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Enhancement of Truck Transportation Efficiency Through Remote Monitoring of Route and Mineral Load

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Abstract

The mining industry faces significant challenges when it comes to ensuring the safety and security of heavy-duty trucks operating outside the boundaries of the mine through remote routes and mineral load monitoring. To address these concerns, this study proposes an approach to enhance safety and surveillance by utilizing the Global Positioning System (GPS) and load cell technology to track trucks beyond the mine boundary and mineral load monitoring. The developed system will provide real-time information about truck location, speed, mass theft, and idle routes. To achieve this, a GPS tracker is installed on the truck, providing accurate and reliable location data, and a load cell is installed to monitor the mineral load. This will help ensure compliance with safety regulations and prevent unauthorized stopping and mineral theft. To monitor the location, speed, mass theft, load monitoring, and unauthorized stoppings BLYNK application is used. This system will facilitate improved decision-making, enable timely response to emergencies, enhance operational efficiency, and reduce the risks associated with truck operations outside the mine.

Keywords: *Blynk Application, Global Positioning System (GPS), Load Cell, Load Monitoring*

1.0 Introduction

Enhancement of truck efficiency through weight and remote route monitoring in mining is a new approach aimed at optimizing the performance of trucks within the mining industry. This project revolves around applying advanced technology and data-driven solutions to improve two key aspects of mining operations: the weight management of haulage trucks and monitoring their routes from a remote location.

In mining, the efficient movement of materials is paramount for productivity and cost-effectiveness. Managing the load of trucks is crucial to prevent overloading, which can lead to spillage of minerals and safety hazards. Tracking and monitoring the routes that these trucks take outside the mine boundary is essential for ensuring that they follow optimal paths, avoid obstacles, and adhere to safety regulations.

Enhanced truck efficiency in mining involves the utilization of various technologies such as load sensors and GPS tracking. By integrating these tools, mining companies can achieve several benefits, including reduced fuel consumption, minimized maintenance costs, increased safety for workers, and overall improved operational efficiency.

Remote route monitoring allows for real-time assessment of truck movements, enabling quick decision-making and proactive responses to any issues that may arise during transportation. The enhancement of truck transportation efficiency through remote monitoring of

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routes and mineral loads has become a pivotal aspect of modern logistics and resource management. This innovative approach leverages advanced technologies to optimize various facets of the trucking industry, addressing challenges and ushering in a new era of streamlined operations.

One key component of this enhancement is the utilization of GPS and telematics systems to monitor truck routes remotely. These systems provide real-time tracking and analytics, allowing fleet managers to monitor the precise location, speed, and status of each truck in their fleet. By leveraging this data, companies can optimize routes, reduce idle time, and enhance fuel efficiency. This not only results in cost savings but also minimizes the environmental impact of transportation operations.

Furthermore, remote monitoring extends beyond just location tracking. It includes the continuous assessment of the truck's health and performance through sensors and *IoT* devices. These devices can monitor engine diagnostics, tire pressure, and other critical parameters, enabling proactive maintenance. This predictive maintenance approach helps prevent breakdowns, reduces downtime, and extends the lifespan of the vehicles, contributing to overall operational efficiency.

Occasionally, an ore spillage caused by a mining vehicle carrying too much weight results in accidents. In many truck hauling applications, it can be challenging to weigh the weight being carried accurately and on time. For businesses like mining, where efficient vehicle loading is crucial, this presents difficulties. Because traditional weigh stations can be labor-intensive and inefficient, more affordable and automated solutions are required. Preventing theft, damage, or loss of minerals during shipment necessitates ensuring their security. Financial losses and interruptions to operations may arise from theft, tampering or pilferage.

Road transport operations, traffic safety, and infrastructure are all seriously threatened by overweight vehicles. Additionally, their use leads to unfair competition between operators and types of transportation. Ensuring trucks adhere to weight regulations is essential to solving these issues[1]. Reasonable management of the highway system depends on precise truck weight measurement. Various methods are employed for this purpose, including weigh stations, WIM systems, and portable scales. It is necessary to evaluate the correctness of these methods and comprehend their limitations in practical situations[2].

Heavy traffic and congestion on roads can cause delays and disruptions in truck transportation, resulting in missed delivery deadlines and increased operational costs. Adverse weather conditions such as storms and flooding can impact truck transportation causing delays, route changes, and safety concerns. The practice of overloading vehicles in the mining industry poses a threat to road safety and contributes to accidents. Despite existing rules and regulations, effective implementation of overloading control requires an organized system[3].

The problem addressed is vehicle overloading, particularly in trucks, and its impact on road safety and infrastructure. overloading leads to an increase in accidents, damages to roads and public property, and financial burdens on proprietors, drivers, and authorities[4].

The high rates of occupational fatalities and injuries in the mining sector are well-known. Because overloading a mining dump truck exceeds the weight capability of its tires and braking system, it increases the stopping distance overall, which is a major risk to worker safety. Moreover, a large portion of deadly incidents and fatalities in Indian coal mines are caused by transportation machinery. To overcome these safety risks, thorough procedures are required[5]. Logistics and transportation systems need to be more effective due to the high cost of fossil fuels. Fleet managers view vehicle tracking as a way to cut expenses since it gives them access to their car's current locations[6]. The designated routes of travel for mineral shipments were altered, and they were cross-loaded onto trucks and trailers purportedly owned or run by the syndicates and some of the respondents. These minerals were shipped to Gauteng and unloaded at each respondent's location[7].

There are two main ways that trailer theft happens, Type 1: A thief, usually a professional one, uses a tractor to break into a facility and take a trailer from a trailer pool with the goal of scrapping or selling it. Type 2: An incoming driver at a facility who is expected to drop off a trailer and keep it longer than permitted, these drivers are usually independent contractors. The majority of trailer losses experienced by our sponsor firm are caused by this second kind of theft, which involves uninvited drivers who are constantly trying to cover the expenses.

2.0 Components and Model Development

2.1 ESP8266 WIFI Module

ESP8266 is a wi-fi-enabled System-on-Chip (SoC) module developed by the espressif system. It is mostly used for development of IoT (Internet of Things) embedded applications.

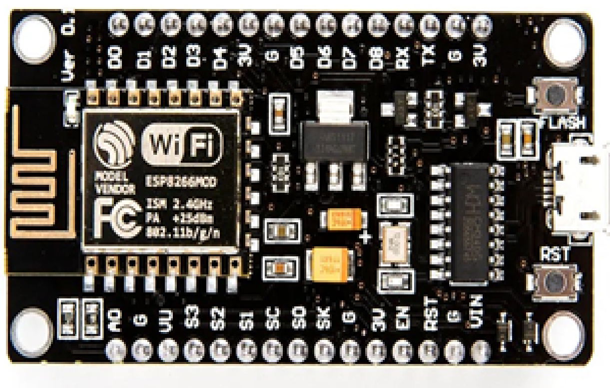


Figure 1. Image of ESP8266 WIFI module.

ESP8266 comes with capabilities of

- 2.4 GHz Wi-Fi (802.11 b/g/n, supporting WPA/ WPA2).
- General-Purpose Input/Output (16 GPIO).
- Inter-Integrated Circuit (I^2C) serial communication protocol.
- Analog-to-Digital Conversion (10-bit ADC).
- Serial Peripheral Interface (SPI) serial communication protocol.
- I^2S (Inter-IC Sound) interfaces with DMA (Direct Memory Access) (sharing pins with GPIO).
- UART (on dedicated pins, plus a transmit-only UART can be enabled on GPIO2) and
- Pulse-Width Modulation (PWM).

2.2 Arduino Mega 2560

Arduino mega 2560 is a microcontroller board based on Atmega2560. It comes with more memory space and *I/O* pins as compared to other boards available in the market. There are 54 digital *I/O* pins and 16 analog pins incorporated on the board that make this device unique and stand out from others. Out of 54 digital *I/O*, 15 are used for PWM (Pulse Width Modulation). A crystal

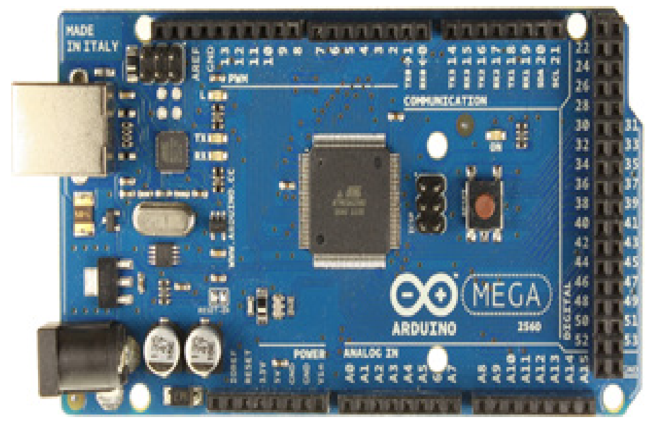


Figure 2. Arduino mega 2560.

oscillator of 16 MHz frequency is added to the board. This board comes with a USB cable port that is used to connect and transfer code from the computer to the board. DC power jack is coupled with the board that is used to power the board.

2.3 Battery

A battery is a device in which chemical energy is directly converted to electrical energy. Itconsists of one or more voltaic cells, each of which is composed of two half-cells connectedin series by the conductive electrolyte. consists of one or more voltaic cells in series.

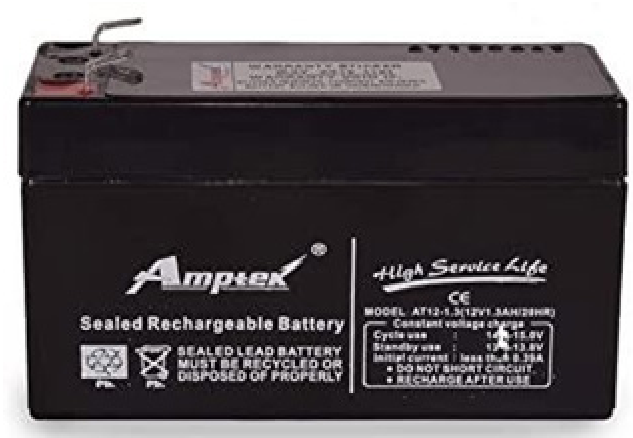


Figure 3. Battery.

2.4 Buck Converter

A buck converter is a type of chopper circuit that is designed to perform step-down conversion of the applied DC input signal. In the case of buck converters, the fixed

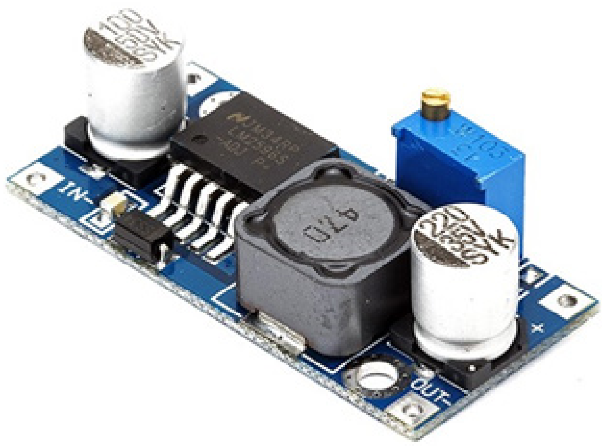


Figure 4. Image of the buck converter.

DC input signal is changed into another DC signal at the output which is of lower value. This means it is designed to produce a DC signal as its output that possesses a lower magnitude than the applied input. It is sometimes called a step-down DC to DC converter, step-down chopper or buck regulator.

2.5 L298 Motor Driver

L298N module is a high voltage, high current dual full-bridge motor driver module for controlling the DC motor and stepper motor. It can control both the speed and rotation direction of two DC motors. This module consists of an L298 dual-channel H-Bridge motor driver IC. This module uses two techniques for the control speed and rotation direction of the DC motors. These

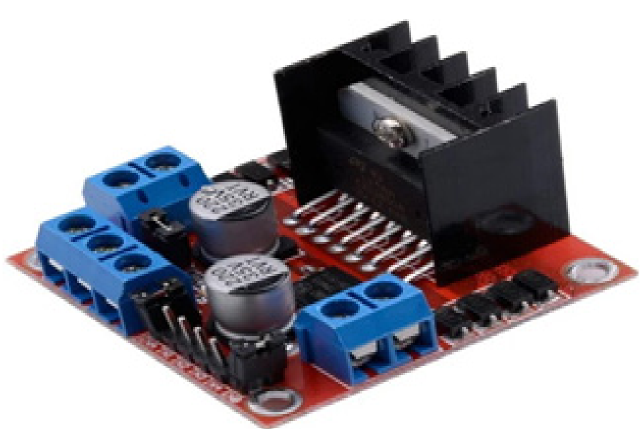


Figure 5. L298 Motor driver.

are PWM – for controlling the speed and H-Bridge for controlling rotation direction. These modules can control two DC motors or one stepper motor at the same time.

2.6 Load Cell

The load cell is a transducer that converts force or weight into an electrical signal shown in the figure below. Here's a brief explanation of its working principles.

Load cells typically contain one or more strain gauges. Strain gauges are thin wires or foils that deform

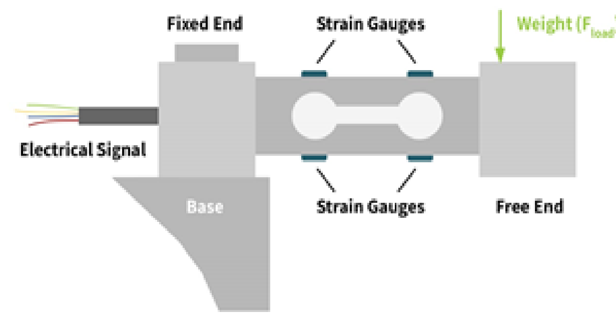


Figure 6. Load cell.

when subjected to force, leading to changes in electrical resistance.

These strain gauges are arranged in a wheatstone bridge configuration, which is a circuit that can detect small changes in resistance. The wheatstone bridge helps in amplifying the signal generated by the strain gauges.

When a force is applied to the load cell, it deforms slightly, causing a change in the resistance of the strain gauges. This change is proportional to the applied force.

The wheatstone bridge circuit produces a differential voltage output corresponding to the applied force. This signal is typically in millivolts.

The low-level voltage output from the wheatstone bridge is amplified and conditioned by electronic circuits to improve accuracy and provide a usable signal.

The conditioned signal is then converted from analog to digital by an Analog-to-Digital Converter (ADC), making it suitable for digital processing and display.

2.7 Assembly of Components

The above figure shows the connection of the components mentioned below

- ESP8266 WIFI module.
- Arduino mega 2560.
- Battery.
- Buck converter.
- L298 Motor driver.
- VI)Load cell.

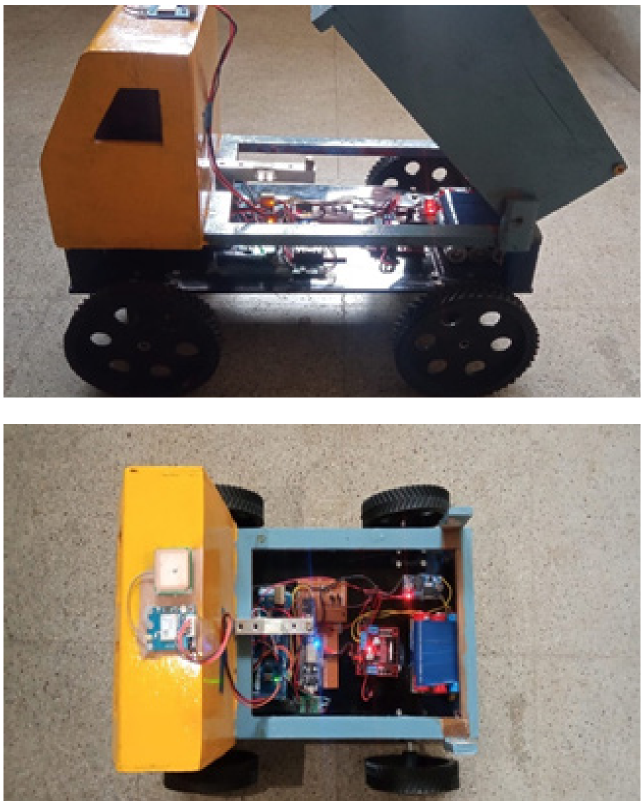


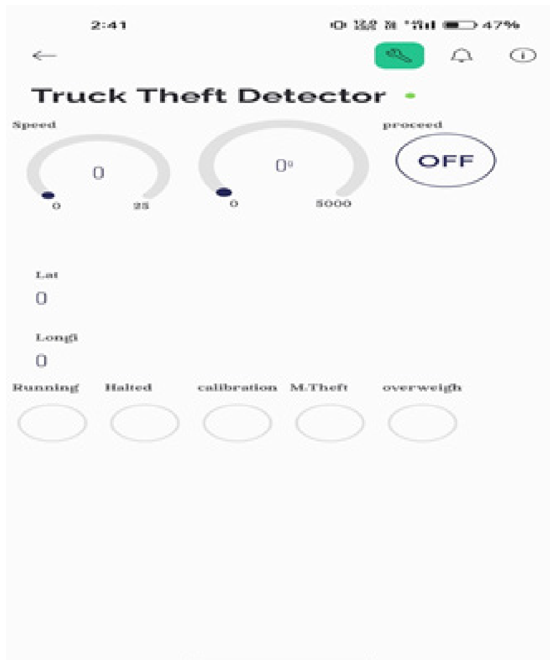
Figure 7. Connection of components.

3.0 Blynk Working Image

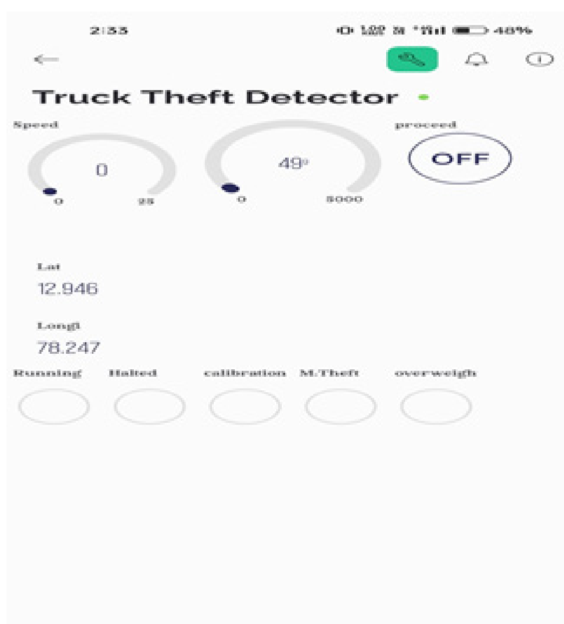
The app shows the current speed of the truck, and there is a text box labeled "proceed" where a speed limit can be entered. If the truck exceeds the speed limit, the app may sound an alarm or send an alert to the owner. GPS tracking: The app shows the latitude and longitude of the truck, which can be used to track the truck's location in real-time. This can be helpful if the truck is stolen.

The app shows the current status of the truck, which can be "running" or "halted." There are also buttons for "calibration" and "M.Theft" (which may stand for "Missing Theft"). It is not clear what the calibration button does, but the M.Theft button may used to report a stolen truck.

The app have a feature that can detect if the truck is overloaded. This can help prevent damage to the truck and avoid fines.



(a)



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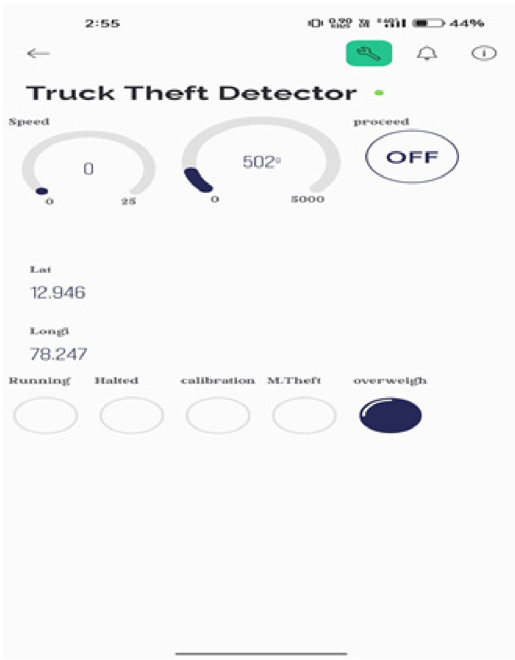

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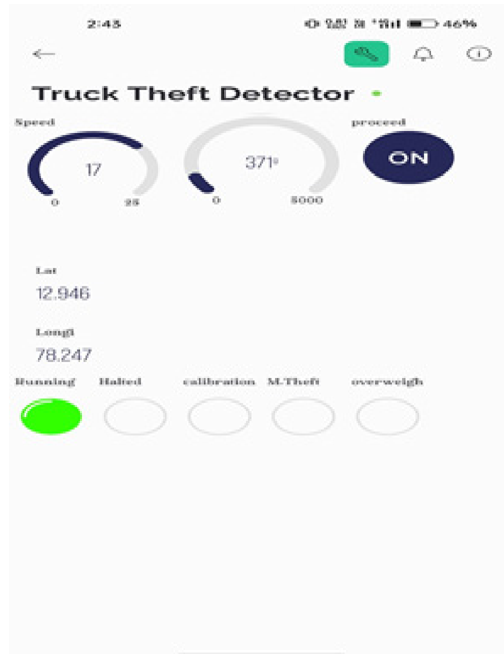

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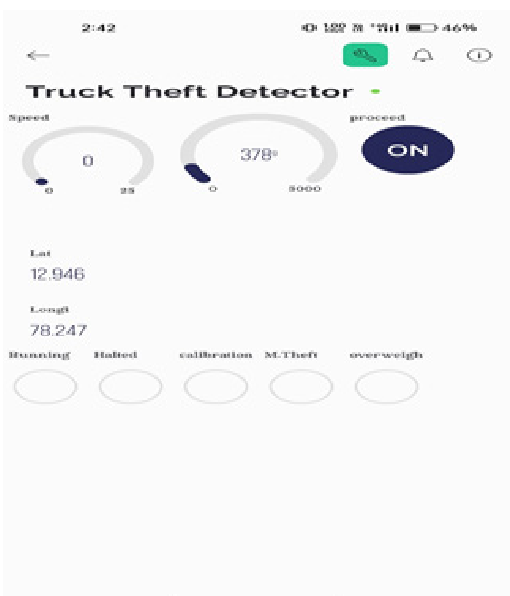
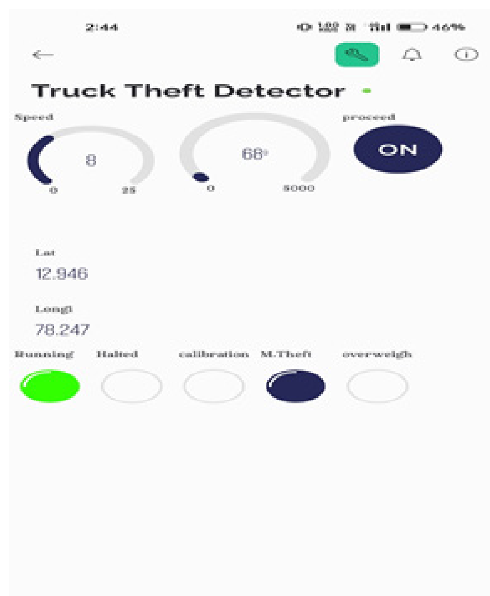


(d)



(f)

Figure 2. **Figure 8. (a)** Blynk **(b)** Calibration of weight **(c)** Overweight monitoring **(d)** Desired weight loading **(e)** Speed and location monitoring **(f)** Mass theft detection.

The Figure (a) image represents the opening of the blynk one on a mobile

The Figure (b) image represents the calibration of weight in the blynk app.

The Figure (c) image represents the weight of the truck about 502 grams. As per the code, more than 400 grams represent the overweight so the overweight button is glowing. The Figure (d) image represents the desired weight loading below the overweight. It is shown in the weight monitor in the app.

The Figure (e) image represents the truck's speed in the app's speed monitor. The image also shows the truck's location in the form of latitude and longitude.

Figure (f) image represents the mass theft in the truck. Due to the reduction in the weight of the load in the truck mass theft button is glowing.

4.0 Developed Model

It shown in Table 1 that the prototype model has accuracy with an error average percentage of $\pm$ 0.6 percentage compared to the conventional weight machine for weighing shown in Figure 9. The weigh scale can be scaled as per field requirements.

Table 1. Error calculation for weight

S.NO	weight in weigh machine in gms	weight in the truck in gms	error		Difference in percentage
1	100	100	0		0
2	170	171	0.00588		0.5
3	210	210	0		0
4	270	271	0.0037		0.3
5	330	332	0.00606		0.6
6	370	371	-0.0026		-0.2
7	450	451	0.00222		0.2
8	497	498	0.002		0.2
9	540	541	0.00185		0.1
10	620	619	-0.0016		-0.1
11	660	663	0.00455		0.4
12	720	721	0.00139		0.1
13	770	772	0.0026		0.2
14	810	811	0.00123		0.1
15	870	873	0.00345		0.3
16	900	902	0.00222		0.2
17	950	951	0.00105		0.1
18	1000	1000	0		0
19	1100	1102	0.00182		0.1
20	1250	1255	0.004		0.4
21	1300	1304	0.00308		0.3
22	1420	1423	0.00211		0.2
23	1550	1551	0.00065		0.06

24	1600	1603	0.00188		0.1
25	1650	1652	0.00121		0.1
26	1700	1698	-0.0012		-0.1
27	1770	1776	0.00339		0.3
28	1810	1812	0.00111		0.1
29	1880	1885	0.00266		0.2
30	1920	1922	0.00104		0.1

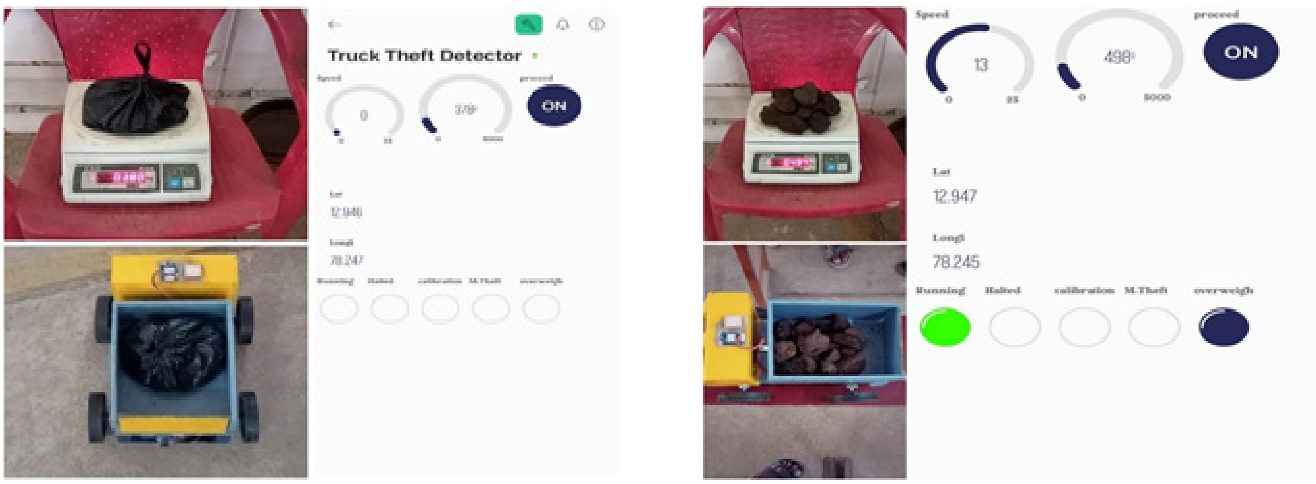


Figure 9. Comparison of weight with weigh machine and developed model.

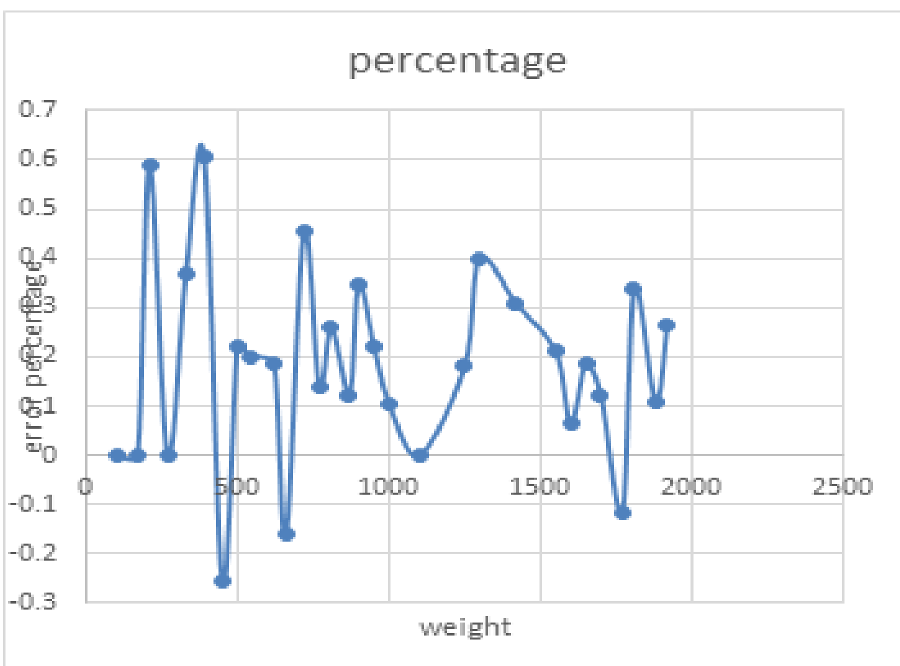


Figure 10. Error percentage graph.

Table 2. Error calculation for latitude

			Gps latitude	Truck latitude	Error	Difference in percentage
Day 1	Morning	Location1	12.946	12.947	0.001	0.1
		Location2	12.945	12.945	0	0
		Location3	12.945	12.946	0.001	0.1
		Location4	12.945	12.946	0.001	0.1
		Location5	12.944	12.945	0.001	0.1
	Afternoon	Location1	12.946	12.947	0.001	0.1
		Location2	12.945	12.945	0	0
		Location3	12.945	12.946	0.001	0.1
		Location4	12.944	12.946	0.002	0.2
		Location5	12.944	12.945	0.001	0.1
	Evening	Location1	12.946	12.947	0.001	0.1
		Location2	12.945	12.945	0	0
		Location3	12.945	12.946	0.001	0.1
		Location4	12.944	12.946	0.002	0.2
		Location5	12.944	12.945	0.001	0.1
Day 2	Morning	Location1	12.946	12.947	0.001	0.1
		Location2	12.945	12.945	0	0
		Location3	12.945	12.946	0.001	0.1
		Location4	12.944	12.946	0.002	0.2
		Location5	12.944	12.945	0.001	0.1
	Afternoon	Location1	12.946	12.947	0.001	0.1
		Location2	12.945	12.945	0	0
		Location3	12.945	12.946	0.001	0.1
		Location4	12.945	12.946	0.001	0.1
		Location5	12.944	12.945	0.001	0.1
	Evening	Location1	12.946	12.947	0.001	0.1
		Location2	12.945	12.945	0	0
		Location3	12.945	12.946	0.001	0.1
		Location4	12.944	12.946	0.002	0.2
		Location5	12.944	12.945	0.001	0.1

Table 3. Error calculation for longitude

Days	Timing		Gps longitude	Truck longitude	Error	Difference in percentage
Day 1	Morning	Location1	78.245	78.245	0	0
		Location2	78.245	78.245	0	0
		Location3	78.246	78.247	0.001	0.1
		Location4	78.247	78.248	0.001	0.1
		Location5	78.247	78.247	0	0
	Afternoon	Location1	78.245	78.245	0	0
		Location2	78.246	78.247	0.001	0.1
		Location3	78.247	78.248	0.001	0.1
		Location4	78.247	78.247	0	0
		Location5	78.246	78.246	0	0
	Evening	Location1	78.245	78.245	0	0
		Location2	78.246	78.245	-0	-0.1
		Location3	78.247	78.247	0	0
		Location4	78.247	78.248	0.001	0.1
		Location5	78.246	78.247	0.001	0.1
Day 2	Morning	Location1	78.245	78.245	0	0
		Location2	78.245	78.245	0	0
		Location3	78.246	78.247	0.001	0.1
		Location4	78.247	78.248	0.001	0.1
		Location5	78.247	78.247	0	0
	Afternoon	Location1	78.245	78.245	0	0
		Location2	78.246	78.247	0.001	0.1
		Location3	78.247	78.248	0.001	0.1
		Location4	78.247	78.247	0	0
		Location5	78.246	78.246	0	0
	Evening	Location1	78.245	78.245	0	0
		Location2	78.246	78.245	-0	-0.1
		Location3	78.247	78.247	0	0
		Location4	78.247	78.248	0.001	0.1
		Location5	78.246	78.247	0.001	0.1

Table 2 shows the calculation of the error between the GPS-reported latitude and a reference latitude, likely for a truck. It shows that readings are taken for two days of data, with multiple readings taken throughout each day due to changes in the GPS readings due to weather changes in the day.

The first column indicates the day. The second column indicates the time of day. The third column refers to a specific location of reading. The fourth column shows the GPS-reported latitude. The fifth column shows the truck's latitude as seen on the blynk app. The sixth column shows the calculated error between the GPS-reported latitude and the truck latitude. The seventh column shows the difference in percentage.

The table also shows an average percentage error of 0.0033.

Table 3 shows the calculation of the error between the GPS-reported longitude and a reference longitude, likely for a truck. It shows that readings were taken for two days of data, with multiple readings taken throughout each day due to changes in the GPS readings due to weather changes in the day.The first column indicates the day. The second column indicates the time of day. The third column refers to a specific location of reading. The fourth column shows the GPS-reported longitude. The fifth column shows the truck's longitude as seen on the blynk app. The sixth column shows the calculated error between the GPS-reported longitude and the truck's longitude. The seventh column shows the difference in percentage.

The table also shows an average percentage error of 0.0033.

5.0 Validation

Table 4 shows the F-test two-sample for variances of weight is conducted for validation and it is proven that the p-value is greater than 0.05 so the value is within the accepted limit.

Table 5 shows the F-test two-sample for variances of latitude is conducted for validation and it is proven that

Table 4. F-test two-sample for variances of weight

	weight in weigh machine	**weight in truck**
Mean	1003	974.6666667
Variance	310680.2857	328034.8506
Observations	29	30
Df	28	29
F	0.947095362	
P(F<=f) one-tail	0.443711204	p>0.05
F Critical one-tail	0.533279793	

Table 5. F-Test two-sample for variances of latitude

	Truck latitude	Gps latitude
Mean	12.9458	12.94486667
Variance	5.7931E-07	5.33333E-07
Observations	30	30
df	29	29
F	1.086206897	
P(F<=f) one-tail	0.412658229	P>0.05
F Critical one-tail	1.860811435	

Table 6. F-test two-sample for variances of longitude

	Truck longitude	Gps longitude
Mean	78.24646667	78.24613333
Variance	1.36092E-06	6.71264E-07
Observations	30	30
df	29	29
F	2.02739726	
P(F<=f) one-tail	0.34112508	P>0.05
F Critical one-tail	1.860811435	

the p-value is greater than 0.05 so the value is within the accepted limit.

Table 6 shows the F-test two-sample for variances of longitude is conducted for validation and it is proven that the p-value is greater than 0.05 so the value is within the accepted limit.

6.0 Conclusion

The developed model has several advantages it can be implemented into real mineral transporting trucks and it resolves problems related to truck theft and mineral theft during transportation. Remote monitoring of GPS data can help to reduce travel time. By remotely monitoring the mineral load weight on the truck, companies can ensure they are not overloading, which can damage vehicles and be unsafe. It can also help optimize loading at mines to maximize capacity without exceeding weight limits. It can also help in onboard monitoring of the mineral load weight so it can identify mineral theft during the transportation of the mineral load.

The enhancement of truck transportation efficiency through remote monitoring of routes and mineral loads presents a promising solution for optimizing operations in the mining industry. By leveraging remote monitoring technologies, such as GPS tracking and load sensors, companies can improve route planning, reduce fuel consumption, and enhance safety measures. This approach not only increases overall efficiency but also contributes to cost savings and environmental sustainability. With continued advancements in technology, the potential for further optimization and integration within supply chain management systems is vast, promising even greater benefits in the future.

7.0 Acknowledgment

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