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ANDROID BASED VEHICLE WEIGHT MONITORING SYSTEM FOR BRIDGES

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Abstract

The Android Based Vehicle Weight Monitoring System for Bridges is an innovative approach to enhance the longevity and safety of bridges by preventing overweight vehicles from crossing. This document details the design, development, and implementation of a system that utilizes the ESP32 microcontroller and Internet of Things (IOT) technology to measure vehicle weight and control access to the bridge. The modern transportation infrastructure is under constant stress due to the increasing number of vehicles and the corresponding rise in vehicular weights. Ensuring the safety and longevity of bridges, which are crucial components of this infrastructure, is paramount. Overloaded vehicles pose a significant risk, as they can cause extensive damage to bridge structures, leading to costly repairs and even catastrophic failures. In response to this challenge, this project presents an innovative solution: An Android-based vehicle weight monitoring system that measures vehicle weights in real-time.

The proposed system not only detects overweight vehicles but also automates the control of entry gates based on weight thresholds. This is achieved using motor drivers and DC motors, which open or close gates in response to the measured weight. An IR sensor is used to detect the presence of vehicles, triggering the weight measurement process. Additionally, the system includes a buzzer to alert when an overweight vehicle is detected, enhancing the safety features.

The integration of an LCD display allows for real-time display of weight readings, providing immediate feedback to operators. The Android application further extends the system's functionality by enabling remote monitoring and control, thereby increasing operational efficiency and response times. This system is designed to be cost-effective and scalable, making it suitable for deployment on bridges of varying sizes and traffic volumes.

By implementing this technology, the project aims to protect bridge infrastructure from damage due to overloaded vehicles, thereby reducing maintenance costs and enhancing safety. The combination of IoT technologies and mobile applications represents a significant advancement

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in the field of transportation infrastructure management. This project not only addresses current challenges but also paves the way for future innovations in smart infrastructure solutions.

Introduction

Bridges are critical infrastructure that require robust protection mechanisms to ensure their structural integrity over time. Overweight vehicles pose a significant threat to the longevity and safety of bridges, leading to potential damage and accidents. Current systems often lack the real-time capability to effectively manage vehicle weights and control access.

The integrity and safety of bridge infrastructure are of paramount importance in modern transportation networks. Bridges are critical components that facilitate the movement of goods and people, playing a vital role in economic activities and daily commutes. However, with the increasing volume of traffic and the prevalence of overloaded vehicles, the structural health of bridges is continually at risk. Overloaded vehicles can cause significant damage, leading to costly repairs, traffic disruptions, and even catastrophic failures.

Traditional methods of monitoring vehicle weights and ensuring compliance with load regulations often rely on weighbridges and axle weight sensors. While effective, these systems require substantial infrastructure investments and are not always feasible for continuous real-time monitoring. The need for a more efficient, cost-effective, and scalable solution has led to the exploration of advanced technologies.

This project presents an innovative Android-based vehicle weight monitoring system for bridges that measures vehicle weights in real-time. Leveraging the capabilities of the ESP32 microcontroller and modern IoT technologies, this system aims to provide a robust solution for protecting bridge infrastructure from the adverse effects of overloaded vehicles. The system employs load cells to accurately measure the weight of vehicles as they cross the bridge, with data processed and transmitted by the ESP32 to an Android application. This real-time data transmission enables immediate action to be taken, such as the automated control of entry gates based on weight thresholds.

The proposed system offers several advantages over traditional methods, including reduced infrastructure costs, real-time monitoring, and automated control mechanisms. By integrating sensors, microcontrollers, and mobile technology, the system not only enhances the safety and longevity of bridges but also improves operational efficiency and user experience.

The development and implementation of this system involve multiple phases, including design, hardware setup, firmware development, system integration, and rigorous testing. Each phase is meticulously planned and executed to ensure the system meets the desired specifications and operates reliably in real-world conditions. This project demonstrates the potential of combining IoT technologies with infrastructure management, paving the way for smarter and more resilient transportation networks.

Literature Review

Overview of Bridge Protection Systems

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A review of existing bridge protection systems highlights the need for more advanced and real-time solutions. Traditional methods rely heavily on static weight limits and physical inspections, which are often insufficient and time-consuming Vehicle weight measurement systems are essential for various applications, including transportation regulation, infrastructure protection, and logistics management. Numerous technologies and methodologies have been developed to achieve accurate and efficient weight measurement. This literature survey provides an overview of key research studies, developments, and advancements in the field of vehicle weight measurement systems.

Weigh-in-Motion (WIM) Systems

Weigh-in-Motion Technology: Weigh-in-Motion (WIM) systems measure the weight of vehicles while they are moving, providing a dynamic and non-intrusive method of weight monitoring. The technology has evolved significantly over the years, incorporating various sensor types such as piezoelectric, strain gauge, and bending plate sensors.

Key Studies and Developments:

- **Jacob and Ferrero (2002):** Their research focused on the accuracy and reliability of piezoelectric WIM systems. They highlighted the advantages of WIM systems in real-time traffic monitoring and enforcement applications .
- **Klein et al. (2010):** This study evaluated the performance of strain gauge-based WIM systems under different environmental conditions, demonstrating their robustness and precision in varying climates .

Applications and Impact: WIM systems are widely used in highway monitoring, toll collection, and bridge protection. They help in reducing road wear and tear by ensuring compliance with weight regulations and are instrumental in data collection for traffic analysis and infrastructure planning.

Static Weighing Systems (Weighbridges)

Weighbridge Technology: Weighbridges are static systems where vehicles must come to a halt to be weighed. These systems are known for their high accuracy and are typically installed at checkpoints, toll stations, and freight terminals.

Key Studies and Developments:

- **Liu et al. (2005):** Investigated the calibration techniques for weighbridges to enhance accuracy and reliability. Their study provided insights into minimizing errors caused by uneven load distribution and external vibrations .
- **Park and Lee (2013):** Focused on the integration of weighbridges with advanced data management systems, allowing for seamless data collection, storage, and analysis .

Applications and Impact: Weighbridges are critical for regulatory compliance and commercial transactions where precise weight measurement is crucial. They are essential for monitoring and controlling the transport of goods, ensuring fair trade, and protecting road infrastructure.

Axle Weigh Pads

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Axle Weigh Pad Technology: Axle weigh pads are portable scales that measure the weight of individual vehicle axles. They are used for both static and dynamic weighing and are often employed in enforcement and compliance checks.

Key Studies and Developments:

- **Timm et al. (2008):** Analyzed the accuracy and usability of portable axle weigh pads in various field conditions. Their research demonstrated the effectiveness of these devices for quick and flexible weight measurement .
- **Smith et al. (2015):** Studied the integration of axle weigh pads with wireless data transmission systems, enhancing the efficiency of data collection and processing .

Applications and Impact: Axle weigh pads are used by enforcement agencies for spot checks and by logistics companies for on-the-go weight measurement. Their portability and ease of use make them valuable tools for ensuring compliance with weight regulations and preventing overloading

Proposed System

The proposed system aims to enhance bridge safety by preventing overweight vehicles from crossing, utilizing an Android-based application to monitor and control vehicle access. This system integrates a variety of sensors and microcontrollers to measure vehicle weight, detect vehicle presence, and control a gate mechanism, all managed through a user-friendly Android interface.

Hardware components

POWER SUPPLY

The power supply section is the section which provide +5V for the components to work. IC LM7805 is used for providing a constant power of +5V.

The ac voltage, typically 220V, is connected to a transformer, which steps down that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation.

A regulator circuit removes the ripples and also retains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.

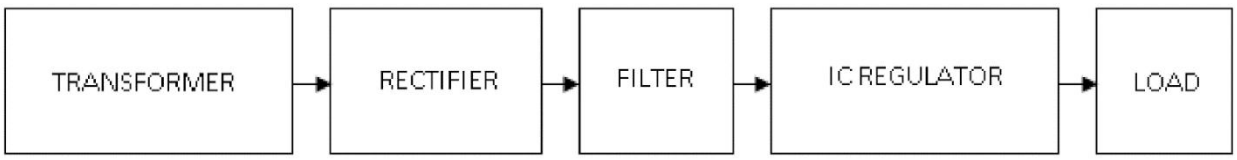

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Figure 1- Block Diagram of Power Supply

Transformer

Transformers convert AC electricity from one voltage to another with little loss of power. Transformers work only with AC and this is one of the reasons why mains electricity is AC.

Step-up transformers increase voltage, step-down transformers reduce voltage. Most power supplies use a step-down transformer to reduce the dangerously high mains voltage (230V in India) to a safer low voltage.

The input coil is called the primary and the output coil is called the secondary. There is no electrical connection between the two coils; instead they are linked by an alternating magnetic field created in the soft-iron core of the transformer. Transformers waste very little power so the power out is (almost) equal to the power in. Note that as voltage is stepped down current is stepped up.

The transformer will step down the power supply voltage (0-230V) to (0- 6V) level. Then the secondary of the potential transformer will be connected to the bridge rectifier, which is constructed with the help of PN junction diodes. The advantages of using bridge rectifier are it will give peak voltage output as DC.

Rectifier

There are several ways of connecting diodes to make a rectifier to convert AC to DC. The bridge rectifier is the most important and it produces full-wave varying DC. A full-wave rectifier can also be made from just two diodes if a centre-tap transformer is used, but this method is rarely used now that diodes are cheaper. A single diode can be used as a rectifier but it only uses the positive (+) parts of the AC wave to produce half-wave varying DC

Bridge Rectifier

When four diodes are connected as shown in figure, the circuit is called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners. Let us assume that the transformer is working properly and there is a positive potential, at point A and a negative potential at point B. the positive potential at point A will forward bias D3 and reverse bias D4.

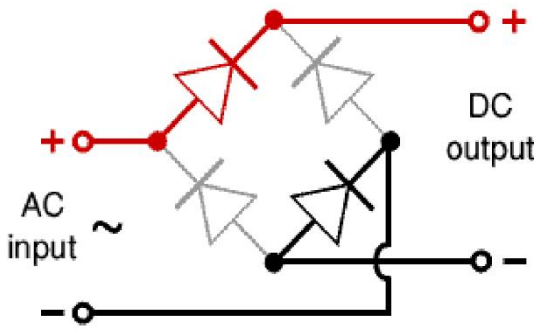

Figure 2- Bridge Rectifier

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Voltage Regulators

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustably set voltage. The regulators can be selected for operation with load currents from hundreds of milli amperes to tens of amperes, corresponding to power ratings from milli watts to tens of watts.

A fixed three-terminal voltage regulator has an unregulated dc input voltage, Vi, applied to one input terminal, a regulated dc output voltage, Vo, from a second terminal, with the third terminal connected to ground.

The series 78 regulators provide fixed positive regulated voltages from 5 to 24 volts. Similarly, the series 79 regulators provide fixed negative regulated voltages from 5 to 24 volts. Voltage regulator ICs are available with fixed (typically 5, 12 and 15V) or variable output voltages. They are also rated by the maximum current they can pass. Negative voltage regulators are available, mainly for use in dual supplies.

Many of the fixed voltage regulator ICs has 3 leads and look like power transistors, such as the 7805 +5V 1Amp regulator. They include a hole for attaching a heat sink if necessary.

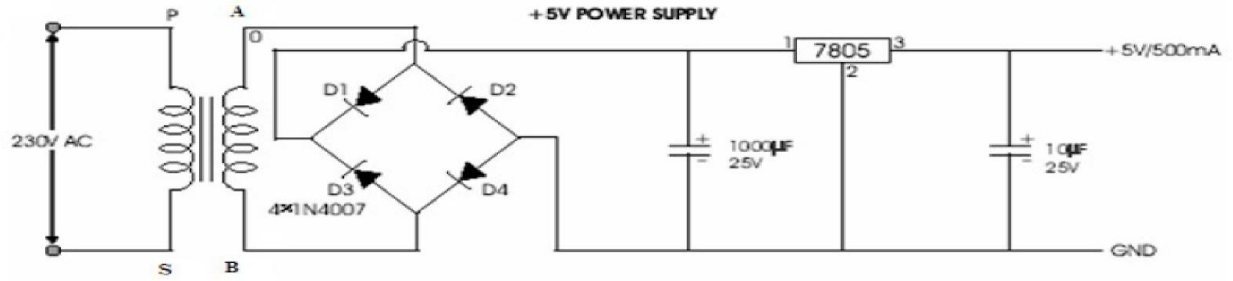

Figure 3- Circuit Diagram of Power Supply

Load Cell: Measures the weight of the vehicle. Multiple load cells can be used to distribute the weight measurement and increase accuracy

Figure 4- load cell

IR Sensor

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An IR (Infrared) sensor is a type of electronic device that is used to detect the presence of infrared radiation. Infrared radiation is a form of electromagnetic radiation that is invisible to the human eye, but can be detected by electronic sensors.

IR sensors are a versatile and widely used technology that provide a way to detect and measure infrared radiation. Their sensitivity, range, and filtering capabilities make them suitable for a wide range of applications, from industrial sensing to consumer electronics.

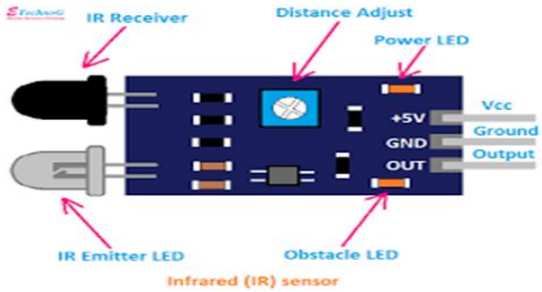

Figure 6- IR sensor description

Microcontroller: ESP32

ESP32 is a series of low-cost, low-power system on a chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth. The ESP32 series employs either a Tensilica Xtensa LX6 microprocessor in both dual-core and single-core variations, Xtensa LX7 dual-core microprocessor or a single-core RISC-V microprocessor and includes built-in antenna switches, RF balun, power amplifier, low-noise receive amplifier, filters, and power-management modules. ESP32 is created and developed by Espressif Systems, a Shanghai-based Chinese company, and is manufactured by TSMC using their 40 nm process.

Actuators:

- **Motor Driver and Motor:** Controls the gate mechanism to allow or block vehicle access based on the weight measurement.

Figure 8- Motor driver

DC MOTOR:

- A DC motor is designed to run on DC electric power. Two examples of pure DC designs are Michael Faraday's homopolar motor (which is uncommon), and the ball bearing motor, which is (so far) a novelty.

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- By far the most common DC motor types are the brushed and brushless types, which use internal and external commutation respectively to create an oscillating AC current from the DC source—so they are not purely DC machines in a strict sense.
- We in our project are using brushed DC Motor, which will operate in the ratings of 12v DC 0.6A which will drive the flywheels in order to make the robot move.

Buzzer:

Buzzer in the Bridge Protection System

The buzzer is an essential component of the Android-based vehicle weight monitoring system, serving as an auditory alert mechanism. Its primary function is to provide immediate audio feedback in response to specific conditions detected by the system, such as the presence of an overweight vehicle. This section details the role, types, and integration of the buzzer within the bridge protection system.

Display:

LCD Display: The display unit is a crucial component of the Android-based vehicle weight monitoring system providing real-time visual feedback and information to bridge operators. This section discusses the types of displays, their roles, integration, and benefits within the system.

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User Interface:

The User Interface (UI) of the Android-based vehicle weight monitoring system for bridges is designed to provide bridge operators with an intuitive and efficient way to monitor and manage the system. The UI comprises both a physical display unit connected to the ESP32 microcontroller and an Android application that communicates with the system wirelessly. This section details the components, design principles, functionalities, and benefits of the UI.

Components of the User Interface

1. **Physical Display:**
    - **LCD/OLED Display:** A display unit, such as a 16x2 LCD or a 128x64 OLED, connected to the ESP32 microcontroller. It provides real-time information on vehicle weights, system status, and alerts directly at the bridge site.
    - **Buzzer:** An auditory alert mechanism that works in conjunction with the display to notify operators of critical events, such as overweight vehicles.
2. **Android Application:**
    - **Mobile Interface:** An Android app that offers a comprehensive view of the system's status and control options. It provides remote access to the system, allowing operators to monitor and manage the bridge protection system from anywhere within the network range.

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Block diagram

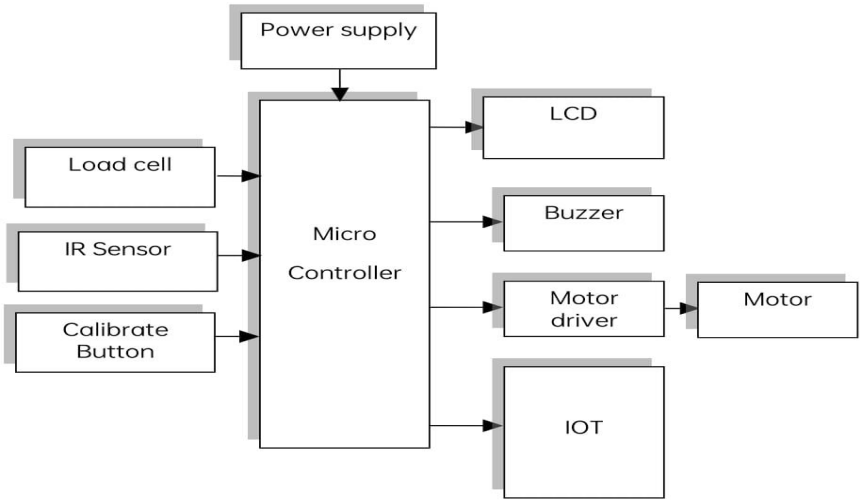

Figure 12- block diagram showing connection

Result:

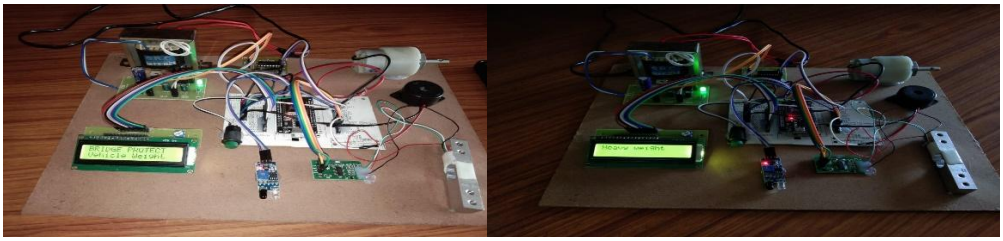

Figure 14-After load is sensed

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Conclusion

In conclusion, the Android-based vehicle weight monitoring system for bridges offers a comprehensive solution to the challenges posed by overloaded vehicles. Through continuous improvements and integration with broader infrastructure management systems, it holds the promise of revolutionizing how we monitor and maintain critical bridge infrastructure, ensuring safer and more efficient transportation networks for the future.

In summary, the future work and scope of the Android-based vehicle weight monitoring system for bridges project lie in enhancing its technological capabilities, expanding its application areas, fostering collaborations, and contributing to sustainable infrastructure development. By continuing to innovate and adapt, this system can play a pivotal role in ensuring the safety and longevity of bridges and other critical infrastructure components globally.

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