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Traffic Anomaly Detection and Alert System

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ABSTRACT:

Traffic accidents caused by reckless driving and violations of traffic rules continue to be a major problem in many countries, posing a significant threat to the safety of drivers and passengers. To address this issue, we propose the development of a Traffic Anomaly Detection and Alert System that leverages cutting-edge computer vision and object detection technology to identify and alert authorities to traffic anomalies and rule violations in real-time. Our system utilizes a commercial NVR and CCTV camera to capture road footage, and employs YOLOv3 and OCR with CNN for character recognition to highlight violations with bounding boxes and record the license plate if it is visible. The detected data is then promptly transmitted to authorities and stored in a database for future reference. By enabling the real-time detection and alerting of authorities to reckless driving and traffic rule violations, our system has the potential to significantly enhance road safety and reduce the number of traffic accidents.

Keywords ***—YOLOv3, OCR, Convolutional Neural Networks***

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I. INTRODUCTION

Nepal has one of the highest estimated road traffic crashes (RTC) fatality rates in South Asia, with 15.9 fatalities per 100,000 population (World Health Organization 2019). Based on police reports aggregated from local traffic police offices, there were 10,178 road crashes, with 2,384 fatalities, 4,250 serious injuries, and 8,290 minor injuries in 2016 (Nepal Police 2019). Traffic Rules Violations along with bad road conditions is one of the main reasons for vehicle accidents in Nepal. According to the Traffic Police Nepal, in 2076/77 there were about ten thousand road accidents, out of those one hundred and fifty-three people lost their lives. There has been a seventeen percent increase in road accidents in 2076/77 compared to 2076/75. According to the studies around sixty percent of the accidents on the road is due to the carelessness of the driver which contains distracted drivers and over speeding the vehicles.

YEARLY ACCIDENT REPORT

Fiscal Year	No of Accidents	Fatality	Serious Accidents	Normal Accidents
070/071	4672	143	229	3481
071/072	4999	133	233	3643
072/073	5568	166	275	3901
073/074	5530	182	201	3914
074/075	6381	194	219	4333
075/076	8511	245	317	5890
076/077	10030	153	240	6684
077/078	9545	166	229	7095

So, in this project we detect traffic violations on a motor vehicle and if possible, recognize their number plate. To be able to detect multiple vehicles on the road we will use an object detection and deep learning algorithm YOLO V1 algorithm that can detect all possible objects in a single take hence the nameYOLO(You Only Look Once). It uses regression instead of traditional classification to calculate the bounding box of the number plate. After getting the image of the number plate, it is then pre-processed before character segmentation.

Individual character after segmentation is classified using CNN.

II. LITERATURE REVIEW

Nurhadi Yatna et. al (2012) Vehicle speed calculation using CCTV information as video data was implemented. In several major cities of Indonesia, CCTV is installed at many intersections, to monitor traffic conditions. Currently, CCTV installation in various cities in Indonesia, especially in Jakarta does not provide any systematic traffic conditions, as it is used for surveillance only. Video and image Processing utilization are widely used as part of an effort to solve the urban traffic problem. Consequently, this research has a focus on speed measurement via video processing, which will make better use of many CCTV s that have been installed on Jakarta streets and many other big cities in Indonesia. [1]

Rachmadi et. al (2011) An adaptive traffic signal control using a camera sensor has been proposed This work produces a vehicle counting system, which can identify traffic density. PCA is used to classify vehicles into a specific class. Vehicle feature data training is fed into the system by the Haar training method.[2]

Panas Tiwari et. al (2022) Proposes Nepali Number Plate detection and recognition using the object detection algorithm YOLO. It presents a new approach to object detection. Prior work on object detection re-purposes classifiers to perform detection. Instead, it frames object detection as a regression problem to spatially separated bounding boxes and associated class probabilities. A single neural network predicts bounding boxes and class probabilities directly from full images in one evaluation. Since the whole detection pipeline is a single network, it can be optimized end-to-end directly on detection performance. Also, vehicular speed detection was done using HB100 motion sensor which was quite difficult to implement in real life system as it cannot detect multiple objects at a time.[3]

Steven Thygerson et. al (2020) This study focused on the rate of helmet use among motorcycle drivers and passengers in Kathmandu, Nepal, and compared helmet use rates based on the type of road. The findings of the study show that while almost all drivers used helmets, the vast majority of passengers did not wear helmets. These results are consistent with previous research that has shown that helmet use among passengers is often lower than among drivers. The study highlights the importance of increasing helmet use among motorcycle passengers, particularly in developing countries where motorcycle use is prevalent and road safety measures are often lacking. The study also adds to the body of literature on helmet use rates in Nepal and provides valuable insights for policymakers and road safety advocates seeking to improve motorcycle safety in the country. [4]

Yaochen Li et. al (2021) This study proposes YOLO-GCC, an object recognition model intended for the identification of minor traffic features in UAV picture sequences, in the rapidly developing field of intelligent transportation. Evaluation on several UAV datasets demonstrates that YOLO-GCC improves real-time performance and tiny object recognition accuracy by integrating a global context attention module and using asymmetric convolution for increased resilience. The paper also presents the Traffic-DQN method, which shows how effective it is in reducing traffic congestion by utilizing deep reinforcement learning with YOLO-GCC traffic data. This work advances the integration of deep learning with UAV technology for improved traffic control.[5]

III. SYSTEM DESIGN

The Power Regulator is connected to the power supply which then provides a 5V DC power to the Raspberry Pi and 12V DC power to the CCTV Camera Unit and its drivers. Live feed from the camera is the input for the system. The camera module is connected to the Raspberry Pi. It detects the motor vehicles by passing the video footage through an object detection model that has been trained. The model detects vehicles in the footage using YOLOv3 algorithm and calculates the vehicles' speed. If the speed is greater than the speed limit then the image is sent to the server along with the time, date and the required information.

The server performs a helmet recognition algorithm, license plate localization, and OCR. It then compresses and saves the data to the database with the current time and date. After all the data is collected and formatted properly, it is sent to the authorities. While these processing steps are being carried out, the camera is still taking in live feed of the road.

A. Proposed system

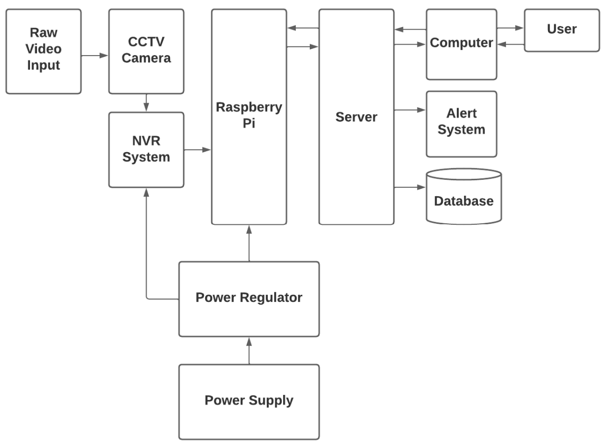

Figure 1: System Block Diagram

B. System Flowchart

This algorithm is a multi-step process designed to monitor and enforce safety regulations on the road. On the Raspberry Pi side, it begins by configuring input/output (I/O) settings and capturing images from a connected camera. These images are then processed using the Euclidean Distance Method to detect instances of vehicle overspeed. If a vehicle is found to be exceeding the predefined speed limit, the system proceeds to capture a still image, sending relevant data to a server for further analysis. If the speed is within the limits, the algorithm loops back to continue capturing images, ensuring a continuous surveillance process.

The server-side system plays a crucial role in enhancing road safety. It processes the images received from the Raspberry Pi by performing helmet localization and classification using YOLOv3, which identifies whether riders are wearing helmets. Moreover, it carries out localization and Optical Character Recognition (OCR) on license plates to extract and store relevant data. The information collected is then saved in a database. In cases where violations or issues are detected, the authorities are promptly alerted, allowing for quick responses to potential safety concerns. This algorithm provides an effective and automated way to monitor vehicle speed, helmet compliance, and license plate data, contributing to road safety and regulatory enforcement.

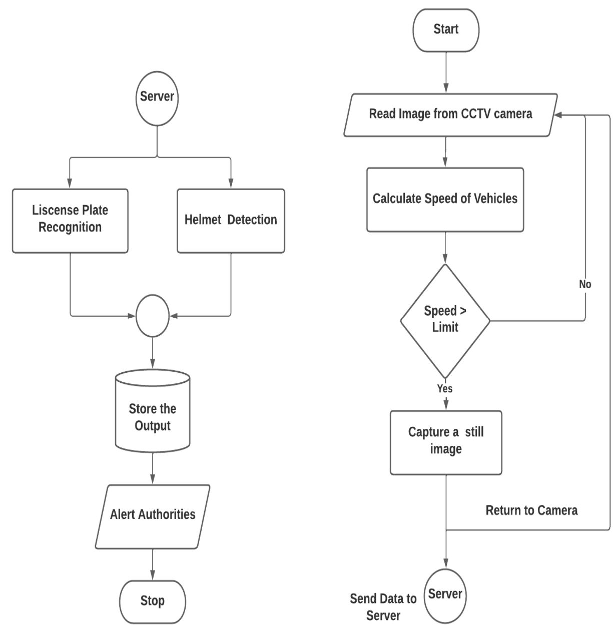

Figure 2: System Flowchart

In summary, this algorithm combines Raspberry Pi-based image processing with server-side analysis to enforce safety regulations on the road. It monitors vehicle speed, ensures helmet usage, and records license plate information, thereby facilitating the efficient management of safety-related data and the timely response to potential violations.

C. Vehicle Speed Estimation

Each Individual car in the video is identified using a Haar Cascade model. The location of each car represented by bounding box coordinates is stored. A subroutine converts the frame image of the video into grayscale image and returns a list of rectangles representing the bounding boxes of the detected cars.

For each detected car, the subroutine tries to find a tracker associated with the car in the memory. If it finds one, it updates the tracker with the current frame of the tracker object. If the tracking quality of the tracker drops below a certain threshold, the subroutine removes the tracker and the corresponding car ID from the dictionaries. If the subroutine does not find a tracker for a detected car, it creates a new tracker object and adds it to the memory with a new car ID. It also adds the bounding box coordinates of the car to the memory. This is how the program keeps updating the bounding boxes with respect to the movement of the vehicles.

h : Camera height above ground (in meters)
θ : Camera angle from ground (in degrees)
w : Road width (in meters)
f : Focal length of the camera lens (in millimeters)
w_i : Width of the video frame in pixels
ppm : Pixels per meter
fps : Frame rate of the video

Then, the function to calculate ppm based on the camera's field of view and the road width is given by:

$$fov = 2\,tan^{-1}(\frac{w}{2h})$$

$$ppm = \frac{w_i}{2tan(\frac{fov}{2}) * f}$$

where w_i is the width of the video frame in pixels. The function to calculate the speed of the vehicle is given by:

$$d_{pixels} = \sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$$

$$d_{meters} = \frac{d_{pixels}}{ppm}$$

$$d'_{meters} = \frac{d_{meters}}{cos(\theta)}$$

$$v = d'_{meters} * fps * 3.6$$

where (x_1, y_1) and (x_2, y_2) are the pixel coordinates of the vehicle in the previous and current frames, respectively, and fps is the frame rate of the video. The quantity d'_meters is the corrected distance traveled by the vehicle, taking into account the camera angle θ.

D. Background Subtraction

Background Subtraction is achieved by converting the normal image into HSV format and thresholding the color values. The process of conversion from RGB to HSV is as follows:

$$H = \begin{cases} 0 & \text{if } R=G=B \; \frac{60^\circ\cdot(G-B)}{R-G} \\ \text{if } R>G>B \; \frac{60^\circ\cdot(G-B)}{R-G}+360^\circ & \text{if } R>B>G \; \frac{60^\circ\cdot(B-R)}{G-B}+120^\circ \\ \text{if } G>R>B \; \frac{60^\circ\cdot(B-R)}{G-B}+240^\circ & \text{if } G>B>R \end{cases}$$

$$S = \begin{cases} 0 & \text{if } R=G=B \; \frac{(R-G+R-B)}{2\cdot\max(R,G,B)-(R+G+B)} \\ \text{otherwise} \end{cases}$$

$$V = \max(R,G,B)$$

IV. RESULT

A. Helmet Detection

Figure 3: Helmet Detection

A dataset [6] for motor vehicles and helmets used along with the YOLOv3 algorithm to further train the pre-trained model for better detection of helmets and motorcycles for our environment. We then tested the model for custom images from our environment. The Helmet detection model has a training accuracy of 0.94 and validation accuracy of 0.89.

B. Vehicle Detection and Speed Estimation

The picture above shows a Haar Cascade Model predicting all the cars in the frame. The script also estimates the speed of each car by calculating the distance travelled by the car between two consecutive frames and dividing it by the time elapsed between those frames.

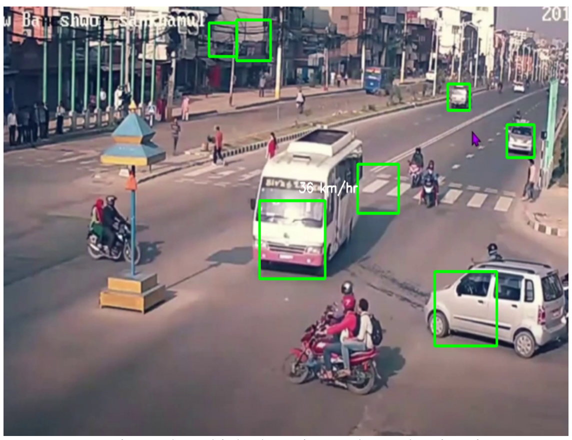

Figure 4: Vehicle detection and speed estimation

To do this, the script stores the location (x and y coordinates) of each car in the previous and current frames. Then, it calculates the distance travelled by the car between the two frames using the Euclidean distance formula. Finally, it divides the distance travelled by the elapsed time to get the speed of the car.

C. Optical Character Recognition

There are two main steps in OCR. They are character segmentation and character classification. In this project, character segmentation is done by making contours after masking. The following is the resulting image before and after character segmentation.

Figure 5: Binary Representation

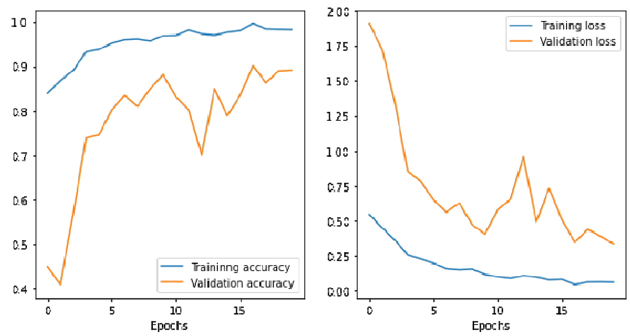

Figure 6: Accuracy and Loss chart for OCR

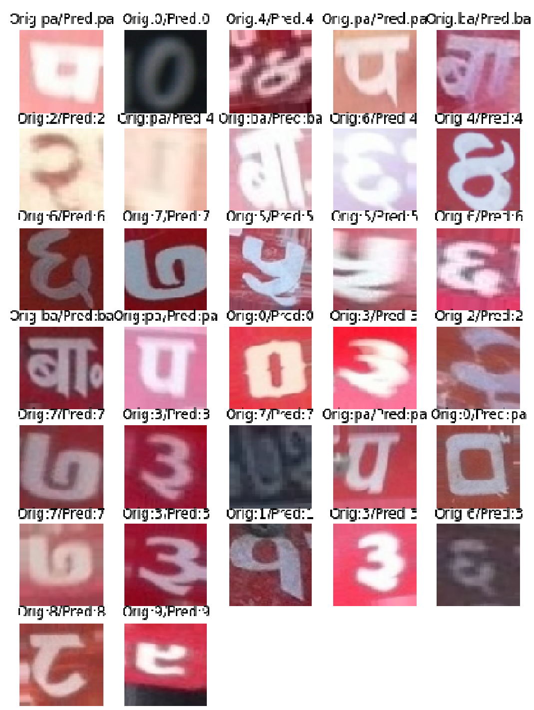

Figure 7: OCR Predictions

Figure 8: Final Result

V. CONCLUSION

In summary, the development of a sophisticated system capable of identifying and reporting traffic rule violations in real time presents a compelling solution to enhance road safety in countries like Nepal. This research not only simplifies the process of monitoring and enforcing traffic laws but also has the potential to save valuable time and resources. Moreover, the data analysis component equips authorities with insights into traffic patterns, offering the opportunity to proactively enhance road safety through well-informed strategies and recommendations. This comprehensive approach underscores the project's potential to make a significant impact on traffic safety and law enforcement.

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