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IOT BASED WOBBLING MOTION DETECTOR FOR MOTOR CYCLES, LIGHT AND HEAVY VEHICLES.

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Abstract:

The Internet of Things (IoT) enabled Wobbling Motion Detector for motorcycles, light, and heavy vehicles is intended to monitor the motion of the wheel and deliver real-time alerts to the driver via a flashing LED. This device is engineered for motorcycles, light, and heavy vehicles where wobbling motion can potentially cause accidents and present a considerable safety hazard.

In response to this concern, we propose an IoT-driven wobbling motion detection system employing ultrasonic sensors integrated into the swingarm/frame of the vehicle. These ultrasonic sensors are tasked with ongoing measurement of the distance from a fixed point on the frame to the rim of the wheel. The microcontroller analyses the sensor data in real-time to detect any sudden or gradual fluctuations. If wobbling is detected, the microcontroller activates the LED display to blink, providing a visual alert to the driver. Simultaneously, the data is sent to the centralized server for further analysis and reporting.

The objective of the IoT-based wobbling motion detector research is to mitigate accidents and improve driving performance by identifying any irregular wobbling of the wheel and issuing immediate alerts to drivers. Leveraging ultrasonic sensors and IoT technology, this system employs a proactive methodology to augment road safety across various vehicle categories.

Index Terms **–** Internet of Things (IoT), Wobbling Motion Detector, Real-time alerts, Ultrasonic sensors, Microcontroller, Centralized server, Road safety

I. INTRODUCTION

In an era marked by continuous advancements in transportation and mobility, the paramount concern for vehicle safety remains undiminished. Safety on the roads, highways, and byways is not merely a matter of paramount importance; it is a moral and legal imperative. Recognizing the urgency of enhancing the safety of both light and heavy-weight vehicles, we introduce a groundbreaking solution that combines the power of the Internet of Things (IoT), real-time data analysis, and proactive maintenance measures. The result is the "IoT-Based Wobbling Motion Detector for Vehicle Safety."

This research aims to address wheel wobbling in vehicles, a critical yet underestimated factor in accidents and efficiency issues. We've developed a robust system using ultrasonic sensors, the ESP8266 microcontroller, cloud-based data analysis, and customizable alert mechanisms to detect and mitigate wheel wobbling, enhancing safety and reducing maintenance costs. This research involves meticulous sensor installation, ESP8266 programming, secure cloud data transmission, real-time data analysis, and instant alarm triggering for wobble detection. Rigorous testing, calibration, and maintenance ensure system reliability and long-term effectiveness.

Our innovative solution incorporates advanced safety enhancements alongside features that optimize vehicle performance and operational efficiency. Through real-time data analysis, including monitoring of wobbling angles, operators receive actionable insights to mitigate risks and enhance maintenance protocols. This proactive approach reduces the likelihood of accidents, improves vehicle upkeep, and enhances fuel efficiency. Leveraging IoT capabilities, our system enables remote monitoring and data logging for comprehensive maintenance planning and execution.

This research aims to introduce a new era of vehicle safety and efficiency by integrating advanced technology into vehicles to enhance protection and optimize performance. While installing the system on new vehicles may be straightforward, retrofitting older vehicles presents a unique challenge that requires skilled installation. It is crucial to recognize that environmental factors, such as road quality and vibrations, may trigger false alarms, necessitating meticulous calibration. Furthermore, the system relies on a power source, whichnecessitates vigilant monitoring to prevent excessive draining of vehicle batteries. Maintenance of the system is inevitable to ensure its continued functionality.

The "IoT-Based Wobbling Motion Detector for Vehicle Safety" research not only aims to improve the safety and efficiency of vehicles but also underscores the importance of user education. By imparting knowledge to vehicle operators regarding the significance of real-time data and the necessity for immediate action upon wobbling detection, we empower them to actively engage in promoting safer road conditions. This involves educating users on the technical aspects of the system, such as the functioning of IoT sensors, data analysis algorithms, and the implications of wobbling motions on vehicle safety. Through such education, users become informed stakeholders in the ongoing endeavor to enhance road safety.

In line with our overarching objectives, we also undertake the analysis of gathered data to discern patterns and trends in wobbling motion, thereby enhancing vehicle maintenance and safety protocols. We emphasize the significance of meticulous documentation, encompassing.

II. LITERATURE REVIEW

Grynal D'Mello et al (Dec 2021): The author presents a novel approach to wheel alignment monitoring systems that typically rely on complex computer vision technologies, expensive high-end cameras, precise objects, and significant computational resources, often requiring experienced operators. In an effort to improve accessibility, the study introduces an easy-to-use, cost-effective solution using an MPU6050 sensor and an ESP32 microcontroller, complemented by a customized graphical user interface (GUI). Testing this IoT-based wheel alignment system on a vehicle yielded results comparable to traditional methods, indicating its practicality and potential as a viable alternative in the field of wheel alignment inspection.
Huibo Wu, China et al (Sep 2020): The author presents an early loosening warning system comprising two modules: the tire monitoring module and the working control module. The tire monitoring module, installed on the tire and designed without its power supply, communicates wirelessly with the control module, located in the vehicle body, via radio frequency. During driving, if a tire becomes loose, the monitoring device sends an automatic wireless alarm signal. Upon receiving the alarm, the driver can promptly initiate emergency measures such as parking and inspection, thereby averting potential traffic accidents resulting from loose tires.
Shiva Paudel et al (July 2020): This paper introduces a straightforward approach for identifying camber and toe in/out errors using a disturbance observer (DOB) without the need for extra sensors or mechanisms. The proposed method is validated through practical application on a differential drive mobile robot, where the robot is commanded to follow a predefined path, and the torque profile is analyzed to determine wheel misalignment. This innovative approach offers potential benefits for electric vehicle alignment assessment without the need for additional hardware.

Riton Kumer Das (Dec 2018): This study focuses on the experimental investigation of wheel alignment systems for light vehicles. Various wheel alignment adjustment techniques are applied in real-time to enhance vehicle performance. The paper introduces a computerized and computer vision-based system for measuring automobile wheel alignment. The experimental analysis indicates that vehicle wheel alignment tends to become misaligned in the range of 4000 km to 5000 km of running. The findings underscore the importance of regular wheel alignment checks using advanced technologies, which substantially extend tire life, enhance tire safety, and improve vehicle handling satisfaction.

Nira Dynamics AB et al (Aug 2016): Their invention utilizes a wheel speed signal for the detection of wheel anomalies, including loose wheels or wheels with zero pressure. It achieves this by generating a first and second detection signal based on the wheel speed signal, in conjunction with a first and second reference signal, respectively. The detection of anomalies such as loose wheels is triggered when at least one of the detection signals surpasses a predefined threshold. This disclosure encompasses methods, systems, and computer program products designed to achieve this objective, providing an innovative approach to wheel anomaly detection.

Brian David Hayes et al (March 2006): The author introduces a loose wheel detection assembly featuring a sensor securely mounted to the hub, which identifies movement between the wheel and hub. A controller processes the data and triggers an in-cabin warning system, bolstering vehicle safety by promptly alerting the operator to potential loose wheel issues.

III. Relevance of Research

In an era marked by continuous advancements in transportation, our research, the "IoT Based Wobbling Motion Detector for Vehicle Safety," emerges as a compelling and highly relevant solution to enhance safety and efficiency across the spectrum of vehicular operations. This research directly addresses the following key areas of relevance.

1. Road Safety Enhancement

The critical issue of wheel wobbling in vehicles by implementing real-time detection and alert mechanisms. This technology enables operators to promptly identify and address potential hazards, thus minimizing the risk of road accidents.2. Preventive Maintenance for Vehicle Efficiency

The research enhances vehicle efficiency and lifespan by detecting and correcting wheel wobbling, which can cause inefficient operation and higher fuel consumption if ignored. This system promotes cost-effective and environmentally responsible vehicle maintenance practices.

3. Cost Savings and Economic Impact:

The research is highly relevant in the context of modern vehicle operation, which increasingly relies on real-time data monitoring and analysis. By providing continuous data on wheel conditions, our system aligns with the industry's growing demand for actionable insights and data-driven decision-making

4. IoT- Integration for Remote Monitoring

The integration of IoT capabilities extends the research's relevance by enabling remote monitoring and data logging. This aspect is particularly valuable for fleet management and remote diagnostics, further enhancing the efficiency and safety of vehicles.

5. Alignment with Vehicle Engineering and Autonomous Vehicles

As a project within the domain of vehicle engineering, our work encapsulates the technical and engineering facets of vehicle safety and performance enhancement. Moreover, our implementation in autonomous vehicles underlines its relevance to the cutting-edge field of autonomous transportation and the enhancement of decision-making and safety in autonomous vehicles.

In summary, the "Wobbling Motion Detector for Vehicle Safety" project provides a robust solution to safety issues in the automotive sector by utilizing this technology to detect wobbling motion. It offers benefits such as enhanced safety, increased efficiency, cost savings, and data-driven decision-making. This makes it a highly relevant and impactful initiative with broad implications for the transportation industry.

IV. RESEARCH METHODOLOGY AND EXPERIMENTATION:

1. Present Theory and Practices:

Current vehicle safety and maintenance practices primarily rely on conventional methods like routine inspections, manual diagnostics, and scheduled maintenance procedures. However, these approaches may not adequately address critical issues such as wheel wobbling, which can jeopardize vehicle safety and efficiency if not promptly detected and addressed.

1.1. Current Practices in Vehicle Safety:

Current theories and practices in vehicle maintenance involve physical inspections, including visual assessments, periodic servicing, and routine maintenance checklists. Operators and mechanics typically rely on visual and manual checks to detect potential issues or signs of wear, particularly related to wheels problem.

1.2. Limitations in Detecting Wheel Wobbling:

One significant limitation of current practices lies in their inability to provide real-time insights into wheel wobbling. Routine inspections often miss subtle or intermittent wobbling issues that can develop during vehicle operation. In many cases, wheel wobbling may only become apparent once it reaches a critical stage, potentially leading to accidents, damages, andincreased maintenance costs.

1.3. Merging Trend in Data-Driven Solutions:

An emerging trend in the automotive industry is the adoption of data-driven solutions to enhance vehicle safety and performance. The integration of sensors and real-time data analysis has shown promise in revolutionizing maintenance and monitoring practices. Data-driven solutions offer the potential for early detection of issues, predictive maintenance, and remote monitoring, aligning with the growing demand for efficiency, cost savings, and enhanced safety.

1.4. Present Relevance and Innovation:

The research, "IoT-Based Wobbling Motion Detector for Vehicle Safety," is situated at the intersection of these trends and limitations, introducing a groundbreaking approach to wheel wobbling detection and prevention. By leveraging IoT technology, ultrasonic sensors, and real- time data analysis, the research represents a significant advancement in the realm of vehicle safety and maintenance practices, offering a solution that can provide real-time detection and alerts, ultimately improving safety and efficiency.

1.5. Expected Contributions:

This research aims to revolutionize vehicle maintenance practices by integrating real-time data analysis with traditional inspections. It utilizes IoT technology to enhance safety and efficiency for both manual and autonomous vehicles. By addressing existing limitations and embracing data-driven trends, the research holds promise for redefining standard practices in the automotiveindustry.

2. Proposed work:

The proposed work for the "IoT-Based Wobbling Motion Detector for Vehicle Safety" researchencompasses a structured plan to accomplish the research's key objectives and deliverables. It isorganized into a series of well-defined tasks and milestones:

2.1 Sensor Installation and Data Collection:

Objective: Securely install an ultrasonic sensor on the vehicle's swingarm to measure the perpendicular distance between the wheel rim and the swingarm. Initiate data collection.

Method: Employ precise engineering techniques for sensor placement to ensure accurate data collection.

2.2 ESP8266 Programming for Real-time Analysis:

Objective: Program the ESP8266 microcontroller to read sensor data, calculate the wobble angle, and trigger alarms in real-time when necessary. Ensure seamless data flow from the sensor to the ESP8266 for further processing.

Method: Develop custom firmware for the ESP8266, enabling data processing and real-time wobble angle calculations. Implement an alert mechanism for immediate feedback to vehicle operators.

2.3 Cloud Integration for Data Transmission:

Objective: Establish a secure connection between the ESP8266 and a cloud-based platform to enable real-time data transmission. Implement communication protocols to ensure the reliable delivery of data to the cloud.

Method: Implement IoT data transmission protocols, such as MQTT or HTTP, to securely and efficiently connect the ESP8266 with cloud-based storage and analysis services.

2.4 Cloud-Based Data Analysis and Alerts:

Objective: Develop cloud-based data analysis scripts and algorithms to receive, process, and analyse real-time data, including wobble angle calculations. Configure the cloud platform to trigger alarms and notifications when wobbling exceeds predefined thresholds.

Method: Utilize cloud services and platforms for data analysis, leveraging Python, Node.js, orcloud-specific tools to perform real-time data processing and alert generation.

2.5 Rigorous Testing and Calibration:

Objective: Conduct extensive field tests under varied road conditions to validate the system's performance. Fine-tune system parameters within the ESP8266 and cloud-based data analysis to minimize false alarms and optimize detection accuracy.

Method: Carry out controlled tests, adjusting the system's thresholds and parameters to ensure accurate wobble detection while minimizing false alarms.

2.6 User Education and Training:

Objective: Develop user-friendly educational materials to educate vehicle operators on the significance of real-time data, wobble angle calculations, and alarm indications. Conduct training sessions to ensure that users effectively utilize the system.

Method: Create user manuals, training videos, and on-site training sessions to facilitate user understanding and system adoption.

2.7 Maintenance Plan Development:

Objective: Create a comprehensive maintenance schedule that outlines routine tasks and schedules for maintaining the ESP8266, sensors, and cloud infrastructure. Ensure the long-term reliability and accuracy of the system.

Method: Define maintenance tasks, intervals, and responsibilities to keep the system in optimal working condition.

2.8 Data Analysis and Insights:

Objective: Analyze collected data in the cloud to identify patterns and trends in wobbling motion. Extract actionable insights for proactive maintenance and safety improvements.

Method: Use cloud-based analytics tools and techniques to extract valuable insights from historical data, enhancing vehicle safety and maintenance practices.

2.9 DOCUMENTATION:

Objective: Produce detailed research documentation that includes installation instructions, maintenance procedures, and the cloud-based data analysis scripts.

Method: Create comprehensive documentation to serve as a reference for future users and maintainers of the system, encompassing both hardware and cloud-based components.

The proposed work section delineates a systematic and integrated approach, harnessing the power of IoT, sensor data, cloud-based analysis, and real-time alerts to enhance vehicle safetyand maintenance. This well-structured plan ensures that the research's core objectives are met effectively and efficiently.

V. EXPERIMENTATION SETUP

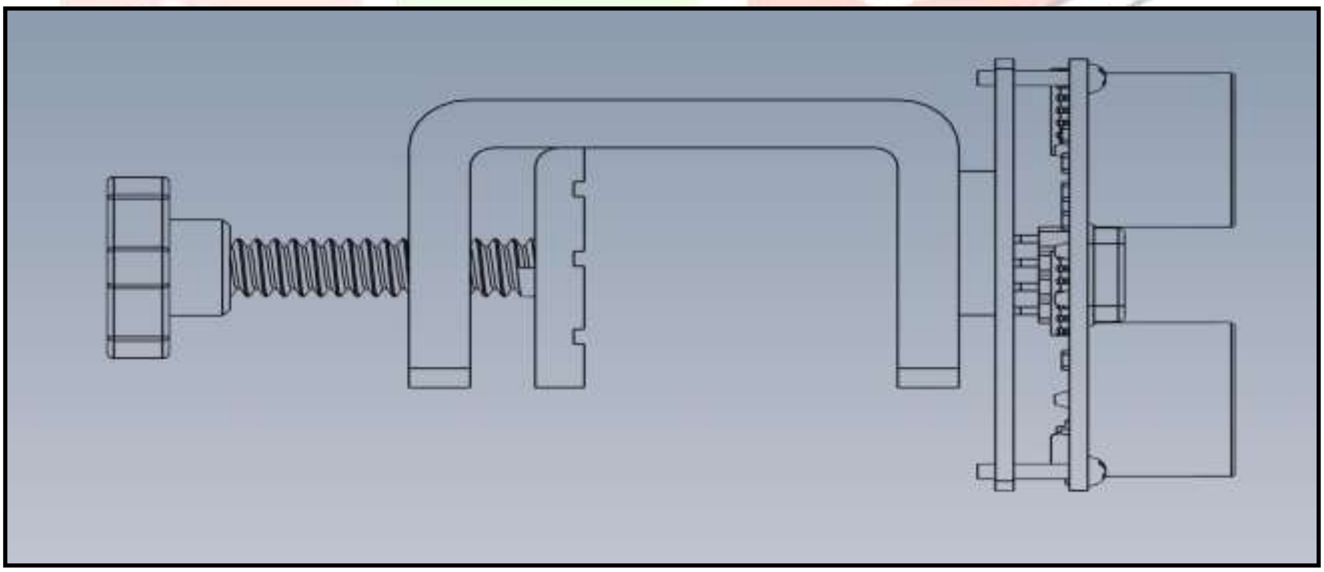
Fig 1 – Wobbling Motion Detection Setup

MATERIALS USED TO GENERATE THE GRAPH TO CHECK RESULT

1. Arduino Board (e.g., Arduino Uno)
2. Ultrasonic Sensor (e.g., HC-SR04)
3. Breadboard and jumper wires
4. USB 2.0 Cable Type A/B 6.3.2

Required Wiring Connections

1. VCC (Power): Connect this to the 5V pin on the Arduino Uno.
2. GND (Ground): Connect this to one of the GND pins on the Arduino Uno.



3. Trig (Trigger): Connect this to a digital pin on the Arduino Uno (e.g., Pin 9).
4. Echo: Connect this to another digital pin on the Arduino Uno (e.g., Pin 10).

VI. RESULTS & DISCUSSION

Ultrasonic sensor is connected to Arduino board along with LIDAR sensor and Arduino connection is given to screen to display the results in the form of graph. The generated code is given to Arduino board to sense the data in real time to carry out the observation. The main goal of carrying out this electronic setup is to check the working of sensor by sensing the object and displaying the result in the form of distance which was required to carrying further task.

1. Continuous Monitoring: The Arduino Uno successfully transmitted real-time data of wheel distance to the computer.

2. Graphical Visualization: The Serial Plotter displayed a dynamic graph of time versus distance, offering a visual representation of wheel behavior.

3. Threshold Identification: Instances of wheel wobbling, exceeding predefined thresholds, were instantly detected and visually represented on the graph.

4. User-Friendly Insights: The graphical interface facilitated quick interpretation, empowering vehicle operators to respond promptly.

5. Accuracy and Calibration: Rigorous testing and calibration procedures ensured accurate and reliable system performance.

6. Integration with Maintenance: Real-time monitoring aligned seamlessly with the vehicle'smaintenance plan, fostering proactive care.

7. Research Validation: Successful real-time testing underscores the system's efficacy inenhancing road safety and addressing wheel wobbling concerns

Fig 2 - Real Time Simulation (Distance Vs Time)

VII. Future Scope:

1. Machine Learning Integration: Incorporate machine learning algorithms to predict and detect wheel wobbling patterns more accurately.

2. Mobile Application Integration: Develop a mobile app that connects to the system, providing real-time wobbling data and maintenance recommendations on their smartphones.

3. Vehicle-to-Vehicle Communication (V2V): Enable vehicles to share real-time wobbling datawith nearby vehicles, creating a network of safety information sharing to prevent accidents.

4. Integration with Autonomous Vehicles: As autonomous vehicles become more prevalent,integrate the system to provide data for effective autonomous decision-making algorithms.

5. Powertrain Accessibility: The vehicle will automatically shut down in case of an emergencyor high risk due to the wobbling motion of the wheel, reducing the severity of the risk.

6. Computer Vision: Video Analysis: High-speed cameras or computer vision systems cancapture the movement of the wheel. Analysing the video frames can reveal any lateral motion.

VIII. Conclusion

In today's dynamic transportation landscape, road safety remains a top priority, and our project contributes to this by introducing an innovative solution tailored for all vehicle types.

The "IoT-Based Wobbling Motion Detector for Vehicle Safety" research represents a significant stride towards enhancing road safety and operational efficiency in the transportation sector. By integrating cutting-edge technologies such as IoT, real-time data analysis, and proactive maintenance measures, our solution addresses a critical yet often overlooked aspect of vehicle safety: wheel wobbling.

This project also successfully demonstrated the integration of an ultrasonic sensors with an arduino microcontrollers to control the blinking of the LED based on distance measurement to detect the wobbling motion. By accurately detecting distance between the swingarm and wheel rim trough arduino programming threshold, the project showcased a practical application of sensors-based integration in electronic system.

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