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A System Of Iot Devices To Prevent Under Loading/ Over Loading Of Railway Wagons

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ABSTRACT:

In this project, we propose a comprehensive IoT-based system designed to prevent under- loading and over-loading of railway wagons. The system utilizes multiple sensors and modules to ensure efficient monitoring and alerts. Infrared (IR) sensors are employed to detect whether a wagon door is open or closed. A GPS module tracks the location coordinates of each wagon, ensuring monitoring of its journey. The system also integrates a GSM module to send alert messages under three critical conditions: underloading, overloading, and when the wagon door opens. These messages include the specific condition and the wagon's location coordinates. To alert nearby personnel, a buzzer is activated in such events. Additionally, an LCD display provides data visualization for onsite monitoring. An ESP32 Camera is used to capture images whenever a wagon door opens, and these images are sent to a designated Gmail account for further inspection. The weight of the goods inside the wagon is measured using a load cell, and this data, along with the wagon door status, is uploaded to the ThingSpeak IoT platform for remote monitoring and analysis. The Arduino UNO serves as the main control unit, orchestrating all the components to work seamlessly together. This system ensures enhanced safety and operational efficiency in railway freight management.

Key words: IoT-based system, railway wagons, underloading, overloading, sensors, GSM module.

Introduction:

Railway freight transportation plays a crucial role in global logistics, ensuring the efficient movement of goods across vast distances. However, managing the loading conditions of railway wagons is a critical challenge that affects both safety and operational efficiency. Overloading can lead to structural damage and increased wear and tear, while underloading results in inefficient use of resources. Additionally, unauthorized access to wagons can compromise the security of the goods being transported. To address these challenges, we propose an IoT-based system designed to monitor and prevent underloading and overloading of railway wagons. This system integrates advanced sensors, communication modules, and cloud-based data management to provide real-time monitoring and alerts. By leveraging technologies such as IR sensors, GPS, GSM, load cells, and ESP32 cameras, the system ensures precise tracking of wagon conditions and enhances the overall safety and efficiency of railway freight operations. The Arduino UNO serves as the central control unit, coordinating the various components and enabling seamless data integration with the ThingSpeak IoT platform for remote monitoring and analysis.

Literature Review:

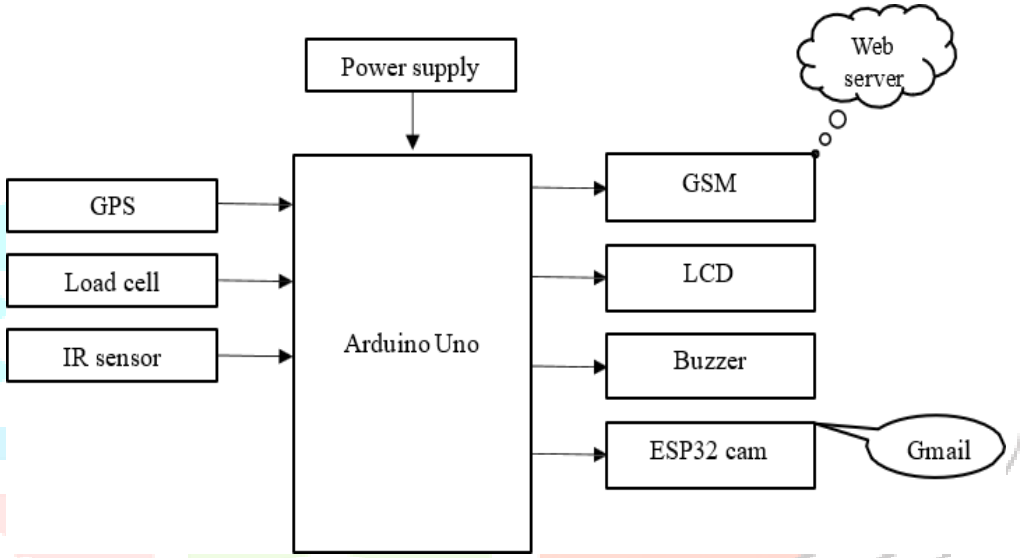
1. The aim of this paper is to research the optimization of loading cargo containers on railway wagons during the formation of railway compositions, by matching technical limitations of the wagons, as required by the wagon engineering discipline ("wagon loading schema" – includes cargo position, weight, and axle load, among other parameters), limitations of the railway (maximum speed, railway class, axle load, cargo height etc.), as identified by the "State of the railway network" document issued by the Railway Infrastructure Manager HŽ Infrastruktura Ltd., and the commercial bill of lading. As a part of the research, a mobile Web application has been created and tested with the key pilot stakeholder, confirming the initial hypothesis that the optimization methodology can successfully be used in optimization of cargo container loading and placement on railway wagons, increasing efficiency and decreasing cost and harmful emissions.
2. This paper proposes an Internet of Things (IoT) based answer to address the issue of under- loading and overloading of railroad carts at Coal India Limited (CIL) sidings. The carts, stacked through legally binding means by payloaders, frequently bring about overloading or under- loading. While punishments for overloading are borne by the buyer, under-loading brings about inactive cargo costs, which are borne by the CIL. The framework's essential parts incorporate burden sensors introduced on every cart, a focal handling unit for information collection and examination, and easy to understand interface for observing and control. The load sensors ceaselessly measure the heaviness of the freight in every cart and send this information to the focal handling unit. The focal handling unit examines this information, recognizes any examples of underloading or overloading, and cautions the significant faculty through the UI. The proposed advanced arrangement includes the utilization of sensors/IoT gadgets to screen and control the stacking of carts. This framework plans to guarantee ideal stacking, accordingly forestalling punishments and diminishing inactive cargo costs. By resolving this issue, the undertaking can altogether improve functional productivity and cost-adequacy in coal transportation at CIL sidings.
3. Intelligent Load Monitoring and Control in Railway Wagons using IoT: This study presents an advanced system utilizing IoT devices to monitor and control the loading of railway wagons. The system aims to ensure optimal loading, thereby enhancing safety and operational efficiency.
4. A System of IoT Devices to Prevent Underloading and Overloading of Railway Wagons: This research introduces an IoT-based system designed to prevent underloading and overloading in railway wagons. The system employs weight and temperature sensors integrated onto the wagons, providing real-time monitoring of cargo conditions and sending immediate alerts to railway operators in cases of underloading or overloading.
5. IoT-Based Load Detection and Weight Distribution in Freight Wagons: This project leverages IoT technology to monitor freight train operations, focusing on load detection and weight distribution in freight wagons. Axle-mounted load cells measure freight weight, detecting underloading and overloading conditions to ensure safe and efficient transportation.
6. IoT Monitoring Sets New Standards in Railway Safety: This article discusses how IoT sensors are revolutionizing railway safety by providing real-time data on various operational aspects, including load monitoring. The implementation of IoT technologies enables operators to proactively address potential safety issues, setting new standards in railway safety.

Existing System:

Conventional methods for monitoring and managing the loading conditions of railway wagons often rely on manual inspections and basic mechanical systems. These methods typically involve human operators who physically inspect each wagon to ensure it is neither underloaded nor overloaded. Load measurements are often taken using stationary weighbridges, which require wagons to be shunted to specific locations for weighing. This process is time- consuming and labor-intensive, leading to potential delays and inefficiencies in railway operations. Additionally, manual inspections are prone to human error, which can result in inaccurate assessments of loading conditions. Security measures, such as seals on wagon doors, are also manually checked, making it challenging to detect unauthorized access promptly. The lack of data and automated alerts in conventional systems limits the ability to respond swiftly to issues such as overloading, underloading, or unauthorized wagon access. Consequently, these methods can lead to increased operational costs, safety risks, and logistical inefficiencies in the railway freight industry.

Proposed System:

The proposed method leverages IoT technology to create an intelligent and automated system for monitoring and managing the loading conditions of railway wagons. This system integrates a variety of sensors and communication modules to provide data and alerts, significantly enhancing operational efficiency and safety. Infrared (IR) sensors detect whether wagon doors are open or closed, while GPS modules continuously track the location of each wagon, ensuring monitoring throughout its journey. Load cells are employed to measure the weight of the goods within the wagons, enabling detection of underloading or overloading conditions. When specific conditions are met, such as the wagon door opening or weight thresholds being exceeded, a GSM module sends immediate alert messages containing the condition and location coordinates. A buzzer provides local alerts to nearby personnel, enhancing on-site responsiveness. Additionally, an ESP32 camera captures images when the wagon door opens, sending these photos to a designated Gmail account for security verification. An LCD display provides on-site visualization of key data, while all collected information is uploaded to the ThingSpeak IoT platform for comprehensive remote monitoring and analysis. The Arduino UNO serves as the central control unit, orchestrating all these components to function cohesively.



Hardware components:

- Arduino UNO
- IR SENSORS
- GPS
- GSM
- BUZZERS
- LCD
- POWER SUPPLY
- ESP32 CAMERA
- LOAD CELL

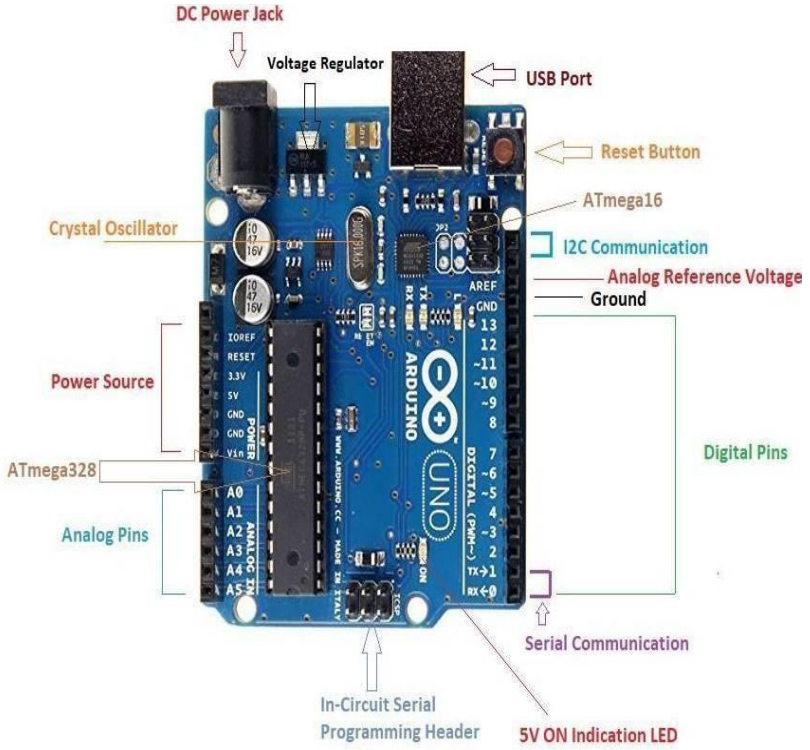
Software components:

- Arduino IDE
- Embedded C

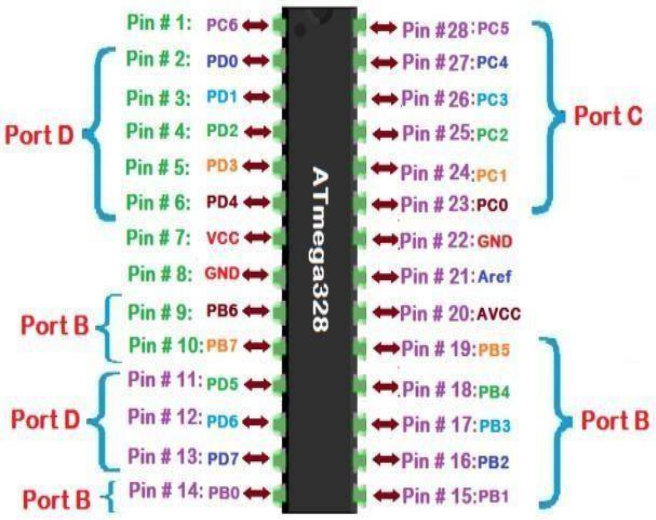
➢ **ARDUINO UNO:**

Arduino UNO is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support

the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.



Arduino UNO



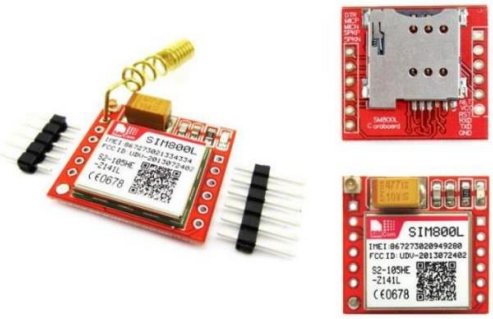
Atmega328 Microcontroller

- **IR SENSOR MODULE:**

Active infrared sensors both emit and detect infrared radiation. Active IR sensors have two parts: a light emitting diode (LED) and a receiver. When an object comes close to the sensor, the infrared light from the LED reflects off of the object and is detected by the receiver.

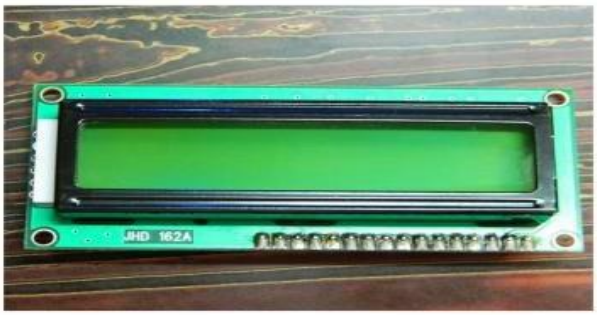
- **GSM MODULE:**

SIM900A GSM Module is the smallest and cheapest module for GPRS/GSM communication. It is common with Arduino and microcontroller in most of embedded application. The module offers GPRS/GSM technology for communication with the uses of a mobile sim. It uses a 900 and 1800MHz frequency band and allows users to receive/send mobile calls and SMS. The keypad and display interface allows the developers to make the customize application with it. Furthermore, it also has modes, command mode and data mode. In every country the GPRS/GSM and different protocols/frequencies to operate. Command mode helps the developers to change the default setting according to their requirements.



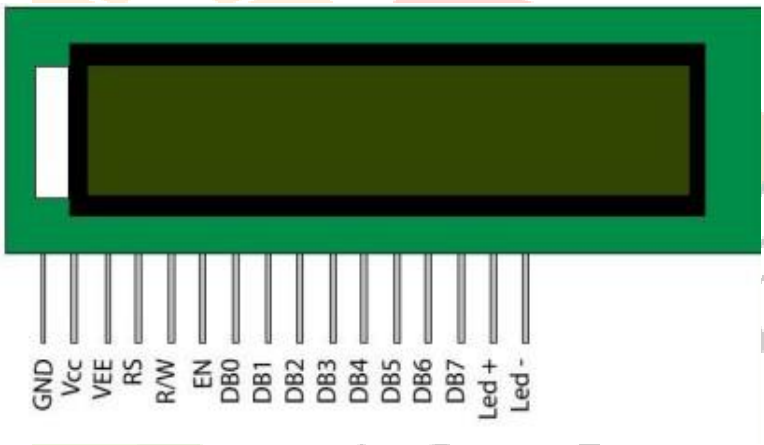
- **LCD:**

LCD is Liquid Crystal Display. it is a passive device, which means that it does not deliver any light to display characters, animations, videos, etc. LCD uses fluorescent tubes to lighten the picture, but can't provide a clearer picture as LED delivers. It consists of millions of pixels made of crystal and arranged in a rectangular grid. In LCD it has backlights that provide light to each pixel. Each pixel has a red, green, and blue (RGB) sub-pixel that can be turned on or off. When all of the sub-pixels are turned off, then it's black and when all the sub-pixels are turned on 100%, then it's white.



LCD – Front View

LCD – Back View



- **BUZZER:**

The piezo, also known as the buzzer, is a component that is used for generating sound. It is a digital component that can be connected to digital outputs, and emits a tone when the output is HIGH. Alternatively, it can be connected to an analog pulse-width modulation output to generate various tones and effects.

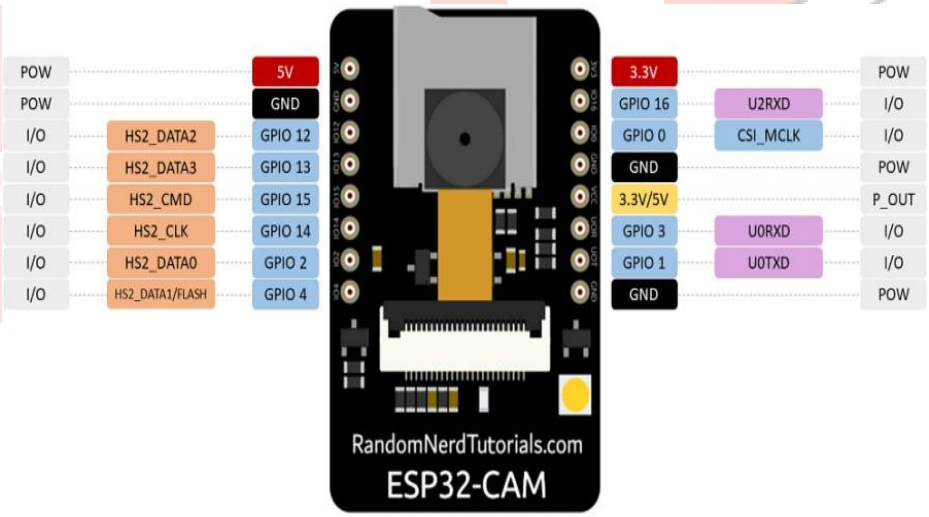
- GPS neo 6M:

The NEO-6M is a widely used GPS receiver module developed by u-blox, known for its reliability and high-performance capabilities in satellite navigation. It operates based on the Global Positioning System (GPS) to provide accurate location data by receiving signals from multiple satellites. The module features a powerful SiRFstarIV GPS chipset, which enables it to achieve high sensitivity and precise positioning even in challenging environments such as urban canyons or dense foliage. The NEO-6M offers a high update rate and supports various GPS features, including multiple position fixes per second and enhanced satellite tracking. Its compact design and ease of integration make it suitable for a range of applications, from personal navigation systems and automotive tracking to IoT projects and geographic information systems (GIS). The module typically communicates with microcontrollers through UART or I2C interfaces, allowing for straightforward integration into various electronic projects and systems.

GPS Receiver

- **ESP32 cam:**

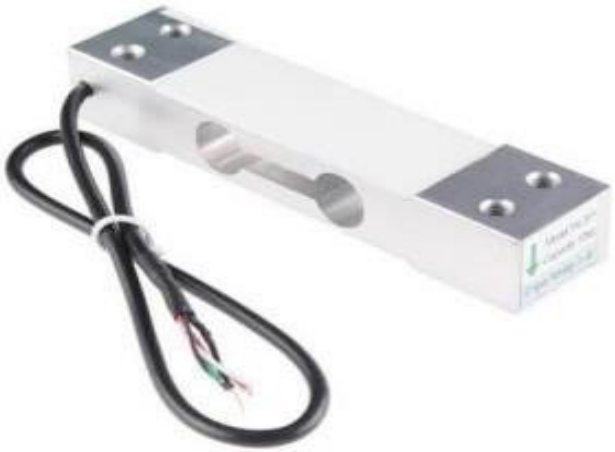
The ESP32-CAM is a versatile and compact module that integrates the ESP32 microcontroller with a camera, offering a powerful solution for a wide range of imaging and connectivity applications. It features a 2-megapixel OV2640 camera, which provides high-quality image capture and supports various resolutions and formats. The ESP32-CAM utilizes the ESP32 chip, which includes Wi-Fi and Bluetooth capabilities, enabling seamless wireless communication and data transfer. This combination of features makes the module ideal for applications such as live video streaming, surveillance systems, and IoT projects that require both visual and wireless connectivity. The ESP32-CAM supports various development platforms, including the Arduino IDE, and provides GPIO pins for additional sensors and peripherals, making it highly flexible for custom projects. Its low cost, ease of integration, and robust performance make it a popular choice for hobbyists and developers looking to implement advanced imaging solutions in their projects.

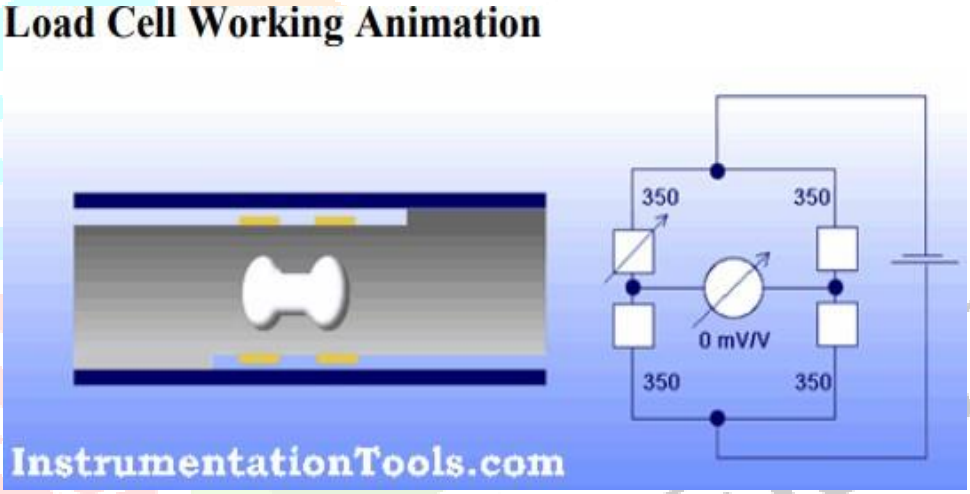


- **LOAD CELL:**

A load cell is a transducer used to measure weight or force by converting mechanical force into an electrical signal. It operates based on the principle of strain gauges, which change resistance when subjected to mechanical stress. Load cells are commonly used in various applications, including weighing scales, industrial machinery, and material testing. The HX711 is a specialized 24-bit analog-to-digital converter (ADC) designed to interface with load cells and amplify their signals for precise measurements. It is widely used in digital weighing systems due to its high resolution and low noise characteristics. The HX711 features a built-in low-noise programmable gain amplifier, which significantly amplifies the small voltage changes from the load cell, ensuring accurate and stable weight

readings. This combination of load cell and HX711 amplifier enables accurate measurement and monitoring of weights in various applications, making it essential for systems requiring precise load and force measurements.





- **ARDUINO IDE:**

Arduino IDE (Integrated Development Environment) is an official program developed by Arduino.cc for creating, compiling, and uploading code to Arduino devices. Almost all Arduino modules are compatible with this open-source software, which can be installed and used to compile code while on the go.

- **Embedded C:**

Embedded C is a programming language that is used in the development of Embedded Systems. Embedded Systems are specialized systems designed to perform very specific functions or tasks. Embedded System is the combination of hardware and software, and the software is generally known as firmware which is embedded into the system hardware. Embedded C is used to program a wide range of microcontrollers and microprocessors. Embedded C requires less number of resources to execute in comparison with high-level languages such as assembly programming language.

- **THINGSPEAK :**

ThingSpeak is an IoT analytics platform that allows you to collect, display, and analyze real-time data streams in the cloud. ThingSpeak enables you to send data from your devices, generate real-time graphs, and issue alerts. ThingSpeak is an open-source Ruby app that enables users to speak with internet-connected gadgets. It makes it easier to access, retrieve, and log data by giving an API to both devices and social networking websites.

Conclusion:

In conclusion, the implementation of an IoT-based system for preventing underloading and overloading of railway wagons presents a significant advancement over conventional methods. By integrating various sensors, communication modules, and data platforms, this system provides real-time monitoring, precise data collection, and immediate alerts, ensuring enhanced safety, security, and operational efficiency in railway freight transportation. The automation and accuracy afforded by this technology reduce human error, streamline operations, and allow for swift responses to any irregularities. Furthermore, the ability to remotely monitor and analyze data via the ThingSpeak IoT platform offers valuable insights and greater control over logistics and supply chain management. Overall, this innovative approach not only addresses critical challenges in the railway freight industry but also sets a new standard for the future of transportation management.

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