ENHANCING TAXI DRIVER SAFETY THROUGH SECURITY EYES

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Abstract - A taxi is a popular transport to carry passenger(s) to their desired destination(s). But nowadays taxi drivers are not secure due to the criminal passengers. Most of the time, they lose their lives by knife stabbing, shooting, or losing consciousness due to the chloroform. Previous researchers haven't worked on this issue. There are no safety measures or alert systems available for the drivers to protect them from potential criminal attacks by passenger(s) seated in the back seat. As a result, drivers are easily attacked by criminal passenger(s). The main aim of this paper is to reduce these heinous crimes and increase drivers' security. That's why the "Security eyes" system is introduced which consists of two camera modules, an alarm triggering system, a data transmitter, and internet connectivity. The system uses the YOLOv3 algorithm to identify suspicious activities (e.g., the use of gun, knife, or chloroform). One camera continuously observes passenger(s) activities. The second camera promptly activates and captures an image of the perpetrator(s), when any threat from the passenger(s) is detected by the first camera. Immediately, the system triggers an alarm to alert the driver and sends the taxi's location coordinates along with the captured image to the police facilitating easier apprehension by law enforcement. Based on the experimental results, the proposed system demonstrates a satisfactory performance rate with a high accuracy detection rate (around 97.82%).

Keywords - Security Eyes, Object Detection Algorithm, Computer Vision, GPS

I. INTRODUCTION

In most countries especially developing and under-developing countries, people mostly depend on taxis to go to their working place, homes, or anywhere else due to low cost, time savings, and safety. That's why these vehicles are so popular. However, the security of these taxi drivers is a critical concern that often goes overlooked. Some researchers worked on avoiding accidents for driver safety. For example, Swati Shilaskar, V. P. designed a system that can detect drivers' drowsiness, unconsciousness, or drunkenness while driving. If they are detected, the car will start to buzz an alarm and automatically reach the corner by detecting the road lane, and other vehicles and stop [1]. Unfortunately, no research has worked on saving taxi drivers' lives or money from the criminal passengers who are back-seated. Due to this research gap, sometimes the drivers face heinous crimes or lose their lives. For instance, in Prince George's County in 2024, a taxi driver was stabbed by a woman and lost his life [2]. Even sometimes, by pointing guns, the criminal passenger(s) take all the money from the driver. These incidents are increasing day by day.

The interior rearview mirror can indeed help the driver watch the activities of the back-seated passenger(s). However, it is tough for the driver to monitor their activities through the mirror while driving. To reduce this heinous crime a system is proposed to install two camera modules which act as "Security Eyes" either on or beside the interior rearview mirror or other suitable position in the car to focus properly on the movement of back passengers. If there is any suspicious movement of the passenger(s) like using knife or gun, at that time it is detected by the first camera module. After that, immediately, trigger an alarm to alert the driver.

This alarm can frighten the criminal passenger(s) and allow the driver to take an evasive action, potentially saving the driver's life. The alarm system may save the driver's life. However, in the future, that criminal passenger(s) may attack other drivers to take away money or other valuable things or even endanger the life of the driver for other reasons. So, to reduce this crime, this system's additional camera promptly activates, captures the image of the criminal(s), & sends that image with current location information to the police station, so that the police can easily catch that criminal(s). But before implementing these processes, it is necessary to detect those objects such as knives, guns etc. The detection of object is a computer vision task which is used to find and identify things in pictures or video frames. Its main aim is to identify various objects within a visual scene and delineate their positions by drawing bounding boxes around them, thereby indicating their spatial extent within the image. Various types of object detection algorithms exist, including R-FCN, SSD, YOLO, Faster R-CNN, Mask R-CNN, and so on [3].



Figure 1:- Driver is in Danger

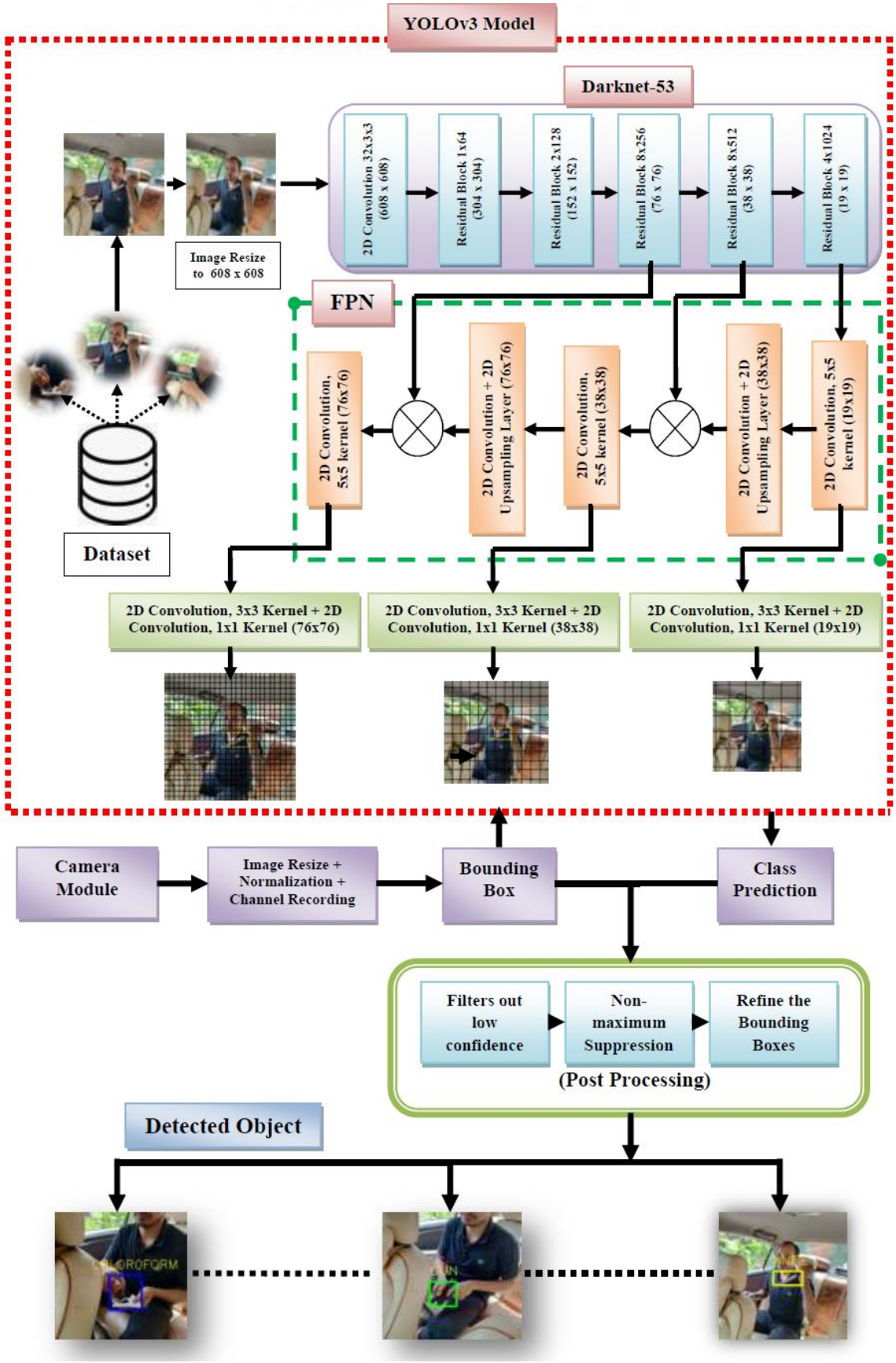


Figure 2:- Object (Knife, Gun etc.) Detection through YOLOv3

In this study, YOLO version 3 (YOLOv3) is utilized as an object detector. It was developed by Joseph Redmon and Ali Farhadi. YOLOv3 stands for "You Only Look Once" version 3. It is well known for its

precision and efficiency in object detection [4]. It operates as a single-stage algorithm, employing a unified neural network architecture to predict both bounding boxes and object class probabilities in real time. YOLOv3 leverages convolutional layers to extract hierarchical features from input images, allowing it to capture a broad range of abstraction levels. After detecting knives, guns, or other weapons for attacking, trigger an alarm to frighten away the offenders, save the driver's life, and inform the police by transmitting valuable information.

The primary contributions of the paper can be summarized as follows:

1. To alert and save the driver's life from criminal passenger(s) by detecting their suspicious activities using the first camera.
2. To quickly activate the second camera and capture the image of the criminal(s).
3. o send the GPS location & captured image of that passenger(s) to the police- station immediately.

II. PROPOSED SYSTEM

Since the proposed system "Security Eyes", consists of two cameras, one is located in such a position to monitor back-seated passenger(s) activities and continuously captures real-time data of the surrounding environment inside the taxi. As a result, no movement or action of the passenger(s) goes unnoticed. After capturing the raw data, the resizing process ensures uniformity across all images. Then pixel values of resized images are normalized typically between 0 and 1 range. This process enhances convergence speed and reduces computational complexity.

The subsequent stage involves executing the YOLOv3 model to extract bounding boxes for objects detected within the preprocessed images. The preprocessed images are divided into various grids. YOLOv3 predicts several bounding boxes along with confidence scores for each grid cell. Bounding boxes are used to predict the height, width, center, and class of objects. YOLO utilizes Intersection Over Union [5] to determine the perfect output boxes for objects. When the predicted bounding box perfectly aligns with the actual box, the Intersection over Union (IOU) score equals 1. This method helps to discard bounding boxes that don't precisely match the actual object [6]. Mathematically, IOU can be represented as:

$$\text{IOU} = \frac{\text{Area of Intersection}}{\text{Area of Union}}$$

The bounding box and class prediction within the yolov3 model predicts the bounding boxes and class probabilities that enclose the detected object.

Finally, the detection is improved by filtering out low confidence and correct output is obtained with bounding boxes, class labels, and percentage of confidence in the post-processing stage. These detected objects are utilized to trigger the security warning system, such as sending images of culprits and location coordinates, thereby increasing the safety of taxi drivers and contributing to the overall security of urban transportation systems.

2.1 Alert the Driver and Corresponding steps

During driving, it is very difficult to observe the activities of the passenger(s) for the driver. This opportunity is often taken by criminal(s) who may attack the driver with a knife or gun, or use chloroform to unconscious the driver and steal their money. To reduce this horrific crime, this paper suggests installing a camera inside the car to monitor passengers. If there are any suspicious activities, such as the use of knife, gun, or chloroform on the driver, it will be detected by the yolov3 detector. Immediately trigger an alarm to alert the driver and inhibit the crime.



Figure 3:- Driver is safe

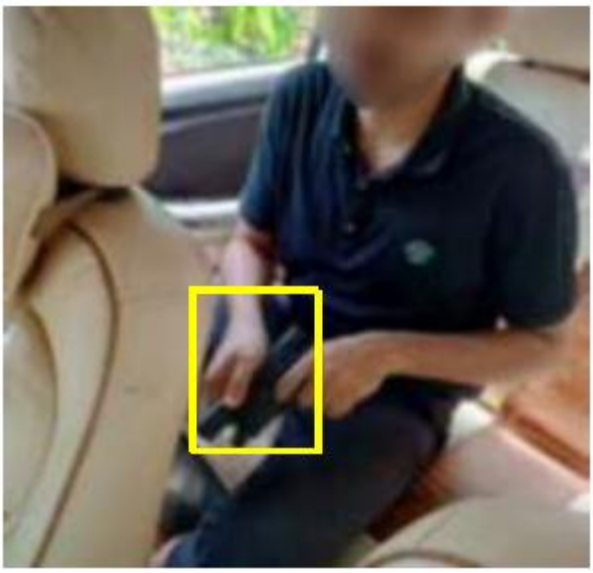


Figure 4:- Driver isn't safe

The flowchart of the whole system's function is shown in Fig. 5.

After informing the driver through alarm triggering, based on the detection of the driver's life risk, the system takes a series of actions promptly:

First of all, the system captures the image of the perpetrator(s) through the second camera module, that is installed with the first camera. This captured image would work as evidence and identification of the delinquent(s).

The next stage is to find the current location coordinates of the incident. To retrieve the exact location coordinates, Geopy Library is utilized in this system. Geopy Library is a Python package that is used in mapping, distance calculation, etc. Obtained GPS location through this library is sent to the police helps the authorities to reach that place quickly.

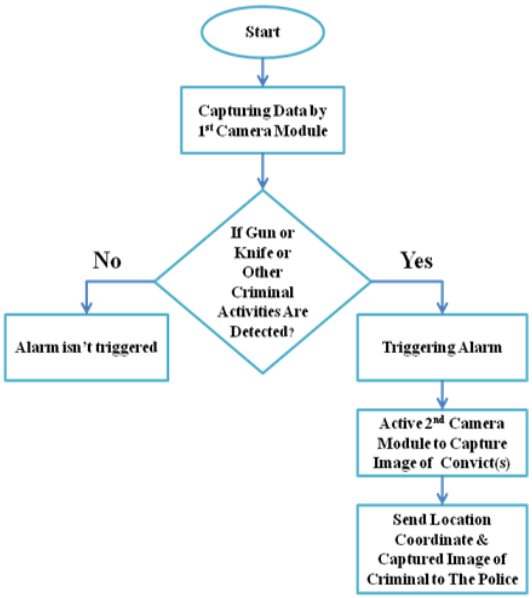


Figure 5:- Flowchart of the Proposed System

Overall, integrating Geopy for location retrieval, Twilio for communication, and the webcam for visual evidence capture, the system ensures swift and efficient dissemination of information to the authorities. This enables law enforcement agencies to take immediate action, swiftly responding to the incident and apprehending the perpetrator, thereby enhancing overall safety and security within the community.

2.2 Performance Indicator

The proposed model's effectiveness is evaluated using three primary metrics: accuracy, precision, and sensitivity. Accuracy measures the proportion of correct predictions out of the total number of predictions, given by the equation:

$$\text{Accuracy} = \frac{\text{Number of Correct Predictions}}{\text{Total Number of Predictions}}$$

However, in a classification scenario where there's a significant imbalance in the number of samples across classes, relying solely on accuracy to evaluate a classifier's performance might be misleading [7]. Therefore, precision and sensitivity are also considered to provide a more comprehensive evaluation of the model. Precision, calculated as:

$$\text{Precision} = \frac{\text{True Positives}}{\text{False Postives} + \text{True Positives}}$$

It evaluates the correctness of positive predictions by indicating the proportion of true positive predictions out of all positive predictions. Sensitivity, also known as recall, is defined as:

$$\text{Recall} = \frac{\text{True Positives}}{\text{False Negatives} + \text{True Positives}}$$

It measures the model's ability to identify all relevant positive cases in the dataset, representing the proportion of true positive predictions among all actual positive instances [8].

III. RESULT & DISCUSSION

The system was shown in Fig.6. This experiment was conducted in a car. A knife, gun, and chloroform were used in the experiment. For detecting the knife, gun, and chloroform, an ESP32 camera module was used which was strategically positioned within the car to monitor the interior environment continuously. When these objects were detected through the camera module, an alarm, which was programmed in the code, would ring as shown in Fig. 7.

After detecting these activities, a photo of the person acting as the criminal was captured by the laptop webcam based on receiving an HTTP POST request that was sent by ESP32 camera. Afterward, laptop sent the captured image as well as current location coordinates of the car were sent to my WhatsApp ID, which was shown in Fig. 8. In this experiment, my WhatsApp ID was used as the data receiver. To capture the photo, the laptop's webcam was used. Due to the slow internet speed, it took a few extra minutes to send the data to my ID.

In order to train the model effectively, approximately 300 images of suspicious activities were collected, encompassing the usage of guns, knives, and chloroform. The performance of the proposed YOLOv3 model for the detection of criminal activities was evaluated through three parameters: Accuracy, Precision and Sensitivity (Fig. 10).

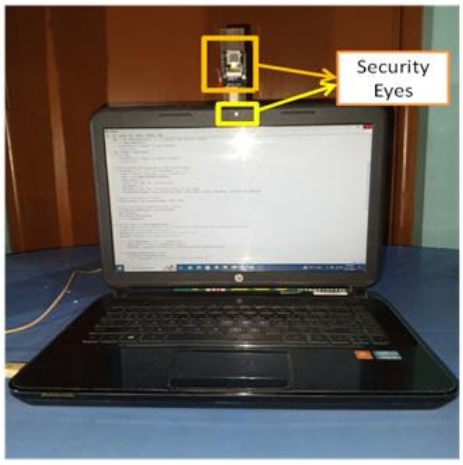


Figure 6:- Security Eyes System

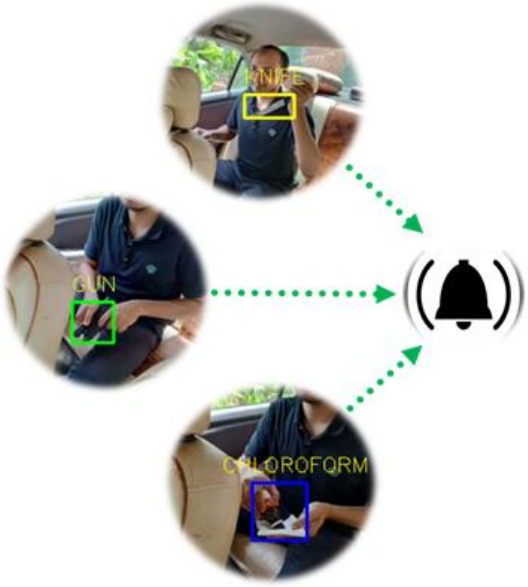


Figure 7:- Reasons for Triggering Alarm

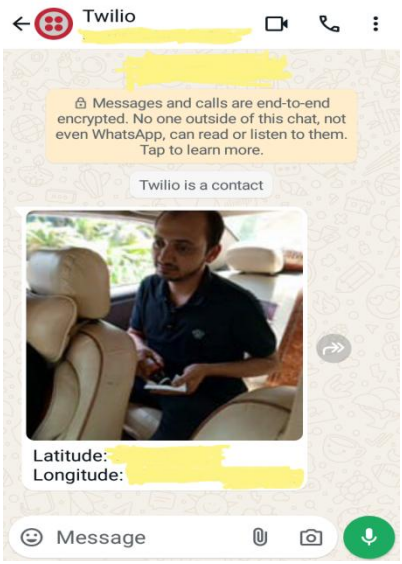


Figure 8:- Sent Massage from the System

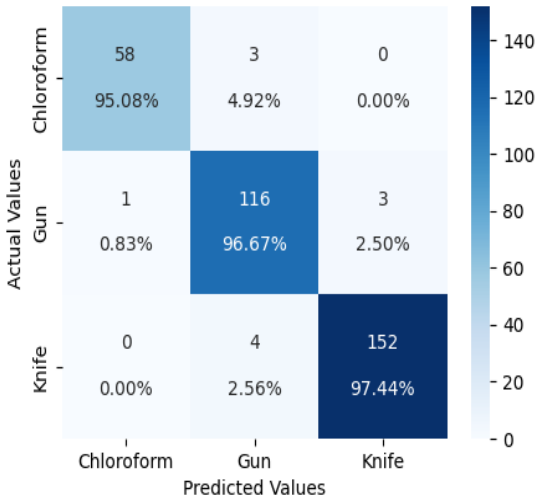


Figure 9:- Confusion Matrix of the Proposed Yolov3 Model for Criminal Activities

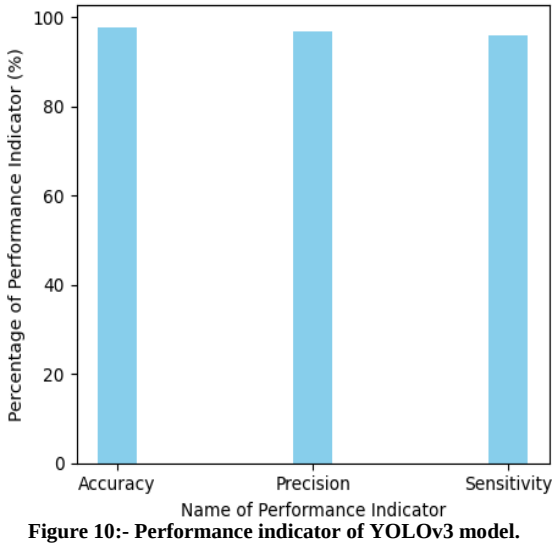


Figure 10:- Performance indicator of YOLOv3 model.

Model	Accuracy (%)	Sensitivity (%)
Hybrid Model (YOLO + Faster R-CNN) [9]	74.3	86
YOLOv3-ResNet [10]	68	--
YOLOv3(Used Model)	97.82	95.98

Table 1: Performance comparison between Object Detectors

The performance comparison between the used model YOLOv3 in this study and other object detectors is presented in Table 1. The percentage of accuracy in the Hybrid Model and YOLOv3-ResNet are 74.3 % and 68%, respectively, which are quite low compared to the used model. These figures indicate relatively lower accuracy rates compared to the pre-existing YOLOv3 model.

The current YOLOv3 model demonstrates a significantly higher accuracy percentage of 97.82%.

It performs better than other models to identify objects accurately in the given dataset. This significant accuracy difference highlights how much efficacy our chosen model has in achieving precise and reliable object detection results.

Even the sensitivity metric measures the ability of the model to correctly identify positive instances, is also assessed. The sensitivity of the proposed system's YOLOv3 model is 95.98%, indicating its high proficiency in detecting relevant objects within the dataset.

When compared to the Hybrid Model, the existing YOLOv3 model exhibits a notable improvement in sensitivity, with a difference of 9.98%. This suggests that used YOLOv3 model not only outperforms in terms of accuracy but also surpasses in sensitivity.

Overall, the system provided a satisfactory response (close to 100%) in sending data when actions (such as the use of chloroform, a gun, or a knife) were detected. However, in a few cases, the YOLOv3 model was unable to correctly detect the weapons. In 2 or 3 instances, due to changes in environmental lighting, the camera module detected a gun or knife despite their absence.

IV. CONCLUSION & FUTURE WORK

The safety of the driver should be a top priority, and this proposed system provides a significant advancement in safeguarding drivers from potential criminal passengers, thereby potentially saving lives and aiding law enforcement. The detection accuracy of each threatened object is remarkably high nearly 100%. However, a significant limitation is present in the processing speed of the detection. Around 2 seconds are required to detect the threatening objects. So in the future, there is a plan to modify the YOLOv3 model to decrease the processing speed. Also, have a plan to include night vision high-resolution cameras to enhance safety during nighttime driving. This forward-looking approach underscores a commitment to ongoing improvement and innovation in driver safety technologies.

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