Real-Time Pothole Detection and Alert System Using Sensor-Based Toy Car Prototype

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***Abstract*—This paper presents the design and development of a low-cost, real-time pothole detection system using a sensor-integrated toy car. The system employs an MPU6050 accelerometer and an optional ultrasonic sensor to detect sudden vertical displacements and depth anomalies. An Arduino Uno/Nano processes the sensor data and triggers visual alerts via an LCD. The prototype serves as a proof-of-concept for future enhancements such as GPS tracking and cloud data integration for large-scale pothole mapping and road maintenance systems.**

Keywords — Pothole detection; accelerometer; Arduino; road safety; IoT; real-time alert system

I. Introduction

Potholes pose a threat to the health of vehicles and road safety, damaging suspensions and tires, driving up maintenance, and causing accidents, particularly for two-wheelers or in poor visibility. Existing detection methods are based on slow and laborious manual scanning and are not response time.

This paper describes an inexpensive real-time pothole detection system using sensor technology. Mounted on moving vehicles or attached to infrastructure, it detects road irregularities in real-time using cameras and accelerometers to detect potholes.

The solution is scalable and IoT-capable for municipal-scale deployment [2], [5]. Sensors transmit data to a central system, enabling cities to track road condition, schedule maintenance, and warn drivers of hazards. The aim is smarter, faster, and more efficient.

II. Measurement Technique

The measurement technique utilized in the pothole detection system focuses on the utilization of an MPU6050 accelerometer sensor coupled with an Arduino microcontroller. The sensor tracks real-time acceleration information to identify abrupt vertical displacements, which are typical of potholes. As a sharp increase in acceleration is detected—most often co-responding to a 2 cm or more vertical deviation—the Arduino detects a pothole and produces a visual warning on a 16x2 LCD screen. The proof-of-concept, used as a platform on a toy car, is very much a realistic simulation of actual driving conditions, and the modular nature of the device promotes scalability and future upgrades like GPS-based location tracking and cloud connectivity for centralized analysis.

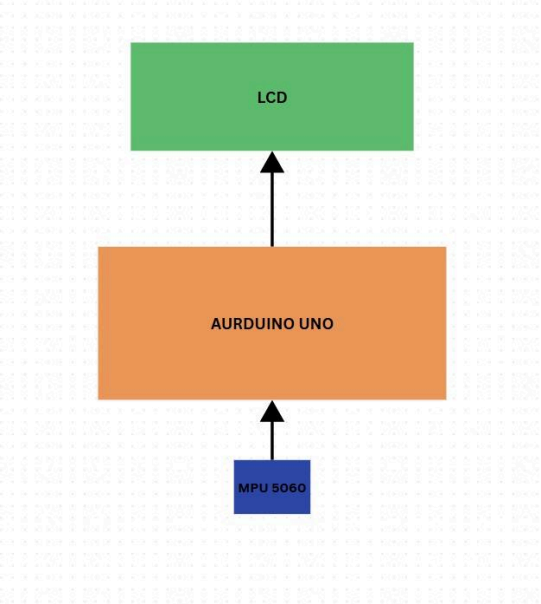

Fig. 1: Block diagram

Description of the Prototype

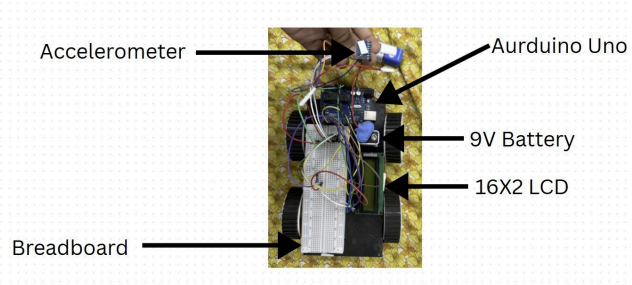

Fig. 2: Prototype

The prototype is a sensor-based(MPU6050) pothole detection system built on a toy car using an Arduino microcontroller. It detects potholes in real time using an MPU6050 accelerometer, and displays warnings on a 16x2 LCD screen when a pothole is encountered . The system is powered by a rechargeable battery and is designed to simulate real-world road conditions in a compact, mobile format. Future upgrades will include GPS tracking and cloud data storage to map potholes for navigation and maintenance purposes [2], [3].

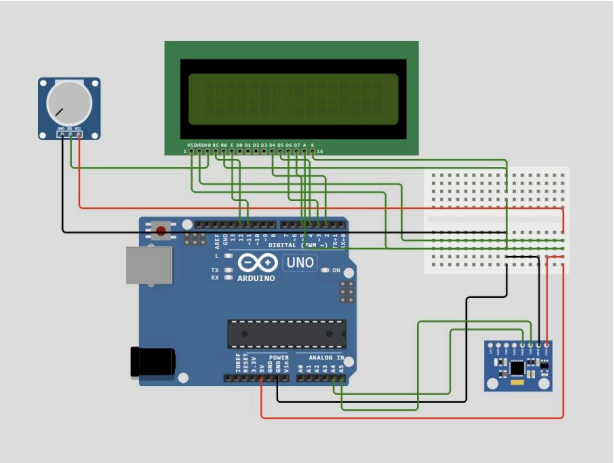

Fig. 3: Schematic of the prototype

A. Toy Car Setup

A self-built toy car used as mobile platform to simulate real driving conditions. Using two 9V batteries ,one aurduino uno and one board as basic setup. Sensors and microcontroller were securely mounted for accurate data acquisition.

B. Sensor Configuration

- MPU6050 Accelerometer: It detects sharp vertical movements while a pothole is encountered [1].

C. Processing Logic

The data given by the sensor is processed by the Arduino Uno ,the spikes in acceleration and significant depth differences are interpreted as potholes .Time require to reset is dependent on our code so it is 300 ms and minimum height on pothole get detected by sensor is 2 cm.

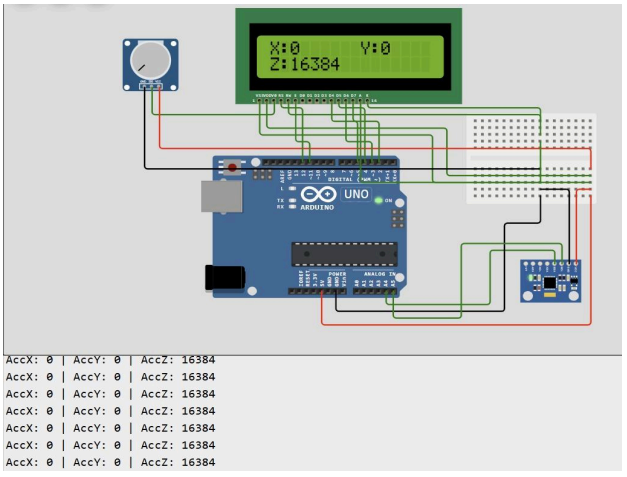

Fig. 4: System Ready For Detection

D. Display and Alerts

An LCD 16x2 module displays on screen “POT HOLE” detected immediately when a pothole is detected.

E. Power Supply

The prototype is fully battery powered. It is powered by a 9V battery.

III. Results

The system demonstrated reliable detection of potholes during test runs. When the toy car passed over potholes, the MPU6050 sensor registered sharp changes in acceleration. These were accurately interpreted by the Arduino and displayed as alerts on the LCD. Although GPS integration was not part of the initial build, the prototype supports future expansion with GPS and Wi-Fi modules for real-time pothole logging

IV. Conclusions

This project presents a low-cost, scalable solution for pothole detection using common sensors and microcontrollers. A toy car platform enabled safe and effective testing of the prototype, which successfully identified road defects based on sensor data.

The system's modular design allows for easy integration into real vehicles and sets the stage for future enhancements, such as GPS for location tracking, cloud-based data storage, and AI-powered road condition analysis [3], [4]. These upgrades could enable real-time reporting to authorities and smarter maintenance planning.

Looking ahead, the system could be deployed across public transport or private vehicles to build a crowdsourced pothole monitoring network [5], improving road safety and traffic management on a larger scale.

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