



DEVELOPMENT

DEVELOPMENT OF AN IOT-BASED FUEL LEVEL AND GEOLOCATION MONITORING SYSTEM

O. K. Ogidan<sup>1\*</sup>, O. I. Joseph<sup>2</sup>, F. O. Onofeghara<sup>3</sup>

<sup>1,3</sup> Department of Electrical and Electronics Engineering, Faculty of Engineering, Elizade University, Ilara-Mokin, Ondo State, Nigeria

<sup>2</sup> Department of Automotive Engineering, Faculty of Engineering, Elizade University, Ilara-Mokin, Ondo State, Nigeria

Corresponding Author's Email: [olugbenga.ogidan@elizadeuniversity.edu.ng](mailto:olugbenga.ogidan@elizadeuniversity.edu.ng)

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ABSTRACT

Fuel theft and frequent vehicle abductions across many African regions inflict heavy economic losses on transportation providers, demanding reliable yet affordable monitoring solutions. Traditional ultrasonic sensors for fuel level detection fall short due to inaccuracies from fuel foaming and the need for invasive tank drilling during installation. This study addresses these challenges by introducing a low-cost, non-invasive telematics retrofit that leverages existing vehicle fuel sensors for real-time fuel level display and geo-location tracking, which are critical tools for fleet management in developing economies with meager resources. The proposed system intercepts the signal cable from the fuel tank sensor to the vehicle dashboard, integrating it with a microcontroller-based data acquisition system. This setup displays fuel levels and GPS coordinates on an LCD screen and streams data to Google Maps via a web application, requiring no tank modifications. The results showed GPS data from the device correlated strongly with mobile phone benchmarks, yielding coefficients of 0.911 for latitude and 0.941 for longitude, validating its precision. These findings demonstrate a practical, retrofit-friendly alternative to ultrasonic methods, enabling theft prevention and efficient fleet oversight without high costs or disruptions. Future work could integrate machine learning to predict fuel consumption, vehicle paths, and driver behaviour.

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1.0 Introduction

Fleet managers struggle to ensure driver accountability for fuel consumption and vehicle operations. This is due to the fact that traditional measurement methods prove inaccurate and lack constant supervision. This has resulted in fuel theft and misuse, resulting in hard-to-trace financial losses. The Internet of Things (IoT) telematics offers a solution to these challenges by enabling remote real-time monitoring of fuel levels and locations. This fosters trust between employers and drivers.

All vehicles use fuel level sensors (FLS) to show tank status, categorized as resistive (float), capacitive, or ultrasonic based on measurement principles (Navixy, 2024). Float sensors are very common because they are factory-installed. A float rides the fuel surface, being tied to a potentiometer that alters resistance and voltage with level changes. This voltage feeds the dashboard via analog wires in older cars or the controller area network (CAN) bus in new ones (Navixy, 2024). Capacitive types of fuel sensors form plates from concentric tubes with fuel as a dielectric. The more the fuel, the higher the capacitance since gasoline conducts better than air, yielding top accuracy for cars, trucks, boats, and machinery. The third type of fuel sensor is the ultrasonic sensor. This sensor draws fleet interest because of its discreet fuel tracking. It pulses sound waves from the tank bottom to the surface and back, computing height from flight time. The challenge

with the ultrasonic fuel sensor is that it is prone to foam interference (Market Report Analytics, 2026; Navixy, 2024).

Telematics systems leveraging IoT technology have been used several times for fuel measurement and tracking, offering features like navigation, route optimization, and misuse prevention (Vovk, 2023; Król and Rokicki, 2021). Early designs often relied on SMS for data relay (Akanda et al., 2022; Aravinda et al., 2022; Joy et al., 2023), but many remained conceptual without prototypes. Nowadays, sensor-measured values are displayed via Liquid Crystal Display (LCD)s, apps, or clouds like ThingSpeak.

The Internet of Things (IoT) has emerged as a powerful tool to tackle longstanding issues in vehicle fleet management, particularly around fuel monitoring and security. By enabling real-time remote oversight of fuel levels and vehicle positions, IoT sensors help administrators track usage without physical presence. Ultrasonic sensors are largely used in recent times for non-contact fuel level sensing in vehicles. Kale et al., (2022) paired ultrasonics with Hall Effect for bunk-fill verification, SMS alerts, and GPS-suggested stations, but real-time data lagged. Hapsari et al., (2021) built a ship system with ultrasonics, flow, temperature/humidity sensors, and GPS, feeding ThingSpeak via Wi-Fi, yet it is not implemented in real life but confined to lab tests.

Prabhu et al., (2022) created a theft-detection suite and utilized different sensors, such as an ultrasonic sensor for levels, a flow sensor for leaks, a vibration sensor for tampering, a GPS for position, and displayed results with ThingSpeak, SMS, and buzzers. Additionally, Mulenga and Halubanza (2025) attempted to track the usage and management of fuel within a storage facility. The authors employed the use of an ultrasonic sensor for measurement, Arduino as a microcontroller, and a GSM/GPRS module for transmission of measured values to the web interface for remote monitoring. The concept proved feasible, but the implementation on a real-life fuel storage facility was not carried out. These studies reflect a surge in the adoption of ultrasonic sensors for telematics (Mulenga and Halubanza, 2025; Kale et al., 2022; Hapsari et al., 2021), driven by IoT integration for remote access.

It could be observed from Table I that previous work has reported the use of ultrasonic sensors for telematics (Kale et al., 2022; Hapsari et al., 2021; Srikanth et al., 2021). Despite its popularity and the fact that an ultrasonic sensor provides a non-contact and relatively inexpensive solution for fuel level sensing, its accuracy and reliability can, however, be significantly compromised by environmental conditions, tank geometry, and may require drilling of the fuel tank for installation (Qiu et al., 2022; SMD Fluid Control, 2025).

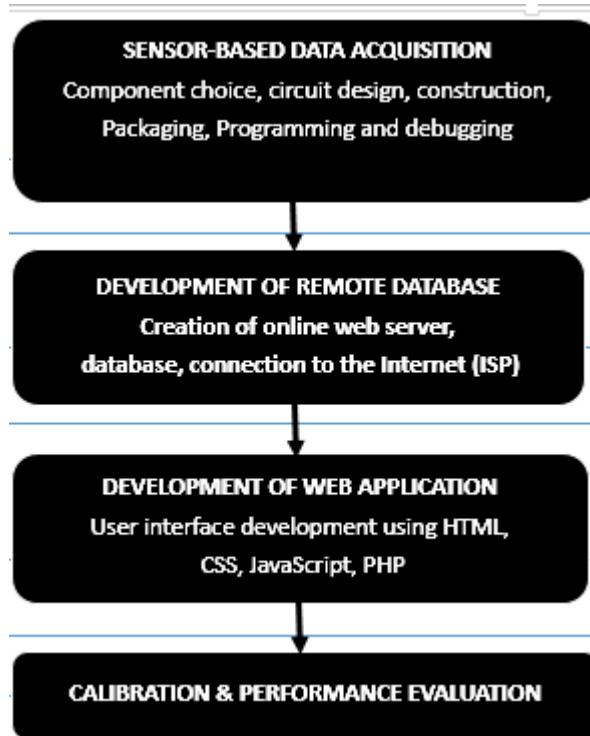
This research adopts the reuse of existing floating sensors, connecting them to a microcontroller-based data acquisition system and incorporating the Internet of Things, thus making the measured fuel values and vehicle coordinates stored in an online database and available to administrators through a web application.

**Table I:** Review of studies carried out regarding fuel sensor and tracking devices

Paper	Type of fuel sensor	Type of transportation	Fuel level	Geolocation	Real-life Implementation
(Kale et al., 2022)	Ultrasonic	ICE vehicle	✓	✓	
(Hapsari et al., 2021)	Ultrasonic	Ship	✓	✓	X
(Mulenga and Halubanza, 2025)	Ultrasonic	Fuel storage facility	✓	X	X
(Zou et al., 2019)	Ultrasonic	ICE vehicle	X	✓	✓
(Srikanth et al., 2021)	Ultrasonic sensor	ICE vehicle	✓	✓	✓
Present work	Off-the-shelf resistive fuel level sensor	ICE vehicle	✓	✓	✓

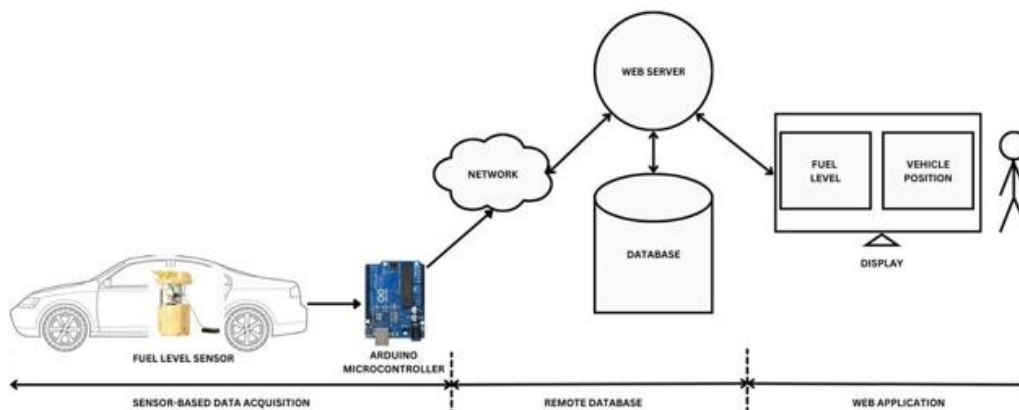
## 2. Materials and Methods

The methodology for this study are grouped as development of sensor-based data acquisition, remote database development, and web application development, calibration of the developed device; and performance evaluation through testing under various conditions, as shown in Figure 1. The system architecture is shown in Figure 2.



**Figure 1:** Overall methodology for implementation of the project

Figure 2 illustrates a car with a fuel sensor that connects to the Arduino Wemos microcontroller prototyping board. From the Arduino prototyping board, the acquired sensor values are transmitted through a network to a remote database consisting of a remote web server and a database. From the web server, the information is made available to the system administrator through a user interface on the web interface.



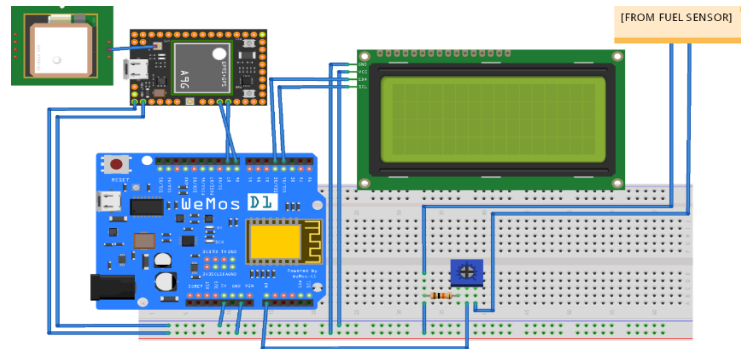
**Figure 2:** System architecture

## 2.1 Sensor-based Data Acquisition

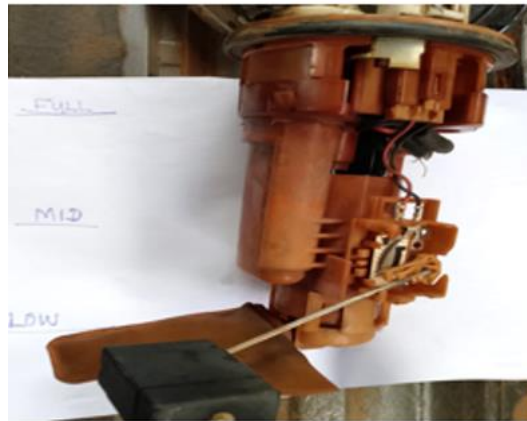
The sensor-based data acquisition can further be divided into hardware and software levels and involves the selection of components, design calculation, circuit design, implementation, and packaging. It also involves programming and debugging.

### 2.1.1 Hardware

The system hardware is as shown in Figure 3, consisting of measured sensor inputs from the fuel level sensor that are passed to the analog input pin A0 of the Arduino Wemos D1 microcontroller, while the GPS coordinates from the A9G GPS module are passed to the microcontroller via its digital pins D6 and D7. A Liquid Crystal Display (LCD) connected to Digital pins D1 and D2 of the microcontroller is to display the measured values for users to see on the site of measurement. The fuel level sensor used in this work is shown in Plate 1. Apart from the LCD output, the Arduino has an embedded Wi-Fi chip that is capable of transmitting the measured data to a remote database.



**Figure 3:** Arrangement of hardware components of the developed system



**Plate 1:** Off-the-shelf fuel level sensor

In order to ensure that the vehicle fuel level sensor operates at the same power level as the microcontroller, an input interfacing circuit was developed consisting of a resistor of resistance 10 kilo ohms and a variable resistor rated 100 kilo ohms, which were arranged in parallel with the total supply voltage flowing across them. The off-the-shelf fuel level sensor used in this work, as shown in Plate 1 act as the variable resistor ( $R_1$ ) in the voltage divider. This was done to protect the microcontroller. The choice of  $R_2$  in Eq. (1) to Eq. (3) helps to ensure that the voltage going into the Arduino microcontroller analog input does not exceed the rated ESP8266 microcontroller input voltage of 3.3 V. This is to prevent damage to the microcontroller.

$$V_{out} = V_{in} \times \left( \frac{R_1}{R_1 + R_2} \right) \tag{1}$$

Where  $V_{in}$  is input voltage from the circuit, V,  $V_{out}$  is the output voltage, V,  $R_1$  is variable resistance of the measuring fuel level sensor,  $\Omega$ ,  $R_2$  is fixed resistance,  $\Omega$ . The fuel level sensor is connected to a 12 V power supply. A multimeter set to measure voltage is then connected to the terminals of the sensor, and its float is moved to the lowest and highest positions. The voltage readings for the lowest and highest levels are then recorded a number of times, and the average value is obtained. The active component of the fuel level sensor is the potentiometer. The potentiometer works as a voltage divider, illustrated by equations 1 to 3. Output voltage using measured values of V and R was calculated using the voltage divider formula shown in Eq. (1). The variable resistor was adjusted such that  $R_1 = 80 \text{ k}\Omega$  and  $R_2 = 30 \text{ k}\Omega$ .

$$V_{out} = \frac{30,000}{110,000} \times 11.9 \tag{2}$$

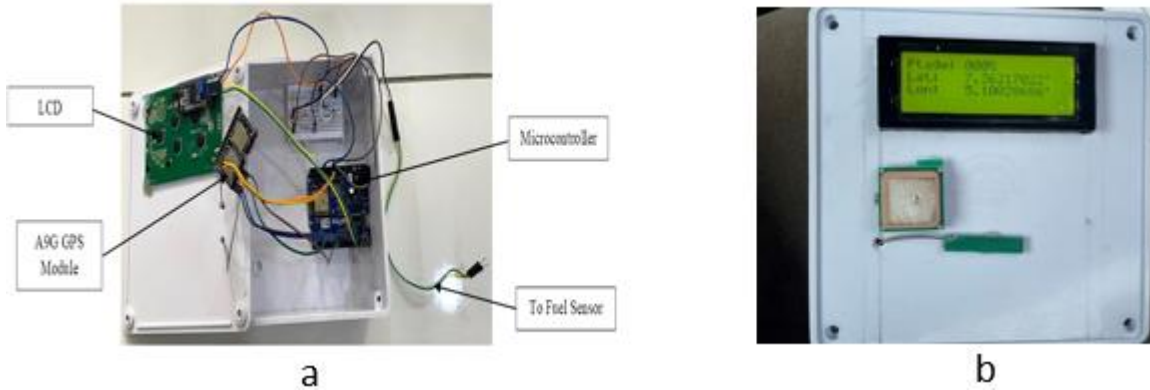
$$V_{out} = 3.24 \text{ V} \tag{3}$$

The A9G GPS module is incorporated into the system for vehicle position tracking. Plate 2a and b are respectively the internal part of the controller unit when it is being coupled and when it is fully coupled and ready for use.

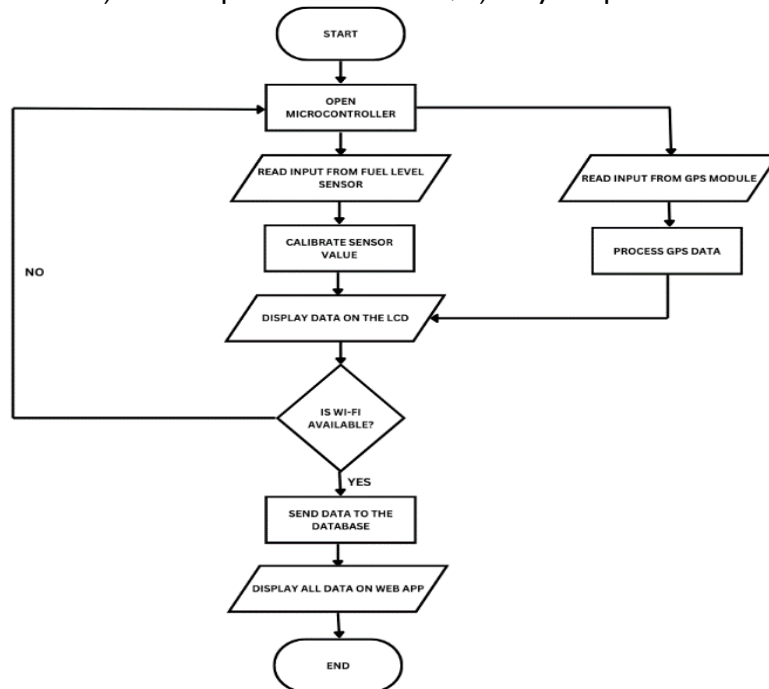
### 2.1.2 Software

A program written in C/C++ language via the Arduino Integrated Development Environment (IDE) and uploaded through a USB cable to the Arduino Wemos microcontroller. This program contains the sequence

of instructions guiding the operation of the developed system as shown in the flowchart in Figure 3. From the flowchart shown in Figure 4, the process starts when the microcontroller is turned on, and it reads in real-time data from the fuel level sensor and GPS module. The current fuel level in percentage, and the geo-location (coordinate) data as latitude and longitude values are displayed on the LCD. The Wi-Fi chip on the microcontroller then searches for available Wi-Fi networks to connect to. If unavailable, the system goes back to measure, process, and display new data on the LCD. If the desired Wi-Fi network is available, the obtained data is transmitted to a remote database, from which a web application can retrieve and display it in a user-friendly manner. The flowchart sequence then comes to an end, indicating that the system has fulfilled its role in measuring and relaying fuel level and geo-location (coordinate) data to relevant stakeholders. This process is repeated for as long as power is supplied to the system.



**Plate 2:** a) Internal part of control unit, b) Fully coupled control unit



**Figure 4:** Flowchart of the developed system

## 2.2. Development of Remote Database

The Arduino Wemos D1 with its Wi-Fi capability is used to transmit measured sensor values to the Firebase, which is the database in this project. The backend code and the web application's user interface are written in Visual Studio Code IDE. This code allows a user to retrieve the data from the database and display the information on a web application. In this work, the implementation is first done on a Local Area Network (LAN) using a personal computer as web server. Then a wireless router with Internet Service Provider (ISP) subscription is connected and the webserver replaced with an online webserver which made information retrieval possible from any remote location over the Internet.

## 2.3. Development of Web Application

This is a user-friendly platform where result of the measured fuel level and coordinates are being made available to the system administrator via a web application. It is developed using the Hypertext Markup Language (HTML), Cascaded Style Sheet (CSS) and JavaScript for the front and PHP for the backend.

## 2.4 Calibration

To complete the development process and to ensure reliability, calibration of the developed device is done. The developed fuel level measurement system is calibrated against the vehicle fuel gauge as standard. This is illustrated in Plate 3a to 9d. In order to achieve this, voltage cable from the fuel gauge to the dashboard is intercepted as shown in Plate 3b and connected to the developed telematics system. The transduced analog voltage values are determined for the full tank and reserve fuel conditions using a multimeter. The voltages obtained were used as the upper and lower limits needed for calibration. From Table 2, it could be observed that the voltage obtained at full tank (1.06 V) is lower than at reserve tank (5.64 V). In order to rectify this anomaly, an inversion is done at the Arduino microcontroller IDE by mapping the fuel level to the analog input pin as shown in Figure 5. This converted the microcontroller input data from bits to voltage. The code is then re-uploaded from the Arduino IDE into the microcontroller. The mapping operation in Figure 5 rectifies the anomaly described in Table 2 through inversion, converts analog voltage to fuel level in percentage and ensures reserve (empty) fuel level produces a value of 0 % and full tank returns a 95 % fuel level. Plate 4 shows the fuel level converted from voltage and displayed in percentage (ptage) (65 %) while the coordinates are displayed as latitude (7.25494) and longitude (5.18559).



**Plate 3:** a) Fuel gauge for vehicle b) microcontroller interception of the cable from fuel gauge to dashboard c) vehicle dashboard when fuel level is in reserve d) vehicle dashboard when fuel level is full

```
// Map sensor value to Ptage (inverted logic for decreasing voltage)
byte mappedVal = map(sensorValue, 140, 1023, 95, 0);

// Convert analog reading (which goes from 0 - 1023) to a voltage (0.5V)
float voltage = sensorValue * (5.0 / 1000.0); //float voltage = sensc
```

Figure 5: Arduino code for calibration

**Table 2.** Measured Fuel Sensor Voltage Test Results Table.

S/N	Fuel Tank Status	Measured Voltage (V)
1.	Full Tank	1.06
2.	Reserve Tank	5.64



**Plate 4:** a) Developed device positioned for measurement in the vehicle b) Display showing Ptage: 065%, Lat: 7.25494480, Lon: 5.18559504

### 3. Results and Discussion

The experiments were carried out at Elizade University, Ilara-Mokin, Ondo State, Nigeria (7.34806 °N 5.11444 °E) and its environs. The developed device was installed in a vehicle, as shown in Plate 4, and driven to different locations. The developed IoT-based fuel and geolocation tracking system was evaluated using the following metrics, including ability to perform remote logging, accuracy, scalability, ease of use, and ease of installation.

#### 3.1 Remote Logging

To evaluate its remote logging ability, while the experimental vehicle was driven around, measurements obtained on the LCD in Plate 4 were logged to a remote database (Firebase) and web application for monitoring purposes. Figure 6 is the online database (Firebase) storing the acquired fuel level and coordinates of the vehicle, while the same information is made available in real-time to the system administrator in the web application in Figure 6. For instance, fuel level is 7 % in the online Firebase in Figure 5, and this is made available to the administrator (user) in the web application, respectively in Figures 6. In the case of GPS coordinates, the Firebase coordinate value is displayed in decimal degrees format as latitude (7.36217022) equivalent to 7° 21' 43.81" in the degrees, minute second format. The longitude (5.10828686) is also equivalent to 5° 6' 29.83". In the case of the web application in Figure 7, the coordinates displayed in degrees, minutes seconds as latitude (7° 21' 44,00"), longitude (5° 6' 29.90") are approximately the same as the record in the online database.

Apart from providing the coordinates of the vehicle in numerical form in the LCD and the web application, it is also made available on Google Maps, displaying the names of the exact location of the vehicle as well as the adjoining towns, villages, and the routes to reaching the identified geo location. This will be very useful to security agencies in an attempt to track a lost vehicle or human in case of an emergency. In the case under consideration, the location of the vehicle, as could be observed in Figure 7, is Elizade University around the New Boys Hostel.



**Figure 6:** Firebase record of fuel level and GPS coordinates

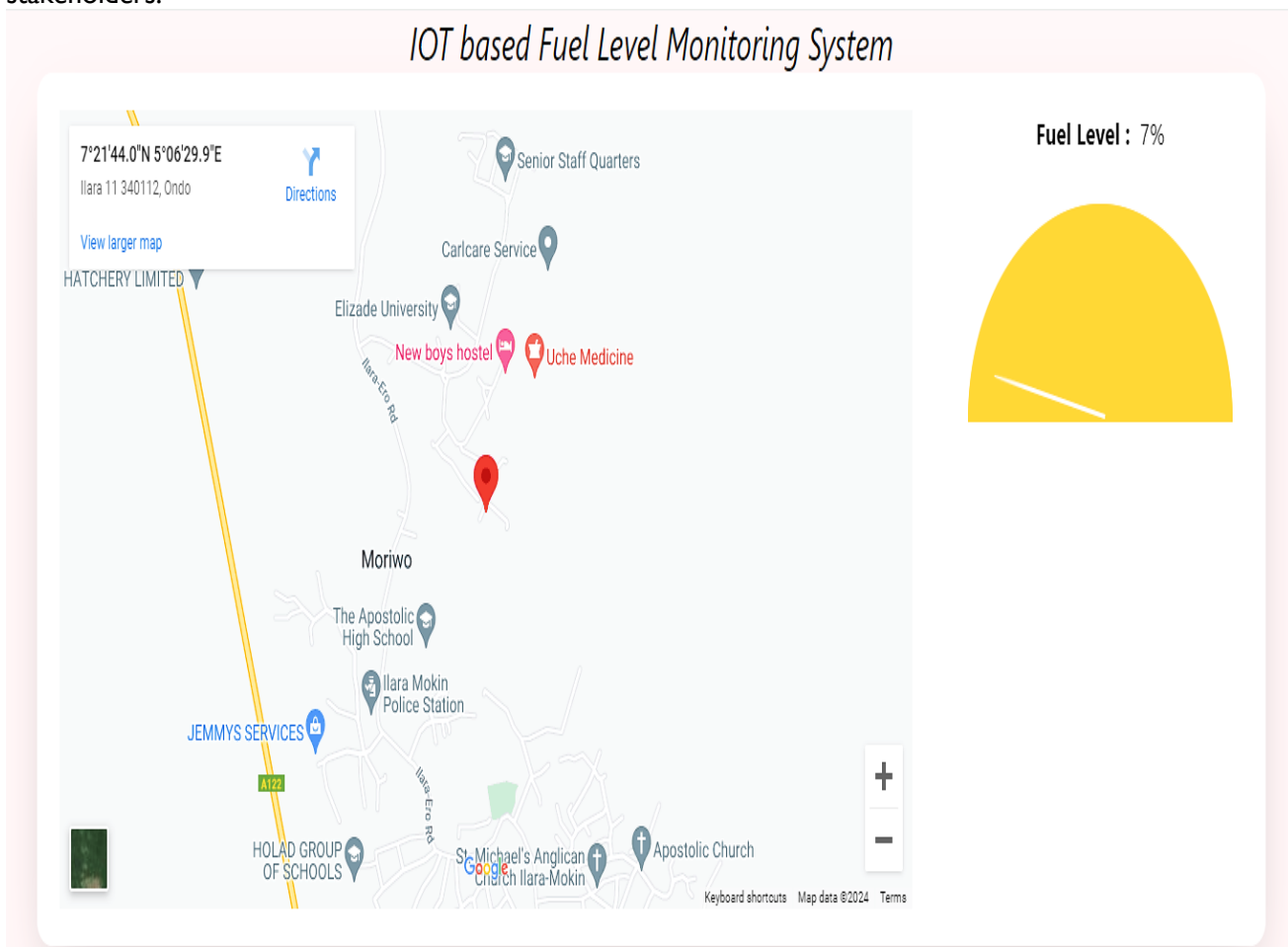
#### 3.2. Accuracy

This was achieved by comparing measured values displayed on the web application and vehicle dashboard, and the coordinates obtained using the developed device with the ones obtained with Android mobile phone applications.

##### 3.2.1 Comparing the web application with the vehicle dashboard

The values displayed on the web applications are also compared with the vehicle dashboard fuel gauge. In Figure 7, the level of fuel displayed in the web application could be seen to be consistent with the vehicle dashboard gauge. For instance, Figure 7, through its monitoring pointer, indicates low fuel as (7 %) with the fuel indicator turned amber colour, which means reserve. Figure 8, in a corresponding manner, also indicates reserve or refuel through the vehicle dashboard fuel gauge. Similarly, Figure 9 shows when the fuel tank is full as shown in the web application monitor displaying a green colour with fuel value at 94 %, the vehicle

dashboard fuel gauge in Figure 10 displays a full level of fuel on dashboard corresponding to the web application. The green colour indicates a safe fuel volume. The implication of this is that whatever the level of fuel shown on the vehicle dashboard, the same level can be monitored remotely and in real-time over the Internet network using the IoT technology. This performance is consistent with several studies reported elsewhere (Mulenga and Halubanza, 2025; Anand and Kathyayini, 2024; Kumar and Vijayakumar, 2025), where measurements were also transmitted in real-time over a network using IoT technology to relevant stakeholders.

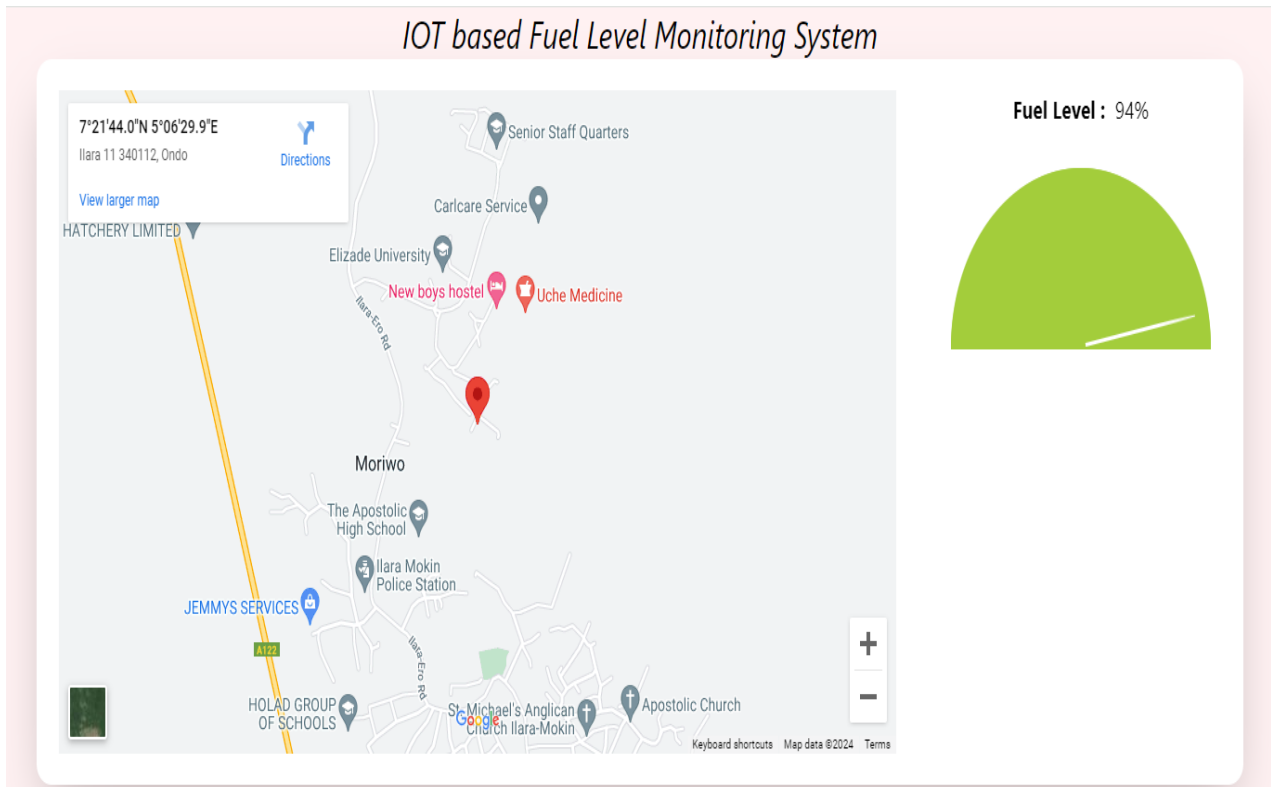


**Figure 7:** Display of fuel level and GPS coordinates via web application

The fuel sensor used in this study is the resistive type (Navixy, 2024), and the measured value is more reliable compared with the ultrasonic sensor, which, apart from the difficult installation procedure, could result in a compromised measurement as a result of foaming of the fuel (Navixy, 2024).



**Figure 8:** Measured reserved values on the vehicle dashboard



**Figure 9:** Measured high fuel values on Web application



**Figure 10:** Measured full tank on vehicle dashboard

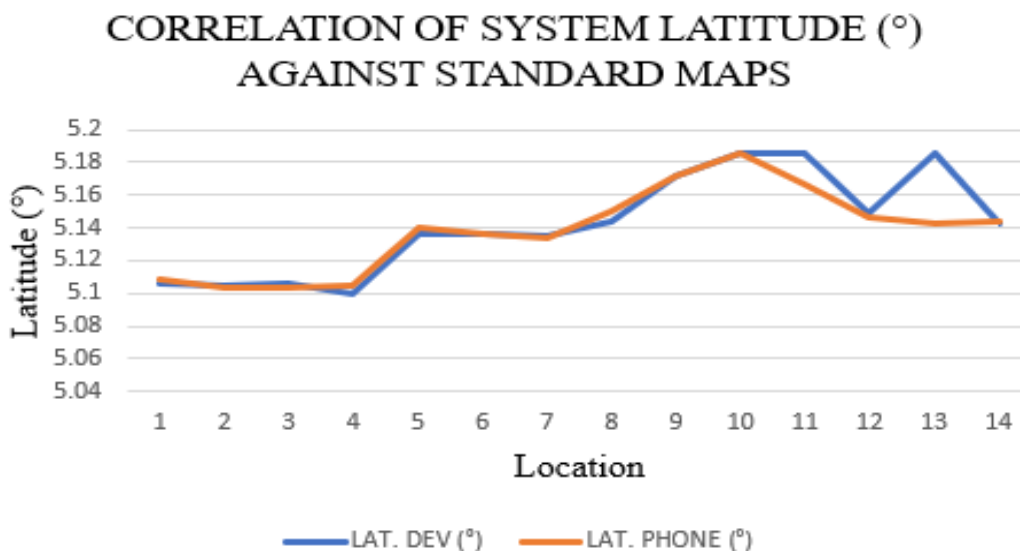
### 3.2.2 Comparing GPS coordinates of developed tracker with mobile phone

In an attempt to validate the measurements of the A9G GPS module, its measured values were compared to those received using an Android mobile phone at different locations. The charts in Figures 11 and 12 show the relationship between GPS data obtained from a mobile phone and that from Google Maps on a web application at different testing locations. The correlation coefficient of the developed system and Google Maps coordinates in terms of longitude and latitude was computed. The correlation coefficient of the Latitudes is found to be 0.911133, while that of the Longitudes is 0.940762. The GPS of the developed system and Google Maps are linearly related, and the developed system is found to have a high degree of accuracy.

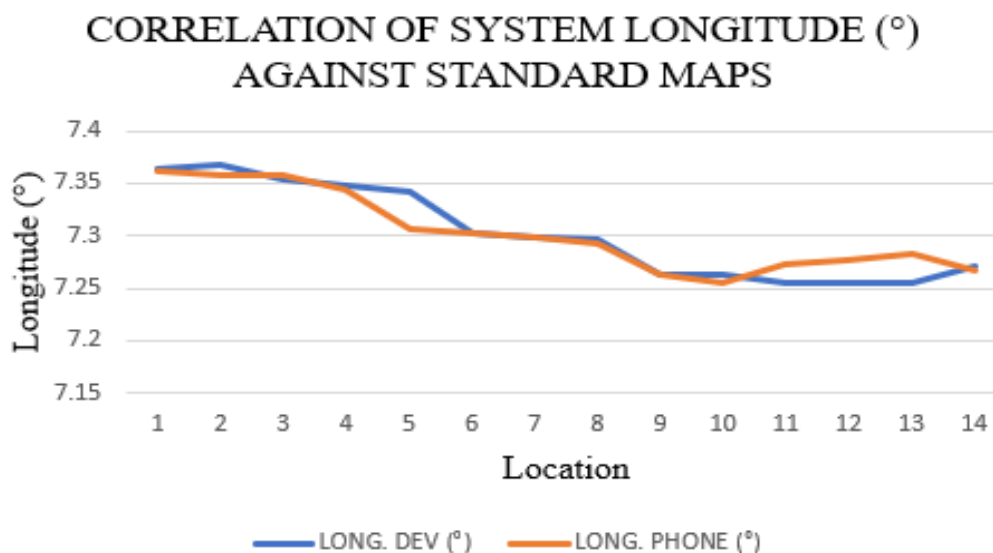
### 3.3 Scalability

In terms of scalability, the developed system is scalable. In this implementation, two sensors were used for data acquisition. The system has the capacity to accommodate other sensors meant to measure different parameters, such as speed of vehicle, temperature, in order to prevent overheating, as well as Radio

frequency Identification (RFID) for improved security features. This might only require an upgrade of the microcontroller for more efficient processing and improved memory capacity.



**Figure 11:** Chart showing Latitude validation



**Figure 12:** Chart showing Longitude validation

### 3.4 Ease of Use

The developed device is portable and can work with vehicles in a plug-and-play manner, as shown in Plate 4, providing information for both online users via the developed web application, as shown in Figures 7, and 9, and offline users on LCD as shown in Plate 4. The correlation, tending to 1 reveal a high degree of accuracy. Colour indication from green when fuel is full, and changed to yellow when it is less than half tank, as shown in Figures 7 and 9, provides a quick way of notifying users about the status of the fuel, especially for the illiterate who might find it difficult coping with numbers. Storing of acquired coordinates and fuel level in the remote database (Firebase) provides an avenue for feeding stored data into machine learning platforms to predict future fuel usage, drivers' routes, and behaviour.

### 3.5 Ease of Installation

When compared with state-of-the-art ultrasonic and capacitive sensors as shown in Table 3, the developed sensory device was found to be low cost since it involved the reuse of existing hardware. The sensor used would be more suitable for vehicles with internal combustion engines (ICE) vehicles compared with ultrasonic which will work best in the laboratory setting or the capacity sensor, which are more suitable for heavy-duty fleets (Heavy Vehicle Inspection, 2025). Ultrasonic sensor though popular, is not easy to install in a vehicle and might often require drilling the fuel tank (Qiu *et al.*, 2022; SMD Fluid Control, 2025). The approach adopted in this work, in which an existing vehicle fuel level sensor is already leveraged provides a

low-cost, non-invasive retrofit solution that overcomes the limitations of ultrasonic sensors in terms of installation ease.

**Table 3:** Comparison of the developed device with ultrasonic and capacitive sensors (Heavy Vehicle Inspection, 2025)

Aspect	Developed Sensor	Resistive	Ultrasonic sensor	Capacitive sensor
Cost	Low (reuses factory sensor)		Medium (non-contact install)	High (custom probes)
Accuracy in Motion	Good (software inversion fixes)	(software existing)	Poor (foam/sloshing errors)	Excellent (stable dielectric)
Installation	Intercept wiring	existing	Tank drilling needed	Invasive retrofit
Vehicle Fit	ICE fleets (tested)		Lab/special tanks	Heavy-duty fleets

Though automation through the use of IoT devices has been applied severally to improve quality of life, including waste management (Yusuf et al., 2024), monitoring and control of home appliances (Isaac et al., 2025), its application in vehicles in this study makes it stand out when compared with (Hapsari, 2021). The authors in (Hapsari, 2021) also used IoT to determine fuel level and coordinates of a ship, but it was only implemented at a laboratory-scale level.

Figures 7 and 9 revealed that the results could be remotely displayed through the web interface over the Internet, and at the site of measurement (on the dashboard of the vehicle as well as through the LCD), as shown in Plate 4. These would assist the driver of the vehicle as well as the transport system administration to ascertain fuel usage and coordinates of the car at any time to enhance the security of lives and the vehicle. This is unlike Kale et al., (2022) who displayed the fuel level and vehicle coordinates through a liquid crystal display (LCD) and SMS on a mobile phone, and as such, it does not give enough detail compared with this study. The fact that measured data could be received in real-time anywhere over the Internet makes it superior to the work of Said et al., (2021), which uses a Bluetooth connection to display water level with a limited coverage range of about 100 m.

The developed device was compared with the work of Ogidan et al., (2022), as shown in Table 4. It could be seen that even though the study in Ogidan et al., (2022) was developed for electric vehicle while this work was applied to and Internal Combustion Engine (ICE), in both cases, operators of fleet of cars were able to track coordinates of the vehicles and the amount of energy or fuel in real-time over a network. The network used in Ogidan et al., (2022) was a Local Area Network (LAN), and the work was not implemented in a vehicle, whereas this research has gone ahead to implement the developed tracking (monitoring) system in a vehicle over the Internet. This present study made use of Firebase for its database implementation, while (Ogidan et al., 2022) made use of MySQL for the database. In the case of Ogidan et al., (2022), the identity of the driver of the EV, including the name, staff number, sex, and so on were tracked by the developed device using an RFID card. The RFID card also ensured that the vehicle did not start (ignite) unless the RFID card used by the driver was authenticated in a remote database. In this study, an RFID card was not used. This could be included in the future. Another major difference in this work and (Ogidan et al., 2022) is that this work made use of off-the-shelf electromechanical fuel gauge and GPS module as sensors; authors in Ogidan et al., (2022) made use of voltage and current sensors to compute the battery power of the electric vehicle.

**Table 4.** Comparison of the developed device with the tracking device for electric vehicles (Ogidan et al., 2022)

Parameters	Developed device	Tracking device for electric vehicle (Ogidan et al., 2022)
Vehicle type	Internal Combustion Engine (ICE)	Electric vehicle (EV)
Energy source	Petrol	Electricity
Measured parameters	Fuel level, vehicle position	Voltage, current, driver identity, vehicle position
Sensor types	Off-the-shelf fuel gauge, GPS module	Voltage sensor, current sensor, RFID, GPS
Implementation	Implemented in a vehicle	Not implemented
Software	Embedded C, JavaScript, MySQL, Firebase	Embedded C, JavaScript, MySQL
Network coverage	Internet	Local Area Network

The AG 9 GPS/GRRS sensor was effective in measuring the geolocation (coordinates) of the vehicle, making the results available to relevant stakeholders. However, its reception was hampered when it was positioned

under a building and by network strength (Ogidan *et al.*, 2022). It is noteworthy that to make it effective in the car, it would have to be positioned not far from the transparent windscreen as shown in Plates 4a and b, such that it would not be covered by the roof of the car. The approach in this study differed from and is better compared with the work of Akinrinmade *et al.*, (2020), which used a Geo-Spatial approach, such as a geographical information system (GIS), to locate dumpsites for the purpose of making them ecofriendly. This is because Akinrinmade *et al.*, (2020) could not determine coordinates in real-time.

#### 4. Conclusion

In an attempt to address the challenge of insecurity, fuel theft, and the problem associated with ultrasonic sensors, this paper proposes an IoT-based fuel level and geo-location monitoring system. It demonstrates a low-cost and non-invasive method for adding telematics to existing vehicles, which is highly valuable for fleet management in developing economies. By leveraging the factory-installed resistive fuel sensor and A9G GPS module interfaced with an Arduino Wemos D1 microcontroller, the system provides accurate real-time fuel levels and coordinates through LCD, Firebase database, and a user-friendly web platform. This approach provides a low-cost, non-invasive retrofit solution that overcomes the limitations of ultrasonic sensors, which usually require drilling into the fuel tank or result in an inaccurate measurement as a result of foaming of the fuel. Future work would include integration of machine learning algorithms on stored Firebase data to predict fuel consumption patterns, optimal vehicle trajectories, conducting about 6 months of field trials in diverse Nigerian terrains to quantify return on investment.

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