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AI Based Safety Alert for Car Door Opening Using Yolov5l Algorithm

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Abstract: Vehicle accidents can occur due to various causes such as human error, mechanical failures, and adverse road conditions. These accidents can result in property damage, injuries, and even loss of life. Vehicle door collision detection and avoidance using ADAS (Advanced Driver Assistance System) is vital for autonomous driving. Accidents of this sort typically happen after the driver has parked the car and tries to open the door to get out, colliding with the vehicles coming up from behind, which may result in injuries to the commuters and the vehicle. To overcome this issue, the AI-SADOM (Artificial Intelligence – Safety Alert for Car Door Opening) model uses YOLOv5l (You Only Look Once) algorithm which gets the input of the safety distance of the vehicle approaching from the rear and then the YOLOv5l detects the presence of an object and calculates the distance. When a vehicle approaches from the rear, the SADOM system is designed to activate the dependable door control, and it will successfully apply vibration at the car's door that commuters may feel.

Keywords: YOLOv5, Raspberry Pi, Distance estimation, Haptic feedback

1. Introduction

After the Covid'19 breakout, individuals have become more aware of choosing private transportation over public transportation, which has increased the sales and use of four-wheelers in recent years. [1]. With one of the world's fastest rates of motorization development, as well as the rapid expansion of the road network and urbanization over the years, our country is facing major challenges in terms of road safety. The deaths caused by road accidents in urban and rural areas are increasing considerably due to various causes [2]. Most traffic accidents are primarily the result of human error and a lack of consciousness [3]. One such accident occurred due to the opening of the car door unconsciously on a busy road that leads to the impact of an approaching vehicle on the door and the driver or passenger who opens the door [4]. This may lead to severe injury to both persons who are in the approaching vehicle and the person in the stalled vehicle. This will also cause damage to the vehicles due to the impact.

Cars and vehicles are now emerging as smarter technologies [5], [6]. Automation of vehicles is thought to increase safety, comfort, and performance for drivers generally while reducing the chances of accidents. The cars of today's modern world come with the Advanced Driver Assistance System (ADAS) [7]. ADAS is also called to be the

supercomputer on wheels this system provides many automated features [8] including Break and lane assist feature [9], with the help of this ADAS feature we came up with a novel idea of developing an innovative system to alert the person who tends to open door of the vehicle about the approaching vehicles.
The car door opening system uses object detection, distance estimation, and YOLOv5l to the door automatically. The system uses a camera module and YOLOv5l algorithm for object detection, distance estimation, and decision-making [10], [11]. The YOLOv5l algorithm is used to detect the presence of a person in the camera's field of view [12]. The algorithm analyzes the image captured by the camera and identifies the location of the person in the image. Once the person is detected, the distance estimation algorithm is used to estimate the distance between the person and the car door [13], [14]. This information is used to determine if the person is close enough to the car door for the door to be opened. If the person is close enough to the car door, the decision-making algorithm sends a signal to the car door opening system to open the door automatically. The system uses a motor or actuator to open the door, and the person can enter the car without having to manually open the door. The car door opening system using object detection [15], distance estimation, and the YOLOv5l algorithm has several benefits. It improves the convenience and ease of entering a car, especially for people with disabilities or those carrying heavy objects. It also enhances the safety of the car occupants by minimizing the risk of a person accidentally opening the door into traffic or other hazards. Overall, the car door opening system using object detection, distance estimation, and the YOLOv5l algorithm is an innovative and useful application of computer vision technology that can enhance the convenience and safety of car use.

2.Experimental setup & methods :

To provide real-time monitoring and warning capabilities, the experimental setup combines computer vision, sensor technology, and edge computing. The YOLOv5 algorithm, the object detection model, will be deployed on a Raspberry Pi, which acts as the edge computing device. The rear-end camera is positioned to capture the area behind the vehicle, allowing the algorithm to detect objects and analyze their distance. This information is crucial for determining whether it is safe to open the car door. If the algorithm detects any objects within a specified distance from the car door, it sends a signal to the Raspberry Pi. Additionally, a vibration sensor is mounted on the lever of the car door to sense any vibrations when the distance is too less from the vehicle behind. This sensor acts as a safety measure. This system alerts commuters to potential dangers and helps prevent accidents caused by opening car doors in the presence of nearby objects.

3.Model algorithm Evaluation index:

In this experiment, the performance of the algorithm was assessed using the parameter quantities Precision (P), Recall (R), F1-score, mean Average Precision (mAP), and Intersection over Union (IoU), where Precision (P), Recall (R), Mean Average Precision (mAP), and F1-score are expressed as:

Precision = True Positives / (True Positives + False Positives) (1)

Recall = True Positives / (True Positives + False Negatives) (2)

$$mAP = \frac{1}{n}\sum_{n}^{i-1} A\,P_i \tag{3}$$

F1-Score = 2 * (Precision * Recall) / (Precision + Recall) (4)

where True Positives (*TP*) represent the number of correctly detected objects, False Positives (*FP*) represent the number of incorrectly detected objects, and False Negatives (*FN*) represent the number of undetected objects. Average Precision (*AP*) represents the average accuracy of an object class [16].

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4.COMPONENTS

Hardware:

The Raspberry Pi 4 Model B is the primary model of the system board. It requires at least 35 bare bones minimum. It includes 64-bit RAM (Random access memory) , four USB(Universal Serial Board) ports, and 40 general-purpose input-output (GPIO) pins. The Raspberry Pi has Python loaded to execute a program[17]. The YOLO algorithm processes the video/image that the USB camera takes, determining whether or not there are any objects present[18]. A haptic feedback unit is a tool that gives users vibrations or tactile input to improve their experience in a physical or digital environment. It consists of a small motor or actuator that vibrates when activated. This vibration creates a sensation that simulates the feeling of touching a physical object or surface. The intensity and duration of the vibration can be adjusted to provide a range of tactile sensations.

(a) (b) (c)

Figure.1 a) Raspberry Pi 4 Model B b) USB camera c) Haptic Feedback – Vibration sensor

SOFTWARE:

DATASET USED:

The KITTI (Karlsruhe Institute of Technology and Toyota Technological Institute)dataset is a widely used benchmark for autonomous driving research and computer vision tasks. It contains 7381 training images with ground truth labels. There are three types of data: automobiles, people, and other objects. It is a difficult process because the items to be recognized come in various sizes and comprise lots of little samples. It offers a diverse range of challenging scenarios, including urban environments, highways, and rural areas. We split the training photos into a training set and a validation set because the labels on the KITTI testing set aren't open to the public.[19]

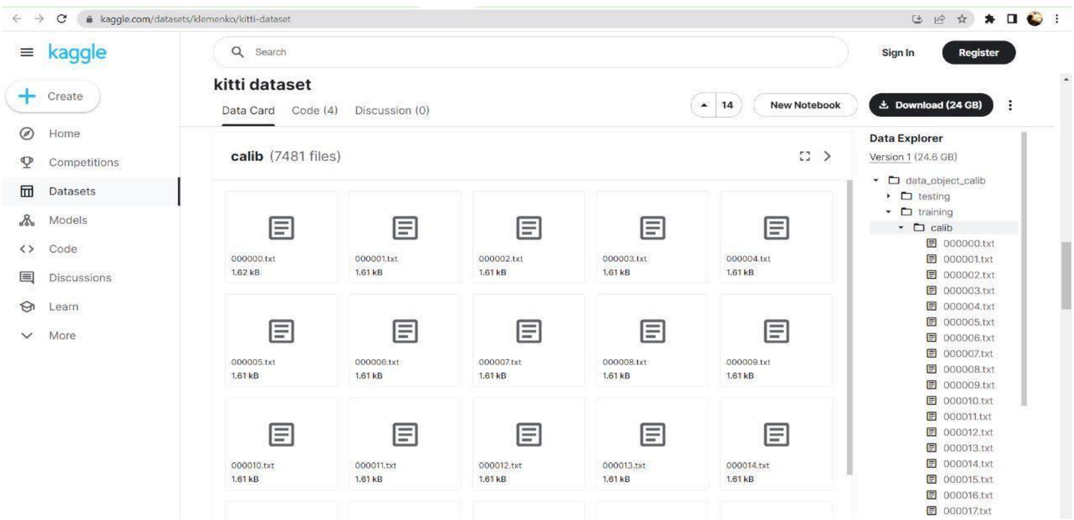

Figure.2 Download KITTI Dataset

YOLOv5l Algorithm:

YOLO is a one-stage method for detecting objects. By applying a CNN (Convolution Neural Network) to the image, it can determine the type and position of the objects in the image, enhancing the speed of recognition. The four versions of YOLOv5 are YOLOv5s, YOLOv5m, YOLOv5l, and YOLOv5x. YOLOv5 is identified by the depth of the depth multiplier control model; for instance, YOLOv5s has a depth multiple of 0.33 and YOLOv5l has a depth multiple of 1. YOLOv5s is the most basic version, has the least file weight, and has a quick recognition rate[20]. The below YOLO network architecture image is sourced from the research article[21].

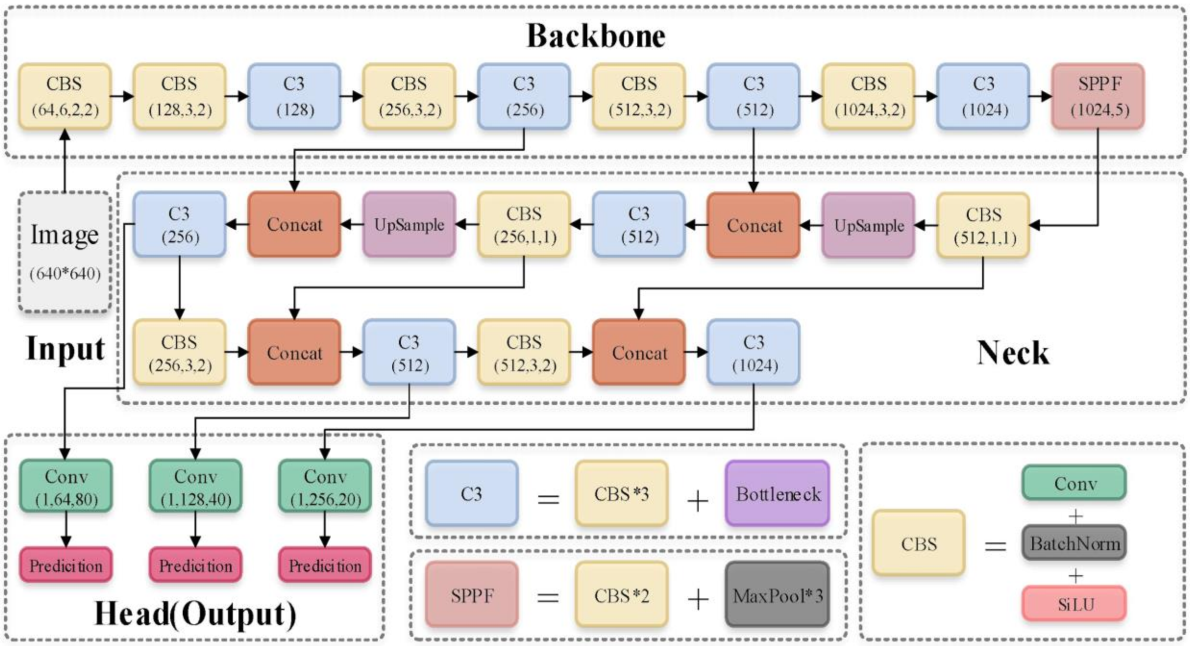

Figure.3 Network Architecture of YOLOv5

Input Layer: This is the first layer of the model and is responsible for taking the input image.

Backbone Layers: These layers extract features from the input image using convolutional neural networks. In YOLOv5l, the backbone layers consist of the CSP (Cross Stage Partial Network) Darknet53 architecture, which is a highly efficient and accurate feature extractor.

Neck Layers: These layers are responsible for fusing the features extracted by the backbone layers to generate a high-level representation of the image. In YOLOv5l, the neck layers consist of the PANet (Path Aggregation Network) architecture, which uses a pyramid of different feature scales to improve detection accuracy.

Head Layers: The bounding boxes and class probabilities for each object in the image are predicted by this layer. A multi-scale prediction head that can detect objects of various sizes and aspect ratios is part of the head layers of YOLOv5l.

Output Layer: This is the final layer of the model and outputs the predicted bounding boxes and class probabilities for the objects detected in the image. In the AI-based safety alert system for car door opening using YOLOv5l, the model is trained on a dataset of car door images to detect and classify whether a car door is safely closed or open. The output of the model is used to trigger an alert if the car door is not safely closed or opened, ensuring the safety of passengers and others on the road.

The following are the precise strategies for improvement:

1) Some suggestions for improvement are made at the input end of the model training stage, including the use of mosaic data enhancement, adaptive anchor frame calculation, and adaptive image scaling.

2) The backbone incorporates certain novel concepts from the Focus structure and CSP structure into other detection techniques.

3) Between the output of the BackBone and Head, an FPN (Feature Pyramid Network) + PAN (Path Aggregation Network) structure is placed.

4) Generalised Intersection over Union Loss (GIOU_Loss) during training and Distance-IoU Non-Maximum Suppression (DIOU_nms) during prediction box screening are both improved [22].

5.PROPOSED SYSTEM:

The car of today's modern world comes with the Advance Driver Assistant System (ADAS) is primarily focused on collision avoidance technologies. The proposed idea is to develop and design the AI BASED Safety Alert Car Door opening model (SADOM) to create awareness among commuters. When the commuters pull the lever which is fixed on the door to get out of the car the signal passes to the raspberry pi. The Raspberry Pi board contains a microprocessor, memory, and other necessary components for a computer system, including ports for USB, HDMI(High-Definition Multimedia Interface.), Ethernet, and GPIO (General Purpose Input/Output).

The camera, sensors, LEDs (Light-Emitting Diode), motors, and other electronic components can be connected to the board via GPIO pins. The surroundings will be captured by cameras that are attached to the Raspberry Pi, and the images are then analyzed using the YOLOv5l algorithm to search for objects. A given input image is resized to a specified size, such as 416x416 pixels, by the YOLOv5l method. A convolutional neural network (CNN) is then used to process the image, extracting several properties from it. YOLOv5l splits the input picture into a grid of cells and predicts bounding boxes for each cell that includes an object. The CNN output is then used to recognize objects in the image. Each bounding box includes the x and y coordinates, width, and height of the object as well as a confidence score that denotes how probable it is that the box contains an object.

To eliminate duplicate detection, the algorithm applies non-max suppression, which removes bounding boxes with low confidence scores and chooses the most accurate box for each object. The final output of the YOLOv5l algorithm is a set of bounding boxes that identify the objects in the image, along with the corresponding class labels and confidence scores. The distance to the detected object is estimated based on the output of the YOLOv5l algorithm can be challenging and requires expertise in computer vision and machine learning technology. Once the distance is calculated, it checks with the threshold value. If the estimated distance is within the safe range no warning will occur. Whenever the distance falls below the threshold value, the haptic feedback gets activated.

The commuters then receive a vibration sensation from the microprocessor to indicate that not to open the car door. Force, vibration, and motion are used in haptic technology to provide haptic feedback. When interacting with something that uses haptic technology, these sensations aim to affect the user's sense of touch. There are other haptic feedback typologies available, however, vibrotactile feedback is the one that is used in this proposed system. The schematic sketch of the working principle system is shown in Figure 4.

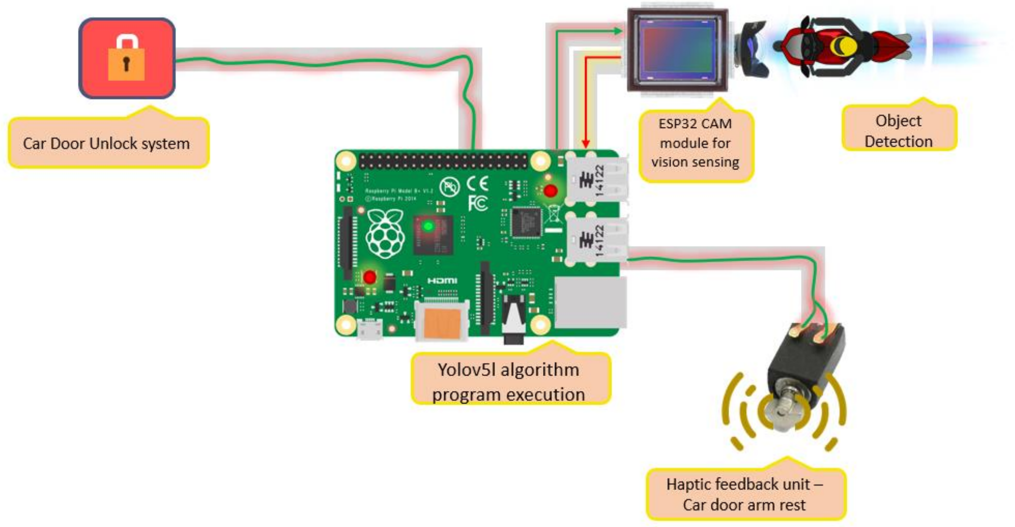

Figure.4 Schematic sketch of working principle

6.RESULTS AND DISCUSSION

Object Capturing using camera:

The camera module plays a critical role in capturing images or videos of the environment and providing input to the object detection algorithm. The camera module used in object detection must have several features that allow it to capture high-quality images or videos that are suitable for analysis by the algorithm. The detection process may involve various steps, such as image preprocessing, feature extraction, and classification. Once an object is detected, its position and size can be determined, enabling subsequent actions to be taken. The schematic sketch of the working principle is shown in Figure 5.

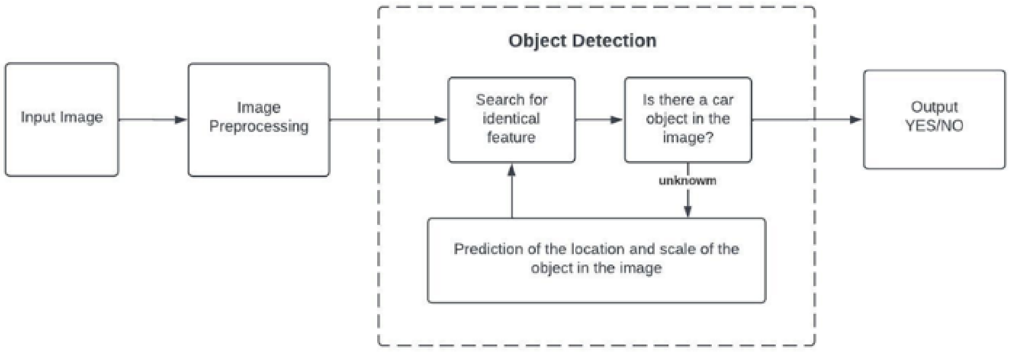

Figure.5 Schematic sketch of object detection

Object detection using YOLOv5l

Object detection using YOLOv5l with a USB camera involves utilizing the YOLOv5l model for real-time detection of objects in a live video feed. By connecting a USB camera to a device like a Raspberry Pi, the camera frames are captured, and the YOLOv5l model is loaded. The model performs object detection on the frames, detecting and localizing objects of interest. Bounding boxes are drawn around the detected objects, and their labels are displayed on the video stream. This approach enables accurate and efficient object detection in real-world scenarios using a USB camera and the YOLOv5l model, making it suitable for various applications like surveillance, robotics, and more.

Distance Estimation using perspective projection

Distance estimation using the boundary values of the detection can be done using the concept of perspective projection. Perspective projection is based on the principle that objects appear smaller as they move farther away from the observer. This principle can be used to estimate the distance of an object in an image by comparing its size in the image to its known physical size. To estimate the distance using the boundary values of the detection, we need to first determine the physical size of the object. This can be done either by measuring the object directly or by using reference objects of known size in the scene. Once we know the physical size of the object, we can use the boundary values of the detection to calculate its apparent size in the image. This apparent size can be used to estimate the distance of the object using the following formula:

$$\text{Distance} = (\text{physical size} * \text{focal length}) / \text{apparent size} \tag{5}$$

where:

- Physical size is the actual size of the object in real-world units (e.g., meters or inches)
- The focal length, measured in millimeters, is the space between the camera's lens and its image sensor. (The focal length is frequently offered by the camera manufacturer, or it can be inferred through calibration.)
- Apparent size is the size of the object in pixels as measured by the image boundary values

The boundary values of the detection can be obtained from the object detection algorithm used to detect the object in the image. It is important to note that this method of distance estimation assumes that the object is at the same height as the camera and that the ground is flat. If the object is at a different height or the ground is uneven, the distance estimation may not be accurate. Additionally, this method may be affected by factors such as lens distortion and lighting conditions, which can affect the apparent size of the object in the image.

Haptic feedback unit – Vibration

The object approaching the halted vehicles is processed, the generated rules are processed, and then the algorithm executes. The driver or passenger then receives haptic feedback from the microprocessor. Haptic feedback is produced through haptic technology through the use of force, vibration, and motion. When interacting with something that uses haptic technology, these sensations aim to affect the user's sense of touch. There are other haptic feedback typologies available, however, vibrotactile feedback is the one that is used in this work. This device, which is placed on the car door handles, warns commuters of oncoming vehicles.

Working of SADOM :

By using object detection and distance estimation, the system can accurately detect objects and estimate their distance, even in complex and dynamic environments. The YOLOv5l algorithm provides a fast and efficient way to perform object detection, making it suitable for real-time applications such as the safety alert car door opening system. The safety alert car door opening system can help reduce the risk of accidents caused by opening car doors into the path of cyclists, pedestrians, or other vehicles. The system can also improve accessibility for people with disabilities by providing audible and visual warnings when the door is about to open. The object detection and recognition of the system are shown in Figure 6.

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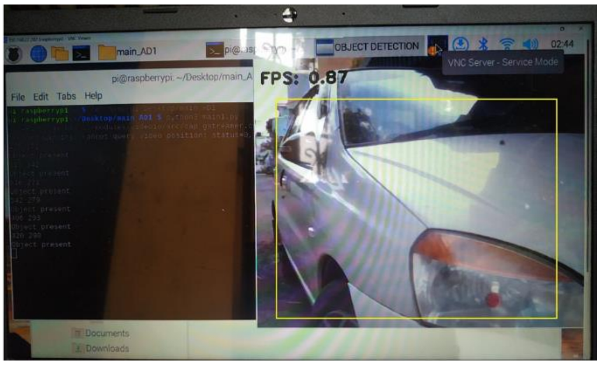

Figure. 6 Object detection using the alert system dates.

7.CONCLUSION:

This methodology is to enhance the safety of the passengers on the board and commuters on the road. There are various systems available to ensure the safety of the passengers and commuters but these systems have various drawbacks that do not provide complete protection on all aspects of the travel. In the field of the automotive industry, numerous innovative features are developed and introduced that make driving safer. Even though there are accidents on the roadways caused by carelessness and unconsciousness. There are also a few innovative technologies in the development stage that ensure the driver does not feel drowsy or feel sleepy while driving but there are no such systems that alert the driver or the passenger about the approaching vehicle while opening the door. In conclusion, the safety alert car door opening system using object detection, distance estimation, and the YOLOv5l algorithm can be an effective solution to enhance safety in vehicles. The work has first explored the technologies that might be employed, such as object detection technology, which can suit the needs of sensing the distance and speed of an approaching vehicle from behind when a car's door is opened. The system can detect the presence of obstacles and pedestrians near the car door, estimate the distance between the car and the obstacle, and issue a warning or prevent the door from opening if necessary. However, like any technology, the safety alert car door opening system has limitations and potential challenges. These include the need for accurate calibration, potential errors due to environmental factors such as lighting and weather conditions, and potential false positives or false negatives in object detection. Overall, the safety alert car door opening system implementing object recognition, distance estimate, and the YOLOv5l algorithm can be an effective way to increase accessibility for individuals with impairments and vehicle safety. However, it is important to carefully consider the limitations and potential challenges of the system and address them appropriately to ensure its safe and effective deployment.

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