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DEVELOPMENT OF A SENSOR-BASED SYSTEM TO MONITOR BRAKE PAD THICKNESS WITH INTEGRATED ALERT MECHANISM

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ABSTRACT: This paper presents the design and development of a sensor-based system for real-time monitoring of brake pad thickness integrated with an alert mechanism. Anchored on the ADDIE model, this study focuses on the Analysis, Design, and Development phases only. The system employs infrared sensors, an ESP32 microcontroller, and a SIM800L GSM module to provide continuous feedback and notifications about brake pad wear. The design includes a multi-channel alert setup comprising an LCD display, buzzer, and LED indicators, ensuring drivers receive timely alerts. The goal is to enhance road safety by promoting proactive brake maintenance through real-time monitoring.

Keywords: Brake monitoring, sensor-based system, ESP32, SIM800L, real-time alert, automotive safety, infrared sensors, prototype design, alert mechanism

INTRODUCTION

The braking system is one of the most crucial components in a vehicle, playing a vital role in ensuring safety and control. Its reliability is essential for preventing accidents, making continuous monitoring and timely maintenance essential to enhance overall vehicle safety. Its function is to enable the driver to control the vehicle speed when the need arises in order to protect the vehicle, driver, and other road users from crashes that might be fatal. Vehicle stability and operation can deteriorate significantly by defective brakes [1] . Although the braking system plays a key role in a safe and smooth vehicular operation, it has not been given proper attention and, hence, brake failures are still underrepresented in traffic safety [1]. As vehicle safety becomes more important, the need for advanced monitoring systems that can provide real-time data on brake pad thickness is critical. Current systems often lack the capability to predict failures before they occur, leading to potentially catastrophic outcomes.

The majority of brake failures are caused due to overheating of the brakes, while wear of lining/pads is another big share-holder. Early detection of such causes can prevent these accidents [2]. Moreover, one of the primary issues with current brake monitoring systems is their inability to provide continuous, real-time information on key factors like brake pad thickness. Brake pad wear can lead to reduced braking efficiency and, in extreme cases, break failure.

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Traditional brake systems only check brake health during regular inspections or when a warning light comes on, which often means problems are not found early enough to prevent accidents. In contrast, advanced monitoring systems use real-time sensors to constantly check the condition of brake parts. The brake system is indispensable for safe driving of the automobile and malfunction or disorder of the brake system can lead to serious accidents, resulting in injury or death [3]. Meanwhile, if the brake system can be monitored on a real-time basis, such monitoring system can notify drivers of dangerous circumstances, like excessive wear of brake pads. These systems give immediate updates and predictions about brake health. By doing so, they improve how accurately the brakes are assessed and alert drivers to potential issues before they become serious. To address the challenges in vehicle safety and maintenance, especially concerning brake pad thickness, several new technological solutions are emerging: Development of Sensors for the Real-time Monitoring of Brake Pad Wear and Brake Disc Temperature in High Temperature [3]. Discusses the development of a sensor designed to monitor brake pad wear and brake disc temperature in real-time, particularly under extreme conditions. A condition monitoring system of the disk brake based on nRF24L01 [4].This system can real-time monitor and display the oil pressure, the clearance and temperature of brake by the sensors, and use the nRF24L01 module to transmit and receive the date. Through real-time monitoring, status analyses and fault alarm, the running safety of the hoist can be assured and it is a good application forward [4]. Brake Pad Wear Monitor using MOC (Motor on Caliper) EPB ECU [5]. The motor current when applying the parking brake is influenced by the mechanical load at the brake pad side of the system. So, by analyzing the time history of the current it is possible to measure the clearance between brake pad and disc induced by the pad wear [5]. The above problem and existing technological solutions enable the researchers to identify the gap. Despite advancements in automotive technology, most vehicles continue to rely on manual inspections or basic warning systems to monitor brake health. These systems are often lacking, as they cannot provide continuous, near-real-time data on critical parameters such as brake pad thickness. The inability to predict brake failures before they occur increases the risk of accidents due to delayed maintenance and undetected brake wear. This gap lies in the absence of advanced systems that utilize real-time sensor data, predictive analytics—tools analyze patterns in data to forecast brake issues, and integrated alert mechanisms to monitor brake health and forecast potential failures. While traditional methods detect problems only after they manifest, there is a need for systems that can proactively inform drivers and automate maintenance schedules based on real-time.

To address this research gap, the researchers will propose to design and develop the following:

a.) Real-Time Monitoring Sensors for Pad Thickness: The implementation of advanced sensors that continuously monitor brake pad thickness in real time. This system will provide constant updates on brake conditions, enabling immediate detection of wear before they reach critical levels.

b.) Automated Alert Systems: Developing automated alert mechanisms that notify drivers of critical issues, such as excessive pad wear. These alerts will prompt timely intervention, reducing the risk of brake failure and enhancing road safety. These solutions aim to significantly improve the accuracy, timeliness, and reliability of brake system monitoring, ensuring a safer driving experience through proactive maintenance.

The Development Model Framework

Many instructional designers and training developers use the ADDIE instructional systems design (ISD) methodology to create courses [6]. The term is an acronym for the five phases of developing training and performance support tools that it defines: Analysis, design, development, implementation, and evaluation are all steps in the process. This study adopted the ADDIE framework, specifically covering the Analysis, Design, and Development phases.

Analysis Phase

A comprehensive analysis was conducted to identify the shortcomings of current brake monitoring technologies. This phase involved a review of relevant literature and existing commercial systems, with a particular focus on their failure to provide continuous, real-time brake pad condition feedback [7] [8]. Field interviews with drivers and vehicle service professionals further validated the need for a more advanced system. Key requirements were

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identified, including real-time monitoring, ease of integration into existing vehicles, and the ability to alert users before brake failure occurs. The findings from this phase established the technical and practical requirements of the system and confirmed the feasibility of a sensor-based prototype utilizing affordable components.

Design and Development Phase

This phase combined the planning and actual realization of the system prototype. The design began with creating a blueprint for integrating hardware and software components:

- Sharp IR Distance Sensor: Measures brake pad thickness by detecting the distance to the pad surface.
- ESP32 Microcontroller: Manages sensor input and system logic.
- TFT LCD Display: Provides real-time data to the driver.
- Buzzer and LED Indicators: Alert the user through sound and light signals.
- SIM800L GSM Module: Sends SMS alerts for remote notifications.

Component selection was guided by criteria like reliability, compatibility, and affordability System flowcharts and block diagrams were drafted to visualize the process. Development began with prototyping on a breadboard, using jumper wires to connect components, and programming the ESP32 using the Arduino IDE.

The IR sensor was calibrated by comparing its digital readings with actual pad measurements to ensure reliability. Multiple tests validated that the system could consistently detect brake pad wear and trigger the buzzer, LEDs, and SMS notifications. The LCD layout was refined for in-vehicle readability.

Additional hardware protection was implemented, including voltage regulators and signal filters, ensuring the system could withstand automotive environments. A 3D layout was also created to guide future enclosure fabrication.

System Components

- ESP32 Microcontroller: Controls data collection and processing
- SIM800L GSM Module: Sends SMS alerts when critical thresholds are met
- IR Distance Sensor: Measures brake pad thickness
- TFT LCD Display: Shows real-time thickness data
- LEDs & Buzzer: Provide immediate visual and audio warnings

Results and Discussion

Although the Implementation and Evaluation phases are not covered in this paper, preliminary testing confirmed that the system can successfully detect brake pad wear and notify the user through SMS, LED, LCD, and buzzer alerts. These findings affirm the potential of the system for future application in real-world scenarios.

CONCLUSION

This paper presents the successful design and development of a sensor-based brake monitoring system. The system integrates real-time sensor data collection and a multi-alert mechanism to inform drivers of critical brake pad wear. Future work will involve full-scale implementation, real-world testing, and evaluation of the system's performance across different vehicle types and driving conditions.

RECOMMENDATION

Based on the outcomes of the design and development phase, the following recommendations are suggested:

- Future studies should implement and evaluate the system under real driving conditions to validate its performance and reliability across various vehicle types.
- Integration with vehicle diagnostics systems (e.g., OBD-II) can enhance data collection and predictive maintenance capabilities.

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- A mobile application interface could be developed to provide users with visual data trends and maintenance history.
- Sensor calibration processes may be further refined using adaptive algorithms to accommodate various brake pad and rotor configurations.
- Collaboration with automotive service centers may support wider adoption and standardization of such monitoring technologies.

References

1. V.-M. K. A. Muhammad Tahmidul Haq, "An investigation of brake failure related crashes and injury severity on mountainous roadways in Wyoming," Journal of Safety Research, vol. 84, pp. 7-17, February 2023.
2. R. P. D. P. Rushikesh Pawar, "Development of a Model for Predicting Brake Friction Lining Thickness and Brake Temperature," International Journal of Prognostics and Health Management, vol. Vol. 13 No. 1, 2022.
3. K. S. B. Jung Joo Yoo, "Development of Sensor for the Real-time Monitoring of Brake Pad Wear and Brake Disc Temperature in High Temperature," International Journal of Automotive Technology, vol. Volume 24, no. December 2023, p. pages 1603–1613, 2023.
4. F. S. Xiao Ke, "A condition monitoring system of the disk brake based on nRF24L01," IEEE 2011 10th International Conference on Electronic Measurement & Instruments, 2011.
5. G. L. J. P. Soohyuk Lee, "Brake Pad Wear Monitor using MOC (Motor on Caliper) EPB ECU 2022-01-1167," SAE International, p. 5, 2022.
6. H. Dong, "Adapting during the pandemic: A case study of using the rapid prototyping instructional system design model to create online instructional content," The Journal of Academic Librarianship, vol. Volume 47, no. Issue 3, 2021.
7. R. P. P. R. P. P. Rushikesh Pawar, "Development of a Model for Predicting Brake Friction Lining Thickness and Brake Temperature," International Journal of Prognostics and Health Management, Vols. vol. 13, no. 1, May 31, 2022.
8. S. G. L. a. J. P. Lee, "Brake Pad Wear Monitor using MOC (Motor on Caliper) EPB ECU 2022-01-1167," SAE SAE Technical Paper, 2022.