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Brief paper

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Autonomous Vehicle Navigation in Communication Challenged Environment - A Simulation Approach

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Keywords: vehicle navigation, connectivity maintenance, automation, monitoring, interface modules.

1. INTRODUCTION

This paper introduces two communication modules any autonomous vehicle requires- a Vehicle to Vehicle (V2V) communication and Vehicle to Tower (V2T) communication. Vehicle to Vehicle Communication refers to a communication module in which a vehicle communicates to the adjacent vehicle .the papers given in [1-5] ,give the idea about how to communicate the vehicle and navigate the same, but no one give the solution of vehicle automation. Vehicle to Tower communication refers to a communication module in which the vehicle communicates to a stationary tower the information regarding the vehicle and the adjacent vehicles. The communication module can be designed by any wireless module which may include Wi-Fi, RFID, ZIGBEE, Radio signals etc. The basic block diagram of such a system is shown in figure 1 and 2. The VB login page is created form [6].

1.1 Basic hardwares used

Autonomous vehicle navigation requires acquiring its global position. The position of any vehicle can be determined with help of longitude and latitude. The longitude and latitude of a vehicle can give the exact location of the vehicle on the surface of the globe. To avail this facility we make use of a GPS modem which can communicate to us the global position of the vehicle. A communication module like a Wi-Fi, RFID, ZIGBEE, Radio signals can be used to communicate with the nearby vehicles. A processing unit which involves a microcontroller or microprocessor or a RTOS can be used to compute the data obtained from the peripheral devices.

The basic components used for this vehicle automation are

1) A Processing Unit to process the data send in by the interfacing devices.

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2) A GPS module to get the Global Position of the Vehicle.

3) A communication module to communicate with the nearby vehicles.

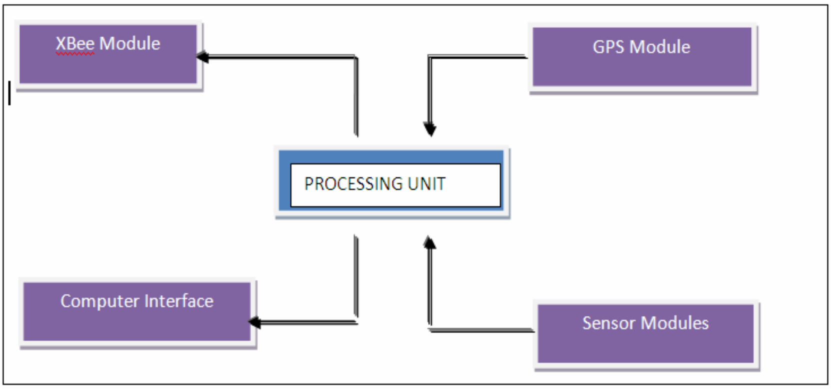


Fig 1. Basic Block Diagram of an Autonomous Vehicle Navigation System.

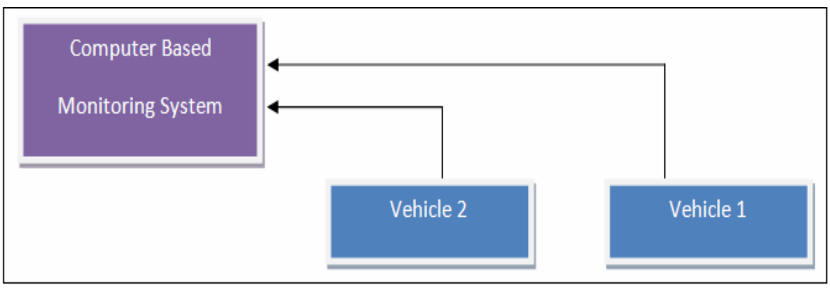


Fig 2. Basic Communication Module

1.2 Processing unit

A processing unit does the function of micro computer i.e. processing the data which is input through various input modules like sensors, image acquiring modules etc. A microcontroller (also microcomputer, MCU or µC) is a small computer on a single integrated circuit consisting internally of a relatively simple CPU, clock, timers, I/O ports, and memory. Program memory in the form of NOR flash is also often included on chip, as well as a typically small amount of RAM. There are various microcontrollers available for use. The selection of microcontroller is based on the requirements of the implementation such as the amount of internal memory required, the number of IO ports required, serial ports used etc.

1.3 GPS module

GPS stands for Global Positioning System. It is the basic way of locating a receiver in three dimensional spaces anywhere on the Earth. GPS is arguably one of the most important inventions of our time, and has so many different applications that many technologies and ways of working are continually being improved in order to make the most of it. In order for GPS to work, a network of satellites was placed into orbit around planet Earth, each broadcasting a specific signal, much like a normal radio signal. This signal can be received by a low cost, low technology aerial, even though the signal is very weak. The signals that are broadcast by the satellites carry data that is passed from the aerial, decoded and used by to the GPS software. GPS system is developed from the information obtained from [7-9].

The information is specific enough that the GPS software can identify the satellite, it’s location in space, and calculates the time that the signal took to travel from the satellite to the GPS receiver. Using different signals from different satellites, the GPS software is able to calculate the position of the receiver. The principle is very similar to that which is used in orienteering – if you can identify three places on your map, take a bearing to where they are, and draw three lines on the map, then you will find out where you are on the map. The lines will intersect, and, depending on the accuracy of the bearings, the triangle that they form where they intersect will approximate your position, within a margin of error.

GPS satellites circle the earth twice a day in a very precise orbit and transmit signal information to earth. GPS receivers take this information and use triangulation to calculate the user's exact location. Essentially, the GPS receiver compares the time a signal was transmitted by a satellite with the time it was received. The time difference tells the GPS receiver how far away the satellite is. Now, with distance measurements from a few more satellites, the receiver can determine the user's position and display it on the unit's electronic map. A GPS receiver must be locked on to the signal of at least three satellites to calculate a 2D position (latitude and longitude) and track movement. With four or more satellites in view, the receiver can determine the user's 3D position (latitude, longitude and altitude). Once the user's position has been determined, the GPS unit can calculate other information, such as speed, bearing, track, trip distance, distance to destination, sunrise and sunset time and more. Today's GPS receivers are extremely accurate, thanks to their parallel multi-channel design. Garmin's 12 parallel channel receivers are quick to lock onto satellites when first turned on and they maintain strong locks, even in dense foliage or urban settings with tall buildings. Certain atmospheric factors and other sources of error can affect the accuracy of GPS receivers. The 24 satellites that make up the GPS space segment are orbiting the earth about 12,000 miles above us. They are constantly moving, making two complete orbits in less than 24 hours. These satellites are travelling at speeds of roughly 7,000 miles an hour.

GPS satellites are powered by solar energy. They have backup batteries onboard to keep them running in the event of a solar eclipse, when there's no solar power. Small rocket boosters on each satellite keep them flying in the correct path. GPS satellites transmit two low power radio signals, designated L1 and L2. Civilian GPS uses the L1 frequency of 1575.42 MHz in the UHF band. The signals travel by line of sight, meaning they will pass through clouds, glass and plastic but will not go through most solid objects such as buildings and mountains. A GPS signal contains three different bits of information - a pseudorandom code, ephemeris data and almanac data. The pseudorandom code is simply an I.D. code that identifies which satellite is transmitting information. You can view this number on your Garmin GPS unit's satellite page, as it identifies which satellites it's receiving. Ephemeris data, which is constantly transmitted by each satellite, contains important information about the status of the satellite (healthy or unhealthy), current date and time. This part of the signal is essential for determining a position. The almanac data tells the GPS receiver where each GPS satellite should be at any time throughout the day. Each satellite transmits almanac data showing the orbital information for that satellite and for every other satellite in the system. The other modules like MP lab and PIC coding is developed from the references [10-14].

1.4 Features for selection of a GPS module

There are several performance characteristics of a GPS system. Starting with power up, the first characteristic is how quickly the module can obtain a lock. A lock is made when the module can receive the GPS signal from enough satellites to calculate position. The amount of time required is referred to as the start time. Other performance concerns are the positional accuracy of the module, and how well it gets and holds a lock in the presence of obstacles (urban settings, canyon areas, etc). These performance characteristics depend on several technological differences. The number of satellite channels the module can simultaneously receive is an important spec. GPS modules today can receive up to 20 channels. More channels mean more places for the module to look for a signal, corresponding to faster locking times and better locking in urban settings. Onboard processing of the GPS signal is also an important factor. Newer chipsets, such as the SiRF III provide faster and more robust locking than previous SiRF II based designs. New features such as the wide area augmentation system (WAAS), or differential GPS (DGPS) provide better positional accuracy by correcting GPS signals using other sources (such as ground stations).

2. METHOD OF OPERATION

Initially the vehicle receives the information of the current location from the GPS module. Once the vehicle receives the information on the current location, the processing unit in the hardware does the function of extracting information from the GPS data .The information from the GPS receiver involves the longitude, latitude, current time. This information is stored in the computer database of each vehicle. The GPS to vehicle communication is shown in figure 3.

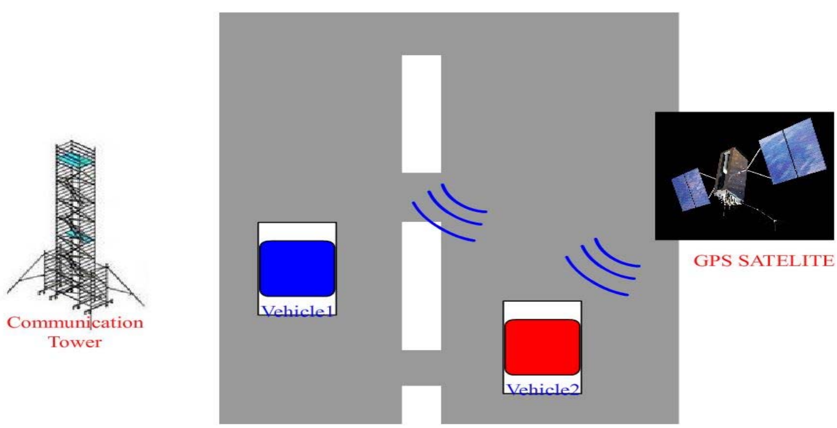


Fig 3. GPS to vehicle communication

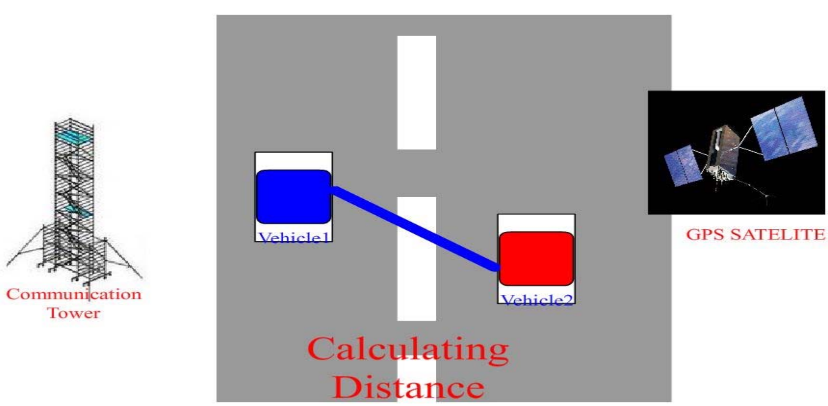


Fig. 4 Calculating the distance between vehicles.

Once the vehicle receives the GPS data the vehicle will calculate the distance with the nearby vehicle .Fig 4 shows how the distance is calculated. The distance can be calculated with the help of laser up to 30 with cm accuracy.

The distance and the current location when communicated with the nearby vehicles along with their unique ID which each vehicle has. Fig 5 show how the vehicles communicate with each other. This Information will provide the correct location of each vehicle with respect to each other vehicle.

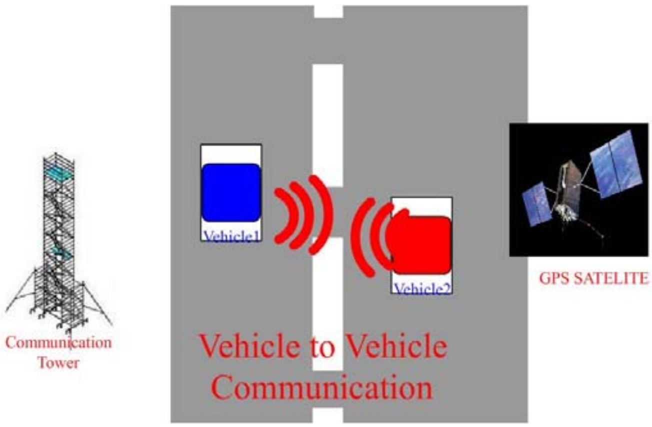


Fig 5. Vehicle To Vehicle Communication

Now the vehicle is completely aware of its current position with respect to the GPS and also with respect to the nearby vehicle. This information is communicated to the Tower where the data is stored and analysed. Fig 6 shows how the vehicle communicates with the tower. This helps the vehicle to map the position of each vehicle with respect to each other.

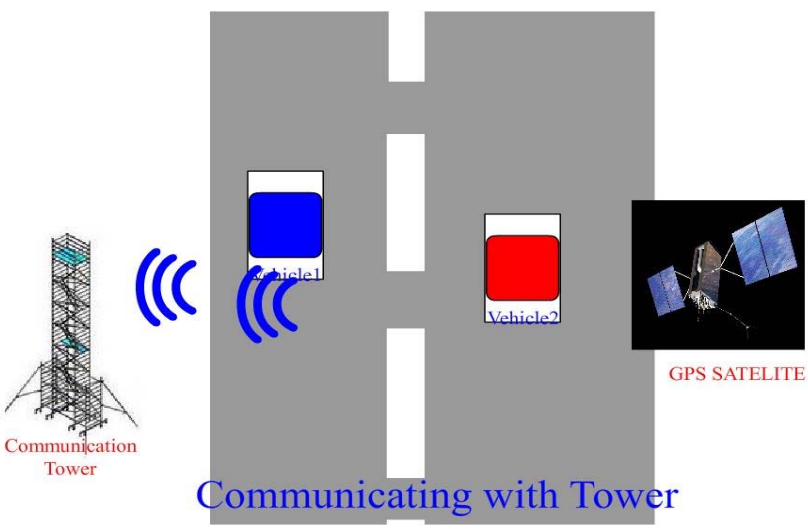


Fig 6. Vehicle to Tower Communication Module

For example, a vehicle with an ID 1111 communicates with the tower that another vehicle with ID 2222 is in to the right at a distance of 10 m and another vehicle with ID 3333 is at a distance of 5m to the front. This information will enable the tower to get a clear map of the location of each vehicle with respect to other. Vehicle location mapped into the computer is given in figure 7 and 8.

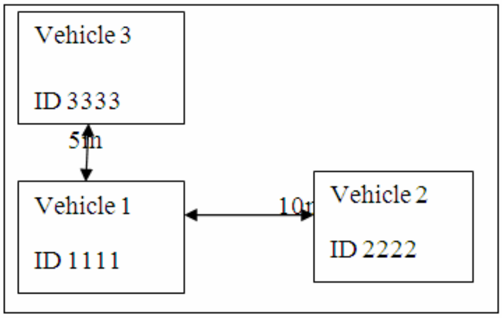


Fig 7. Vehicle location mapped into the computer

Thus with this map in memory the tower will be able to communicate with the vehicle instructions for the navigation without any collision.

ID3333	X
ID1111	ID2222

Fig 8. Vehicle Location mapped into the computer.

With the memory map and determining the distance of each vehicle with respect to other, it will be possible to calculate the speed of the vehicle as change of distance with respect to the vehicle. This will enable the avoid any collision as if the speed of the vehicle ahead of a particular vehicle is greater than the other vehicle , the speed of the vehicle should be limited to a speed lesser than that vehicles speed. Even when the speed of the vehicles to the right and left fall below a threshold value, alert signals can be generated to either vehicles avoid possible collision.

3. CIRCUIT DESCRIPTION

The Microcontroller PIC 16F877A is the central unit of the circuit where actually the processing of all the data acquired from the various interfaced devices like GPS modem and Zig Bee are received. The circuit is powered by a 5 V supply which is given to the microcontroller through a voltage regulator IC 7805. IC 7805 regulates the input voltage and gives as output 5v. Input voltage can vary from 6v to 12v. The circuit diagram of the devices interfaced for autonomous vehicle navigation is given in figure 9. The oscillatory circuit provides the oscillation required for the operation of the microcontroller. The two pins of the crystal oscillator is connected to the 14^{th} and 15^{th} pin of the microcontroller along with capacitors. The project requires the use of both the GPS modem and a Zig Bee modem. Since both the devices as interfaced using the serial port and only a single serial port is available in the PIC microcontroller, a transistor based switching circuit is used. The working of this circuit is based on the simple principle that whenever a base voltage is available, the transistor starts conducting. Now the base of the microcontroller is connected to four pins of the microcontroller which when set to high will activate the device to start the device. A MAX 232 IC is used to communicate a microcontroller with a computer. The MAX 232 IC is connected to the TX and RX pins of the microcontroller. When data is send throught the TX pin it is read and converted MAX 232 to be read by the computer.

Similarly, when the computer sends as data it is received by the MAX232 IC and is converted so as to be read. The circuit diagram for this method is shown in figure 9.LCD is also attached to the microcontroller. A LCD is a Liquid Crystal Display .It display the data send from the microcontroller. A LCD has 16 pins.

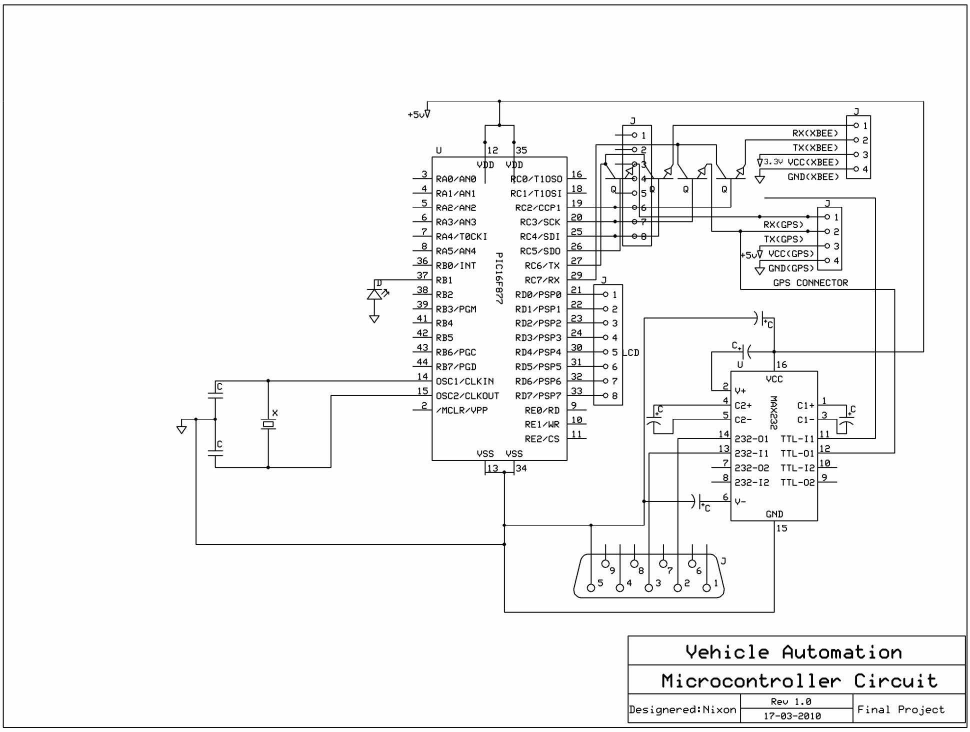


Fig 9. Devices interfaced for autonomous vehicle navigation

3.1 Algorithm

Step 1**:** Start

Step 2 : Initialize the variables to be global variables to be used for the project.

Step 3: Initialize the global functions used throughout the program.

Step 4: Initialize the Ports used for communicating with the peripheral device.

Step 5: Initialize the serial port.

Step 6: Read the data from the serial port.

Step 7: If the data read from the serial port is “$GAGLL” Goto Step 8 else Goto Step 6.

Step 8: Read the data required from GPS data such as the Longitude and Latitude.

Step 9: Store the data in a separate variable.

Step 10: Display the variable in the LCD unit.

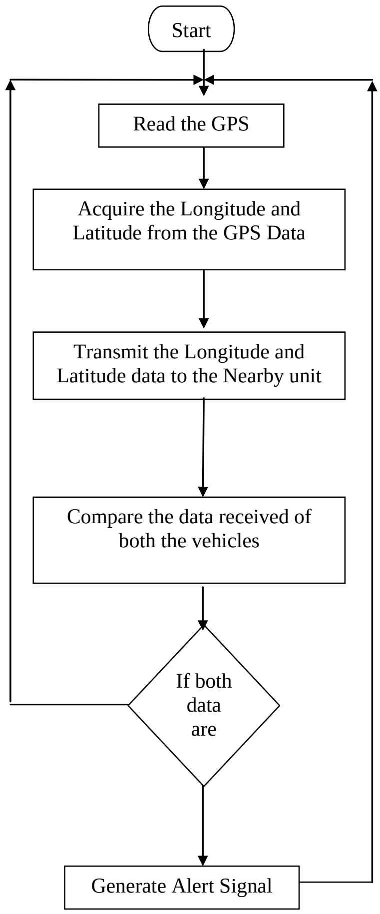
Step 11: Transmit the data through the ZigBee module to the nearby unit.

Step 12: Transmit the unique Vehicle ID read from the EEPROM of the microcontroller through the ZigBee module.

Step 13: If the present location of the GPS module and the GPS data received from the ZigBee module is equal trigger an alert signal by glowing the LED

Step 14: Goto Step 6

3.2 Flow chart



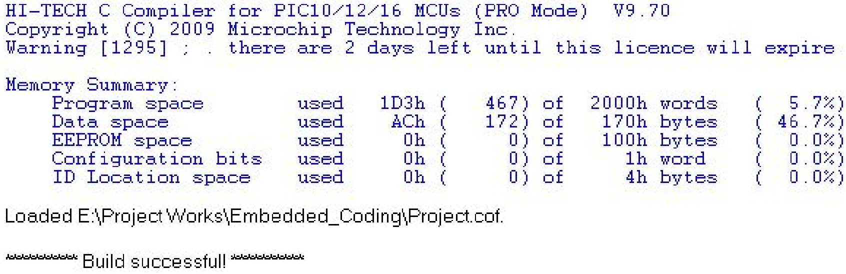
4. SIMULATION

4.1 MPLAB simulation

The figure.10 shows the successful simulation of the code. It shows the amount of memory used by the program memory of the whole available memory and space occupied by the data in the program. The output file is stored in the location given in .cof format. Cof format is used for simulation of the code in an IDE like MPLAB.

4.2 Visual basic simulation

Visual Basic is used to develop an interface which helps in viewing the data received from the GPS module. User authentication is a very important feature that is added with the Interface. Only an authorized user will be able to Login into the system. Once the user logs in he gets access to view and edit features required to interface with the serial port. Fig 11 shows the login page where the user enters the Username and Password.



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HI-TECH C Compiler for PIC10/12/16 MCUs (PRO Mode)  V9.70
Copyright (C) 2009 Microchip Technology Inc.
Warning [1295] ; . there are 2 days left until this licence will expire

Memory Summary:
    Program space          used   1D3h (   467) of  2000h words   (  5.7%)
    Data space             used    ACh (   172) of   170h bytes   ( 46.7%)
    EEPROM space           used     0h (     0) of   100h bytes   (  0.0%)
    Configuration bits     used     0h (     0) of     1h word    (  0.0%)
    ID Location space      used     0h (     0) of     4h bytes   (  0.0%)

Loaded E:\Project Works\Embedded_Coding\Project.cof.

********** Build successful! **********
```

Fig.10 Compilation and Built Successfully

Fig 11. Visual Basic User Login Interface

The authorized user logs in and connects to the microcontroller with user interface. Fig 12 shows a logged in screen where the user will be able to select the Baud rate, the Port, the number of data bits, parity to connect to the serial device. A provision for command string has been given through which the user can enter the command strings to the device.

Fig 12. Logged In Window

The interface also has a Read GPS Data button which read the GPS data and extracts the relevant data required such as the Time , Longitude ,Latitude the direction and it is displayed in figure 13.

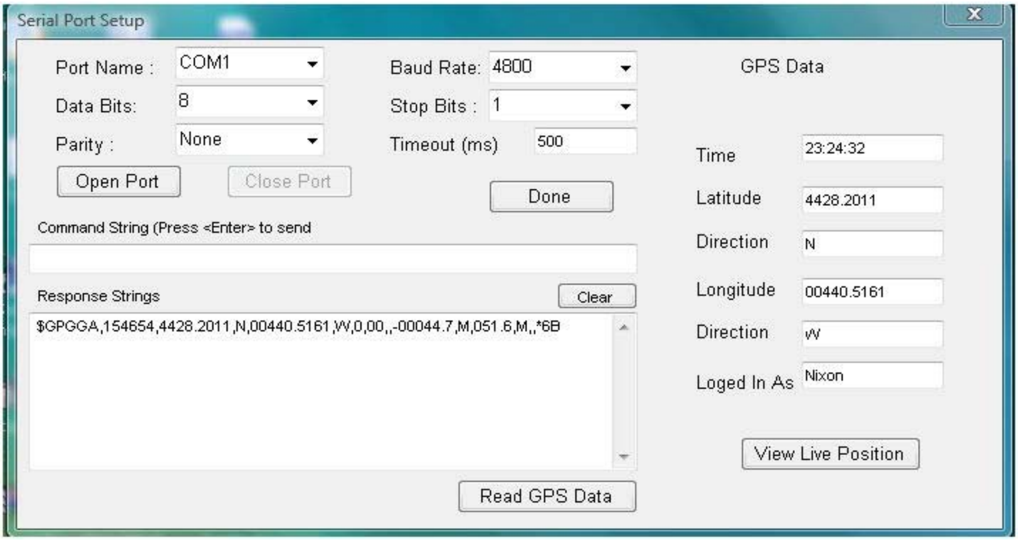

Fig 13. Extracting Data From the GPS MODEM Serial Output

In figure 14, Live Position gives the current position of the vehicle. This enables the user to view where the vehicle is heading to .this data can be transmitted to a nearby server where all the data relating to a particular vehicle can be stored.

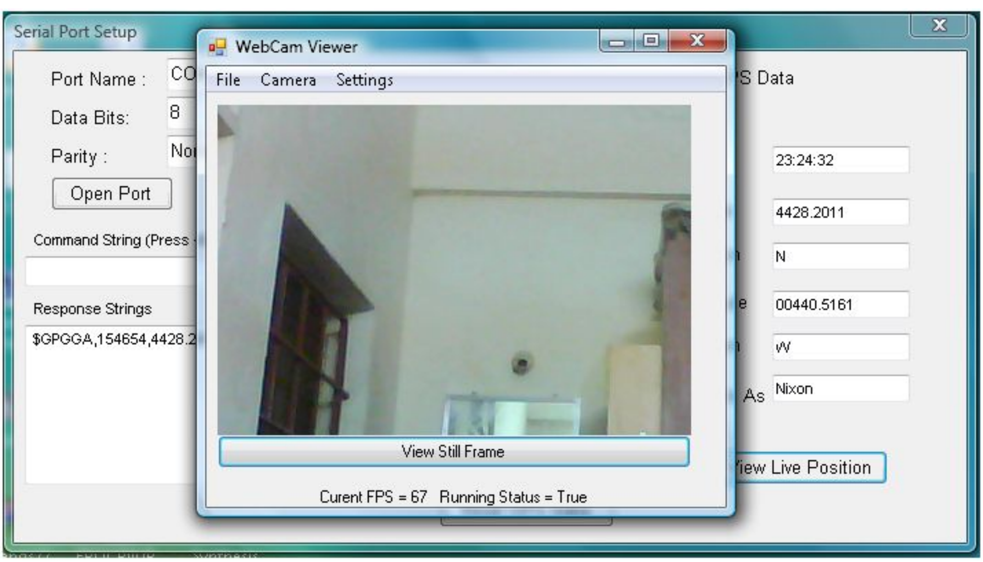

Fig 14. Viewing the Current position of the vehicle through the VB Interface

5. CONCLUSION AND FURTHER SCOPE

In conclusion, this project has been able to successfully build a system which is able to communicate with the nearby vehicles on its real time position and take decision based on the inputs from the other vehicles around it. There can be additional features which can be added on to the project which will ensure maximum security and maximum efficiency of the data received by the vehicle. Autonomous Vehicle Navigation is a dream which will come to reality in near future. Vehicles with build in computing system which performs real time calculations based on environmental inputs will come into existence. Vehicles will be able to adapt themselves to new surroundings which will prove to be a boon to mankind. Autonomous Vehicle Navigation is an area of research with in numerous scope of technological advancement. This project is just a step to achieving a communication module between two vehicles on move. There are infinite other factor that are to be developed before the fruit of the research can be achieved. Vehicle navigation in not confined to a particular filed alone but required inputs from various branches of Electronics and Mechanical like image processing, communication, signal processing, etc.

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