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Potholes and Humps Detection System in Real-Time

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Abstract: *Potholes are formed as a result of unavoidable wear, tear and weathering of roads. It causes uneasiness to the travelers and may also lead to death due to vehicle accidents. The main purpose of the project is to prevent the road accidents occurring in and around the world. Many people do not slow down as they fail to recognize the potholes and humps on the road while driving, which leads to life hazard or vehicular damage. The proposed method involves the usage of cameras and sensors to collect the data, identify and distinguish between the humps and pothole region and alert the driver with different buzzer sounds. The pothole detection can be achieved using YOLOv4 algorithm, which is efficient in spotting the potholes. The hump detection is carried out using the ultrasonic sensor and Arduino. Therefore, in order to avoid accidents in significant number we have come up with the pothole and hump detection project for social good.*

Keywords: potholes, humps, accidents, cameras, sensors, YOLOv4 algorithm, buzzer, ultrasonic sensor, Arduino

I. INTRODUCTION

Roads are the most dependent mode of transport in India. Road transport is the main cause, accounting for about 87% of passenger transport in the country. However, maintaining road safety and vehicle safety is an important aspect of road transport. The Indian government said a total 4.4 thousand accidents occurred in the year 2022 due to potholes. Potholes are caused due to small surface cracks, heavy rainfall, high traffic volume, and also due to lack of proper maintenance. Some humps are present without any warning, which will lead to accidents and vehicle damage. Major challenge is to develop an advanced Pothole and Hump Detection System using machine learning and image processing techniques, integrated with real-time alerting mechanisms for vehicles. Existing methods for pothole and hump detection lack real-time capabilities. Therefore, the primary aim is to create a system that can accurately detect the presence of potholes and humps on roadways, and then provide timely alerts to vehicles. This in turn reduces the risks associated with road hazards. Pothole and hump detection can be done in real time. Detection of potholes is done using Yolo algorithm and ultrasonic sensor, Arduino is used for hump detection. Advantages over existing system are easy to implement, maintain and cost effective.

II. BACKGROUND

Road infrastructure faces constant challenges from wear and tear, leading to issues like potholes and humps. Potholes are caused as aresult of by traffic, weather, and water, pose a significant threat to road safety. They can cause sudden jolts to vehicles, potentially leading to accidents and damage for drivers and pedestrians. Conversely, humps, also known as speed bumps, are intentionally built to slow down traffic and enhance safety, particularly in residential areas, school zones, and parking lots. While both potholes and humps impact road safety, they do so in contrasting ways.

Traditional methods for pothole and hump detection rely on manual inspections, a time-consuming and subjective process. To address this limitation and improve overall road safety, automated detection systems using deep learning algorithms have emerged. This project proposes a real-time pothole and hump detection system utilizing the YOLOv4-Tiny algorithm.

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YOLOv4 is a powerful object detection algorithm known for its accuracy and real-time processing capabilities. However, the standard YOLOv4 model can be computationally expensive for deployment on resource-constrained embedded systems. This is where YOLOv4-Tiny comes in. This lightweight and efficient variant is specifically designed for real-time applications on mobile devices or Internet-of-Things (IoT) platforms. By leveraging YOLOv4-Tiny, this project aims to develop a cost-effective and efficient detection system for potholes and humps. Trained on a specifically curated dataset capturing various lighting and weather conditions, the system will be able to identify these road irregularities in real-time. This real-time detection capability holds immense potential. Early identification of potholes allows for prompt repairs, minimizing accident risks and vehicle damage. Similarly, detecting humps in advance ensures their effective integration into traffic management systems, optimizing their role in maintaining safe driving speeds. Ultimately, this project strives to contribute to a safer and more efficient transportation network by implementing a proactive and cost-effective pothole and hump detection system using the YOLOv4-Tiny deep learning algorithm.

III. SYSTEM DESIGN

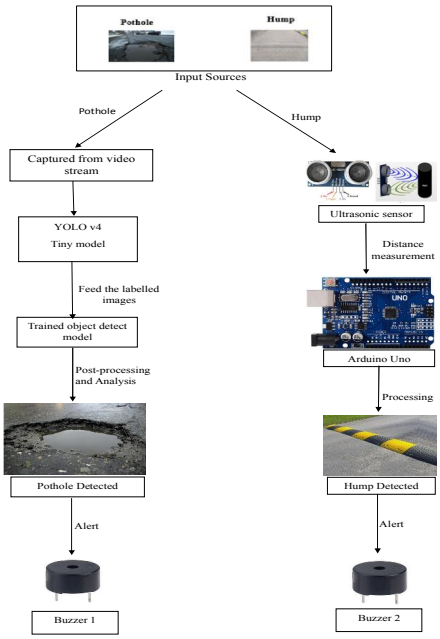

Fig.1.System Architecture

Pothole

- **Input Source:** The system captures a video stream as the input source.
- **YOLO v4 Tiny Model:** The video stream is fed into a pre-trained convolutional neural network model called YOLO v4 tiny model. This model is specifically designed to identify potholes in images.
- **Labelled Images:** The YOLO v4 tiny model was trained on a dataset of labelled images containing potholes. During training, the model learned to recognize the features of potholes in images.
- **Object Detection:** When the YOLO v4 tiny model processes a frame from the video stream, it outputs a bounding box around any potholes it detects in the frame.
- **Post-processing and Analysis:** Check the size and shape of the bounding box around the pothole. Consider a confidence score from the model to see how certain it is about the pothole. analyze detections across multiple video frames for consistency.
- **Pothole Detected:** A pothole is likely detected when the model identifies darker areas with sharp edges and significant depth, along with irregular shapes or shadows cast within the depression
- **Buzzer 1:** The buzzer is an alerting device that emits a sound when a pothole is detected.

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Hump

- **Ultrasonic sensor:** The ultrasonic sensor emits 40Hz waves and waits for their return. When a wave hits an object, it bounces back and is detected by the receiver. By measuring this time, the sensor calculates distance accurately.
- **Distance measurement:** The Arduino Uno receives the signal from the ultrasonic sensor and uses it to calculate the distance of the object.
- **Hump detected:** If the distance measurement is below a certain preset threshold value, it indicates that a hump has been detected.
- **Processing:** The Arduino Uno processes the signal from the ultrasonic sensor and determines whether a hump has been detected based on the distance measurement.
- Alert: When a hump is detected, the Arduino Uno will activate an alert.
- **Buzzer 2:** The buzzer is a device that emits a sound to alert when a hump is detected.

IV. METHODOLOGY

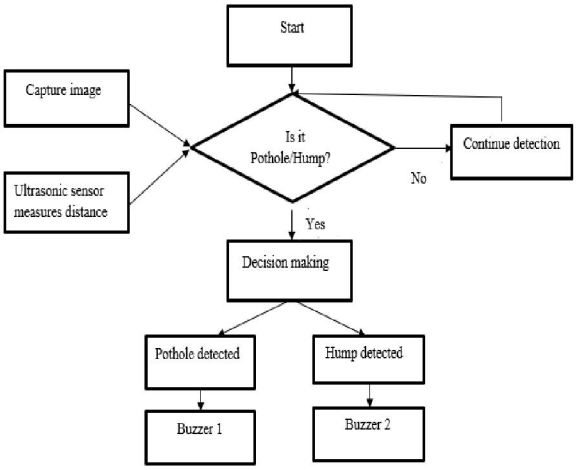

Fig. 2. Flow Chart

The beginning of the pothole and hump detection is marked by start. The pothole and hump detection is carried out independently. Firstly, live video is captured in potholes detection and each frame from the video is analysed using the YOLOv4 tiny model. If the object identified matches the pothole criteria then the system alerts the driver with a distinct buzzer sound. On the other hand, hump detection is carried out using a hardware setup comprising of ultrasonic sensor integrated with Arduino. If the object detected is with protrusions on the road surface, then it is identified as hump and an alert is given to the driver with another distinct buzzer sound.

Hardware Implementation:

Prototype Development includes the following hardware tools like Arduino UNO, Ultrasonic sensor, Buzzer, Camera. The Arduino uno contains a set of analog and digital pins that are input and output pins which are used to connect the board to other components. Arduino Uno is integrated with ultrasonic sensor and buzzer. Ultrasonic sensor is placed at end of prototype to detect the presence of hump on the road. Ultrasonic sensor measures the distance between road and the bike and it is received by Arduino. The distance between the road and the bike will be fixed, if the distance detected is less than the fixed value then it will be detected as hump. Upon detection of hump, buzzer will provide the alert. Camera will be mounted on the top of the model in such a way to capture the road ahead. Camera will provide the video of road as an input for the system. By analysing the video with the help of YOLOV4 algorithm system will provide the alert, if pothole is detected.

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V. RESULTS AND DISCUSSION

Fig 3. Potholes detected

The system makes use of the YOLOv4 Tiny model's pothole detection capabilities in real-time. A bounding box precisely encloses the identified pothole, accompanied by a confidence score of 85%. This high score suggests the model is highly confident in its detection. Notably, the YOLOv4 Tiny architecture achieves this with impressive speed, potentially reaching frames per second**.** This efficiency makes it suitable for real-time applications on embedded systems with limited resources. Further evaluation with various image sets containing potholes under diverse conditions will solidify these initial findings.

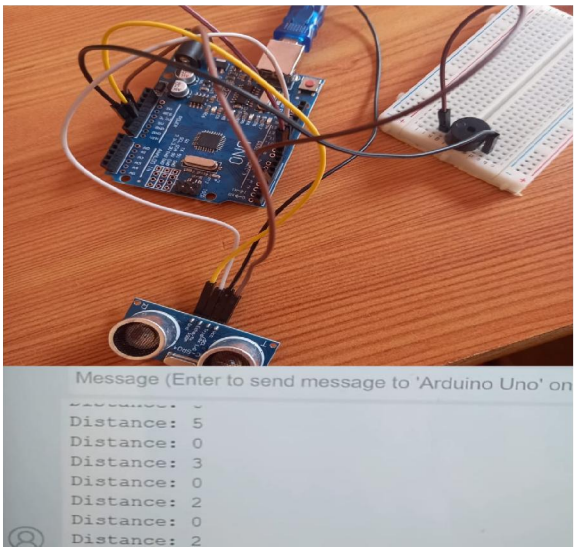

Fig 4. Prototype for hump detection

The Arduino Uno and HC-SR04 ultrasonic sensor successfully measured the distance to a hump in the test scenario. The LCD display indicateda distance of 2 centimeters, signifying that the ultrasonic sensor is very close to the obstacle. This demonstrates the feasibility of using an ultrasonic sensor to detect the presence of a hump. Further testing under controlled conditions with various hump sizes and distances is recommended to determine the optimal placement and sensitivity of the ultrasonic sensor for robust hump detection in real-world applications.

VI. CONCLUSION

This project developed is based on real-time potholeand hump detection system using a YOLOv4-Tiny algorithm, ultrasonic sensors, Arduino, and a webcam. This innovative approach combines the strengths of image processing and sensor data to accurately identify and locate potholes and humps on the road. The custom object detection YOLOv4-Tiny algorithm has been implemented to detect potholefrom live images captured by the webcam and humps are detected using ultrasonic sensor and Arduino.

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VII. FUTURE SCOPE

- **Smart Infrastructure Integration:** Pothole and hump detection systems will be integrated with smart city infrastructure, such as IoT sensors embedded in roads and traffic lights. These interconnected systems will enable automated maintenance workflows, where detected road defects trigger immediate repair requests or adjustments to traffic flow to minimize congestion around damaged areas.
- **Water-Filled Pothole Detection**: Future pothole detection systems will include specialized sensors capable of detecting water-filled potholes. These sensors may utilize technologies such as sonar or conductivity measurements to identify areas where water has accumulated within potholes, alerting authorities to potential safety hazards caused by reduced traction or road instability.
- **Traffic Flow Optimization:** By integrating real-time hump detection with traffic management systems, authorities can optimize traffic flow by adjusting signal timings or routing vehicles to alternate routes to minimize delays caused by speed humps. This can lead to smoother traffic flow and reduced congestion, benefiting both commuters and the environment.

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