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AI-Driven Speed Breaker Detection and Alert System

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Abstract – The AI-Driven Speed Breaker Detection and Alert System aims to improve road safety by detecting road hazards such as speed breakers, potholes, and damaged road surfaces in real time. The system uses a camera-based approach combined with the YOLOv8 deep learning model to analyses live video frames. The model identifies road anomalies under various lighting and environmental conditions and provides timely alerts to the driver. The system generates both visual and audio warnings, helping to reduce accidents, prevent sudden braking, and enhance driving comfort. This approach demonstrates the effective use of computer vision and artificial intelligence in intelligent transportation systems.

KEYWORDS: - Computer Vision, YOLOv8, Speed Breaker Detection, Road Safety, Real-Time Detection.

INTRODUCTION

An intelligent system that uses computer vision and AI to find speed bumps and potholes in real time with a camera setup. The model looks at pictures of the road to find speed bumps that are coming up and warns the driver ahead of time with audio and visual signals. This helps lower the chance of sudden braking, makes driving safer, makes the ride more comfortable, and keeps the car from getting damaged. It's especially helpful for finding potholes, poorly marked roads, or roads you don't know well. Safety on the road is very important, especially in developing countries where speed bumps are often not marked or hard to see. Drivers often have trouble seeing these obstacles in time, especially at night or when the weather is bad. The progress of AI and computer vision has made it possible to make smart systems that can find problems on the road. This paper suggests an AI-based system that uses a camera to find speed bumps and send drivers real-time alerts.

The system captures live video, processes it using the YOLOv8 model, and provides alerts to the driver through a dashboard interface and buzzer sound. This improves safety and reduces the risk of accidents.

I. LITERATURE SURVEY

In recent years, significant research has been carried out in the field of road hazard detection using computer vision and deep learning techniques. These studies aim to improve road safety by identifying anomalies such as potholes, cracks, and speed breakers.

One of the earlier approaches focused on image processing techniques to detect potholes from road images. These methods used edge detection and filtering techniques to identify irregularities on the road surface. Although effective in simple scenarios, these approaches were limited by lighting conditions and lacked robustness in real-time environments.

With the advancement of deep learning, more accurate and efficient models have been developed. The RDD-YOLO model is an improved version of the YOLOv8 algorithm designed specifically for road damage detection. It utilizes convolutional neural networks (CNNs) to extract features and provides high detection accuracy with real-time performance.

Another study on lane and speed breaker detection used machine learning techniques combined with camera-based systems. This approach helped in identifying road structures and providing warnings to drivers, thereby reducing sudden braking and improving driving safety.

Additionally, deep learning-based methods for detecting potholes in Indian road conditions have shown promising

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results. These systems use trained neural networks to analyses road images and accurately detect defects, even under varying environmental conditions.

Paper Title	Journal & Year	Detection Method	Technologies Used	Key Feature	Conclusion / Outcome
Road Pothole Detection System	ITM Web of Conferences, 2023	Vision-Based Detection	Image Processing, Computer Vision	Detects potholes from road images	• Improves road maintenance• Enhances driving safety
RDD-YOLO: Road Damage Detection Algorithm Based on Improved YOLOv8	Applied Sciences, 2024	Deep Learning-Based Detection	YOLOv8, CNN, Computer Vision	High-accuracy road damage detection	• Improved detection accuracy• Suitable for real-time applications
Detection of Lane and Speed Breaker Warning System for Vehicles Using Machine Learning	IRJAEM, 2024	Camera-Based Detection	Machine Learning, Image Processing	Detects lanes and speed breakers	• Reduces sudden braking• Enhances driver awareness
Deep Learning Based Detection of Potholes in Indian Roads Using YOLO	ScienceDirect, 2020	Deep Learning-Based Detection	YOLO, Deep Neural Networks	Detects potholes on Indian roads	• Effective on real-world road conditions• Improves road safety

II. PROBLEM STATEMENT

In many regions, especially in developing countries, road conditions are often poor and not properly maintained. Speed breakers, potholes, and damaged road surfaces are frequently unmarked or difficult to notice in time. Drivers may fail to identify these hazards due to low visibility, poor lighting conditions, lack of proper signage, or unfamiliar routes.

As a result, vehicles often encounter these obstacles suddenly, leading to abrupt braking, discomfort, potential vehicle damage, and increased risk of accidents. Traditional navigation systems mainly focus on route guidance and do not provide real-time detection of road surface conditions.

There is currently no widely available system that can continuously monitor the road ahead and alert the driver about such hazards instantly. This creates a need for an intelligent, real-time solution that can detect road anomalies and provide timely warnings to enhance driver safety.

Drivers cannot detect speed breakers and potholes in time due to poor visibility and a lack of markings, which can cause accidents and vehicle damage. So we developed an AI-based system to detect these hazards in real time and alert the driver.

III. OBJECTIVES

The main objective of this project is to design and develop an intelligent system that can detect road hazards in real time and assist drivers in making safer decisions. The specific objectives of the system are as follows:

1) To develop a real-time road monitoring system using computer vision techniques that can identify speed breakers, potholes, and damaged road surfaces.

2) To train and implement a deep learning model (YOLOv8) capable of accurately detecting road hazards under different environmental conditions, such as varying lighting, shadows, and road textures.

3) To process live video input from a camera and perform continuous frame analysis for dynamic hazard detection.

4) To provide clear visual feedback by drawing bounding boxes and displaying labels for detected objects on the screen.

5) To design an alert mechanism that generates immediate audio warnings using a buzzer to notify the driver about potential hazards.

6) To create a user-friendly dashboard interface for monitoring system output, controlling detection, and improving usability.

7) To improve overall road safety by enabling early detection of hazards and reducing sudden braking and vehicle damage.

IV. METHODOLOGY

The proposed system is designed to detect road hazards such as speed breakers and potholes in real time using computer vision and deep learning techniques.

Initially, a dataset of road images is collected and labelled to identify different types of hazards. The labelled dataset is then used to train the YOLOv8 object detection model, which learns to recognise features of speed breakers, potholes, and damaged roads.

In the real-time phase, a camera captures live video of the road. The video is divided into frames, and each frame is processed using OpenCV. These frames are then passed to the trained YOLOv8 model for detection.

The model identifies road hazards and displays bounding boxes along with labels and confidence scores. When a hazard is detected, the system generates alerts through a visual display on the dashboard and an audio buzzer.

The overall system operates continuously, enabling real-time monitoring and timely warnings for the driver.

1. Data Collection

A dataset consisting of images of speed breakers, potholes, and damaged roads was collected and labelled.

2. Model Training

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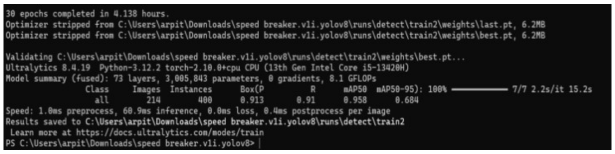
The YOLOv8 object detection model was trained on the dataset to identify road hazards with high accuracy.



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30 epochs completed in 4.138 hours.
Optimizer stripped from C:\Users\arpit\Downloads\speed breaker.v1i.yolov8\runs\detect\train2\weights\last.pt, 6.2MB
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Validating C:\Users\arpit\Downloads\speed breaker.v1i.yolov8\runs\detect\train2\weights\best.pt...
Ultralytics 8.4.19  Python-3.12.2 torch-2.10.0+cpu CPU (13th Gen Intel Core i5-13420H)
Model summary (fused): 73 layers, 3,005,843 parameters, 0 gradients, 8.1 GFLOPs
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100% ━━━━━━━━━━━━ 7/7 2.2s/it 15.2s
                   all        214        400      0.913       0.91      0.958      0.684
Speed: 1.0ms preprocess, 60.9ms inference, 0.0ms loss, 0.4ms postprocess per image
Results saved to C:\Users\arpit\Downloads\speed breaker.v1i.yolov8\runs\detect\train2
 Learn more at https://docs.ultralytics.com/modes/train
PS C:\Users\arpit\Downloads\speed breaker.v1i.yolov8> |
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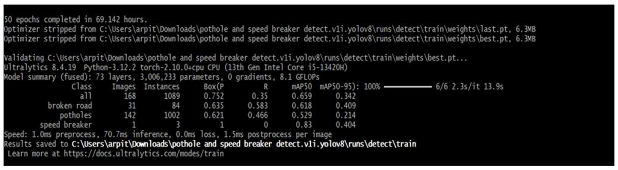

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50 epochs completed in 69.142 hours.
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Optimizer stripped from C:\Users\arpit\Downloads\pothole and speed breaker detect.v1i.yolov8\runs\detect\train\weights\best.pt, 6.3MB

Validating C:\Users\arpit\Downloads\pothole and speed breaker detect.v1i.yolov8\runs\detect\train\weights\best.pt...
Ultralytics 8.4.19  Python-3.12.2 torch-2.10.0+cpu CPU (13th Gen Intel Core i5-13420H)
Model summary (fused): 73 layers, 3,006,233 parameters, 0 gradients, 8.1 GFLOPs
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100% ━━━━━━━━━━ 6/6 2.3s/it 13.9s
                   all        168       1089      0.752       0.35      0.659      0.342
           broken road         31         84      0.635      0.583      0.618      0.409
              potholes        142       1002      0.621      0.466      0.529      0.214
         speed breaker          1          3          1          0       0.83      0.404
Speed: 1.0ms preprocess, 70.7ms inference, 0.0ms loss, 1.5ms postprocess per image
Results saved to C:\Users\arpit\Downloads\pothole and speed breaker detect.v1i.yolov8\runs\detect\train
 Learn more at https://docs.ultralytics.com/modes/train
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3. System Architecture

Camera → Frame Processing → YOLO Model → Detection → Alert System

4. Detection Process

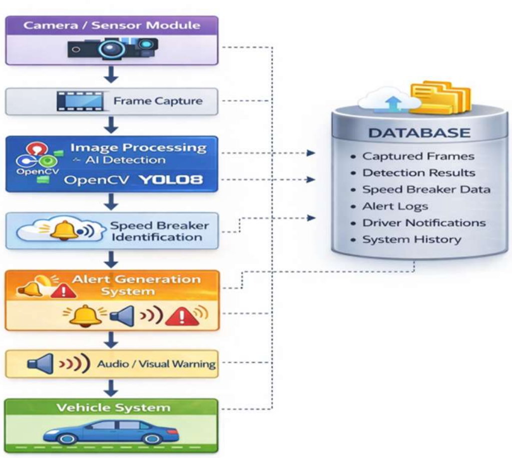
The camera captures live video frames.

Each frame is processed using the YOLO model.

The model detects objects and assigns labels and confidence scores.

5. Alert System

When a hazard is detected: A bounding box is drawn, a warning message is displayed and A buzzer sound is generated.



V. IMPLEMENTATION

The implementation of the proposed system focuses on building a practical, real-time application that continuously monitors the road and alerts the driver when hazards are detected. The system combines computer vision techniques, a trained deep learning model, and a simple dashboard interface to achieve this functionality.

A. Development Setup

The system is implemented using Python because of its flexibility and support for machine learning libraries. OpenCV is used for handling video capture and frame processing, while the YOLOv8 model is used for detecting road hazards. A graphical interface is developed using Tkinter to make the system interactive and easy to use.

The trained model file (best.pt) is loaded into the program at runtime. This model contains the learned features of road hazards such as speed breakers and potholes.

B. Camera Integration and Frame Handling

The system begins by initialising the camera using OpenCV. The camera captures live video frames continuously. Each frame is read in a loop and converted into a format suitable for processing.

Unlike traditional systems that work on static images, this implementation works on a continuous stream of frames. This allows the system to monitor the road dynamically as conditions change.

To maintain smooth operation, frame processing is optimised to reduce delay, ensuring real-time performance.

C. Real-Time Detection Process

Each captured frame is passed to the YOLOv8 model for analysis. The model processes the image and identifies objects based on the training data.

For every frame:

1)The model scans the entire image.

2)Detects potential hazards.

3)Assigns labels such as "speed breaker", "pothole", or "broken road".

4)Calculates confidence scores.

If the confidence value is above a certain threshold, the detection is considered valid. A bounding box is then drawn around the detected object, and the label is displayed on the screen.

D. Alert Generation System

The alert system is an important part of the implementation. It ensures that the driver is immediately informed about the detected hazard.

The system generates alerts in two ways:

Visual Alert
When a hazard is detected, the dashboard displays a warning message such as “Speed Breaker Detected” or “Slow Down”. The bounding box is highlighted to attract attention.

Audio Alert
A buzzer sound is generated using the win sound module. This helps in notifying the driver even if they are not looking at the display.

To avoid continuous beeping, a short delay is added between alerts so that the sound is not triggered repeatedly for the same object.

VI. RESULTS AND DISCUSSION

The proposed AI-based system was tested under real-time conditions using a webcam to evaluate its performance in detecting road hazards such as speed breakers, potholes, and damaged road surfaces.

A. Experimental Setup

The system was executed on a standard laptop with a built-in camera. Live video input was captured and processed frame-by-frame using the trained YOLOv8 model. The model was tested on different road scenarios, including normal roads, uneven surfaces, and varying lighting conditions.

B. Detection Performance

The system successfully detected road hazards in most cases with satisfactory accuracy. The model was able to identify speed breakers and potholes by analysing features such as shape, texture, and contrast.

1)Bounding boxes were accurately drawn around detected objects

2)Labels such as “speed breaker” and “pothole” were correctly displayed

3)Confidence scores provided a measure of detection reliability

The detection worked well when the objects were clearly visible in the frame.

C. Real-Time Operation

One of the important outcomes of the system is its ability to work in real time. The model processed video frames continuously and produced detection results without noticeable delay.

The frame rate (FPS) remained stable during execution, ensuring smooth video display and timely alerts. This confirms that the system is suitable for real-time applications.

D. Alert System Evaluation

The alert mechanism performed effectively during testing. When a hazard was detected:

1)A warning message was displayed on the dashboard

2)A buzzer sound was generated immediately

3)The detected object was highlighted on the screen

The combination of visual and audio alerts ensured that the driver received clear and immediate notifications.

VII. FUTURE SCOPE

The proposed system demonstrates the potential of using artificial intelligence and computer vision for road hazard detection. However, there are several areas where the system can be further improved and expanded for real-world applications.

One important enhancement is the integration of a **GPS module**, which can be used to record the location of detected hazards. This would allow the system to create a database of road conditions and help other drivers receive prior warnings about dangerous areas.

Another improvement is the implementation of **distance estimation techniques**. By calculating the distance between the vehicle and the detected hazard, the system can provide early warnings such as “Speed breaker ahead in 50 meters,” which would be more useful for drivers.

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The system can also be integrated with **smart vehicle technologies** or Advanced Driver Assistance Systems (ADAS). This would allow automatic speed control or braking in response to detected hazards, further improving safety.

In addition, the model performance can be enhanced by training it on a larger and more diverse dataset that includes different road conditions, weather situations, and lighting variations. This would improve accuracy and reduce false detections.

A mobile application or cloud-based system can also be developed to store and share hazard data. This would help in building a **real-time road monitoring network**, benefiting a larger number of users.

Finally, the system can be implemented on embedded platforms such as Raspberry Pi or edge devices, making it portable and suitable for installation in vehicles.

VIII. CONCLUSION

The AI-Driven Speed Breaker Detection and Alert System successfully demonstrate how computer vision and deep learning can be used to improve road safety. The system is capable of detecting road hazards such as speed breakers, potholes, and damaged road surfaces in real time using a camera-based approach and the YOLOv8 model.

By continuously analysing video frames, the system identifies hazards and provides immediate visual and audio alerts to the driver. This helps in reducing sudden braking, preventing vehicle damage, and improving overall driving comfort. The use of a dashboard interface makes the system easy to monitor and control.

The experimental results show that the system performs effectively under normal conditions and is able to deliver reliable detection with acceptable speed. Although some limitations exist in low-light conditions, the system provides a strong foundation for intelligent road safety applications.

Overall, this project highlights the practical implementation of artificial intelligence in real-world scenarios and demonstrates its potential to be integrated into smart vehicles and advanced driver assistance systems in the future.

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