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Fuel Tanker Theft Prevention System using Internet of Things and Machine Learning

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Abstract : Fuel is among the most valuable commodities globally, and this has resulted in a significant increase in fuel theft worldwide. A considerable portion of fuel is pilfered during transportation between industries. The detection of such theft is complicated due to the numerous logistical challenges involved. A solution is proposed to address this issue by implementing a secure system aimed at preventing fuel theft from tankers. This system involves continuous monitoring of the fuel level in the tanker's storage tank. An alert is triggered when the fuel level drops below a predetermined threshold, notifying both the driver and the fuel agency. Additionally, a security system employing password authentication serves as the initial layer of protection. Furthermore, a GPS module allows authorities to track the truck's location via a web application. The innovation of the proposed system lies in its IoT (Internet of Things) enabled security features, facilitating communication between sender and receiver parties. Upon confirmation, fuel dispensation is enabled. This system is anticipated to play a pivotal role in mitigating fuel theft.

Keywords: **- Fuel Theft, IoT, NodeMcu, GPS, fuel level Sensor, Cloud, Machine Learning.**

I. INTRODUCTION

Fuel is indispensable to global economies and industries, serving as a cornerstone resource that drives progress worldwide. However, the pervasive threat of fuel theft, especially during transportation, casts a shadow over its seamless distribution. The escalating incidents of fuel theft from tanker trucks present a formidable challenge to the transportation and logistics sectors, posing significant financial losses, security risks, and environmental hazards. Traditional security measures have proven inadequate in stemming this tide, underscoring the urgent need for innovative solutions that harness advanced technologies to proactively combat fuel theft. The Fuel Tanker Theft Prevention System proposed in this project represents a groundbreaking convergence of Internet of Things (IoT) and Machine Learning (ML) technologies, offering a holistic solution to mitigate fuel theft during transit. Beyond addressing immediate security concerns, this system holds the promise of revolutionizing fuel transportation by bolstering security measures, optimizing operational efficiency, and fostering environmental stewardship. Positioned at the forefront of fuel security innovation, the Fuel Tanker Theft Prevention System using IoT and ML heralds a new era in fuel logistics, poised to shape the trajectory of industry practices and societal impacts. In the subsequent sections, we will explore the system's components, functionalities, database requirements, and its potential ramifications across academia, industry, and broader society.

II. METHODOLOGY

Fuel tanker monitoring project encompasses several key stages. Firstly, we conducted thorough requirement analysis to define the system's specifications and functionalities, ensuring alignment with stakeholder needs. Following this, we meticulously planned the system's design, considering hardware and software components required for efficient monitoring. Hardware implementation involved the procurement and integration of sensors, microcontrollers, and peripherals into the fuel tanker. Concurrently, we developed the necessary software, including firmware for data collection and communication protocols for seamless integration with the cloud. The cloud setup encompassed the establishment of an infrastructure for data storage and processing. Subsequently, we embarked on machine learning model development, utilizing historical fuel consumption data to train models for predictive analytics. Application development focused on creating an intuitive interface for real-time monitoring and visualization. Integration and testing phases ensured the seamless functionality and reliability of the integrated system. Finally, deployment, maintenance, and continuous monitoring and optimization were emphasized to ensure sustained performance and user satisfaction.

Algorithm

III. Algorithm

The proposed system is designed for detecting potential fuel theft using an ultrasonic sensor and outlier detection. This algorithm analyses the fuel level data collected by the ultrasonic sensor over time, identifies anomalies (outliers) in the data, and takes appropriate action (such as sending an SMS alert) if the data deviates significantly from the expected range.

Key Components:

1. **Fuel Level Data**: The system uses fuel level data gathered by an ultrasonic sensor. The data is assumed to be stored in a time series format, likely within a database.
2. **Outlier Detection**: The algorithm uses a rolling mean and a threshold to detect outliers in the fuel level data. An outlier is detected if the most recent fuel level value deviates significantly from the average of the last 5 values.
3. **Threshold**: A difference threshold is set (in this case, 5 units) to determine whether the deviation from the rolling mean is significant.
4. **Database Connection**: The code connects to an SQLite database (**data.db**) to read the last SMS sent status and to update the database after sending an SMS alert.
5. **SMS Alert**: If an outlier is detected and an SMS alert has not been sent recently, the code sends an SMS alert.

Algorithm:

1. **Retrieve the Last 5 Values**: The function **get_last_5_values()** retrieves the last 5 fuel level values from the data source (assumed to be a function that interacts with a database or data storage).
2. **Calculate the Rolling Mean**: Convert the last 5 values to a pandas Series and calculate a rolling mean (average) over a window size of 5.
3. **Determine Current Value**: Extract the most recent fuel level value from the series.
4. **Calculate Difference**: Calculate the absolute difference between the current fuel level value and the rolling mean.
5. **Check Threshold**: Compare the calculated difference with the predefined threshold (5 units in this case). If the difference is greater than the threshold, an outlier is detected.
6. **Database Check and SMS Alert**:
   - If an outlier is detected, the code connects to the SQLite database and checks the SMS sent status of the most recent data entry.
   - If an SMS alert has not been sent (as indicated by the database), the code triggers the function **send_sms()** to send an SMS alert.
7. **Update SMS Sent Status**: Once the SMS alert is sent, the code updates the SMS sent status in the database to avoid sending duplicate alerts for the same incident.

Summary:

The algorithm effectively uses an ultrasonic sensor to monitor fuel levels and relies on outlier detection to identify potential fuel theft. If an outlier is found (i.e., a sudden change in fuel level that is beyond the predefined threshold), the algorithm sends an SMS alert and updates the database to track the alert status

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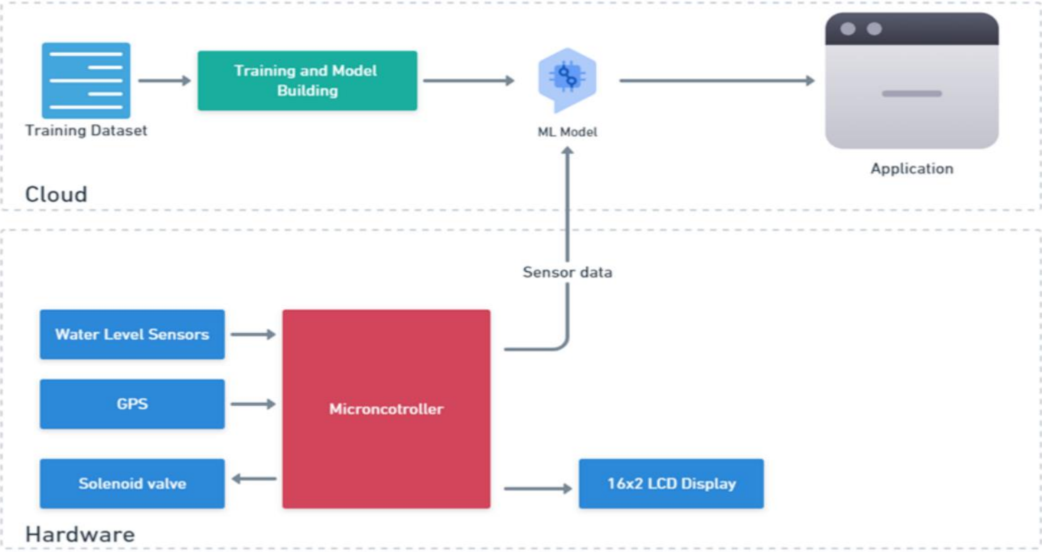
IV. SYSTEM ARCHITECTURE



The architecture of the fuel tanker theft prevention system integrates IoT and machine learning technologies to provide robust security measures. At its core, the fuel tanker serves as the primary component, equipped with sensors including ultrasonic. These sensors collect real-time data on fuel levels, crucial for monitoring the tanker's status. The collected data is transmitted to a microcontroller, such as NodeMCU, acting as an interface with the cloud. Within the cloud, data is stored and processed using machine learning algorithms, particularly a Decision Tree Algorithm, which analyzes sensor data to detect anomalies indicative of potential theft. Additionally, a web application enables users to receive notifications and monitor the fuel tanker's status in real-time, facilitating timely intervention if any suspicious activities are detected. Ultimately, this architecture ensures comprehensive monitoring and enhances security measures to prevent fuel theft incidents effectively.

IV. RESULTS ANALYSIS

The image displays an electronic display showing the initial and current fuel levels, both indicating a value of 15. This demonstrates the functionality of the Fuel Tanker Theft Prevention System in accurately monitoring fuel levels in real-time. The system effectively captures and displays essential information regarding fuel levels, enabling stakeholders to stay informed about the status of fuel in the tanker. Such real-time monitoring capabilities are crucial for ensuring the security and efficient management of fuel during transportation, ultimately contributing to the prevention of fuel theft and the safe operation of fuel tankers.

Fig.2 LCD Display

The graph illustrates the change in fuel level over time, offering a visual representation of fluctuations in fuel quantity. The x-axis denotes the timestamp, while the y-axis represents the fuel level value. The graph demonstrates a sudden decrease in fuel level at a particular time, indicating a potential alteration in the fuel quantity. Such visualizations are integral to detecting anomalies in fuel levels promptly, enabling effective monitoring and management of fuel resources, especially in preventing theft or unauthorized usage.

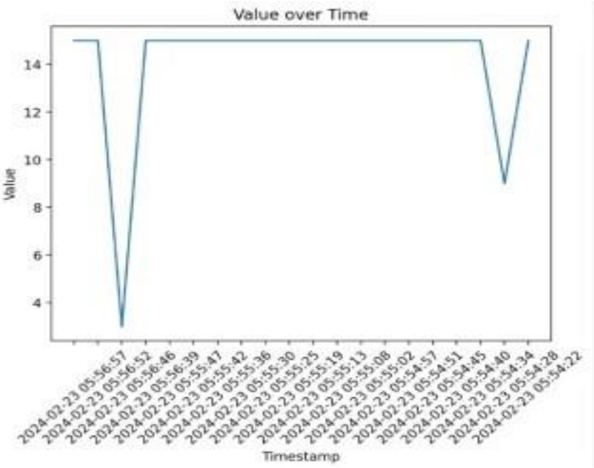


Fig.3 Graph

V. CONCLUSION

The Fuel Tanker Theft Prevention System, integrating IoT and ML technologies, presents a robust solution to combat fuel theft during transportation. This project signifies a substantial advancement in securing valuable fuel resources, curbing financial losses, and refining the efficiency and safety of the transportation sector. The successful deployment of this system promises improved security, heightened operational efficiency, and prompt interventions to deter theft incidents. Given the significance of fuel as a finite resource, the Fuel Tanker Theft Prevention System not only protects this valuable asset but also fosters a more secure and sustainable future for the transportation industry.

The development and implementation of the fuel tanker monitoring system represent a significant step forward in enhancing the security and efficiency of fuel transportation operations. By leveraging innovative technologies such as ultrasonic sensors, GPS modules, cloud infrastructure, and machine learning algorithms, the system offers real-time monitoring and anomaly detection capabilities to mitigate risks associated with fuel theft and unauthorized access. The deployment of Arduino-based sensors coupled with AWS EC2 instances for cloud processing enables seamless data collection, analysis, and visualization, facilitating informed decision-making for fleet managers and security personnel. Furthermore, the integration of Twilio for SMS alerts and Streamlit for web-based data visualization enhances communication and accessibility, ensuring timely responses to potential security breaches. As a comprehensive solution, the fuel tanker monitoring system not only addresses immediate security concerns but also lays the foundation for future advancements in fuel management and logistics. Moving forward, continuous maintenance, monitoring, and refinement of the system will be essential to uphold its reliability, effectiveness, and adaptability in dynamic operational environments. Through ongoing collaboration and innovation, we remain committed to enhancing the safety, efficiency, and sustainability of fuel transportation systems for the benefit of all stakeholders involved.

VII. ACKNOWLEDGMENT

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VIII. REFERENCES

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