An Intelligent Voice Enabled Distance to Empty and Navigation System

Dhruba Ningombam, Chitra, Nitashi Kalita, Vinita Pat Pingua

Abstract: Recent years have witnessed a fast growth in automobile sector, leading to increased urge for an intelligent man machine interaction system for navigation. This paper describes the development and implementation of an intelligent speech agent based navigation system and distance to empty (DTE) calculation for autonomous land vehicle applications. This system, initially determines the current location using Global Positioning System (GPS). The GPS outputs NMEA (National Marine Electronics Association) sentence that contains information about current location including longitude and latitude. The input to the system i.e. the desired destination is through voice command and outputs the following-(i) the road distance and the amount of fuel required, through speech, (ii)the altitude difference between the current location and the destination, which is further used to calculate the mileage variation with altitude and (iii) displays the route from the current location to the destination on a map along with the prediction whether the user will be able to reach the desired destination with fuel left in the automobile, how much distance it can travel with the remaining fuel and how much additional fuel is required to be filled up to reach the destination.

Index Terms: altitude difference, DTE (Distance to Empty), GPS (Global Positioning System), intelligent speech agent, man machine interaction, map, mileage variation, Navigation, NMEA (National Marine Electronics Association).

I. INTRODUCTION

This system is implemented by its interaction with human. The voice command from a user is through a microphone. The user needs to speak out the destination and the application processes the voice command. If the user gives a valid destination, the further processes are carried out. The processes include determining current location, route distance to destination, altitude difference between current location and destination which alters the mileage value, DTE of vehicle, fuel required to reach the destination and additional fuel required to reach the desired destination. Navigational System tracks vehicle's current location and route distance to destination. It uses a GPS navigation system to acquire information in order to locate a vehicle on the road. To know whether the vehicle can reach the desired destination, the DTE (Distance To Empty) value of the vehicle must be known.DTE is the estimated distance a vehicle can travel before it runs out of fuel. Fuel level and type of automobile affects the DTE value.

Ultrasonic sensor is deployed to calculate the level of fuel in the fuel tank. Ultrasonic sensor is also known as transceivers as it both sends and receive signal. Ultrasonic sensor [1] evaluates the desired property of a target by sending high frequency sound wave and receiving and processing of the echo. The time interval between sending the wave and receiving the echo is used for calculating distance to any required object. With the level of fuel and automobile type, the approximate DTE value is calculated. Thereafter, it evaluates the additional amount of fuel to reach the destination.

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Dhruba Ningombam, Computer Science and Engineering, Sikkim Manipal Institute Of Technology, Gangtok, India.

Chitra, Computer Science and Engineering, Sikkim Manipal Institute Of Technology, Gangtok, India.

Nitashi Kalita, Computer Science and Engineering, Sikkim Manipal Institute Of Technology, Gangtok, India.

Vinita Pat Pingua, Computer Science and Engineering, Sikkim Manipal Institute Of Technology, Gangtok, India.

II. PROBLEM DEFINITION

Here, the problem defined is to determine whether the desired destination can be reached with the remaining fuel and a fair account on route distance between current location and destination, DTE of the vehicle, how much distance a vehicle can travel with residual fuel and how much additional fuel is required to reach the desired destination. The platform used for the development of this application is Microsoft Visual Basic 2008. A windows form is developed, which can take voice command from user to mention the destination. After entering the destination the further actions are carried out and the desired outputs are through voice command.

III. LITERATURE SURVEY

There is a variety of automatic "vehicle navigational system" and "vehicle distance to empty (DTE) system" that has been developed and used to provide different information like the current location and DTE value. The common purpose of such systems is to automatically maintain knowledge about different vehicle parameters as the vehicle traverses. For example, one general approach to vehicle navigational system is The Travelpilot : a second-generation automotive navigation [1] . In this system dead reckoning and map matching are used for navigation. The system can find destinations and display them to the driver. The dead

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reckoning sensors in the original navigator involves a magnetic compass(to measure vehicle heading) and wheel rotation sensor on the two undriven wheels (to measure distance travelled and turning information).The information from the magnetic compass for the Dead Reckoning and Map Matching is not reliable. It is not the fault of the compass, instead it is because of the anomalies in earth's magnetic field. These anomalies can be caused by steel reinforcements in elevated roads and overpasses, by steel enclosed bridges, by trolley tracks in the roadway or by other metallic objects in, under or near road. Such magnetic anomalies can result in producing errors in measuring vehicle heading, as a result it ends up in the system following the wrong road. To avoid the problem, it can be replaced by a Global Positioning System (GPS) based navigation system which is to be installed in vehicle.

Yet another significant invention in the field of navigational systems is "Land Vehicle Navigation Using GPS" [2].The basic function of the land vehicle navigation system is to accurately track the vehicle location. Here, this aim is achieved by an on board computer that uses sensors and continually collects data from it. The sensors are fixed inside the vehicle. The sensor data is used by the computer to determine the vehicle's location and this location is conveyed to the vehicle's driver by an electronic user interface. Today a huge number of possible combinations of navigation aids that can be used in systems exists, but the question is, what criteria is being used by navigation system designers when selecting sensors for use in the vehicle navigation system. The main objective of system designers on selecting sensors is maximizing the systems performance while minimizing its total cost. This paper basically includes an audit of the impact that navigation sensors put on the performance of a land vehicle navigation system.

Above mentioned navigational systems include, tracking of a vehicle as one of their objectives. Method to improve such vehicle tracking is clearly explained in Vehicle Navigation System and Method [3]. A variety of automatic vehicle navigational systems has been introduced and developed. These offers knowledge about the actual vehicle location when it moves over streets. The objective of the invention is to provide an apparatus and method which can improve the vehicle tracking accuracy. The above mentioned objectives are obtained by several means including, first means is providing data and information identifying respective vehicle positions, each position having an accuracy with respect to actual location of the vehicle and one of the positions being current position, second means is providing a map database of the streets, and means for deriving any of the parameters(one or more) in dependence on one or more respective positions of the vehicle and streets of the map database to determine if more probable current position exists. Thus, in the apparatus and method of this invention the desired result in the form of parameters (one or more) may be derived from the positions of the vehicle and map database.

An approach to vehicle distance to empty (DTE) system is in the invention in "Apparatus For Indicating Distance To Empty of a vehicle and a method thereof" [4].The working of this apparatus initially includes the checking of whether fueling is completed or not.Then the fluctuating fuel economy is calculated. Thereafter the amount of remaining fuel in the vehicle is determined. Two categories of DTE are calculated, the first DTE is based on the fixed fuel economy and the second DTE is based on the fluctuating fuel economy. The second DTE, that is according to the fluctuating fuel economy, is worked upon by a compensation value so that its accuracy increases compared to that of the Initial DTE which is based on fixed fuel economy.

Intelligence is a learning process that makes us understand the problem, seek solution for it and to make decisions [6].By maintaining communication between man and machine through terminals provides a standard view on intelligence. the simulation of real world application "An Architecture For An Intelligent Home Automation System" [9] is a system that involves the techniques fulfilling the comfort and security requirements of private homes. This system is implemented in visual basic 6 and printer port is used to control the hardware. It controls the devices connected to the server computer through the use of client computer. It operates by controlling the hardware components by setting the alarm to switch ON/OFF a specific device at a specific time, senses the activities, and controls the AC Power switches to turn on or turn off the devices.

Water sensor, water level indicator and a power control switch together forms the hardware of the system. LED is used as water level indicator, which indicates the level sensed by the water sensor activates the different devices attached to it through the printer port.

IV. SOLUTION STRATEGY

Microsoft Visual Basic 2008 is the platform used for this application. SAPI (Speech Application programming Interface) [8][9] in which voice recognition engine is provided, is an API developed by Microsoft, which helps us in windows speech application. This can be used in Visual Basic to take input and give output through voice commands.GPS can be used to track the current location of the automobile. The route distance between the present location and the destination and altitude of the current location and destination can be found out using Google Map API version3, so one must have access to the internet. The straight line distance between the current location and the destination can be evaluated by a formula using the coordinates of source and destination and the radius of the earth. Ultrasonic sensor is deployed in fuel tank to determine the fuel level that can be used to calculate DTE value. Architecture of application is shown in figure 1.

The architecture illustrates an intelligent system which takes in the destination through user's voice command and produces the desired voice output by processing the values from tank level indicator module and GPS module using Google Map API.

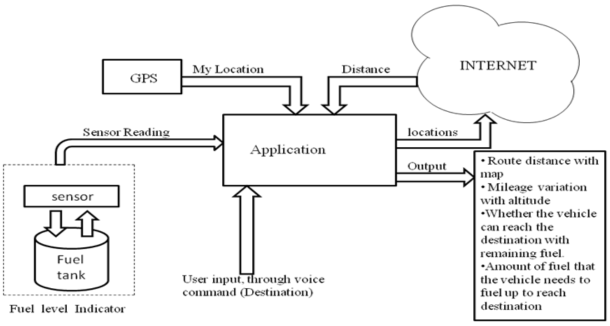


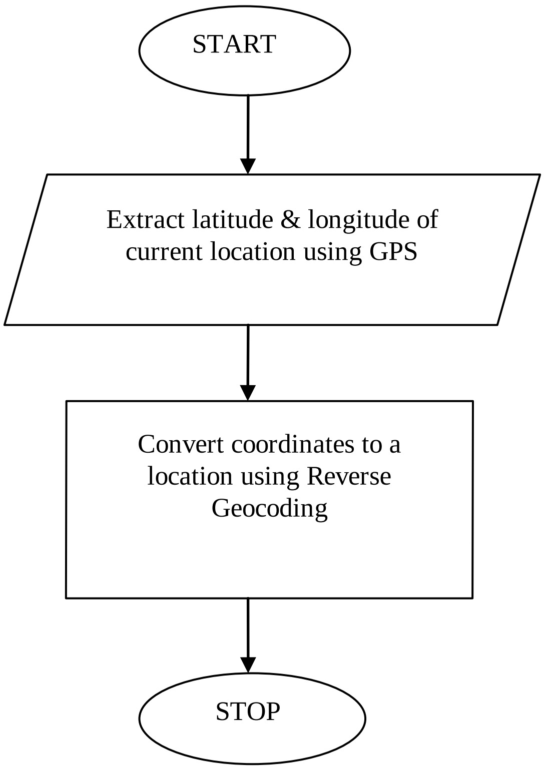
Fig 1. Architecture of "An Intelligent Voice Enabled DTE and Navigation System"

V. IMPLEMENTATION

The implementation part includes following modules:

A. Current location module

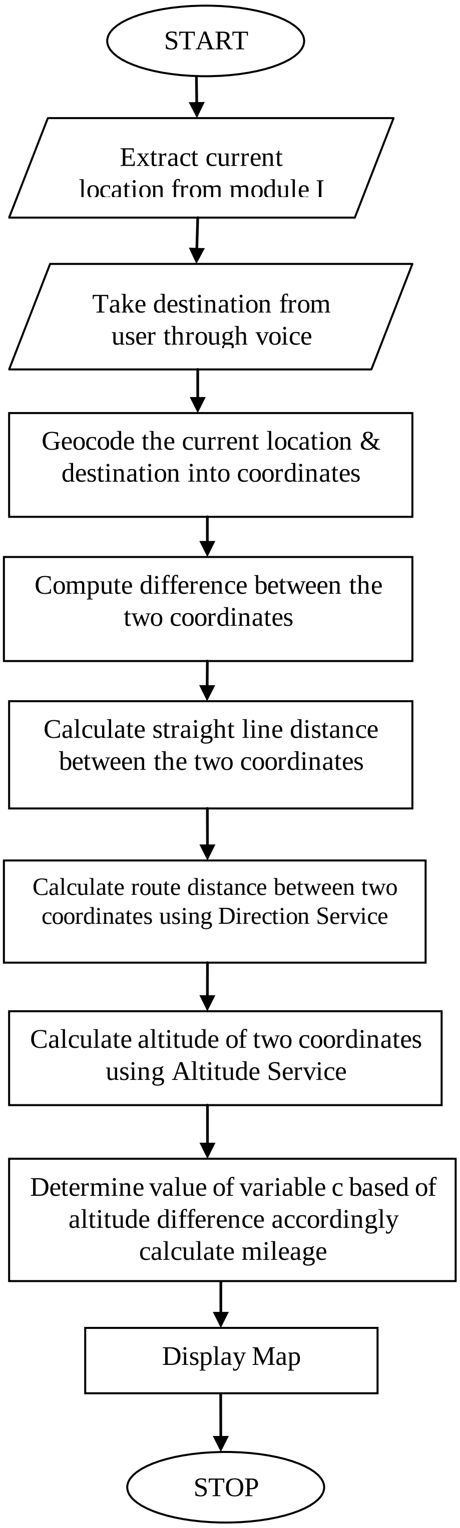
The current location of a vehicle can be found out using a GPS (Global Positioning System) and a method called Reverse Geocoding. Reverse Geocoding is a method of finding an address or any other type of resource for a given pair of latitude and longitude. The information about the current location i.e. coordinates (latitude and longitude) are extracted from the NMEA (National Marine Electronics Association) sentence provided by GPS receivers. These coordinates are encoded into the corresponding address using Reverse Geocoding.



Flow chart 1. Current location module

B. Distance between current location and destination module

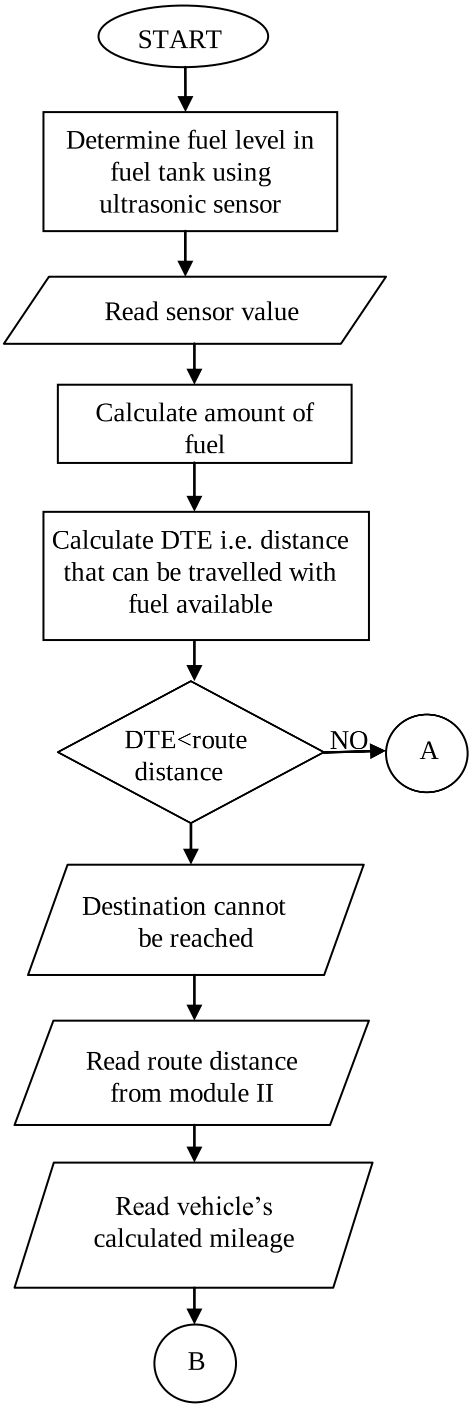
This module uses the output of the previous module discussed i.e. the current location module. The destination is entered by the user through voice command. The two locations are broken down to their corresponding coordinates using the method known as Geocoding. Geocoding is the method of extracting geographic coordinates from other geographic data. To find the straight line distance, a formula including coordinates and radius of the earth is used. Google Map API v3 is used to find out the route distance between the two locations. The output i.e. route distance is though voice. A map showing markers on the two locations along with highlighted route is displayed.

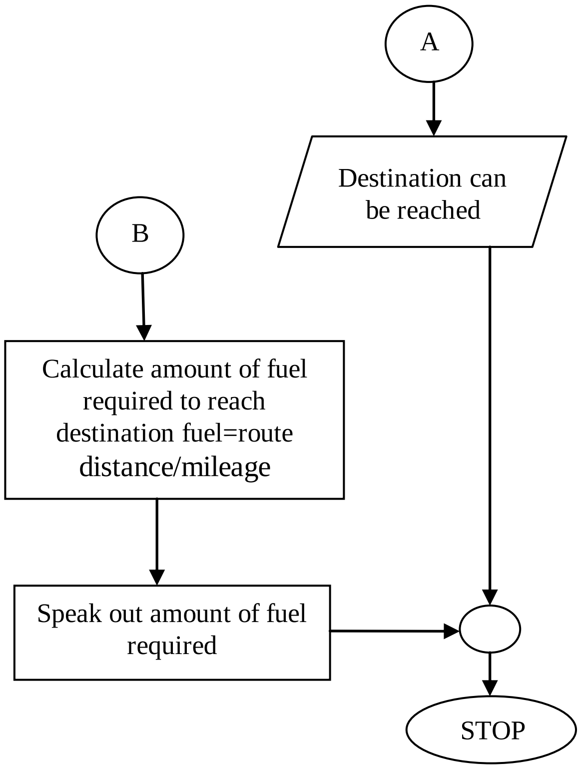


Flow Chart 2 : location and destination module

C. DTE and Fuel Requirement to reach Destination

For this module, an ultrasonic sensor is deployed in the fuel tank which measures the height up to which the tank is empty, thus level of the fuel in the tank is calculated. Using the fuel level the volume of fuel in fuel tank is determined. Applying the formula: mileage= (distance travelled/fuel amount), the distance which can be travelled with remaining amount of fuel i.e. DTE is calculated. If this DTE is greater than the route distance (route distance is determined in module B, i.e. “Distance between current location and destination” module) , the desired destination can be reached by a vehicle. If not, user will need to fill the fuel tank. To find out the amount of fuel needed to reach the destination can be calculated using the following formula: amount of fuel= (route distance/mileage).





Flow Chart 3 : DTE and fuel requirement to reach destination module

VI. RESULTS

Ultrasonic sensor has been used in the fuel tank indicator. The sensor generates high frequency sound waves and receives back its echo. The time interval between the transmitted wave and the received echo is calculated to determine the distance to an obstacle [10]. The “ECHO” ultrasonic sensor is mounted on the top of the fuel tank and it outputs the distance between the sensor and fuel level. The fuel tank is divided into ten divisions and three readings of fuel in tank for each source destination pairs are taken.

The straight line distance and route distance between the current location and the destination and altitude difference are found out using the Google map API with its services Geocoding, Reverse Geocoding, Direction Service and Elevation Services. The mileage is assumed to be 15km/ltr. The total amount of fuel required to reach the destination is found out by dividing the route distance by mileage (total fuel=route distance/mileage). Readings are taken for different levels of fuel in the tank (test cases: (i)8 litres left in the fuel tank (ii) 12 litres left in the fuel tank (iii) 32 litres left in the fuel tank (iv) 36 litres left in the fuel tank (v) 40 litres left in the fuel tank) for different source and destination pair, to find out whether the vehicle can reach the mentioned destination with remaining amount of fuel. If the vehicle cannot reach the destination with the remaining fuel then, how much additional amount of fuel is required to reach the destination is evaluated by the application. The readings are plotted against a table as follows:

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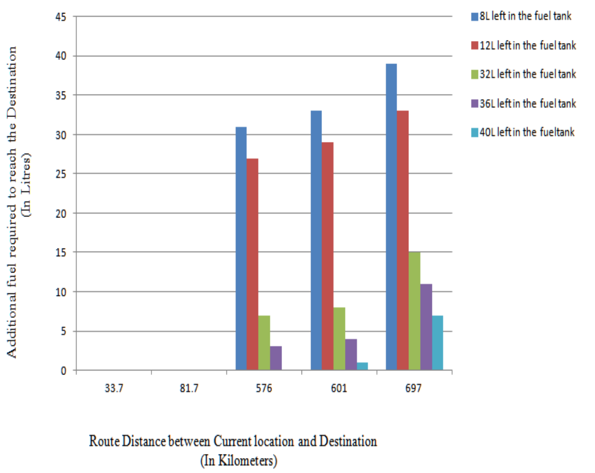
Table 1: Table showing the fuel required to reach the destination without considering altitude difference

Current location	Destination	distance	Additional Fuel Required to reach the Destination with :				
			8L left in tank	12 L left in tank	32L left in tank	36L left in tank	40L left in tank
Majitar	Gangtok	33.7km	0L	0L	0L	0L	0L
Majitar	Siliguri	81.7km	0L	0L	0L	0L	0L
Majitar	Asansol	576km	31L	27L	7L	3L	0L
Majitar	Durgapur	601km	33L	29L	8L	4L	1L
Majitar	Kolkata	697km	39L	33L	15L	11L	7L

Based on the above table, a graph is plotted. Here, a study is done to check the variation in the additional fuel required with the change in the current location and destination and change in residual fuel.

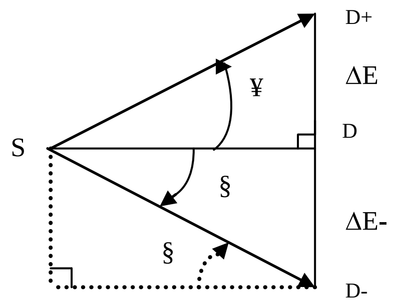


Graph 1. Comparision fuel required to reach the Destination

Altitude is an important factor that must not be overlooked/ ignored. It affects mileage value of an automobile. The mileage value varies with the difference of altitude between the source location and the destination location.

It is observed that, while travelling uphill, the mileage of an automobile decrease with a variable c, the value of which increases with the increase in the angle of altitude, resulting in greater consumption of fuel for a same route distance compared to the route distance without altitude. And it is seen that while travelling downhill, the mileage of an automobile increases with variable c, the value of which increases with the increase in angle of depression resulting in lesser amount of fuel consumption as compared with route distance without altitude.

Mathematical representation:



Assumption: Route distance is a straight line.

Sign convention:

Angle change is positive, if taken in clockwise direction, Angle change is negative, if taken in anticlockwise direction.

Formula used:

SinØ = perpendicular/ hypotenuse (using trigonometry)

Altitude Difference, ΔE = Destination altitude – Source altitude

Symbol used:

¥ =angle of altitude

§ = angle of depression

ΔE+=change in positive altitude

ΔE-=change in negative altitude or depression

S = source location

D+=destination location at altitude w.r.t to source location

D-=destination location at depression w.r.t to source location

D=destination location is at 0 altitude or depression w.r.t to source location.

Case1: when moving uphill

sin¥ = ΔE+ /Route distance

Case2: when moving downhill

sin§ = ΔE- /Route distance

Mileage calculation:

mileage of the automobile ,M

mileage- uphill: M-c

mileage-downhill: M+c

Where c is a variable depending upon angle of altitude (¥) or angle of depression (§) and the condition of road on which automobile will run.

The mileage of a vehicle increases while downhill and decreases while going uphill by a small factor "c". The following table shows the variation in mileage calculated by the application , due to uphill and downhill.

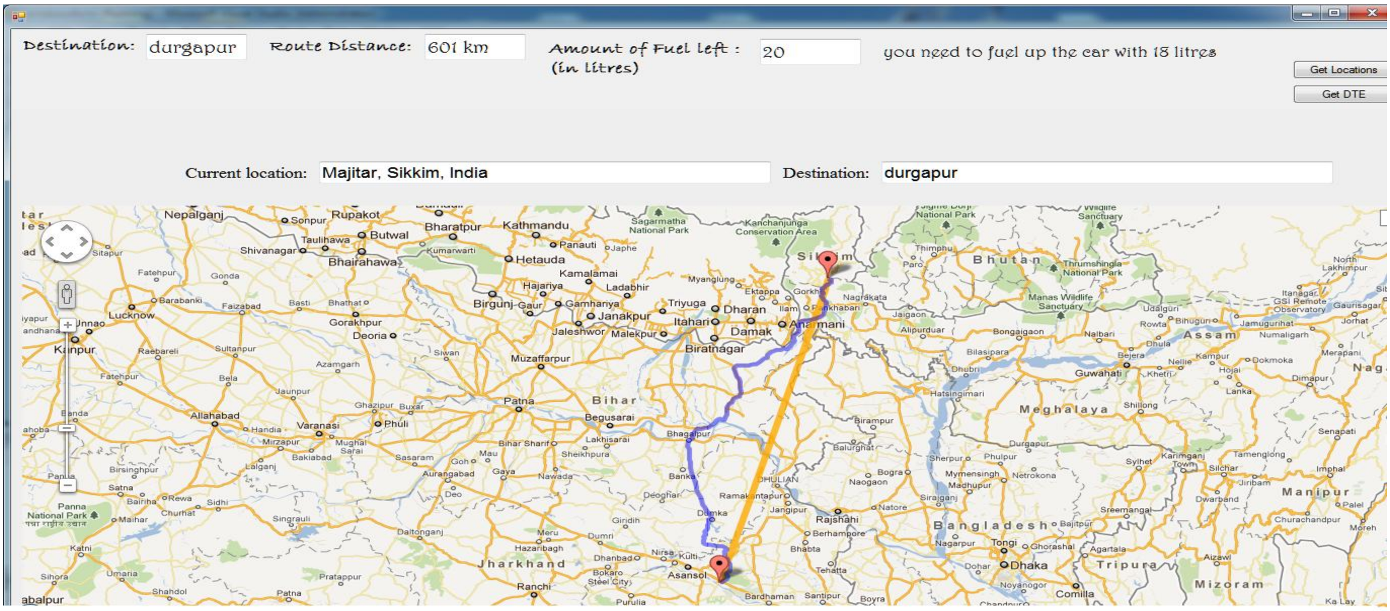
Table 2:Mileage calculation taking altitude difference in cosideration, where mileage of vehicle=15km/ltr

Present Location (PL)	Altitude of Present Location (APL)	Destination (DL)	Altitude of Destination (ADL)	Δε=ADL-APL	Uphill/down-hill	Mileage	Approx Mileage
Majitar	381.80	Gangtok	1507.94	1126.14	Uphill	M-c	12
Gangtok	1507.94	Majitar	381.80	-1126.14	Down-hill	M+c	18
Siliguri	122.00	Majitar	381.80	259.79	Uphill	M-c	14
Majitar	381.80	Siliguri	122.00	-259.79	Down-hill	M+c	16

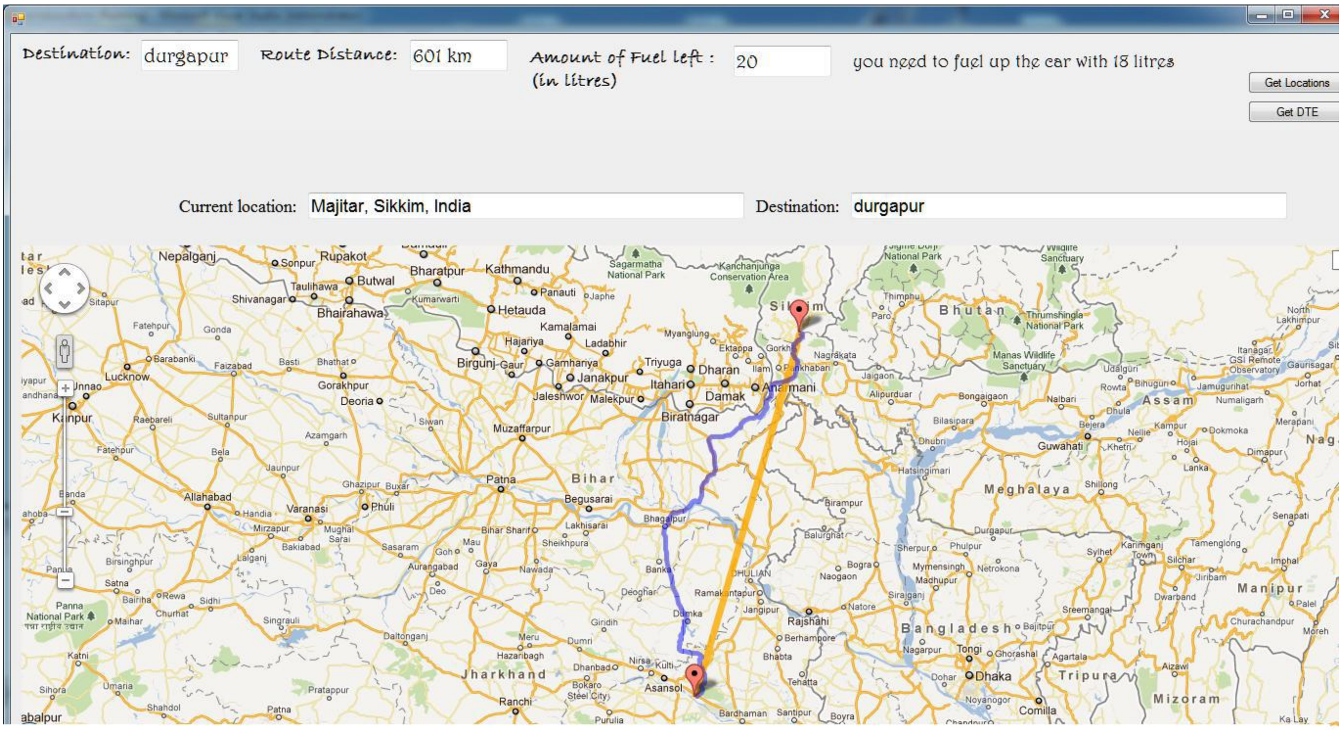
From the above table the approximate change in mileage due to altitude variation is known. So, the additional fuel required in the test cases already considered in table 1 will change, due to the change in mileage.This change is reflected in the following table.

Table 3: Table showing the fuel required to reach the destination considering altitude difference

source	Destination	Altitude Diff.	Approx. mileage (km/L)	Distance (km)	Additional Fuel required to reach the destination with: 8L left in tank	12L left in tank	32L left in tank	36L left in tank	40L left in tank
Majitar	Gangtok	1126.14	12	33.7	0L	0L	0L	0L	0L
Majitar	Siliguri	-259.79	16	81.7	0L	0L	0L	0L	0L
Majitar	Asansol	-264.91	16	576	28L	24L	4L	0L	0L
Majitar	Durgapur	-306.69	16	601	30L	26L	6L	2L	0L
Majitar	Kolkata	-367.85	16	697	36L	32L	12L	8L	4L



Snapshot 1: Snapshot showing the route distance, amount of fuel left, and fuel required to reach destination and a map where source is majitar and destination is gangtok



Snapshot 2: Snapshot showing the route distance, amount of fuel left, and fuel required to reach destination and a map where source is Majitar and destination is Gangtok

VII. CONCLUSION

"An Intelligent Voice Enabled Distance To Empty and Navigation System" can easily and successfully accept the destination through voice command and determine current location using global Positioning System. The current location and destination are the basic parameters of this application and the rest of the actions are carried out succesfully. This application can be deployed in vehicles and it helps the driver to get the knowledge of how much additional fuel is required to fuel up the vehicle to reach the desired destination. Not only route distance but altitude is also taken into account in overall evaluation. The major limitation is that it cannot be deployed in places where there is no network for internet connectivity. However, this drawback can be resolved by using offline maps and offline calculation to plot the current location and destination, route distance and altitude.

VIII. DISCUSSION

With the rapid evolution in automobile technology, the need of designing a Navigation and DTE System holds an important place in providing an efficient, reliable and accurate result to automobile drivers.

As Google map API version 3 is free of cost, provides numerous services which can be used in numerous ways for developing various navigational applications for automobile drivers to track the routes to the destination location. various intelligent algorithms such as Neural Network and Fuzzy Logic can be deployed in the application to enhance the flexibility and efficiency to greater extend. Cloud Computing can also be implemented for adding flexibility and synchronization of the Intelligent Navigation System.

This paper can be extended by deploying real time data such as traffic data, temperature etc. and offline map to make the navigational process more userfriendly and efficient.

We can improve the Navigational and DTE System to a great extend, by increasing the number of services and sensors.

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AUTHORS PROFILE

Dhruba Ningombam is currently with Deaprtment of Computer Science and Engineering, Sikkim Manipal Institute of Technology, India. Until now he has published two international conference proceedings. He did his Masters in Technology from Sikkima Manipal University, Gangtok, Sikkim India and Bachelor of Engineering from Government of College of Technology, Coimbatore, Tamil Nadu, India. His area of research areas includes artificial intelligence; robotics and computer graphics. He has also coached the team "Supernova" which stood on 24th position in 2006 at ACM international collegiate programming contest (ASIAN REGION) at Coimbatore and 13th position in 2007 at ACM international collegiate programming contest (ASAN REGION) at IIT Kanpur.

Chitra is currently an eight semester B.Tech student of Computer Science and Engineering Department, Sikkim Manipal Institute of Technology, Sikkim,India.

Nitashi Kalita is currently an eight semester B.Tech student of Computer Science and Engineering Department, Sikkim Manipal Institute of Technology, Sikkim,India.

Vinita Pat Pingua is currently an eight semester B.Tech student of Computer Science and Engineering Department, Sikkim Manipal Institute of Technology, Sikkim,India.