# ADAPTIVE VEHICLE SPEED MONITORING AND COTROL USING GPS

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***Abstarct* -- Achieving automatic vehicle speed monitoring and control with minimum add-ons ensures that the size and the cost of the vehicle does not increase significantly. In this paper, GPS has been used to achieve speed determination and speed control based on the current vehicle location. The entire geographical region has been divided into finite sized cells for speed assignment. The system can be implemented in a variety of vehicles right from auto rickshaw, taxis to the luxurious SUVs. Also, the idea can be extended to dynamically change the speed-limit of a cell based on the traffic density in the cell.**

***Keywords – GPS, ECU, Microcontroller, Google maps, Kalman Filter***

## I. INTRODUCTION

Every year, millions of precious human lives are lost all over the world due to road accidents. A major reason for this is over-speeding of the vehicles, which also leads to engine damage. With this in backdrop, it becomes necessary to incorporate systems in cars that would keep a check on vehicle speeds and prevent over-speeding, directly or indirectly.

Thus, the concept of *driver assistance* comes into picture. Such systems, when incorporated with a safe Human-Machine interface, increase car and road safety. A lot of research has already been carried out for the development of embedded systems in this regard. [1] discusses about an onboard speed regulation module for vehicles which can monitor as well as control their instantaneous speed in comparison with the maximum permissible speed of that location. The location is determined using GPS and GSM modules. It also talks about a unique position matching algorithm. [2] talks about a GPS enabled speed regulation module that slows down an overspeeding vehicle by sending signals to the engine control unit(ECU). Speed regulation is carried out using vehicle speed sensor(VSS) and engine RPM(rotations per minute) signals. Mohammad A. Al-Khedher in [3] has elaborated about a hybrid GPS-GSM localization system. He also talks about GPS reading correction using Kalman filter. Greenfeld in [4] mention about the technique for plotting GPS locations on map.

There is still a scope of improvement in the area of embedded system design and implementation for vehicle speed control. This paper proposes a system that calculates instantaneous vehicle speed using GPS readings and slows the vehicle down in case of overspeed. A validating algorithm is used to validate the GPS readings. Kalman filter is used to filter out these readings. Haversine formula is used to calculate instantaneous speed of the running vehicle. An audio and visual warning is issued to the driver in case of over speeding. Appropriate signals for ECU are generated. We made test runs of our system using a small self built car model, the results of which are discussed in the section VIII.

## II. SYSTEM BLOCK DIAGRAM

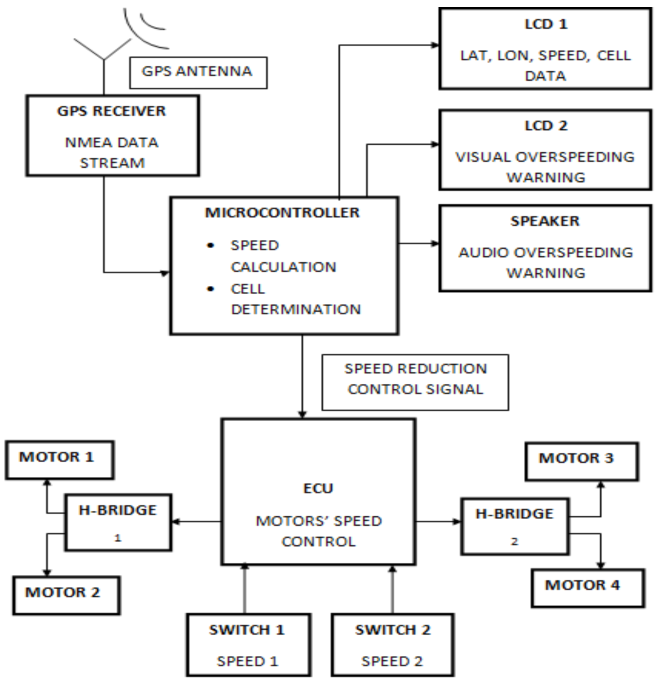


Fig. 1. Embedded system block diagram

Fig. 1. gives a systematic representation of our module. GPS receiver collects data, which is processed by the microcontroller. Signal sent from microcontroller is used for slowing down the overspeeding vehicle.

## III. HARDWARE DESIGN

For practical testing of the system, we built a small car model. A microcontroller is used to model both the signal processor and the ECU. Two H-Bridge ICs are used to make our four DC motors run, each H-Bridge controlling two motors. H-Bridge is a necessity as motors require more current and voltage to operate then the microcontroller output pins can supply. The DC motors draw a lot of current and generate tremendous amount of noise. Hence, they are not powered from the microcontroller. Additionally, we can control the direction of motor rotation using a H-Bridge. We interfaced an ultra high sensitivity and low power GPS receiver module to the microcontroller. Two 16*2 LCDs and a speaker are also interfaced for the purpose of driver warning.

## IV. DATABASE DESIGN

The effective system design required an efficient database of speed limits for different geographical regions. Fig. 2. shows a sample cell division. The database is hardcoded in the microcontroller memory and can be easily updated.

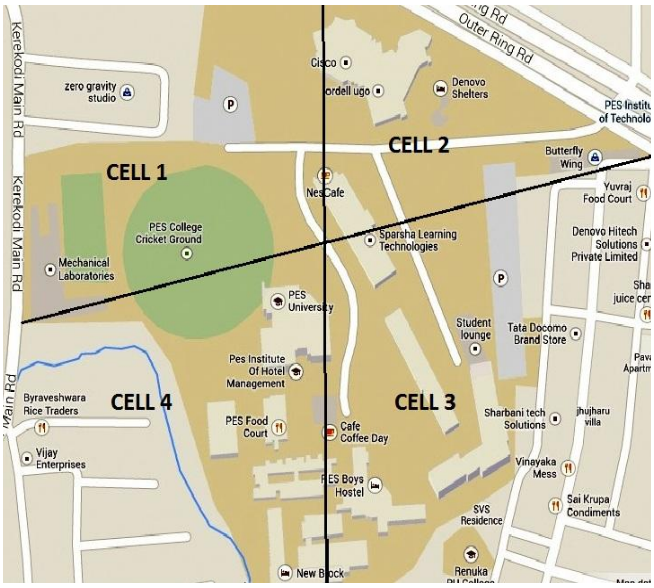


Fig. 2. Cell Demarcation for PESIT,Bangalore

## V. GPS READING VALIDATION AND KALMAN FILTERING

The GPS module outputs its data in the standard NMEA-0183(National Marine Electronics Association) serial data transmission protocol. Out of the commonly available NMEA sentence types, we made use of $GPGGA type, because of the relevance to our application. The module first reads the data in all the formats, buffers the required format and then prints the buffered data using the switch statements.

Kalman filter is used to clean the received GPS data. Kalman filter is an optimal estimator that infers parameters of interest from indirect, inaccurate and uncertain observations.

## VI. CODE FLOW

The ECU and the controller are programmed separately to accommodate timing constraints. A generalized pseudo code is as follows.

```
------------------------------------------------------------------------
PSEUDOCODE 1:
------------------------------------------------------------------------
Set pins for motor1
Set pins for motor2
Set pins for motor3
Set pins for motor4
Set Enable pin for H-bridge1
Set Enable pin for H-bridge2
Set Enable pin for H-bridge3
Set Enable pin for H-bridge4
Set pin for speed1
Set pin for speed2
Set pin to communicate control signal1
Set pin to communicate control signal2
SETUP
  Begin serial communication-9600bps
  Define input and output pins
  Set enable pin for 4 H-bridges
END SETUP
LOOP
  Set direction for 4 motors
  IF speed1>0
    Run car at speed1
  ELSE IF speed2>0
    Run car at speed2
  END IF
  Read control signals
```

```
  IF over_speed>0
    IF cell>0
      Set speed to cell1 speed-limit value
    ELSE
      Set speed to cel12 speed-limit value
    END IF
  ELSE
    Run car at default (or current) speed
  END IF
END LOOP

Initialize required variables
Counter=0
SETUP
  Set pins as input and output
  Give default values for control signals
  Clear data array
END SETUP
LOOP
  Check for data on serial port
  Separate $GPGGA string from other data coming out of GPS receiver
  Convert character (lat,long) readings to float
  IF lat!=89.6 && long!=0
    Use haversine formula to find speed of car
    Counter=0
  ELSE
    Update counter
  END IF
  WHILE (lat,long) is in specific range
    Assign corresponding cell number through signal "cell"
    Assign speed_limit corresponding cell number
   END WHILE
  IF current_speed > speed_limit
    Over_speed=1
  ELSE over_speed=0
  END IF
END LOOP
```

---------------------------------------------------------------------------

## VII. INSTANTATNEOUS SPEED CALCULATION USING HAVERSINE FORMULA

The speed calculation from GPS readings was carried out using Haversine formula. We choose to calculate speed on our own rather then taking it from an odometer because an odometer would have been an additional feature that would have required extra space. Moreover, we get accurate instantaneous speed using our method.

The haversine formula remains particularly well-conditioned for numerical computation even at small distances ,unlike calculations based on the spherical law of cosines. It gives well-conditioned results down to distances as small as a few metres on the Earth's surface.

For any two points on a sphere, the haversine of the central angle between them is given by

$$hvs(d/r) = hvs(ø_2-ø_1)+\cos(ø_2)\cos(ø_1)hvs(\lambda_2-\lambda_1) \quad (1)$$

where hvs is the representation for haversine function defined as

$$hvs(\theta)=\sin^2(\theta/2)=(1-\cos(\theta))/2 \quad (2)$$

If *d* is the distance between the two points

and if *r* is the radius of the sphere

- $ø_2,ø_1$ : latitude of point 1 and latitude of point 2
- $\lambda_2 ,\lambda_1$: longitude of point 1 and longitude of point 2
- d/r is the central angle, assuming angles are measured in radians

Solving for *d* by applying the inverse haversine

$$D=hvs^{-1}(h)=2r\arcsin(\sqrt{h}) \quad (3)$$

where $h = hvs(d/r)$, h should not exceed 1.

Therefore,

$$D=2r\arcsin(\sqrt{(hvs(ø_2- ø_1)+ \cos(ø_2)\cos(ø_1)hvs(\lambda_2 - \lambda_1))})$$

$$=2r\arcsin(\sqrt{(\sin^2((ø_2- ø_1)/2)+\cos(ø_2)\cos(ø_1)\sin^2((\lambda_2-\lambda_1)/2))} \quad (4)$$

Once we have distance with us, speed calculation involves mere division of the distance with the time. For our system, we calculated speed at every one second.

## VIII. FIELD TESTING AND RESULTS

Test runs for the car model were made at two different locations in Bangalore,India. Different speed limits were assigned for both the regions. The car was made to run at a speed greater than the speed limits. The speed reduction was successfully achieved at both the locations.

Table. 1. Contains the GPS readings of four different locations inside PESIT,Bangalore, obtained using the G-Map and the GPS receiver.

Table. 1. GPS Readings Comparison

| | GOOGLE MAP READING | | GPS READING | |
|---|---|---|---|---|
| | Latitude | Longitude | Latitude | Longitude |
| Parking Lot (1) | 12.93398 | 77.53562 | 12.55830 | 77.32246 |
| MRD Block (2) | 12.93564 | 77.53524 | 12.56256 | 77.32593 |
| Mech Lab (3) | 12.93496 | 77.53329 | 12.56258 | 77.32228 |
| G Block (4) | 12.93375 | 77.53398 | 12.56384 | 77.46244 |

*A. Accuracy of the GPS receiver*

Due to practical limitations, the readings of the GPS receiver will have errors. Every 1 degree of latitude spans a distance of 111.18km. So, even an error of 0.1 degree can cause an error of nearly 11km.

When we went out for field work with our GPS receiver, we found that, all our latitude readings had an error of around 0.37degrees and the longitude readings had an error of around 0.21 degrees. So, the erroneous location can be as far as 40-45km from the actual location. This can prove to be very exorbitant because the cell size itself can be lesser than this number.

Hence, there is higher probability that the cell in which the vehicle is travelling is totally different from the cell identified by the system. As a result, speed control might not happen as intended.

This problem can be solved in two ways; either change the receiver to a more sensitive one or analyze the error distribution and make the system as accurate as possible.

Analyzing the error gave us a clear indication that the error is always positive and is uniformly distributed. So, the constant error value can be added to the practical values obtained from the receiver to get the actual lat-long readings. Then, the rest of the system can work on" real-time location-based speed-limit allocation". Hence, we decided to go about with this approach.

Fig. 3 and Fig. 4 show the comparison between the GMAP and the practical readings at the four different locations given in the Table. 1.

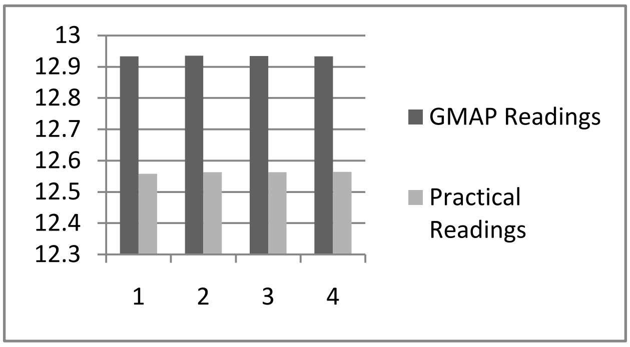


Fig. 3. Latitude Readings

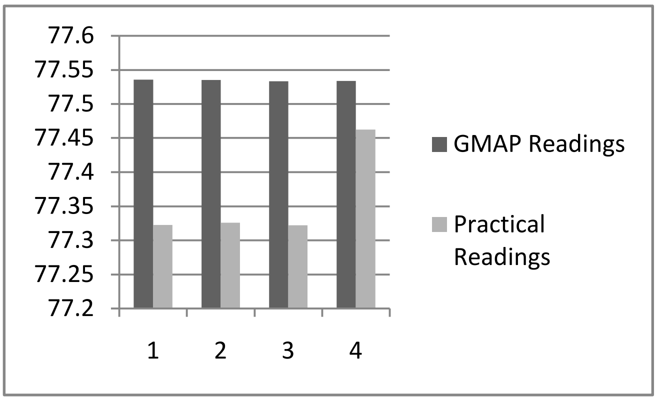


Fig. 4. Longitude Readings

The errors in the GPS latitude and longitude readings are as shown in the Fig. 5 and Fig. 6.The latitude error ranges over 0.37 to 0.376.

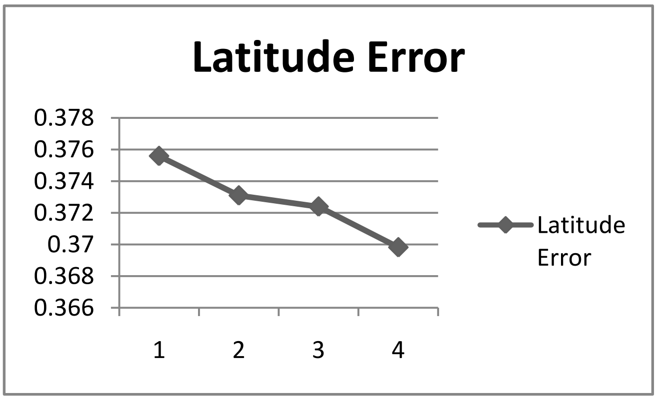


Fig. 5. Latitude Error

The longitude error ranges over 0.055 to 0.2.

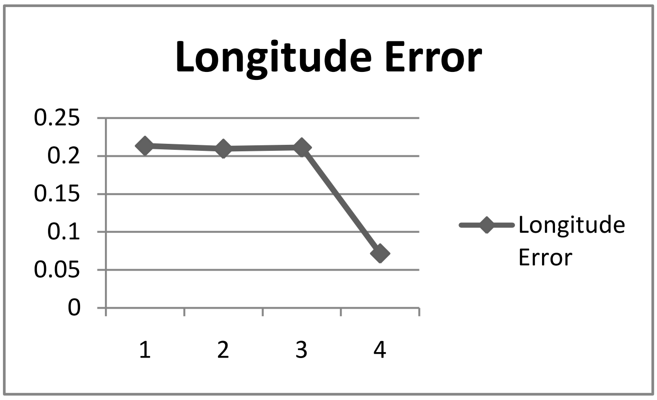


Fig. 6. Longitude Error

The Fig. 7 & 8 show the partial LCD display reading in the two geographical cells with different speed limits.

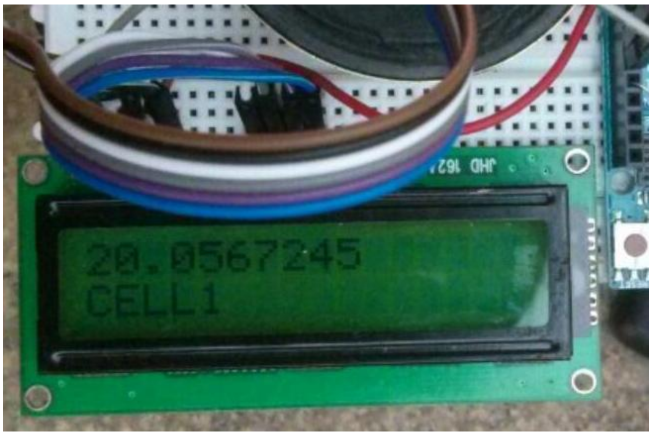


Fig. 7. LCD display in Cell 1


Fig. 8. LCD display in Cell 2

## IX. CONCLUSION

This model can not only be used to limit the speeds based on its location and speed limit defined for that location, but also, helps the traffic police. This project can build a symbiotic relationship between the traffic police and normal public. This is explained here: Since the vehicle is slowed down on an occasion of over-speeding, the speed of the vehicle is always within the speed limit defined for that area. This reduces the job of the traffic police, who have to chase the over-speeding vehicle to fine them. This also saves money of drivers who over-speed without knowing speed-limit of the area in which they are driving. Moreover, in many of the Indian metropolitan cities, reception of such fines repeatedly leads to cancellation of the driver's license. With such a system implemented, there is no arousal of such a situation. All these are bonus to saving many lives by not over-speeding. This summarises the importance of need for such a system, especially in Indian cities.

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