



ZONESAFE

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Abstract : With the growing quantity of cars at the roads, the driver safety has emerged as a chief problem, especially due to adjustments in accidents associated with lanes and blind area during merger. Blind spots are areas around an automobile that don't seem to the driver the use of conventional mirrors, ensuing in common conflicts. The "Zone Safe" project addresses this task by way of launching a wise blind spot detection gadget designed to boom street protection. The device integrates an excessive-resolution camera, ultrasonic sensor and an Arduino microcontroller to provide real-time monitoring and alert. Live videos are processed the usage of python and OpenCV, and item detection is finished the use of YOLOv8 algorithm, which is thought for its precise and pace. A Region of Interest (ROI) is defined to optimize the efficiency of detection, even as ultrasonic sensors provide accurate distance measurements to help visible popularity. When detecting an automobile within the blind region, the gadget triggers a caution through LED or buzzers through Arduino communication. Zone Safe is designed to be flexible, value effective and easy to install, providing a sensible answer for secure and clever shipping systems.

IndexTerms - Blind Spot Detection, Driver Assistance Systems, YOLOv8, Object Detection, Arduino, Ultrasonic Sensors, Computer Vision, OpenCV, Real-Time Monitoring, Road Safety.

I. INTRODUCTION

In today's fast-paced and crowded traffic environment, it has become rapidly important to ensure driver safety. One of the most important challenges faced by drivers is the inability to detect vehicles, pedestrians or other obstacles in their blind spots. Blind spots are specific areas around a vehicle that live outside the driver's vision area, with the use of rearview and side mirrors. These unseen areas pose a serious risk during lane changes, merger or inverted, resulting in accidents often that can be prevented otherwise. The need for a reliable and intelligent solution to monitor and address blind spots has never become clearer. To effectively deal with this problem, the "Zone Safe" project presents an innovative, modular and cost-affected blind spot monitoring system that combines modern computer visions, embedded hardware and intelligent alert mechanisms. Unlike traditional security systems, which are often integrated into expensive or only high-ended vehicles, Zone Safe provides an accessible solution that can be installed in a wide range of vehicles, including the older models. The project is designed to empower drivers with real -time awareness about its surroundings, which reduces the chances of collision due to limited visibility.

The Zone Safe system has a high-resolution camera at the core, such as a smartphone configured through ESP32-CAM or IP webcam app. This camera is strategically installed to capture live video feeds from blind places of the vehicle. The hardware setup is deliberately flexible, which allows optimization based on the specific structure and blind spot areas of various vehicles. It ensures wide coverage by maintaining cost-defense by taking advantage of the inexpensive, off-the-shelf components. Captured video feeds are processed in real time using python and open -time library, which facilitates the definition of an area of interest (ROI). This helps the ROI system to focus only on the most important areas where obstacles are likely to appear, which adapt to computational resources and enable smooth operation on the system with limited processing power. A major strength of the Zone Safe device lies in the use of the Yolov8 (you handiest once, version 8) object detection set of rules[5]. Yolov8 is a present-day deep learning version, recognized for its excessive accuracy and pace, which makes me best for time-touchy programs along with blind spot tracking[7]. The algorithm processes each frame in milliseconds and is capable of detecting many objects such as vehicles, pedestrians and other obstacles within the defined ROI. Its compact and mild architecture makes it well -suited to embedded and real -time systems, which ensures reliable performance even in variable light and weather conditions[8].

On detecting a potential danger, the system communicates with an Arduino-based alert module that responds to the driver immediately. This module consists of both visual indicators, such as flashing LEDs, and audio signals via buzzers. The alert is designed for both noticeable and non- intrusive, helping the driver immediately respond without overwhelmed or distracted. Additionally, the alert mechanism is tailored, permitting customers to modify intensity and form of reaction depending on man orwoman possibilities or unique car necessities[9][10]. The Zone Safe mission is going past instantaneous protection benefits by way of imparting a scalable and upgradable platform. The modular architecture supports destiny enhancement which includes integrating ultrasonic sensors to hit upon higher obstruction in a hard environment which includes heavy rains or fog. Further extensions may include GPS modules for connectivity with location-aware danger notifications or other advanced driver assistance systems (ADAS) such as lane departure warning and automatic conflict avoidance system. This adaptability ensures that Zone Safe is not just a standalone solution, but a fundamental system that can develop with carrying motor vehicle technologies forward.

From a comprehensive perspective, Zone Safe system represents an important step in making road safety technologies more

inclusive and widely deployed. While many modern vehicles are equipped with sophisticated security systems, today a large percentage of vehicles on the road, especially in developing areas, lacks such features due to high costs or old designs. Zone Safe addresses this difference by offering a practical, inexpensive and easily installed solution that brings the benefits of modern security technology to a very large population of drivers. The Zone Safe project simulates the practical application of computer vision and embedded system in solving real -world problems. By monitoring real -time, by detecting the exact object and offering an effective alert mechanism, the system enhances situational awareness and empowers drivers to make safe decisions[11]. Its low -cost design, modularity and ability to upgrade the ability to make it a forward -looking appearance in the field of intelligent transport systems. Through Zone Safe, the goal is not only to monitor blind spots, but to pave the way for clever, safe and more accessible vehicle safety technologies.

II. RELATED WORK

A. Y. Ramteke et al. [1] The system integrates the HB-100 microwave motion sensor with an Arduino microcontroller, which uses Doppler radar principles to detect moving objects and calculate their distance and speed. Due to poor lighting and better performance in adverse weather conditions, radar technology on traditional cameras and ultrasonic systems was selected. The radar sensor is associated with a pre-amplifier circuit to increase the signals received, which is then processed by Arduino to identify obstacles. A buzzer is used as a real-time audio alert mechanism, indicating the driver when the objects are detected within the 20-meter range. This system also provides the capacity of extended applications, such as parking aid and collision prevention. Major challenges such as incorrect alarms and signal reliability are addressed through advanced filtering techniques and sophisticated signal processing. Experimental verification confirmed the accuracy and accountability of the system. This study demonstrates the effectiveness of radar technology in addressing blind spot hazards and supports its integration in advanced driver support systems (ADAS) for safe, clever driving.

BF. Lin et al. [2] A vision-based system proposed to detect vehicles in blind-spot areas by integrating the appearance and edge features. The system addresses boundaries in traditional mirror-based identity, increasing security during lane changes. The appearance-based features capture visual texture and intensity, while the edge-based features define the vehicle figure. These are extracted using surf interest points and edge segmentation techniques. To adapt to detection, an Adaboost-based algorithm selects the most relevant and geometrically coherent features. The video frame is analyzed using trained detectors, and a centroid voting mechanism identifies the position of the vehicle within a defined polling place, reduces false positives caused by background elements. The system was evaluated on highway video dataset, which attains an accuracy of 84% and an accuracy of 75%. Although performance is sometimes affected by vehicle appearance and variation in complex backgrounds, the approach displays strength and reliability. This study highlights the effectiveness of combination of image-based techniques for blind spot detection, contributes to the development of real-time driver support systems (DAS).

X. Cui et al. [3] It was discovered how blind spot design affects the cognitive load of drivers during lane changes in intelligent vehicles. Since road accidents remain a major cause of global deadly people, the study emphasizes the need for customized human-machine interaction (HMI) system. Although blind spot monitoring systems are common, their design can unknowingly increase the driver's distraction. To address this, the study uses a better present algorithm to evaluate cognitive load based on eye-tracking and head rotation data collected in real-world driving scenarios. Under separate traffic conditions, three types of intelligent vehicles were used, which focused on blind spot image shape, position and proximity. The results analyzed using the Bayesian Logistic Ordinal Regression (BLOR) and CatBoost showed that the driver is displayed close to the driver and capturing more screen spaces reduces cognitive stress significantly. Research provides actionable insight for designing, more user -friendly blind spot system designing.

H. Z.M Fadzil and S. Nisa [4] developed a blind spot detection (BSD) system using an Arduino nano microcontroller to improve the driver's safety by addressing the dangers of blind spots. The system ultrasonic sensor is strategically placed on the side mirrors and rear surfaces of the vehicle, which monitors blind spot areas continuously for nearby vehicles or obstacles. When an object is detected, the system activates a combination of warning indicators, including the red LED, a bizarre sound and messages displayed on the LCD. Arduino Nano processes the sensor data and triggers alert when the object occurs within a predetermined distance. Experimental results demonstrated the reliability of the system in detecting vehicles from different directions. Green LED detected was burnt in the absence of objects, while the red LEDs and warnings are active on detection. This work highlights the viability of using cheap, skilled hardware to improve driver awareness and reduce blind spot-related accidents .

J. Jose et al. [5] Addressing the challenges of blind spots in heavy vehicles, which pose a significant security risk. The study uses the method of VIKOR multi-criteria decision-making method to evaluate and rank various blind location mitigation measures based on their effectiveness. The research analyzes design parameters such as the height and glass structure of the vehicle to customize rear window visibility. Public transport systems and advanced decision -making techniques were employed by data collection, including entropy measurements and cluster analysis. The study shows that better design features with advanced blind spot detection systems increase driver awareness and safety. Conclusions highlight the value of heavy vehicle designs and integrating the devices and technology for minimum accidents.

T. Konig et al. [6] These systems, radar and camera-based technologies, detect pedestrians and VRUs like a bicycle in voice or alert drivers and alert drivers alert with a view or hearing warning. The study evaluated the abilities to detect through static and dynamic tests under various scenarios, given the speed of the vehicle, VRU speed and lateral distance. The radar-based system demonstrated high identification accuracy (up to 95% within 4 meters) compared to the camera-based system (limited to 2.2 m). Despite their effectiveness, the two systems shown the rate of failure to detect the rate of failure of more than 30%, struggling with visual obstacles. The study highlights the ability of these systems to improve urban traffic safety, but also emphasizes the need for increased barrier for more reliable performance [6], standardization and extended sensor range.

Paper by Chinthaka Premchandra et al.[7] The driver presents a comprehensive functioning to detect and track moving items at road intersections using a 360-degree camera system to help and increase automatic driving. A 360-degree camera is installed on the roof of the vehicle to catch the omniscient fish images of the intersections. These deformed images are corrected using an integrated launch model, converting them into suitable perspective ideas for analysis. A mild version of yolo (you look only once) is employed due to the object detection algorithm due to its real -time efficiency, enabling the accurate identity of dynamic goods such as vehicles, pedestrians and cyclists. Once detected, the movement of these objects is tracked using the Kalman Filter-based algorithm, which predicts their future positions based on current and previous states when assigning unique IDs for continuous

tracking. Composed items can be leveraged for collision warning systems and automatic decision making, which provides a valuable contribution in the development of advanced driver-help system and future autonomous driving technologies.

The paper[8] proposes a framework to increase blind-spot detection (BSD) in low-light environment, such as night-time, using generic adversarial network (GANS). Camera-based BSD systems often face a decline in performance at night due to lack of night images in training datasets. The proposed solution involves converting images of day time into synthetic night images using a conditional GAN, trained on the publicly available front-view dataset. This method eliminates the requirement of additional night data acquisition, which reduces the labor and cost of collecting annotated night images. Synthetic images are then used to increase training dataset, which improves the performance of the vehicle detection system in low-light conditions. The system is based on a side-rectilinear image approach, which helps to avoid the limits of radar-based systems. Experiments suggest that the framework perfectly improves the performance of detection compared to the trained systems on day images. This approach addresses the challenges of obtaining adequate label night data and increases the reliability of BSD systems in various lighting conditions.

III. METHODOLOGY

The proposed workflow diagram is shown in Figure 1. The user interacts with the system through a live video feed captured from the blind spot areas of the vehicle, which is then analyzed in real time to detect potential hazards and generate an alert.

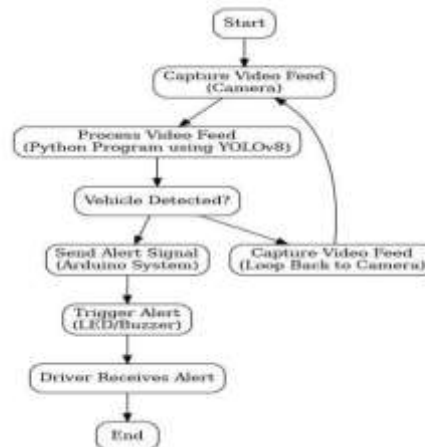


Fig.1: The Workflow Diagram.

The system begins its operation with a strategically mounted camera, such as ESP32-CAM or IP webcam-running smartphones. This camera constantly captures high-resolution video feed from blind spot zone. These videos serve as the primary input of the frame system, which enables constant and reliable monitoring. A Python-based application processes a video captured video using image processing for real-time object recognition and OpenCV for YOLOv8 for a state-of-the-art object detection algorithm. A specific area of interest (ROI) is defined within each frame, which focuses only on important areas to detect nearby vehicles, pedestrians or obstacles, reducing computational loads.

When the YOLOv8 detects an obstacle within the ROI, the system sends an indication to an Arduino microcontroller. Arduino then triggers an alert mechanism that includes visual alerts (bright shining LEDs) and hearing alert (separate buzzers) to warn the driver. These alerts are easily made noticeable without causing distraction, enabled the driver to respond immediately.

If no obstacle is detected, the device loops again and maintains tracking the next set of the frame. These real-time comments loop ensures uninterrupted safety monitoring. As a bendy and scalable device, this blind spot detection setup can be tailored to various programs beyond automobiles - along with industrial safety tracking, robot navigation and visitor's control. Future promoting may also encompass ultrasonic or infrared sensors to improve performance in terrible weather or lighting situations, in addition to integration of wi-fi conversation (Bluetooth or Wi-Fi) for remote alerting and records logging.

The blind spot detection system is an advanced security mechanism designed to alert the driver about vehicles in their blind spots, the areas around the vehicle that do not appear through the mirror. The system depends on a combination of computer vision and machine learning algorithms to detect real-time vehicle, in which the driver is informed effectively, with a hardware-based alerting mechanism.

3.1 Camera setup and video streaming

The system begins with a video capturing unit to monitor the blind location of the vehicle. Capturing device can be an ESP32-CAM module, a low-to-lace, Wi-Fi-capable camera with an inbuilt microcontroller, or the IP webcam application running on a smartphone. The option of ESP32-CAM or IP webcam depends on installation preference and available hardware. ESP32-CAM is equipped with a built-in camera, capable of streaming video on Wi-Fi. It may be connected to the system by using a browser to reach the live video feed.

Alternatively, the IP webcam app on smartphones can stream live video on the computer via local Wi-Fi network. Video feed is accessible through an IP address that the system's software can connect, using Opencv for image processing

3.2 Video Processing Using OpenCV

Once the camera starts streaming the video, the subsequent step is to manner each frame in real time. This is wherein OpenCV (Open-Source Computer Vision Library) comes in the sport. OpenCV is a crucial Python Library used for image processing duties which includes body seize, decision and object detection.

The OpenCV library constantly captures the video frame from the digital camera movement, converting each body right into a format that can be processed via the device gaining knowledge of model.

Each captured frame is shaped for an appropriate decision, making sure that it fits the input necessities of YOLO 8 models. OpenCV allows to normalize these pictures by means of normalizing these snap shots to normalize the pixel values, practice adjustments and possibly reveal the applicable characteristics to stumble on the vehicle.

3.3 Vehicle Detection Using YOLOv8

After preprocessing, each frame is passed to the YOLOv8 model to detect the vehicle. YOLO (you see only once) is a state-of-the-art real-time object detection algorithm, and the V8 variants provide better accuracy and speed. The YOLOv8 model is pre-educate on a large dataset like COCO, allowing it to detect various types of items including vehicles. The model uses a deep neural network to identify and classify objects in the frame. For this project, the system is interested in detecting vehicles (eg, cars, trucks, buses, motorcycles) that enter the blind spot area of pre-determined region of interest (ROI).

In the system, to cover the blind spot zone of the vehicle, the area of interest (ROI) is carefully chosen. This area usually matches the side mirror area, where the driver cannot see the objects directly. By focusing on the region, the system ensures that it monitors only important areas. Once YOLOv8 processes the model frame, it provides the output for items of detection as a bounding box and class label. If a vehicle is detected within the ROI, the model triggers alert for the system.

3.4 Arduino Alert Mechanism

The subsequent section involves alerting the motive force after finding a automobile. This part of the system uses an Arduino uno microcontroller, which is liable for activating the alert mechanism.

Python script, jogging on the system that techniques video feed, communicates with Arduino via the serial interface. When a automobile is observed in a blind place, the python script sends a signal (eg, "1") to the script Arduino to the USB serial connection. If no car is detected, the signal "zero" is dispatched, indicating that the blind area is apparent.

Arduino, a simple script is going for walks that listens to the imminent serial signal. When the Arduino signal gets the "1", it shows that a vehicle is in a blind location, it activates each an LED mild and a buzzer. The LED affords a visible q, sparkling to attract the eye of the driver, whilst the buzzer emits a audible sound to make sure that the driving force is alerted even when distracted. When a automobile is not detected, both LED and Bajer are closed, indicating that the vicinity is secure.

3.5 Real-Time Operation and Efficiency

The real-time operation of the system is one of its main features. Since the vehicle detection is based on the frame-by-frame, the system must immediately process the video feed to offer alert. The combination of YOLOv8 and OpenCV allows for real-time detection, where each frame is processed in milliseconds. This ensures that the system can still react rapidly to alert the driver when close to the blind space.

Complete detection pipeline - To capture the video to send an alert - needs to work with minimal delay. YOLOv8, being adapted to real-time applications, helps significantly reduce this delay, ensure that the driver gets timely warnings when a vehicle reveals the blind place.

Frame processing for object detection and using OpenCV for YOLOv8 ensures that the system maintains high accuracy and speed. The system can detect vehicles under various driving conditions, including various lighting and environmental settings.

3.6 Integration and Power Efficiency

Since the system uses an ESP32-CAM or IP webcam, integration is straightforward and does not require complex wiring. ESP32-CAM can be planted on the vehicle, while the video feed is processed from local or distance. Arduino UNO is operated separately, usually using 5V USB power source, and it controls the alert system based on the outcome of detection.

Additionally, since the system operates on the computer using the camera feed and the basic processing logic using Wi-Fi, the setup remains modular and flexible. It can be adapted for various vehicles and driving conditions.

This setup ensures a spontaneous integration of hardware and software for the blind spot detection system, which provides real-time detection and quick alert to improve vehicle safety. Through continuous monitoring, quick response and time alert, this system serves as a powerful tool to help the drivers safely navigate by eliminating risks associated with blind spot zone.

IV. RESULTS AND DISCUSSION

The blind spot monitor system effectively improved the driver's safety by detecting vehicles entering the blind spots and distributing immediate alerts. It operates in two continuous stages - monitoring and alert. During the monitoring phase, illustrated in Figure 2, a camera installed near the side mirror or rear corner of the vehicle streams the real-time video of the blind spot area. The camera is suitable for various lighting conditions to maintain clarity, enables reliable input to further process. This video stream is processed by a Python script that runs the YOLOv8 object detection model. The YOLOv8 scans each frame to detect items such as cars or motorcycles within the predetermined area of interest, ensure only monitoring of relevant vehicles. If a vehicle is not detected, the system conserves energy by the remaining in standby mode.



Fig.2: Before Detection.

When a vehicle is detected, as shown in Figure 3, the YOLOv8 model verbs the object using the bounding box and the confidence

score, and sends a signal via serial connections to the Arduino module. Arduino then activates a visual and audio warning system to warn the driver. This process is shown in Figure 4. The LED naps for a second, providing a clear view cue, while a buzzer simultaneously emit a small tone to ensure the driver's attention. These alerts are designed to be disintegrating, to be noticeable without maintaining the driver comfort.



Fig.3: After Detection.



Fig.4: Alert system.

Transition from monitoring to alert and back is spontaneous, which occurs within the milliseconds, which is important for the reaction of real-time danger in the rapidly running driving environment. This ensures that the driver receives immediate warning, allowing enough time to avoid and avoid possible conflicts. During testing, the system performed frequent and reliable performances in various driving scenarios-including busy urban roads, narrow streets and high-speed highways-delayed or missing delays. It also maintained high identity accuracy by reducing false positive through sophisticated confidence threshold and zone-specific identity. By taking advantage of the speed and accuracy of YOLOv8, which processes several frames per second, the system accurately identifies the minimum computational delayed vehicles. Combined with light and reliable Arduino-based alert mechanisms, which facilitates rapid signal processing and hardware reaction, the overall system remains both cost-effective and easy to apply in a wide range of vehicles. In addition, its modular design allows for future promotion such as directional alerts, night-vision support, or even the integration of radar and lidar sensor. With this adaptation capacity, its low power consumption and minimal hardware requirements, it creates a practical, efficient and scalable solution to increase motor vehicle safety and reduce blind location-related accidents.

V. CONCLUSION AND FUTURE WORK

The blind spot monitoring system developed the usage of Yolov8 to discover actual-time vehicle indicates a sensible, inexpensive and effective approach to an Arduino-based alert mechanism to enhance road protection. Through the use of a continuous tracking of the blind area of a automobile and using accurate item detection, the gadget as it should be identified the automobiles close by and immediately tell the motive force the usage of visible (LED) and hearing (buzzer) alert. This twin-phase setup-one monitoring phase and a vigilant segment-enhancement-which drivers are simplest alerted whilst vital, lessen distraction and improve situational recognition. The implementation creates a balance between technical sophistication and ease, that is suitable for a huge variety of automobiles. The use of open-source technologies and coffee-cost hardware components enhances accessibility and allows clean customization or improve. In addition, the performance of the system is regular in various lighting fixtures and environmental situations, which guarantees reliability and efficiency in normal use.

Looking ahead, many can increase the capacity and user experience of the system. Including sensor fusion techniques-integrating the lidar with radar, ultrasonic sensor, or YOLOv8-can significantly improve the accuracy detection, especially in complex traffic or low-visible landscapes. Upgrade to more advanced AI models or light nervous networks will further enhance adaptable processing speed and efficiency for embedded systems. Applying wireless communication (eg, Bluetooth or Wi-Fi) will enable spontaneous interaction with a smartphone or in-vehicle infotainment system, while simply integration can support the direct vehicle system response. Future versions can also offer smart alert systems, such as haptic feedback vibrating seats or steering wheels, and adaptive notifications based on vehicle speed and traffic reference. In addition, expanding the setup to include several cameras can offer 360- degree coverage, turning the system into a comprehensive driver aid solution. This improvement will not only make the system more intelligent, but will also be suited for deployment in scalable and autonomous or semi-late vehicles. Its modular architecture additionally supports extended operation with minimal energy consumption, making it a permanent protection answer for the modern- day riding environment.

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