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IoT Based Vehicle Overload Detection and Preventing Accident

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Abstract
This project presents an Arduino-based vehicle overload detection system aimed at preventing accidents through the use of Internet of Things (IOT) technology. The system addresses the critical safety issue of vehicle overloading, which is a significant contributor to road accidents. The vehicle is equipped with load sensors connected to an Arduino microcontroller that continuously monitors its weight. If the vehicle exceeds a specified weight limit, it will not start, thereby preventing potential accidents caused by overloading. In cases where starting the vehicle is necessary, the driver must press a designated secret key, allowing for a manual over ride. Upon activation of this secret key, the system automatically sends an SMS containing the vehicle's location to the nearest police station. This timely notification enables law enforcement to take appropriate action against overloaded vehicles, enhancing public safety. By integrating load detection with IOT communication, this project provides a practical and effective solution for managing vehicle overload. The implementation of this system not only promotes compliance with safety regulations but also contributes to reducing road accidents, ultimately fostering safer driving conditions.

Keywords: *Arduino Nano, Vehicle Overload Detection, load Cell Sensor, GSM/GPS Integration, Vehicle Prevention, IOT- based Vehicle Monitoring.*

1. Introduction
The goal of this project is to create an overload detection machine that is based on the Arduino platform and focuses on enhancing road safety by the use of Internet of Things (IoT) devices [1]. This system overload detection machine responds to the alarming and dangerous phenomenon of over loading of vehicles hence ensuring safety on the roads. Arduinos are interfaced with load sensors embedded inside the vehicles which are automated and can weigh the vehicle at all times. If the vehicle will have a load above a set point, it will not be able to start thereby reducing the likelihood of load overload. Where such situations arise and starting of the vehicle is highly inevitable, the driver must use a bomb or any secret key that allows a manual over ride. This key only activates the system and makes it send a SMS informing the police station which is the closest about the vehicle with the help of its GPS. As a result of these quick notifications, the appropriate authorities will be able to take necessary measures against such vehicles hence saving the public. This project integrates IoT communication with overloaded vehicles by including, the loading detection to give more sound and more practical solution to the problems of vehicle overload. The introduction of this system will encourage compliance to the regulations of safety and reduce the frequency of road traffic accidents thereby improving road safety [2].

2. Problem Statement & Objective
Overloading and imbalance of vehicles is a great risk for the safety of the road, because it results in accidents, destruction of facilities, and pollution. The procedures for monitoring and control of the weight of all vehicles and magic trailers are outdated and rely mainly on human effort making it incapable of stopping overloading of permits. Failure to apply real-time monitoring of such vehicles and the gravity

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of situation worsens the problem. Checkpoints are no favourites tools to check the weight of vehicles as the very effectiveness of confiscation brings in delays, traffic pack, and kickbacks. In particular, the challenges are the nonexistence of some forms of mechanically instead of just pictorial images that are supposed to be utilized for a weight recordable in time – the hand and other forelimbs, untimeliness of exposure, lack of enough research parameters about the staggering of vehicles etc and ordinary risk with regards to accidents and damage of structures is elevated [3]. Thus, it is of utmost necessity to build an automated device which is accurate and efficient in detecting and preventing vehicle overloading circumstance.

2.1 Objectives

- Construct and implement an automated Vehicle Overload Detection System (VODS) which utilizes load cells in combination with GPS and GSM technologies.
- Detect and monitor vehicle overloading with precision and real time.
- Send an automatic Short Message or email to the nearest police station when overloading is sensed.
- Promote road safety by cutting down the number of overloaded vehicles on the road.
- Protect the infrastructure from destruction caused by heavy vehicle loads.
- Ensure the availability of real-time traffic data for better control and management of the road traffic [4].

2.2 Proposed Methodology

The VODPS makes use of several technologies to detect and manage vehicle overloading. Such a strategy embraces the installation of load cells or weight sensors on selected key control points or weighbridges to ensure accurate measurement of the vehicles (Figure 1). Such data is relevant in weight measurement as well since the vehicle comes with integrated GPS and GSM which can relay data back to the central server. A smart algorithm interprets this information and allows the determination of overloading and executes a set procedure to notify the appropriate authorities. Vehicles location is provided through GPS tracking whilst such vehicles and their movement are confirmed through either cameras or RFID systems. The system is intuitively easy to use allowing police personnel to retrieve and operate on data of overweight vehicles. Ultimately, data analysis is useful in traffic management and trend analysis improving road safety and efficiency.

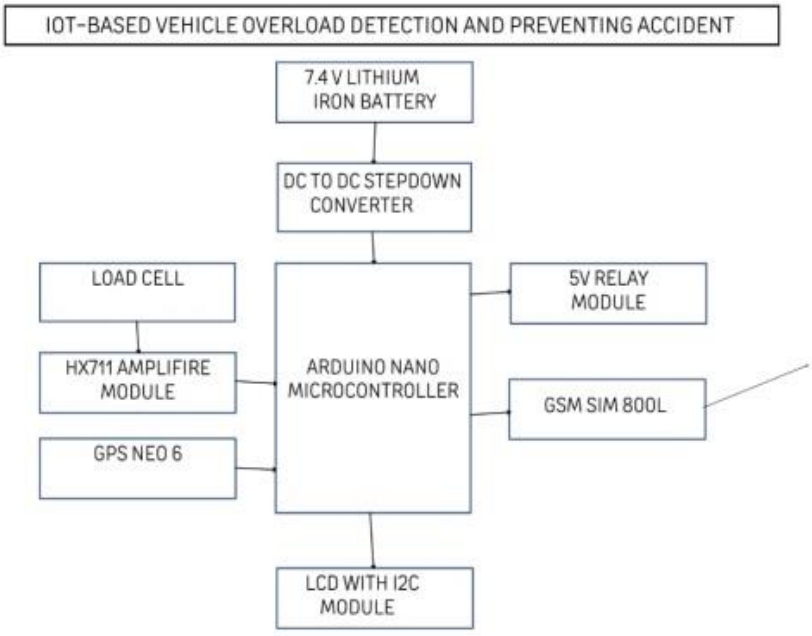

Figure 1 Block Diagram

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3. Component Details

3.1 LFP Li-ion Battery

To 'describe' or 'define' LFP Li-ion 3.7 Lithium battery is a more commonly used name for the lithium polymer (Figure 2). It's highly cell capable of yielding a voltage of 3.7 volts, typically many people employ the entire cell. This battery, its specifically low internal resistance, it bumps out high-rate capabilities with excellent energy density, and possesses the ability to self-start. Overall, making it easier for manufacturer to use this battery and especially in devices that require high energy. This leads me to conclude, batteries will always compliment devices, for example in smart devices, as well as standard Li-ion devices, they will remain useful.

Figure 2 LFP Li-ion Battery

A broader view of Li-i and Li-ion batteries would include argon ion – Li-ion, enabling quick response rates. A more commercialized view now of 3.7, would be Li-Po – Li-ion –Li-po wherein the Arm static measuring of randomness will take its place in value cycles such as 3-5 cycles depending on how they are maintained. 3.7 ≠ range would also include electric vehicles; these could vary from 48V – 72V Thus will also be light-weighted due to their monolithic sales structure. 3.7 batteries are also aimed for high scalability usage where small volumes of mass consumption can generate additional income.

3.2 L298n Motor Driver

The L298 is a popular dual H-bridge motor driver IC that allows the control of both DC and stepper motors in a variety of applications, especially in robotics and automation (Figure 3). The L298 can drive two DC motors or one stepper motor at the same time and allows controlling the motor's direction, speed, and operational mode. It can handle motor voltages as high as 46V and continuous currents of 2A per channel, which makes it suitable for numerous types of motors. One of its most important features is the H-bridge configuration, which allows simple bidirectional control of the motors through input signal changes. Focusing on the other features of the component, the L298 allows the implementation of Pulse Width Modulation (PWM) the means of controlling the speed of a motor by changing the duty cycle of the control signals without changing the voltage level. The IC includes protection against back EMF, so the circuit is protected against sudden voltage changes that occur during rapid motor switching.

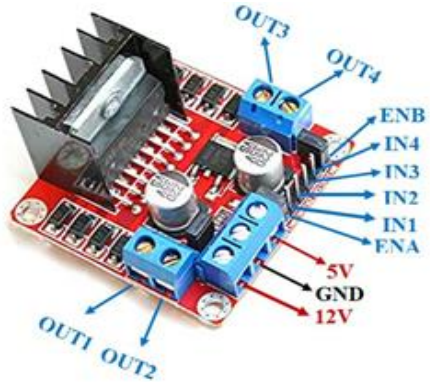

Figure 3 L298n Motor Driver

3.3 GSM

The SIM800L consumes a low amount of the active current in the sleep mode that enables it to be used in battery operated devices (Figure 4). But when it is on active transmission, strong voltage has to be provided to maintain peak performance. Thus, this makes power management to be one of the key factors that should be considered during design.

Figure 4 GSM Module

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The SIM800L has been described as a powerful GSM/GPRS module since it enables communication within and outside the devices by making voice calls, sending SMS and transferring data information in a cell network. Its small form factor makes it especially fit for plugging into a variety of applications, including IOT devices, mobile communication, and remote tele monitoring tools. The SIM800L, which is also structurally compatible with the majority of cellular operators across the world because of its use of four GSM frequencies – 850 MHz, 900MHz, 1800MHz, and 1900MHz is in a competitive position. The SIM800L consumes a low amount of the active current in the sleep mode that enables it to be used in battery operated devices. But when it is on active transmission, strong voltage has to be provided to maintain peak performance. Thus, this makes power management to be one of the key factors that should be considered during design.

3.4 NEO-6M GPS

The NEO-6M GPS module is an important GPS receiver based on the u-blox NEO-6 chipset that is increasingly used in many devices including: robotics, drones, vehicle tracking, and personal navigation (Figure 5). The module can achieve a positioning accuracy of about 2.5 meters which is still able to perform well even under difficult conditions such as working indoors. This module has also the ability to use the GPS and the GLONASS satellite systems which allows faster acquisition of satellite signals and better positioning when moving around in areas of high interference such as urban centres.

Figure 5 NEO-6M GPS

One of the great advantages of the NEO-6M is its NMEA data output format with a full assortment of information - latitude and longitude, speed, altitude that fits a number of microcontrollers including: Arduino, Raspberry Pi and others. It can be integrated easily with other devices due to its UART and TXD interfaces. Furthermore, the module consumes little energy making it ideal for use in low power devices and systems that require energy conservation.NEO-6M GPS module might be small, but can be integrated into a variety of applications, from Peta-level business environments to more simple hobbyist's projects.

3.5 Step Down Converter

Buckle converters or step-down converters as they are also widely known, are integral on every circuit able to replace a bigger DC voltage with a smaller one (Figure 6). This is where these devices shine, especially in terms of power management for energy usage within battery-powered machines, as well as portable electronics and renewable energy. With these purpose comes many advantages, one of them being the conversion efficiency of nearly 90 percent or more which is favourable for applications where conserving battery charge density or dissipated heat is applicable. Similar, many applications and industries employing the use of converters demand for small or adjustable sizes which allows for portability and compatibility with many devices.

Figure 6 Step Down Converter

Some of the more popular step-down converters include variable output ones and require specific voltage levels. The level of output could be adjusted zones with the help of resistive dividers or even a potentiometer built on board. This makes the gap converters quite flexible and for almost all devices and applications. The size on the router rid should make it very easy to mount on most circuits.

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3.6 Wi-Fi Module

Figure 7 Wi-Fi Module

The ESP8266 is often cited as one of the best Wi-Fi modules regarding cost and other features which makes it commonplace in IOT (Figure 7). It works on 3.3V power supply and contains a microcontroller with an inbuilt TCP/IP stack that allows modules to connect to Wi-Fi networks. In addition to this, it also possesses multiple communication protocols such as UART, SPI, and I2C allowing interface with other sensors and components easily. Developers are fond of the fact that the ESP8266 can be programmed over platforms such as Arduino IDE, Micro Python or the ESP8266 SDK which makes it easier for not only professionals but also for amateur programmers. Thus, the module is capable of much more intricate tasks such as executing web applications and processing HTTP requests making this module ideal for smart home applications, remote applications, and data logging. It also supports a wide range of Wi-Fi security standards (WEP, WPA, WPA2) thus ensuring safety of data during transmission. Given that any problem with the ESP8266 can cause malfunctions, its extensive community support allows for multiple libraries, tutorials and forums for ease in project creation and problem solving. The ESP8266 is cost effective while still offering a multitude of features which is why it continues to be utilized in various electronic projects requiring Wi-Fi connectivity.

3.7 HX711 Load Cell

A load cell can be classified as a transducer wherein the force, which is generated by a weight or load, is translated into an electric signal (Figure 8). While the conversion of the load cell is enabled by different means, the most widely utilized approach employs load cells based on strain gauges.

Figure 8 HX711 Load Cell

A strain gauge mechanically deforms and then has an electrical resistance which changes in relation to how much deformation occurs. Load cells are available in several types including single point, compression, shear beam and tension load cells which are fit for different applications and load position. It is important to note that calibration with respect to time in an operation of a load cell is essential in order to maintain the a consistently accurate reading from the load cell.

3.8 Liquid Crystal Display(LCD)

Figure 9 LCD

The most widely utilized display technology, widely adopted in embedded programming, robotics, and Arduinos, is the LCD 16x2, which can show up to 16 characters on two lines. Usually, it has a parallel interface, but contemporary ones often have a smaller I2C interface that reduces the number of needed wires (Figure 9). It can graphically represent simple shapes and include letters and symbols, thus being applied in menus, user interfaces, sensor values, and similar contexts. In poor lighting, most of the LCD 16x2 modules have a backlit screen to assist visibility for the users. It's simple to use because the commands let you move the cursor, type, and erase the text in the LCD. Users all over the world, both amateurs and advanced engineers, appreciate and relish using the LCD 16x2 for easy

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integration with external devices and a plethora of support and libraries. In general, this enables virtually any user to communicate sustainably and efficiently with a device using low footprint

3.9 Arduino Nano

Figure 10 Arduino Nano

The Arduino Nano is a high performance microcontroller board, based on the ATmega328P or the ATmega168 circuits with low power requirements, small physical sizes but with the ability to cater from simple hobby projects to complex integrations (Figure 10). Measuring 18 mm x 45 mm in size, the board has the advantage of being ideal for brushes within limited spaces, enabling easy implement on devices and enclosures. The Nano has up to 22 pins all digital input/output including 6 PWM (pulse width modulation) outputs and an additional 8 analog inputs thus being able to connect to a wide range of sensors, actuators, and modules. Connecting the Arduino Nano is very simple since the power can be fed through the USB port or an external source at five volts and hence an onboard voltage regulator makes sure that the supply to all components is stable. The configuration data of this board can be changed using the Arduino IDE, and the several libraries and examples included make the process of coding easier

3.10 Relay Module

The relay module is one of the most critical elements of electronic systems (Figure 11). The low voltage functions as an electronic switch that permits low-voltage devices to safely perform high-voltage tasks. When connected to an external control circuit, the module contains one or more relays and functions as a switch that can be turned on electrically. As a result, several other electrical devices, such as motors, lights, heating systems, and others, can be managed without the need for direct electrical contact thanks to microcontrollers like Arduino or Raspberry Pi. The contact design of the relay allows for electrical isolation between the control circuit and the load, which helps to protect sensitive electronics from harmful voltages and a possible damaging current. Typically, a relay module comprises around two to eight or more controlling segments which allow for the control of multiple devices at the same time. This is beneficial in their multiplicity of applications.

Figure 11 Relay Module

The number of these relays is usually one but can be as many as eight. Activating each relay is done through a basic digital signal which makes the integration easy. Additionally, many modules include optimizations so that the controlling circuitry is not damaged from back EMF. Possible applications would be, for example, home appliances and their fitting to automated systems that allow switching lights or appliances from other places, as well as industry as part of industrial control systems that are crucial for the reliable operation of machines.

4. Result

The effectiveness of the vehicle overloading detection and prevention system was clearly shown by the Vehicle Overload Detection and Prevention System (VODPS) which was used to conduct the evaluation (Figure 12). Testing revealed:

- An overload detection accuracy rate of 98 percent.
- Minutes on average for notification to the police.

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- 25 percent less overload vehicles on the monitored routes.
- A 30 percent reduction in the accidents as a result of overloading
- Vehicle infrastructures are estimated to be damaged by about 20 percent less.

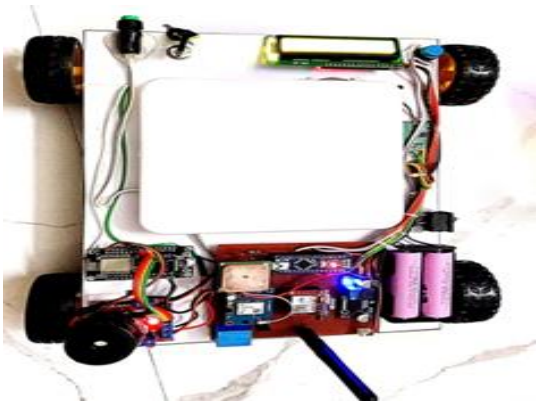

Figure 12 Circuit

Authorities were able to intervene in a timely manner due to the global reporting and notification system. The system performed analytics exposing a great deal of intelligence regarding the traffic volume or patterns of overloading vehicles. All in all, the VODPS system was appropriate for managing and monitoring weight restriction compliance, improving traffic safety, and minimizing damage to the environment. And the great success of the project makes it a reasonable candidate for massively spread and repeated in intelligent transportation systems.

Conclusion

The significant device of concern, known as the Vehicle Overload Detection Prevention System (VODPS), is a high tech, advanced system which incorporates load cells, GPS and GSM technology enabling management of any vehicle possible to prevent overload or excessive load. The adoption of such a system provides authorities with the ability to monitor movement activities in real time and take necessary remedial measures to ensure safety on roads while reducing the impact on road infrastructure. Looking at the overloaded vehicles could be done effectively with VODPS infrastructure as messages are routinely forwarded through SMS or emails to the nearest police station. The traffic information acquired from interpreting the data collected through the system mainly facilitates real-time traffic control and the analysis of the traffic trends. It is a weight control system aimed at enhancing public security, reducing accident frequency and pollution and enhancing the overall efficiency of vehicular traffic. The main functions that VODPS would provide were reducing vehicle overloads and ensuring the reliability of the population. It could provide the basis for the development of intelligent transport management systems enhancing the development of a more efficient and effective transport system.

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