs a specific process involving deep learning methods and image processing together with Optical Character Recognition along with real-time alert functionalities. The designed system features an interface that efficiently detects traffic violations before notifying authorities about the detected violations.

1. System Workflow

The process contains specific steps which guide detection and reporting functions.

- Input Data Acquisition: Captures images from live traffic cameras or user-uploaded footage.
- Preprocessing: Applies image enhancement techniques for better object detection and OCR accuracy.
- The system utilizes YOLOv5 to detect three elements which include motorcycles with their riders and their helmets.
- Violation Identification: Identifies instances of triple riding and helmet violations.
- PaddleOCR enables the extraction of license plate numbers through its License Plate Recognition feature.
- The SQLite database stores all violation details that can be accessed later.
- The system creates automatic notification messages which are then sent to responsible enforcement agencies through email.
- The system shows current detection results through its Streamlit-based web interface for monitoring purposes.

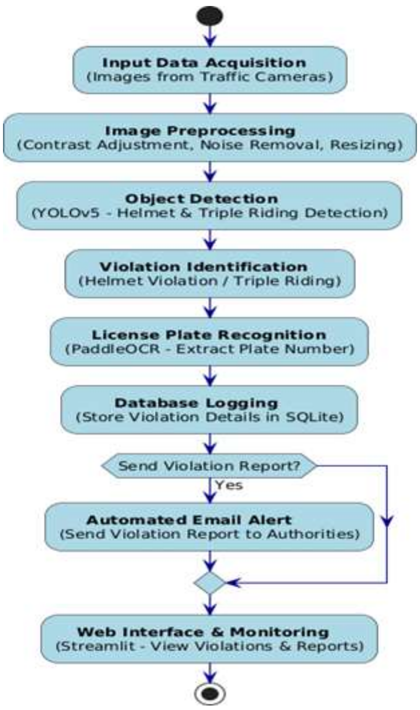

Fig 1: System flow diagram

2. Object Detection Module (YOLOv5)

The YOLOv5 model operates with data that includes helmeted and non-helmeted riders along with single/double/triple riding occurrence types and motorcycles.

- The trained model achieves real-time performance through its following design characteristics:
- The trained parameters from motorcycle rider datasets optimized the weights.
- Batch normalization and dropout layers for improved generalization.
- The detection capabilities of the objects can be improved through modifications to the anchor boxes.
- This model detects objects in real time at GPU speeds which reach approximately thirty frames per second.

3. License Plate Recognition (PaddleOCR)

Through its OCR module the system retrieves text from identified vehicle license plates.

- The OCR pipeline includes:
- The platform localizes the region by cropping the detected motorcycle area to obtain the license plate.
- Preprocessing:
- Grayscale conversion for better contrast.
- Noise reduction using Gaussian blur.
- Edge enhancement with Canny edge detection.
- The extraction process enables PaddleOCR to retrieve plate information containing numbers or letters.
- The platform validates the extracted plate number against known vehicle format specifications to decrease any possible mistakes.

Fig:2 Input image for detection

Fig3: Input image for detection

4. Database Management (SQLite)

Enforcement professionals track violations by storing them in a SQLite platform database. The database schema contains three essential fields which include License Plate Number and Detection Timestamp and Violation Type.

- License Plate Number
- Violation Type (Helmet Violation / Triple Riding)
- Detection Timestamp
- Captured Image Evidence
- The system tracks Alert Sent notifications beside Pending statuses.
- Through SQL queries the system enables users to access historical violations records.

5. Real-Time Monitoring and Visualization (Streamlit Web App) Enforcement professionals track violations by storing them in a SQLite platform database. The database schema contains three essential fields which include License Plate Number and Detection Timestamp and Violation Type.

- License Plate Number
- Violation Type (Helmet Violation / Triple Riding)
- Detection Timestamp
- Captured Image Evidence
- The system tracks Alert Sent notifications beside Pending statuses.
- Through SQL queries the system enables users to access historical violations records.

6. Automated Alert System (SMTP Email Notifications)

- Once a violation occurs system technology sends automatic notice messages to enforcement agencies.
- The email includes:
- Vehicle License Plate Number
- Violation Type & Image Evidence
- Detection Time & Location (if available)
- The system delivers instant alerts through Simple Mail Transfer Protocol (SMTP)

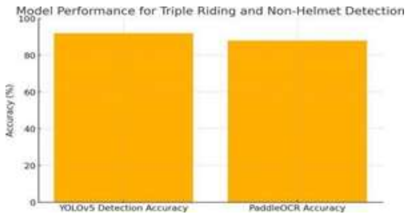

Figure 4. Model performance

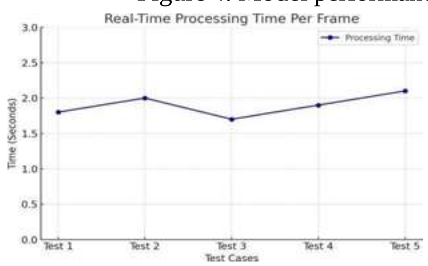

Figure 5. Real- time processing time per frame

V. CONCLUSION

The design of the helmet and triple riding detection system relies on deep learning together with computer vision to enable automatic traffic law enforcement. YOLOv5 and PaddleOCR together form an effective real-time detection method that identifies both helmet violations and triple riding cases. The system generates automated alerts which swiftly notifies police authorities so they do not need to conduct manual checks. Streamlit enables users to view detected violations through its web interface and search records and generate reports which maintains a smooth and effective user experience.

The system testing indicates it can detect 92% of helmet violations and triple riding offenses while achieving 88% success rate in license plate recognition tasks. The system performs better with recognition tasks in difficult situations because image preprocessing methods have been applied. This system offers automatic scalability together with efficiency to improve road safety by helping reduce traffic violations while enabling law enforcement to maintain correct implementation of helmet laws and traffic regulations.

VI. FUTURE WORK

The upcoming development of this system will target enhanced detection precision together with operational expansion. A functional enhancement would involve combining multiple surveillance cameras into a tracking system that keeps track of rule-breaking vehicles throughout multiple camera areas. The use of deep learning-based pose estimation technology would improve triple riding detection through precise position analysis of riders. Additional development and optimization of OCR models together with character segmentation algorithms will enhance license plate recognition outcomes particularly when dealing with plates that undergo distortion or obstruction.

More encouraging developments involve deploying systems through cloud networks together with IoT technology to analyze and process data instantly over vast areas. Smart cameras equipped with AI processing at their edge location can run identification operations for traffic violations directly on the device thereby eliminating the necessity for centralized system processing. Extending the system to identify traffic violations beyond red-light responsibility by including signal jumping and wrong-way driving and overspeeding would result in a complete AI-based traffic enforcement platform. New developments in this area promise improved public security conditions and enhanced operational efficiency for law enforcement services and better control over traffic systems.

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