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Adaptive Semi-Active Suspension System

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Abstract: Safety, reliability and cost are the major driving factors for research in automotive applications. The current suspension systems available today prove to be a bit lackluster by compromising on either the ride quality or stability of the vehicle. By compromising stability, traction also gets compromised. Automotive suspension systems play a vital role in ensuring the comfort and safety of a vehicle. Our project proposes an adaptive version of the semi-active suspension system with a new design that focuses on cheaper production and better stability. It aims to tackle the above-mentioned issues by monitoring the conditions and determining the type of irregularity present in the road ahead, and reacting to these irregularities and conditions by pumping a specific amount of oil into the suspension system in order for the suspension to stiffen or soften accordingly.

The suspension system proposed by us displays the integration of Artificial Intelligence (AI) and IOT together that aims at improving the traction and holding the position of the vehicle to the surface of the road thus improving the stability of the vehicle, reducing body roll and trying to prevent motion sickness, leading to better riding comfort.

Keywords: You Only Look Once (YOLO), Canny edge detection, Euclidean distance and Morphological Operations.

1. INTRODUCTION

In this ever-expanding world, the use of transportation systems has also observed a massive expansion. Along with this the demand to reach somewhere rapidly is very crucial. This has led to reckless driving behaviour, which in turn leads to accidents. It has been observed that every day approximately 1,130 accidents occur on Bhartiya roads which can translate to 422 deaths per hour on average. To tackle such situations the need to enhance vehicle safety, comfort, and performance becomes very important. This has

led to many significant advancements in recent years, with passive suspension systems becoming the industry standard due to the performance ratio they provide for the cost of production and active suspension being a niche category among high-end users. Yet, there are challenges which are faced by the industry. Factors such as the adaptiveness of the passive suspension system, which either leads to compromise in safety at high speeds or the ride comfort of the user, high power consumption of active-suspension system, and the high chance of failure if the rubber membrane ruptures in the active-suspension system. This project is designed to provide a comprehensive solution to these challenges.

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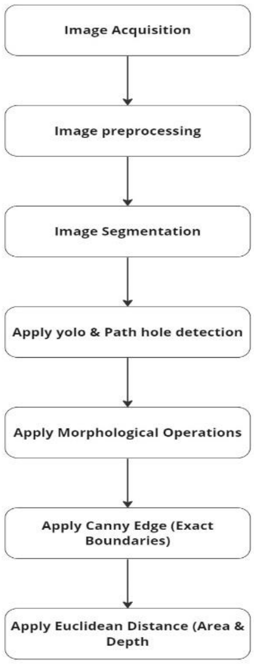

2.METHODOLOGY

The provided methodology involves several steps for image processing, including image acquisition, pre-processing, segmentation, applying YOLOv4 for path hole detection, morphological operations, Canny edge detection, Euclidean distance calculation, and finally, determining the area and depth. This process is designed to extract and analyse specific features from images, such as detecting and measuring the size of path holes.

Image acquisition: This step involves capturing an image using a camera or other imaging device.

Image pre-processing: This step includes any necessary adjustments to the image, such as contrast or brightness adjustments, to improve the quality of the image.

Image segmentation: This step involves dividing the image into different regions or segments based on specific characteristics, such as colour or texture.

Applying YOLOv4 and path hole detection: YOLOv4 is a state-of-the-art object detection model that can be used to detect path holes in the image.

Morphological operations: These operations involve applying a structuring element to the image to process it based on shape. Dilation and erosion are two common morphological operations that can be used to fill gaps or remove small objects from the image.

Canny edge detection: This step involves detecting edges in the image, which can help identify the boundaries of objects.

Euclidean distance calculation: This step involves calculating the distance between two points in the image, which can be used to determine the area and depth of the path hole.

3.LITERATURE REVIEW

Ghoniem et al.,[1] This study offers a new design for a low-cost semi-active suspension system, consisting of a hydraulic piston with a proportional throttle valve mounted outside the piston cylinder between two inlet ports. The throttle valve is used to dissipate hydraulic energy in the cylinder's oil. This valve is controlled via an ANN controller to regulate the valve opening to achieve the needed equivalent dampening coefficient.

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Aditya Shinde et al.,[2] This study provides us with insights into the importance of the timely detection of road damage for the prevention of accidents. Also, the use of the CNN model to detect damages including cracks, potholes and patches on consumer roads with approximately 94% accuracy is also proposed.

S. S. Eligar et al.,[3] This study emphasizes the major driving factors such as safety, reliability and cost for automotive applications and provides us with a better understanding of the pros and cons of different suspension systems i.e., passive suspension systems, active suspension systems, and semi-active suspension systems. It also portrays the trade-offs in design, ride comfort versus road handling and the implementation of comfort criteria at low frequencies.

R. G. Shete et al.,[4] This study showcases that vehicle suspensions are inclining towards the active suspension system due to their precise and adaptable force control, lower maintenance, high ride quality, simple design and tractable performance. We learn that an active suspension consists of mechanical components that are operated by an algorithm using sensor feedback. The irregularities on the roads are monitored by image processing to provide prior information.

C. Saisree et al., [5] This study gave us knowledge of algorithms for detection potholes on both muddy and highway roads which is critical for detecting road defects, manual detection methods are time-consuming and often are imprecise.

D. H. Heo et al.,[6] In this study we got to know about a new algorithm which was made to detect potholes in 2D images by modifying yolo V4 it also proposes a risk assessment algorithm that assesses size of potholes.

M. Xu et al.,[7] In this study we learned about an improved yolo V4 model for detection of vehicles, it compares the new model with normal yolo V4 model and concludes that newer model has better accuracy and also has a literature review of object detection using yolo v4.

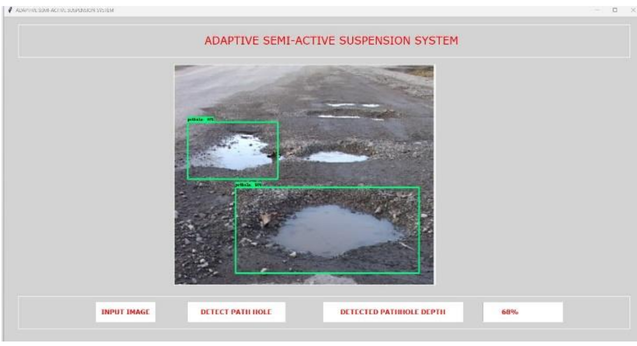
Wenjie Jiang et al.,[8] This study highlights the problem of potholes in various countries and shows limitations of current detection models and proposes a real-time automatic
pothole detection system using a Convolutional Neural Network (CNN).

M. Vm et al.,[9] This study helped us understand that TensorFlow, Keras and Yolo are very powerful resources for enhancing real-time object detection and computer vision across diverse domains.

4.SUMMARY

yolo version for Image reputation is a completely effective device utilized in project, but sole dependence on yolo for detection can lose a few crucial information and decrease the accuracy of reputation. To address those we've delivered extra technology to conquer those shortcomings like morphological operations this may assist method the picture primarily based totally on its shape, may be used to fill gaps or put off small item from picture, Canny area detection is used to enhance the threshold detection and allows in figuring out the bounds of objects, Euclidean distance is used to calculate distance among factors withinside the picture and used to decide the region and intensity of the pothole.

5.RESULT



Through the rigorous testing process, the Adaptive Semi-Active Suspension System demonstrated its effectiveness in detecting road irregularities, adjusting suspension settings in real time, and enhancing vehicle stability and comfort. The system's accuracy, recall, and precision metrics met predefined benchmarks, indicating its reliability and suitability for

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practical deployment. Overall, the project's successful outcomes validate the efficacy of the chosen components, methodologies, and development process in achieving the desired objectives of improving ride comfort and safety on the road.

6. CONCLUSION

The Adaptive Semi Active Suspension System represents a significant advancement in vehicle suspension technology, aiming to improve ride comfort, stability, and safety by dynamically adjusting suspension settings based on real-time detection of road irregularities. Through the integration of sensors, control algorithms, and user interface components, the system demonstrates promising performance in detecting and responding to potholes, speed breakers, and other road hazards. The successful implementation and testing of the system in simulated and real-world driving scenarios validate its effectiveness in enhancing the overall driving experience and reducing the risk of accidents.

For future work, several avenues for improvement and expansion are identified. Some of them are:

Integration with Autonomous Systems: Explore the integration of the suspension system with autonomous driving systems to enable proactive suspension adjustments that anticipate road irregularities and enhance vehicle stability and comfort during autonomous operation.

User Experience Enhancement: Continuously refine the user interface design and functionality to improve user experience, accessibility, and customization options, allowing drivers to personalize suspension settings according to their preferences and driving conditions.

Enhanced Sensor Technology: Explore the use of advanced sensor technologies, such as LiDAR or radar, to improve the accuracy and reliability of road irregularity detection under various environmental conditions, including low visibility or adverse weather.

Advanced Control Algorithms: Investigate the development of advanced control algorithms, including machine learning techniques, to optimize suspension adjustments based on driver preferences, road conditions, and vehicle dynamics in real-time.

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