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IOT based Digital Fuel Fraud Detection Digital Gasoline Indicator

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Abstract – Carefree usage of petroleum, the most commonly used fossil fuel, and the exploitation of such carelessness by fraudulent means needs to be curbed. The general population needs to have a means of checking fuel levels concisely, in an affordable manner. One must be able to identify trustworthy petroleum outlets in a simple manner to ensure they are getting proper compensation. The IoT Fuel Fraud Detection system proposed helps solve these predicaments using a simple ultrasonic sensor.

I. INTRODUCTION

Physical fuel gauges are an inefficient and mostly incorrect way of knowing fuel levels. The error bracket is too high.[1] That being said, a good amount of two-wheelers, typically bikes, do not come with fuel gauges at all. For legacy reasons, i.e. Bikes were never designed for fuel efficiency, they were an item of luxury.

As a generation of consumers, it is our right to fair compensation for expenses on commodities. Fuel is one such commodity. Fuel fraud is a long bearing issue challenging this right. This project is an attempt to identify and alert individual users against fuel fraud in real time as well as recommend better outlets to other consumers based on trust rating.

This project attempts to issue alerts to the customer if fuel fraud is detected during petrol refill activity. It also attempts to rate petrol pumps based on fraud occurrence, and direct new users to more trustworthy petrol outlets in their route or area, and prevent loss using its recommendation system. The fuel tank is proposed to be calibrated for ease of implementation. The manufacturer provides the specification that each bar maps to the corresponding liters of fuel approximately. To the contrary every one of us might have experienced the problem with improper estimations of the current fuel level in the tank with the existing bars representation system. Today in this digitalized world, if the fuel indicator in the automobiles is also made digital it will help to know the exact amount of fuel available in the tank. [6] The above furnished fact is considered in our project. Being able to provide an affordable, commonly available application set that gives precision and autonomy to the individual consumer and detects fraud while also setting trust values on petrol outlets is the prime motivation of this project.

II. PROPOSED SOLUTION

The system proposed consists of an ultrasonic sensor for fuel level (depth) sensing purposes. This sensor is robust. As the name indicates, ultrasonic sensors measure distance by using ultrasonic waves. The sensor head emits an ultrasonic wave and receives the wave reflected back from the target. Ultrasonic Sensors measure the distance to the target by measuring the time between the emission and reception.

The distance can be calculated with the following formula:

$$\text{Distance } L = 1/2 \times T \times C$$

where L is the distance, T is the time between the emission and reception, and C is the sonic speed. (The value is multiplied by 1/2 because T is the time for go-and-return distance.) The calibrated fuel tank level can be gauged to respond with the level of fuel before and after refilling.[9]

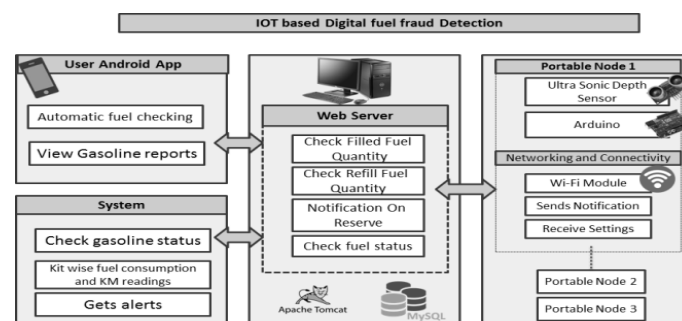


Figure 1: System Overview

A. Objectives fulfilled

- To gather fuel data in real time.
- Sync data with centralized petrol pump database and customer's android app.
- To detect fraud by comparing fuel levels and trigger alarms on Arduino kit display.
- To automatically assign positive/negative rating to petrol outlet in central database on server using current reading and machine learning factors.
- To create, sync and maintain petrol outlet recommendation system based on such ratings in real time.

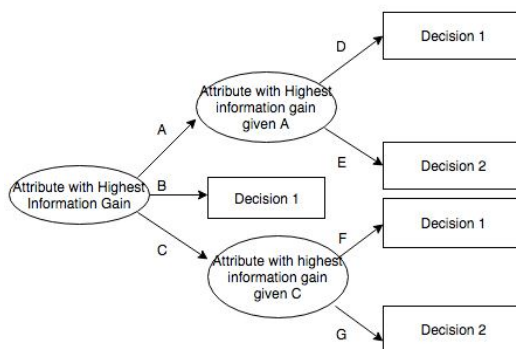


Figure 2: Iterative Dichotomiser 3 (ID3) Algorithm Overview

The system can extend to tanks of irregular shape provided they can be calibrated and modeled in advance. Following is a methodology to calibrate tanks of cylindrical shape which is currently used for demonstration purposes as it appears on TankCalc – a repository for series of programs and mathematical methods written by Paul Lutus to compute partial volumes in storage tanks.[9]

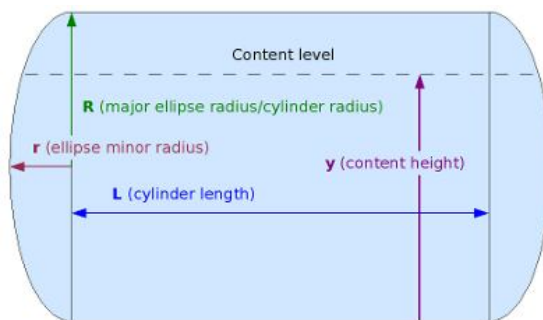


Figure 3: TankCalc

$$\text{Depth1 (initial)} - \text{Depth2 (after fuel filling)} = \text{Depth of fuel filled (y : content height)}$$

Formula for volume of a standard irregular (capsule) fuel tank :

For the half-ellipses at each end of the tank (they can be treated as one spheroid), with major radius **R** and minor radius **r**, bisected by content height **y**:

III. SYSTEM REQUIREMENTS

The proposed Fuel Fraud Detection System takes the following steps:

- Gather fuel data in real time
- Sync data with centralized petrol pump database and customer's android app
- Detect fraud by comparing fuel levels and trigger alarms (optional)
- Assign positive/negative rating to petrol outlet in central database.



Create, sync and maintain petrol outlet recommendation system based on such ratings in real time.

The system requirements for the steps aforementioned are:

A. Remote Node

- 1) Arduino UNO
- 2) Ultrasonic Depth Sensor

B. Database

- 1) MYSQL
- 2) Local Data Sync Node:
 - a) Server: Apache Tomcat Server
- 3) Android App Local Database:
 - a) SQLite

C. Connectivity

- 1) ArduinoWiFi module (ESP8266 WiFi Module)

D. Google Integration

- 1) Google Maps API

Internet of Things (IOT) is a concept that considers pervasive presence in the environment of things and unique addressing scheme to interact with each other. Cloud computing is an emerging computing technology that uses the central remote server to maintain data and application. Internet Of Things (IOT) is a concept and a paradigm that considers pervasive presence in the environment of a variety of things that through wireless and wired connections and unique addressing schemes are able to interact with each other and cooperate with other things to create new applications/services and reach common goal.

IV. MATHEMATICAL MODEL

The fuel Fraud detection System(S) is defined by

$S = (I, \text{decision}, O, \text{level}, \text{recommend})$

Where I is the set of input such as

$I = \{\text{user_id}, \text{fuel_quality}, \text{fuel_refill_quality}, \text{user_route}\}$

Level is the set of sensed fuel levels such as

$\text{Level} = \{\text{initial_fuel_level}, \text{final_fuel_level}\}$

Decision is the decision function of algorithm to detect fraud such as

$\text{Decision} = \{\text{fraud}, \text{no_fraud}\}$

O is the set of outputs such as

$O = \{\text{fraud_flag_alert}, \text{rating_flag}, \text{new_outlet_rating}, \text{transaction_log}, \text{recommended_outlets}\}$

Recommended is the recommendation function that maps user_route to output recommended_outlets

$\text{Recommend}(\text{user_route}) \rightarrow \{\text{recommended_outlets}\}$

Where

(a) $\text{user_route} = \{\text{source}, \text{destination}\}$

(b) $\text{recommended_outlets} = \{(\text{outlet1}, \text{rating}) \dots (\text{outlet n}, \text{rating n})\}$

V. COMPONENTS AND TECHNOLOGIES

A. Ultrasonic Sensor

Ultrasonic sensors work by transmitting a pulse of sound, this pulse travels away from the range finder in a conical shape at the speed of sound (340 m/s). The sound reflects off an object and back to the range finder. The sensor interprets this as an echo and calculates the time interval between sending the signal and receiving the echo



B. ArduinoWemos D1

WEMOS D1 is a WIFI development board based on ESP8266 12E. The functioning is similar to that of NODEMCU , except that the hardware is built resembling Arduino UNO.

C. Stand-Alone Power Supply

A stand-alone power system (SAPS or SPS), also known as remote area power supply (RAPS), is an off-the-grid electricity system for locations that are not fitted with an electricity distribution system. Typical SAPS include one or more methods of electricity generation, energy storage, and regulation. Electricity is typically generated by one or more of the following methods: Photovoltaic system using solar panels, Wind turbine, geothermal source Micro combined heat and power Micro Hydro Diesel or bio-fuel generator Storage is typically implemented as a battery bank

D. Xively

Xively (formerly known as Cosm and Pachube) offers an Internet of Things (IoT) platform as a service, business services, and partners that enable businesses to quickly connect products and operations to the Internet.

E. Algorithms Used: ID 3 ((Iterative Dichotomiser 3) Algorithm

ID3 builds a decision tree from a fixed set of examples. The resulting tree is used to classify future samples. The leaf nodes of the decision tree contain the class name whereas a non-leaf node is a decision node.

The decision node is an attribute test with each branch (to another decision tree) being a possible value of the attribute.

ID3 uses information gain to help it decide which attribute goes into a decision node.

Algorithm:

- 1) Establish Classification Attribute (in Table R)
- 2) Compute Classification Entropy.
- 3) For each attribute in R, calculate Information Gain using classification attribute.
- 4) Select Attribute with the highest gain to be the next Node in the tree (starting from the Root node).
- 5) Remove Node Attribute, creating reduced table RS.
- 6) Repeat steps 3-5 until all attributes have been used, or the same classification value remains for all rows in the reduced table.

F. Entropy

$$H(X) = - \sum_{i=1}^n p(x_i) \log_b p(x_i)$$

G. Information Gain

For Set S, Attribute A
 Where S is split into subsets based on values of A
 $C_S^A = \text{Subset A of S}$

$$I_E = \text{Entropy}, p(C_S^A) = \frac{\text{size}(C_S^A)}{\text{size}(S)}$$

$$I_G(S, A) = I_E(S) - \sum (p(C_S^A) * I_E(C_S^A))$$

Attribute_name	Type
fuelOutletID	Number/hash
userID	Number/hash
requestedFuelQuantity	number
filledFuelQuantity	number
fraud	boolean

Figure 4: Attributes in dataset considered for splitting in ID3



VI. PROPOSED SYSTEM COMPARISON WITH EXISTING SYSTEM

The system in focus has certain initiation demerits. Previous implementations include using digital cameras[2] which is inapplicable for the current dynamic of fuel tanks. However they can be easily overshadowed by the benefits of creating the system. Due to the accuracy and speed of operation of the ultrasonic sensor for static as well as dynamic liquid levels[5] the system can yield accurate results in real time and thus can be used directly at fuel outlets.

A. Pros

- 1) Ultrasonic Sensor is a non-contact sensor applicable to multiple fuel tanks.[3]
- 2) It is only placed above tank temporarily. No permanent installation required.
- 3) Cost-effective solution

B. Cons

- 1) Different fuel tanks require to be modeled and calibrated to calculate volume of fuel based on depth sensing alone.
- 2) It is achievable with CAD but will require manufacturer's tank dimension info [9]

VII. FUTURE SCOPE

This system will enable us to study fuel trends and activity at fuel outlets which is essential in understanding market trends in supply and demands. Fuel quality delivery can be tracked and improved.[4] Factors causing loss in fuel quantity and overall distribution can be streamlined.[8] We can apply similar systems on miscellaneous frequent liquid storage-retrieval facilities. A fuel theft detection system can be produced in similar fashion using sensors of higher range. [7]

The Fuel Fraud Detection system above will most likely be more accurate, more reliable, and cheaper than other analog meters, and will allow for added features that benefit both the customer.

In the near future, the different vehicle company manufacturers will implement this kind of fuel system which also provides security for the vehicle owners. Not only will the measurement be more accurate, but, the consumers also will not be cheated for their hard earned money.

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