Fuel Adulteration Detection System

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Abstract

The emissions from automobiles result in increase of greenhouse gases like carbon dioxide. One of the major reasons for increased emissions is adulteration of automotive fuel. The adulterant that is mixed with petrol and diesel generally is kerosene. The reason why kerosene is chosen as an adulterant is its low cost. This adulteration results in reduced performance and lifetime of engine and other components of an automobile. Diversion of large amounts of kerosene for the purpose of adulteration reduces its availability to the poor people. So this has forced them to use wood as an alternative to kerosene for their household purposes. This indirectly leads to increase in global warming by increasing air pollution and cutting down of trees. So to prevent all these ill effects, an approach to automatic fuel adulteration detection and reporting system is proposed in this paper.

Keywords: Adulteration, Level Detection

1. Introduction

There are many methods to detect adulteration in fuel like density measurement method, fibre grating sensor technology, emission testing, filter paper method etc. Density measurement technique couldn't be implemented inside vehicles because of various factors like densities of adulterated and unadulterated fuels are nearly same and also density can only be measured for a liquid that is stagnant which is impossible to achieve inside a vehicle due to engine vibrations and other factors. The sensor grating method uses laser transmitter and receiver which are too costly for just an add-on to an automobile. The emission testing equipment is too bulky to be fitted inside an automobile. This paper presents a low cost adulteration detection system that can be installed in an automobile

2. Methodology

2.1 Basic Property of Crude Oil

Crude oil is a mixture of fuels like diesel, petrol, kerosene etc. These are extracted from the crude oil by the process of fractional distillation. This process uses the property that different fuels have different boiling points. Figure1 shows the boiling point of various fuels obtained from crude oil under normal atmospheric pressure. And from this it is observed that of all the fuels petrol has the least boiling point and kerosene has the highest boiling point.

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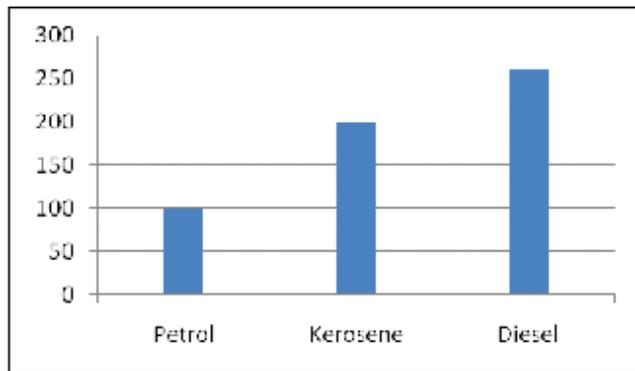
Figure 1. Comparison of boiling points of petrol, diesel and kerosene (degree Celsius).

2.2 Technique Used

In this method of fuel adulteration detection, a sample of the fuel that is being filled is heated to a temperature which is equal to the boiling point of petrol or kerosene. In case of diesel fuel, it is heated to a temperature equal to the boiling point of kerosene and in case of petrol fuel, it is heated to a temperature equal to the boiling point of petrol. So that any one of the constituent gets evaporated and the other constituent is left in the sample. For example, in case of petrol adulterated with kerosene, the constituent left would be kerosene. Likewise in case of diesel adulterated with kerosene, the constituent left would be diesel. From this the amount of adulteration in the fuel can be detected.

2.3 Methods of Level Detection

The amount of the left out sample after heating the adulterated fuel is detected by using two different methods. The first method uses IR sensors and the second method uses camera based Imaging system for level detection.

2.3.1 Infra-red Method

Infra-red light source is placed on one side of the glass tube and photo detector is placed at other side. The voltage output of the photo detectors is different in the presence and absence of liquid. By getting these voltage values, the microcontroller detects the level of liquid in the tube.

2.3.2 Image Processing Method

A camera is placed at a fixed position that takes a picture of the glass tube. By using level detection technique, we detect the amount of fuel level in the glass tube. From this

level the amount of adulteration can be calculated very accurately.

2.4 Raspberry–pi

Picture that is taken by the camera is fed to a microcontroller which is programmed in such a way, that it calculates the percentage of adulteration by comparing the level of fuel left out in glass tube by using image processing technique. The microcontroller is interfaced to an LCD display that displays the percentage of adulteration in the fuel.

3. Implementation

3.1 Actual Implementation
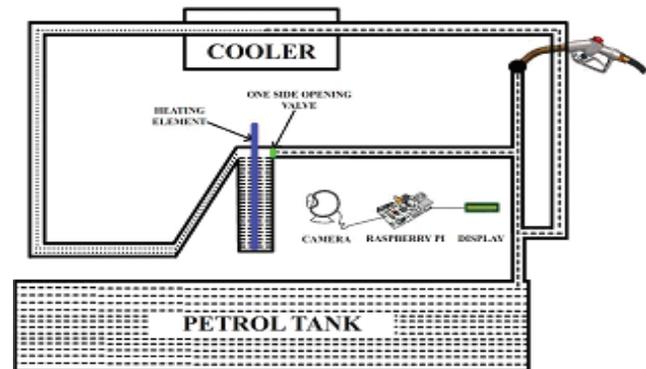
Figure 2. Actual implementation in automobiles..

Figure 2 shows the actual implementation of fuel adulteration detection in automobiles. In this process, when a person opens the lid of the fuel tank and starts filling fuel in to it, a small portion of the fuel goes in to a small chamber of capacity 50ml. This chamber is made out of glass and a camera is placed at a fixed position at a distance of approximately 20 centimetres. When the filling is over and the lid of the tank is closed, a signal is given to the Raspberry-pi. After receiving this signal, the Raspberry-pi automatically starts to heat the chamber by sending a signal to the heating element that heats the chamber. This heating will occur only for a predefined amount of time that is pre-programmed in the Raspberry-pi according to the fuel used.

3.1.1 Petrol

This is the actual amount of time required for 50ml of pure petrol to evaporate completely under normal conditions.

If the filled in fuel is adulterated, after the heating, the liquid left in the chamber consist only the adulterants. The camera takes picture of the glass tube and sends it to the Raspberry-pi for processing. By using the canny edge detection technique, the Raspberry-pi processes the image and tracks the pixel at which the edge occurs. Using this pixel value, the Raspberry-pi calculates the amount of adulterant left in the tube. This is converted in to percentage and displayed in the LCD.

3.1.2 Diesel

Here one should know the actual amount of time required for 50ml of Kerosene to evaporate completely under normal conditions. After the heating, the liquid left in the chamber will consist of only the diesel fuel. The camera takes picture of the glass tube and sends it to the Raspberry-pi for processing. By uses the Canny edge detection technique, the Raspberry-pi processes the image and tracks the pixel at which the edge occurs. Using this pixel value, the Raspberry-pi calculates the amount of diesel in the tube. From this value, the Raspberry-pi calculates the amount of adulterated kerosene in the diesel fuel. This is converted in to percentage and displayed in the LCD.

If a person has smart phone the adulteration detector can detect the amount of adulteration in the fuel and send this information to an application in smart phone through Bluetooth. The application can update this information about the adulteration level in that filling station to a server using internet, the location of the filling station can be found by using GPS in the smart phone. The server can exchange this information to other smart phones that use this application via internet. So when a person has this software in his phone or computer then he can easily find out the best filling station in that area.
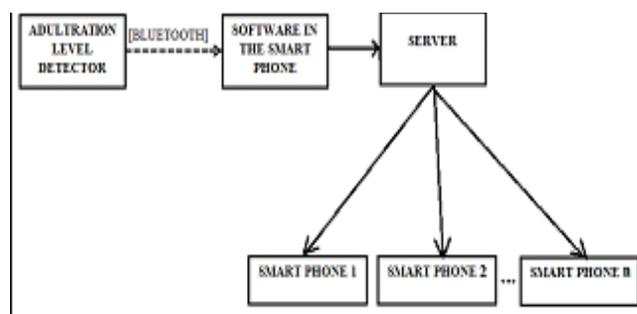
Figure 3. Information sharing.

When the application receives low adulteration level signal from the adulteration detector, it can just update the server and can keep quiet. If it receives a medium adulteration level signal from the adulteration detector, it can update itself and also trigger the alarm. If it receives a high adulteration level signal from the adulteration detector, it can update itself, trigger the alarm and also send a message from the phone to the nearest police station that this filling station has a high adulteration level as shown in Figure 3.

3.2 Level Detection using IR Sensor

Figure 4 shows the experimental setup of detecting the fuel adulteration using IR sensors. When a person opens the lid of the fuel tank and starts filling fuel in to it, a small portion of it goes to a small chamber of capacity 50ml.
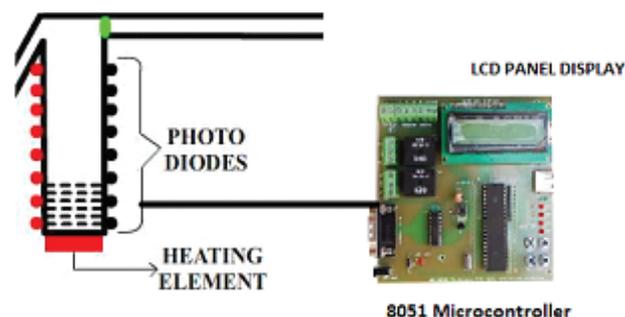
Figure 4. Experimental setup using IR sensors for detection of adulteration.

This chamber is made out of a glass and it is fitted with IR transmitters on one side and IR receivers on the other side. When the filling is over and the lid of the tank is closed, a signal is given to the micro controller. After receiving this signal, the controller automatically starts to heat the chamber by sending a signal to the heating element that heats the chamber. This heating will occur only for a predefined amount of time that is pre-programmed in the microcontroller according to the fuel used.

3.2.1 Petrol

One has to know the actual amount of time required for 50ml of petrol to evaporate completely under normal conditions. If the filled in fuel is adulterated then, after the heating, the liquid left in the chamber will consist of only the adulterants. There are totally nine IR transmitters and receivers fitted to the chamber. Now the light emitted

by IR transmitter is received by the IR receiver. If there is a presence of liquid in between the transmitter and receiver, then the path of light is obstructed and the receiver gives an output voltage. Let this output voltage be V1. Similarly, if no liquid is present between the IR transmitter and receiver, then it gives a different output voltage. Let this be V2. So from this we can say that, a set of receivers will be showing output voltages V1 and the other set of receivers will be showing V2. Now all these output voltages are fed to the microcontroller. Now the microcontroller compares these output voltages and finds the adjacent receivers which show different values. From this the micro controller finds the level of liquid left in the chamber which is directly proportional to the percentage of adulteration.

3.2.2 Diesel

Here one should know the actual amount of time required for 50ml of diesel to evaporate completely under normal conditions. If the filled in fuel is adulterated then, after heating, the liquid left in the chamber will consist of only pure diesel. There are totally nine IR transmitters and receivers fitted to the chamber. Now the light emitted by IR transmitter is received by the IR receiver. If there is liquid present between the transmitter and receiver, then the path of light is obstructed and the receiver gives an output voltage. Let this output voltage be V1. Similarly, if no liquid is present in between the IR transmitter and receiver, then it gives a different output voltage. Let this be V2. So from this we can say that, a set of receivers will be showing output voltages V1 and the other set of receivers will be showing V2. Now all these output voltages are fed to the microcontroller. Now the microcontroller compares these output voltages and finds the adjacent receivers which show different values. From this the micro controller finds the level of liquid left in the chamber which is inversely proportional to the percentage of adulteration.

3.3 Level Detection using Image Processing

In the experimental setup shown in Figure 5, first a fixed quantity (50ml) of pure petrol is heated so that it completely evaporates and the time taken for this evaporation is recorded. Then the adulterated fuel is heated for the same amount of time so that entire petrol in the adulterated mixture
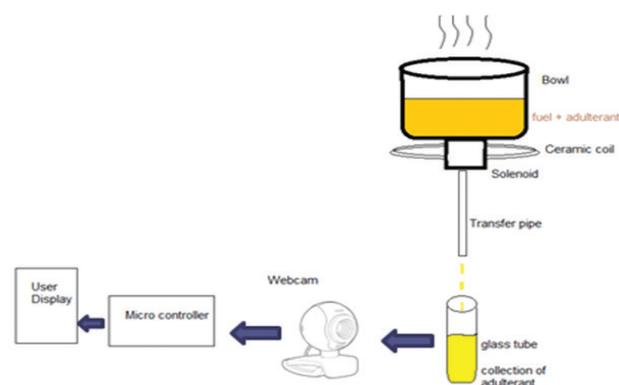
Figure 5. Experimental Setup using Image processing method.

gets totally evaporated and only the adulterant remains. Then this adulterant is transferred to a glass tube of 50ml volume. The camera takes picture of the glass tube at a resolution of 320*240 pixels and sends it to the Raspberry-pi for processing. Raspberry pi processes the image to find the level of the liquid. Canny edge detection is used for this purpose.

Figure 6. Original image.

Figure 6 is used to demonstrate canny detection technique. It depicts a glass tube containing adulterant. All images taken by cameras contain noise, so to prevent noise from being mistakenly detected as edges, noise has to be removed. So the image is first smoothened by using a Gaussian filter. Canny algorithm finds edges where the grey scale intensity of the image changes the most. First the gradients in the x and y directions are approximated by using kernels. By using Pythagoras theorem the Euclidean distance is measured. The smoothened image is then compared with the computed edge strengths. After all these processes, the edges will become visible

but the edges are very broad and do not indicate exactly where they are. Now, the blurred edges in the image need to be converted to sharp edges, for this purpose image suppression is used. The edge strength of the current pixel is compared with the pixels in the positive and negative gradient direction. The value of edge strength is preserved if it is above a certain threshold value else it is suppressed. After this, the remaining edge pixels strengths are marked pixel by pixel. The Canny edge detection algorithm uses double thresholding. Edge pixels stronger than the high threshold are marked as strong; edge pixels weaker than the low threshold are suppressed and edge pixels between the two thresholds are marked as weak. Strong edges are included in the final edge image immediately and weak edges are included only if they are connected to strong edges.
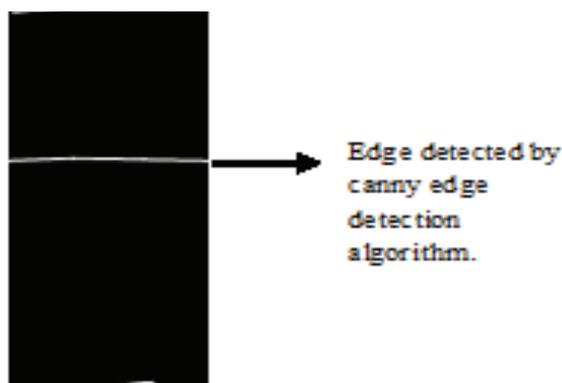
Figure 7. Image after canny edge detection.

By using the canny edge detection technique, the Raspberry-pi processes the image and tracks the pixel position at which the edge occurs as indicated in Figure7 above. Using this pixel value, the Raspberry-pi calculates the amount of adulterant left in the tube. This is converted in to percentage and displayed in the LCD

3.4 Comparison of Both the Methods

Table 1. Infra-red method vs. image processing method

Infra-Red method	Image Processing method
Uses photodiodes as the main source for level Detection	Uses camera as the main source for level detection
Photo diodes are cheap in cost. So the setup is cheap.	The setup is costlier compared to the cost of IR method detection.
Medium level of accuracy. Ex: 20%, 30%, 40% etc. Since we are placing photodiodes at only some fixed points , the level of the liquid cannot be determined , but it is rounded to the nearest10s digit value and displayed.	High level of accuracy: Ex: 1%, 2%, 16%, 76% etc. Since we are placing a camera at a fixed distance and take a snap shot of the entire glass tube, each and every pixel in the picture is scanned and the exact level of left out fuel is measured.

4. Conclusion

This paper presented couple of methods of adulteration detection techniques which are cost effective and can be fitted in any automobile with little modifications. The two methods performed are easy to implement but the image processing method provided a better result in terms of accuracy when compared to IR detection method. Finally, IR method can be used where one needs a low cost solution and image processing method can be used where one needs a highly accurate solution. Adulteration is one of the major causes for engine failures. Hence, this approach helps in reducing adulteration, thereby increasing engine lifetime with a good performance and finally to attain a clean and healthy environment.

5. Acknowledgement

6. References

1. Kelter PB, Mosher MD, Scott A. Chemistry: The Practical Science.
2. Mishra, V, Jain SC, Singh N, Poddar GC, Kapur P. Fuel adulteration detection using long period fiber grating sensor technology. Indian J Pure Appl Phys. 2008; 46:106–110.
3. Sivapradha CR, Sarkar S. Fuel Adulteration.
4. Wiziack NKL, Paterno LG, Fonseca FJ, Mattoso LHC. A Combined Gas and Liquid Chemical Sensor Array for Fuel Adulteration Detection. AIP Conference Proceedings. 2011; 1362(1):178.
5. Gilmartin B. Fuel adulteration: Rubber swelling as a new method of detection.
6. Canny J. A computational approach to edge detection. Pat-

tern Analysis and Machine Intelligence. IEEE Transactions on, PAMI. 1986 Nov; 8(6):679–98.

7. Moeslund TB. Signal, Image and Video Processing. 2008 Aug.

8. Mai F, Hung Y Zhong H, Sze W. A hierarchical approach for fast and robust ellipse extraction. Pattern Recognition. 2008 Aug; 41(8):2512–24.

9. Azernikov S. Sweeping solids on manifolds. Symposium on Solid and Physical Modelling; 2008. p. 249–55.

10. Boyle R, Thomas R.°Computer Vision: A First Course. Blackwell Scientific Publications; 1988. p. 52.