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Development of an OBD Information Cluster for Non-OBD Vehicles

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***Abstract*— OBD (On-Board Diagnostics) has been associated with the automotive world since 1960s. Due to extensive use of electronics in the vehicles, the parameters what OBD monitors have changed largely. In spite of such an influence of OBD on vehicles, there are still many cars on the road which are devoid of this feature. The motive of the dissertation is to eliminate this drawback for old cars by developing an easy, efficient and portable information cluster system. An information cluster system is designed and developed using a microcontroller and compatible sensors which achieve the desired the functionality. Vital information like digital fuel level, CO level, proximity of obstacles, temperature and humidity, are monitored and the results are displayed in a user friendly manner on a touch screen based display. The developed system is portable, which means it can easily fit in and operate in any car irrespective of make and model.**

Index Terms—**Digital Fuel Level, Infotainment, Load cell, On-Board Diagnostics (OBD), Ultrasonic.**

I. INTRODUCTION

On-Board Diagnostics or commonly referred as OBD, which was developed by SAE (Society of Automotive Engineers) mainly focussed on monitoring vehicle emission levels. In the early 1980s, first OBD systems were installed in the cars, during the manufacturing stage itself. The focus was to monitor fuel injection and emission levels. Whenever an error occurred or the emission levels exceeded the limit, a fault code was stored in the vehicles on board computer (Burje, 2014). An indication of it was given to the user through the dashboard. Through these fault codes, technicians could diagnose the problems. The U.S government observed the lower emissions in vehicles which had OBD installed and considering the fact that it is a valuable technology; they came up with a much advanced and improved standard OBDII (OBD Solutions, 2016). By 1996, it was regulated that all the vehicles had to meet specific standards for OBD systems.

A. Motivation

In India, OBDII standard is found on cars manufactured after 2010. It means most of the vehicles on road are still devoid of the standard. This is the main driving point to take up the topic. The advancement in electronics can be used to design a compact, user friendly, retro-fitting model, so that the cars can be upgraded to have a better information cluster system.

B. Concept

The main idea is to develop a OBD related information cluster system using the latest sensors and controllers. Some of the vital information the user of the car requires apart from the available details like RPM, oil level among others are, the temperature of the cabin and the coolant. Since air conditioners are used extensively in the cars, any leakage or malfunction in the unit might result in the release of harmful gases. It will be useful if the user gets the information about the levels of harmful gases in the cabin. The number of vehicles is increasing rapidly; one of the major issues faced by the drivers as a result is the difficulty to find safe parking places. Parking sensors can be used, so that the driver can get the distance from the vehicle to any obstacle. Cheating in petrol bunks, while filling the fuel is another issue faced commonly. The analog fuel gauge present in the vehicles do not give exact value, a sensor can be used to obtain the digital value in litres, so that the driver has accurate information about the fuel available. Based on the requirements, these four parameters are selected and a suitable microcontroller is selected. An information cluster is developed by processing these sensors and the information required is presented in a user friendly manner.

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C. Scope

The design is simple and cost effective and yet it caters to the need of the user. The concept of microcontroller based OBD is published in many research papers. The unique feature of this project is that it addresses the most frequently required parameters and presents them in an attractive way like a touch screen based user friendly. Limited sensors are used and the power required is also less and the vehicles battery can be used for the purpose. All those factors increase the scope of the project to an extent such that it has ability to reach maximum number of people. Apart from the potential success of the product, the design addresses a few issues like digital fuel level display which prevents the common people from being cheated in the bunk and the CO concentration displayed helps the user to keep a check on the harmful gases in the cabin.

II. DESIGN SPECIFICATION

Based on the literature survey carried out and the background study, design specifications can be written. At first, functional and Non-functional requirement specifications are identified. In order to achieve these requirements, various specifications like hardware interface, user interface, software interface and operation of the system are explained. Once the design specifications are arrived at, important design parameters like high level block diagram, a detailed low level block diagram, software flow and algorithm are chalked out. After the software design, it is important to select appropriate hardware, which is compatible with the software design. The hardware peripherals are to be selected carefully, so that they are not only in accordance with the design and requirements but also compatible with each other. Although the designing and the developing part of the system is done, it is required to test the system under various conditions and circumstances. The design specifications are as follows

A. Assumptions

There is an assumption made in the calculation of fuel level. The fuel density changes slightly with temperature. The fuel level calculations are done by assuming the fuel tank to be at 25°C. During summers, the temperature might go up causing the density to vary, however the variation is very less and negligible. Apart from this, there are no major assumptions made during the design of the system.

B. User Interface

A Thin-Film Transistor (TFT) based display with touch screen is used for user interface. The user input is accepted by the TFT display module based on the position of the touch on the screen. The corresponding output is processed and displayed on the screen.

C. Hardware Interface

An Arduino microcontroller which is compatible with most of the sensors is used. In order to achieve the requirements, a suitable controller like Arduino ATMEGA 2560 is selected. Different sensors like Load cell, Carbon Monoxide gas sensor, temperature and humidity sensor, sound sensor and ultrasonic sensors are interfaced with the controller. The controller processes the inputs obtained from these sensors and the processed output is displayed on the TFT display screen. The actuator part consists of RGB LEDs.

D. Software Interface

To program the arduino controller, arduino IDE is used. Code is written in C++ language. Dedicated libraries like UTFT and Utouch developed by Henning Karlsen are used for the touchscreen module. In addition, DHT and HX711 libraries are used for DHT sensor and Load cell respectively. The code is compiled and ported on to the board using the same arduino IDE. Dia software is used for drawing high-level, low-level block diagrams and flowcharts. Fritzing software is used for designing the hardware schematic.

E. Operation

When the Information cluster system is switched ON, main menu is displayed which includes a set of five options. CO Level, Distance Sensor, Digital Fuel level, temperature and humidity and RGB LED buttons are the five options which are given to the user to select. Based on the button selected, the appropriate Sub Menu is displayed. Proximity of obstacles is shown when distance sensor button is pressed, similarly CO Level and temperature and humidity of the cabin is displayed when CO Level button and Temperature/Humidity button is pressed respectively. The available fuel level in liters is displayed when the fuel level button is pressed. Two options are given to the user when the RGB LED button is pressed, which includes music and manual mode. In the music mode, the LEDs blink according to the music played. In the manual mode, two more options are provided. The user

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can either select the predefined colors or can vary the red, green and blue colors intensity through the sliders to get any desired color. In each sub menu, a Home button is present, through which the user can go back to the main menu.

III. DESIGN OF THE SYSTEM

Various design parameters like high level block diagram, low level block diagram, algorithm, flow of the system, peripherals required and the calculations involved are explained in this section.

A. Flowchart

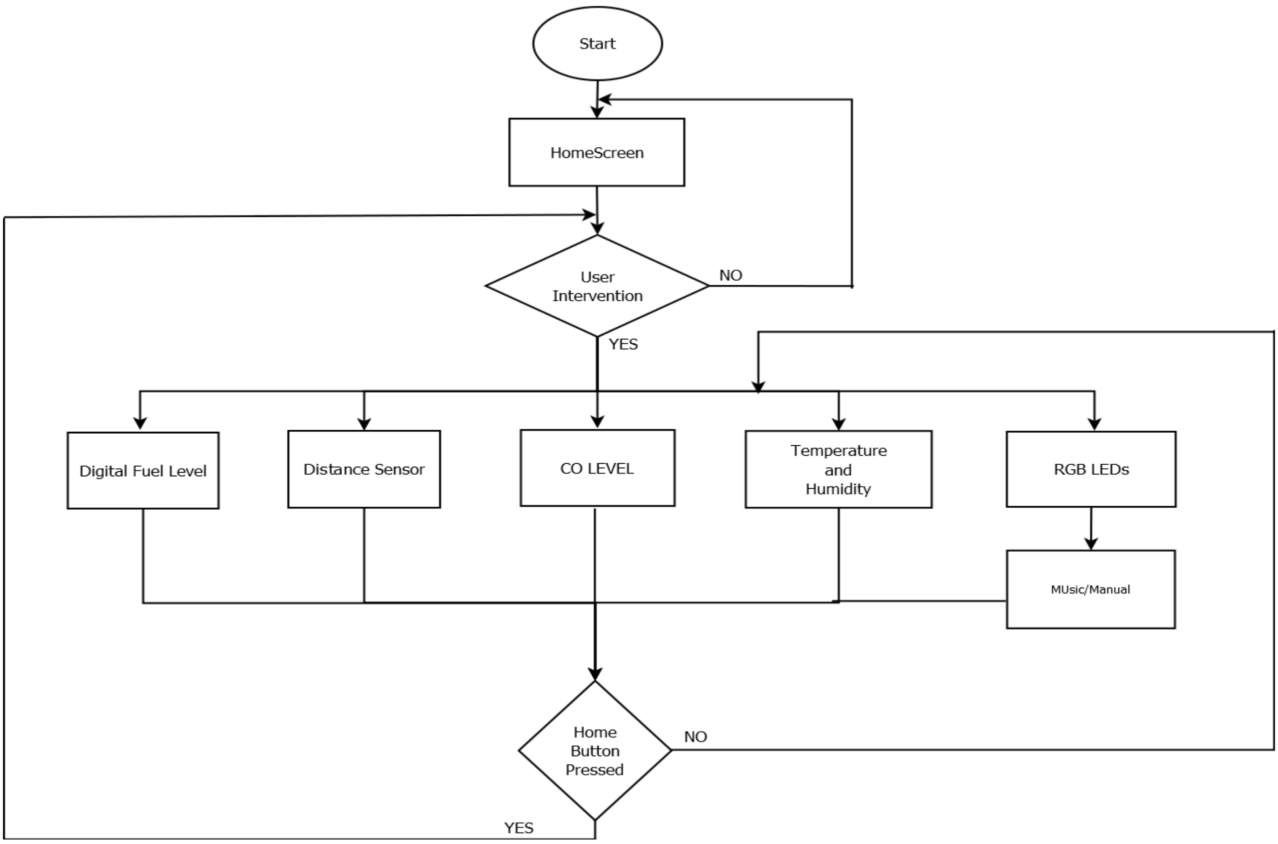

Fig 1. Flowchart of the system

B. Peripherals Required

These are the following hardware components required to implement the system
Sensors: - Dht22 temperature and humidity sensor, MQ7 CO level gas sensor, Ultrasonic senor, load cell sensor, sound sensor.
ADC: - HX711 24 bit ADC
Controller:- Arduino Atmega 2560 board
Actuator:- RGB LEDs, TFT touchscreen, TFT shield.

C. *Calculations*

This section explains the calculations involved to obtain the digital fuel level from the load cell values, distance calculations from the ultrasonic sensor values and also the inputs given to the individual pins of RGB LEDs to obtain the required color.

Fuel Level Calculations from load cell

Fuel density is used for the calculation of fuel level from the load cell values. Kilograms per cubic meter are usually the unit used to express the density of fuel. The molecular weight of the fuel contributes for the fuel density. Thus, greater the molecular weight, higher the fuel density.
According to the values published in engineering toolbox website, the fuel densities of some common liquids are as follows

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Table I. Fuel Density Values

Liquid	Temperature in °C	Density in Kg/m^3
Pure Water	4	1000
Sea Water	25	1025
Vehicle Petrol	15	737.22
Vehicle Diesel	15	885

Liquids expand and contract with heat. Thus, their energy density varies with temperature. The fuel level is calculated for tanks assuming it is at 15°C. During summer, it might go up to 25°C to 30°C. Under such conditions, the density increases, however, the change will be about 0.5 to 1%, for every 5°C temperature change. Thus, during summer, the fuel level may show variations of about 150 ml to 200ml during peak summer time.

Vehicle Petrol has density of about $737.22 kg/m^3$ which means,

1 kg of vehicle petrol = 1.35644 litres or in other words,

0.7372199 kg of vehicle petrol = 1 litre

Similarly, for diesel vehicles, diesel has a density of about 885 kg/m^3 which means,

1 kg of vehicle diesel = 1.1299435 litres or in other words,

0.885 kg of vehicle diesel = 1 litre

Depending on the additions to the petrol, the density might change, however the change is too small and does not affect the fuel level, thus can be neglected.

Ultrasonic Sensor Distance Calculations

The concept of dolphin and bat is used for calculating the distance to an object. Ultrasonic waves are sent out and the time taken for it to travel back is used to calculate the distance to an object. Ultrasonic waves have a spread velocity of 340 m/s in the air. The trigger pin sends out sonic waves and it needs to be set high for 10 µs.

Time = distance / speed -------------- (1)

Speed = 340 m/s = 0.034 cm/µs ----- (2)

From equation (1),

Distance = speed * time---------------- (3)

Since the time considered is for the waves to travel to the object and returning back, the calculations must be divided by 2, to get the distance.

Therefore, from equation (2) and (3),

Distance = time * 0.034/2

The trigger pin is set as output and the echo pin is set as input.

RGB LED color variations

Common anode RGB LED is used in this application and hence a 5V Input is given to the pin. The LEDs are designed such that they operate at a voltage of about 1.5V to 3V. Arduino mega2560 operates at 5V, thus a current limiting resistor is required. A 330 ohm resistor is used for this purpose. One resistor end is connected to the LED pins and the other end is connected to the PWM pins on the board. Through these PWM pins, the value can be varied from 0 to 255 to give different voltage levels. Analog value of 0 will give 100% duty cycle, 255 will give 0% duty cycle and 127 will provide 50% duty cycle. Using these values from 0 to 255 to different LED pins, various color combinations can be obtained. For example, to get Red color, the red pin of LED is given a value of 0 and the green, blue pin are given a value of 255. Similarly, other color combinations can be obtained.

IV. RESULTS

After vigorous testing of the developed system, the results obtained are analyzed. This section briefly explains the results obtained. The values obtained from the sensors are compared for its accuracy.
When the system is on, Home screen is displayed

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Fig 2. Home Screen

The Fig 2. shows the home screen being displayed, when the system is powered ON. It displays text at the top of the screen which reads " Welcome to Information Cluster System". An image of the car which is of 75 x 74 pixels is displayed. The module did not support higher image quality, thus it is reduced to an appropriate size which the module supports. A small button at the bottom of the screen is present, which gives access to main menu.

Main Menu

Fig 3. Main Menu

The Fig 3. shows the Main Menu being displayed. It has 6 buttons, each of which has a dedicated function. The home button takes it back to the home screen.

CO Level Screen

Fig 4. CO Level Screen

The Fig 4. Shows the CO Level screen. This screen is drawn when the CO level button is pressed and the MQ7 sensor gets activated. It displays the CO Level in ppm. The levels as obtained from the CO level detector in the service centre and those values obtained from MQ7 sensors are compared.

Table II. CO values comparison

Pocket CO level detector values	MQ7 sensor values
30	33
48	52
88	94
76	80
55	52

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It can be observed that there is a variation of 5-7 ppm as compared to the values obtained from the service center. This variation can be neglected, since it does not affect the result considerably.

Fuel Level

Fig 5 Fuel Level Screen

The Fig 5. shows fuel level screen. This screen is drawn when the fuel level button is pressed. It displays available fuel level in litres. The comparison of practical values obtained against the load cell values are as shown

Table III Fuel level comparison

Practical Value	Sensor Value
500ml	530ml
750ml	775ml
1000ml	1044ml
1500ml	1554ml
1750ml	1788ml

There is a variation of about 35-45 ml from the sensor values to actual values.

Temperature and Humidity

Fig 6. Temperature and Humidity Screen

The Fig 6. shows the temperature and humidity screen. When the temperature and humidity button is pressed, this screen is drawn and DHT 22 Sensor is activated. The temperature values obtained from the sensors are compared with the values obtained from the value given by another device.

Table IV. Temperature Value Comparison

Digital Time/Temperature Device	DHT22 Sensor
31.6	31
27.4	27
28.8	29
24.2	24
25.7	26

It can be observed that, there is a variation of decimal values, which can be neglected.

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Distance Sensor

Fig 7. Distance Sensor

The Fig 7. shows the parking sensor or the distance sensor screen. This screen is drawn when the parking sensor button is pressed. It gives the proximity of obstacles in either cm or inch, depending upon the mode selected by the user. The values obtained from the sensor are compared against the values obtained by using a ruler.

Table V. Distance sensor values

Ultrasonic Sensor values	Ruler or scale values
4cm	4cm
9cm	9cm
14cm	14.6cm
21cm	21.6cm
27cm	27.6cm
30cm	30.3cm

It can be observed that, the values are almost same and the minute variation can be neglected.

RGB LED

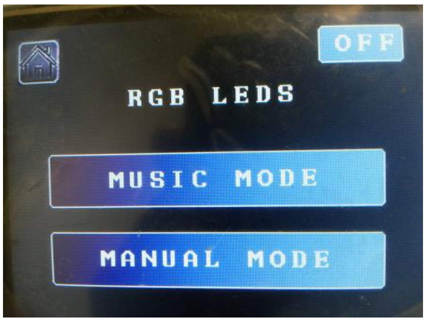

Fig 8. RGB LED Menu

The Fig 8. shows RGB LED menu. The screen is drawn when RGB LED button is pressed. It displays two buttons music mode and manual mode. There is also a home button on the top left corner of the screen, which takes back to the main menu.

Music Mode

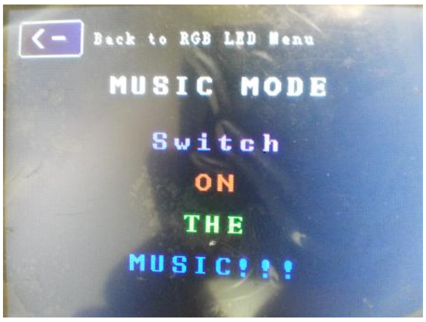

Fig 9. Music Mode

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The Fig 9. Shows music mode screen. Sound sensor is activated and the LED blinks based on the music played in the car. The sound sensor switches on the LED only when sound exceeds the limit. The music mode worked well as per the requirement.

Manual Mode

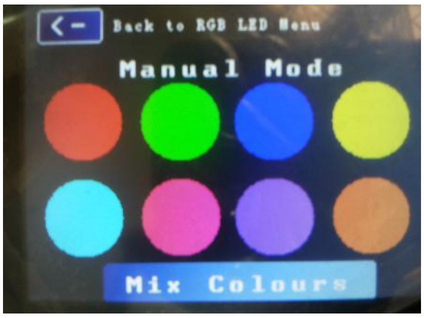

Fig 10. Manual Mode

The Fig 10. shows the manual mode screen. There are 8 predefined colours displayed, 4 in each row. The user can select the colour based on which the LED glows. The results obtained are good since LED glows as per the colour selected by the user. In addition there is a mix colour button at bottom of the screen.

Mix Colour

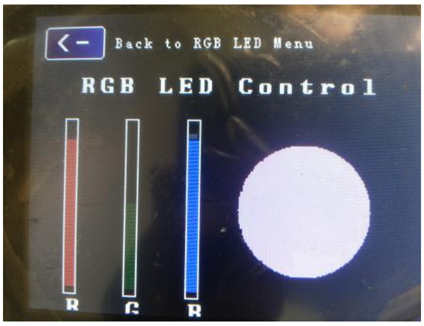

Fig 11. Mixing Colour Mode

The Fig 11. shows the mixing colour screen. It has three vertical sliders, each for red, green and blue. The slider values are mapped for 0 to 255. By varying the sliders, required colour can be obtained. The selected colour is displayed on the circle next to sliders. The LED glows the required colour successfully. There is also a return button, which takes back to RGB LED menu. The results obtained are briefly explained and the accuracy comparisons are done for each sensor used. It can be concluded that, the developed system works well and the values are nearly accurate and overall system results are good.

V. CONCLUSION

A microcontroller based information cluster system is designed and implemented in accordance with the requirements. The design is a retro-fit model which was not the case in earlier systems and this design provides a better user interface since it uses touchscreen based TFT display compared to the LCD screen used in previous systems. Power requirements are also reduced since this design uses single controller, not multiple master and slave devices. Thus, it can be concluded that the implemented system is advantageous in terms of portability, power requirements and user interface as well as monitoring more parameters.

VI. FUTURE RECOMMENDATIONS

The future recommendations are suggested to make the system more efficient and have a wider application. They are listed as follows.

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- An android/IOS application can be developed to make design smarter, so that it can be controlled by passengers from the rear seat as well.
- Database can be created to record the values for individual passengers.

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