



Final Report

ME4342

Driver Fatigue Detection System

By

Index No.	Name	Marks
090027U	B.S.Ariyaratna	
090166T	S.D.Gunawardhana	
090565P	L.N.S.Wijayasingha	

**Department of Mechanical Engineering
University of Moratuwa
Sri Lanka**

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DECLARATION

This report contains no material which has been accepted for the award of any other academic qualification in any University or equivalent institution in Sri Lanka or abroad, and that to the best of our knowledge and belief, contains no material previously published or written by any other person, except where due reference is made in the text of this report.

Index No.	Name	Signature
090027U	B.S.Ariyaratna	
090166T	S.D.Gunawardhana	
090565P	L.N.S.Wijayasingha	

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B.S.Ariyaratna

S.D.Gunawardhana

L.N.S.Wijayasingha

ABSTRACT

Several approaches were proposed for the detection and prediction of drowsiness. The approaches can be categorized as estimating the fitness of duty, modelling the sleep-wake rhythms, measuring the vehicle based performance and online operator monitoring.

This paper is the culmination of work to determine if steering behaviour could be used to detect driver fatigue. Driver fatigue can be detected using steering wheel angle and angular velocity. There are different algorithms that can be used for the detection. This driver fatigue warning system is used algorithm of a time-based one and it detects delayed feedback of the driver using steering angle and angular velocity.

This steering-based fatigue detection system can detect drowsiness of drivers according to steering behaviour and able to give pre-warnings and warnings to drivers at fatigue situations. This low cost driver fatigue detection system can use as guide to develop advanced driver fatigue detection system.

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CHAPTER 1

INTRODUCTION

This report gives work done towards of driver fatigue detection system through five chapters. The background, aim and objective of this research and research gap are mentioned in this chapter as introduction.

Driver fatigue; falling asleep at the wheel is a major cause of road accidents, accounting that serious accidents on motorways and monotonous roads in not only Sri Lanka and other countries in the world. Micro sleep is where a driver of a vehicle momentarily falls asleep and awakes almost immediately. It is very common; the driver continues with his previous activity without interruption and usually drives along without any incident. However, if an oncoming vehicle cuts into opposite lane, or if the driver is negotiating a curve, or if the vehicle in front suddenly slows or stops, the normal reflexes are absent to react fast enough and an accident is the result.

Fatigue and drowsy driving is a worldwide problem. As an example 20% road accidents caused in United Kingdom due to driver fatigue and drowsiness. And also in America 17% of fatal accidents on roads were fatigue related [1].The situation in Sri Lanka is more than to those countries, according to the researches more than 30% of road accidents due to driver fatigue and drowsiness [2].

In Sri Lanka, the researches and projects implemented on such driver fatigue detection systems are fairly limited. It has become a national requirement to carry out researches on this field to develop a system to warn the drivers when fall asleep while driving. Considering this as a motivation factor we selected this project of designing and developing driver fatigue detection system for the drivers who fall asleep while driving as a solution of reducing road accidents due to fatigue and drowsiness.

1.1 BACKGROUND

Driver fatigue detection systems intend to warn the driver when the driver's alertness is below a level that is no longer consistent with safe operation of the vehicle. To develop such a system it is required to know characteristics of drowsy driver. Some of them are unable to keeping the head and the upper part of the body straight, yawning frequently and frequent blinking and heavy eyelids. These characteristics can be keep to monitor the driver is going to asleep or not. So the system should have sensors to detect such drowsy movements of the driver. And also steering pattern of drowsy driver is really different from steering pattern when a driver doesn't fall into asleep. So we can use steering pattern changes to detect drowsiness of the drivers. There should be an alert system

to warn the driver at such situation. The warning system should be seat vibration or alarm or sudden shock that must be able to awake the driver quickly.

There are some advanced driver fatigue warning systems available in the world. Some systems are developed and embedded into vehicles by the vehicle manufacturing companies. The existing systems are developed to identify previously mentioned characteristics of a driver and give a warning to the driver when falling asleep. Some systems use cameras to monitor driver's behaviour visually. Most commonly used method is detecting the driver's eyelid movements. According to that various type of driver fatigue monitoring systems are available in the world. If a system detects such drowsiness situation, it makes audible noise or some vibration to awake the driver.

1.2 RESEARCH GAP

Although there are available driver fatigue detection systems which introduced by vehicle manufacturing companies, still number of accidents happened due to the drowsiness of drivers. The country like Sri Lanka, there is a few people practise to use such systems in vehicles. Mainly these advanced driver fatigue detection systems are in most modern vehicles thus most Sri Lankans use old vehicles due to their economic situation. So low cost driver fatigue detection system is an essential requirement for country like Sri Lanka to minimize road accidents due to drowsiness.

There is a negative stand for the researches in those areas in Sri Lanka though there are number of accidents happened due to this reason. So we selected this project of designing and developing driver fatigue warning system as a solution of reducing road accidents due to drowsiness.

1.3 AIM

The aim of the project is to design and develop a system to detect a driver fatigue and make a warning to the driver.

1.4 OBJECTIVES

For the development of driver fatigue warning system the objectives are to,

- ❖ Develop a system to detect driver fatigue accurately
- ❖ Give a warning to the driver when falls asleep
- ❖ Keep always driver awake
- ❖ Reduce road accidents due to driver fatigue and drowsy
- ❖ Develop low cost practicable driver awaken system

CHAPTER 2

LITERATURE REVIEW

2.1 TECHNIQUES FOR DETECTING DROWSY DRIVERS

There are several possible techniques for detecting drowsiness in drivers. They can be generally divided into the following categories [7]: sensing of physiological characteristics, sensing of driver operation, sensing of vehicle response, monitoring the response of driver.

2.1.1 MONITORING PHYSIOLOGICAL CHARACTERISTICS

When consider the above methods, the best and most accurate technique is the detection of human physiological phenomena [8]. This technique is implemented in two ways: measuring changes in physiological signals, such as brain waves, heart rate, and eye blinking; and measuring physical changes such as sagging posture, leaning of the driver's head and the open/closed states of the eyes [7] [8]. The first technique, while most accurate, is not realistic, since sensing electrodes would have to be attached directly onto the driver's body, and hence be annoying and distracting to the driver. In addition, long time driving would result in perspiration on the sensors, diminishing their ability to monitor accurately. The second technique is well suited for real world driving conditions since it can be easily monitored by using optical sensors of video cameras to detect changes [7].

2.1.2 OTHER METHODS

Driver operation and vehicle behaviour can be implemented by monitoring the steering wheel movement, accelerator or brake patterns, vehicle speed, lateral acceleration, and lateral displacement [7]. These too are non-intrusive ways of detecting drowsiness, but are limited to vehicle type and driver conditions. The final technique for detecting drowsiness is by monitoring the response of the driver. This involves periodically requesting the driver to send a response to the system to indicate alertness. The problem with this technique is that it will eventually become tiresome and annoying to the driver.

2.2 EXISTING DROWSINESS DETECTION SYSTEMS

Commercially available driver fatigue detection systems which are embedded to automobiles are based on sensing physiological characteristics of drivers. And there are some systems to detect steering wheel operations and break patterns.

Volvo uses a camera mounted behind the rear-view mirror that looks at road markings, along with a combination of inputs including steering movements and use of the accelerator and brake pedals to determine drowsiness. If it is detected driver fatigue, drivers will hear an audible chime and will get a written warning in the instrument panel that says "time for a break" along with a coffee cup [10].

Mercedes Benz rolled out drowsiness detection in 2009, in the 2010 E-Class. Its "Attention Assist" creates a driver profile within 20 minutes of driving, which forms the baseline in determining how the driver operates the vehicle. The system uses a steering sensor, along with software that tracks 70 inputs, including such details as where the vehicle is in the lane, how often the driver adjusts the radio controls and moves the steering wheel, and how long they've been driving. The algorithm constantly compares how the driver performs to the baseline to decide when to set off the alert. When the system identifies erratic steering corrections attributable to drowsy driving, it triggers an audible warning and a "Time for a Rest" message with a coffee cup on the instrument panel [10].

Ford Motor Company is also used a camera system to detect driver's motions and give warning drowsing situations. BMW also developed a system to steering variations of the driver to give warnings [10].

Aisin Seiki Company has already introduced one anti-drowsy system and is developing a new one that it hopes to complete in three years. The existing system, already introduced on some Toyota Motor Corporation models, uses a compact camera to monitor the driver's eyelid movement and sounds an alarm when it detects drowsiness or a wandering gaze [11].

2.3 RESEARCHES ON DRIVER FATIGUE DETECTION SYSTEMS

Automated drowsiness detection system [9] was developed by E.Vural et al while using three methods that video of the driver's face was recorded using a digital video camera, head movement was measured using an accelerometer that has 3 degrees of freedom and use the facial action coding system (FACS) method for coding facial expressions in the behavioural sciences. The system describes facial expressions in terms of 46 component movements, which roughly correspond to the individual facial muscle movements.

An algorithm for detecting heavy-truck driver fatigue from steering wheel motion [3] was developed by D.J.King et al while using functions in the time, frequency, and phase domains were developed to quantify changes in steering wheel input. They developed steering based weighting function formula to detect whether driver falls into sleep or not while driving. As our driver fatigue detection system mainly identify whether driver is going to sleep or not using steering wheel motions, we consider this research paper as source to develop our system.

CHAPTER 3

METHODOLOGY

3.1 REQUIREMENTS OF DRIVER FATIGUE DETECTION

- ❖ Detect fatigue situations of driver correctly
- ❖ Give pre warning
- ❖ Give warnings to wake up driver at drowsy situations

3.2 METHODOLOGY

Driver fatigue can be detected using steering wheel angle and angular velocity. There are different algorithms that can be used for the detection. An algorithm that is derived by [3] is used in this project. This algorithm is a time-based one and it detects delayed feedback of the driver using steering angle and angular velocity [4].

The mean steering angle is taken as zero. Small and quick deviations of the steering angle from the mean value indicate an alert driver. In contrast, large and slow deviations from the mean are resulted from the fatigue of the driver. Furthermore, fast corrections of the steering angle towards the mean position are resulted from a fatigue driver who is about to fall asleep.

A value, Amp_theta is calculated using the following formula [3]

$$\text{Amp_theta} = 100/N \sum_{n=1}^M (A_j * t_j)$$

Where $A_j = j^{\text{th}}$ block of the steering angle data

t_j = length of the j^{th} block of the angle data

N = total number of samples

M = number of blocks

100 is a scaling factor

A block is where steering wheel angle is off from its mean value (refer the figure below). Θ_m is the mean value and is taken to be equal to zero.

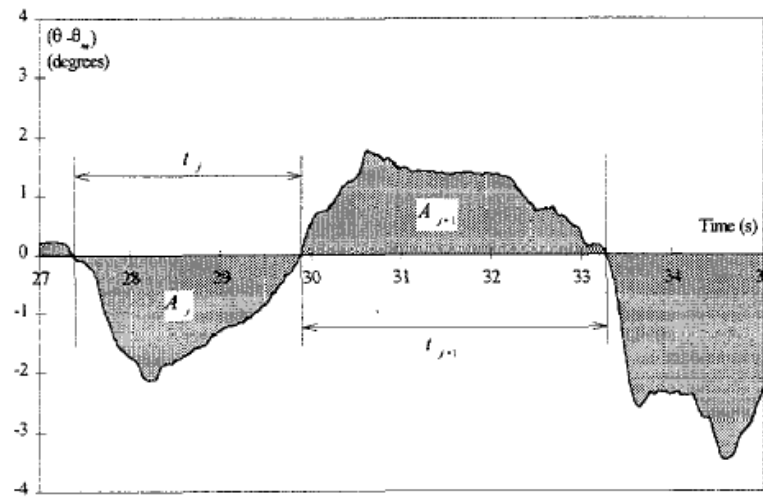


Figure 1 - Steering wheel angle vs. Time (Source – [3])

[3] has proposed a cut-off limit Amp_theta where upon exceeding that, the driver can be determined to be fatigue. It was found to be between 5.0 and 6.3 by experiments. When Amp_theta exceeds the above value range, a warning message is shown on a LCD. At the same time, a buzzer is activated to alert the driver.

3.2.1 ELIMINATING ERRORS USING INDICATOR LAMPS

However, above formula is only suitable for vehicles travelling along straight lines. Therefore, when the driver takes a bend, overtake or turn, the system will give warnings erroneously. As a measure to eliminate this drawback partially, our system automatically turns off the warning system while one indicator lamp of the vehicle is turned on. Therefore, a vehicle with the fatigue detection system can turn or take over another vehicle without triggering the warning.

3.2.2 HIGHWAY MODE

This fatigue detection system would be ideal for detecting fatigue on a highway. At the time of start of the system, the detection system is inactive. However, if the vehicle begins to travel on the highway for a set amount of time, the fatigue detection system automatically turns on. However, still, the constraint of no bends on the road exists.

When on the highway, the speed of vehicles is always greater than the lower speed limit of the highway. Also, the speed does not vary significantly. Therefore, this system reads in the speed of the vehicle. If it is both greater than the speed limit and also its variability is less than some critical value, the fatigue detection system turns on. Otherwise, it stays inactive. In the demonstration, we use a potentiometer as the speed input to the microcontroller.

3.2.3 COMMUNICATING WITH COMPUTER

This project is still in research level. Proper cut-off levels are still to be found and they may be different from person to person. Therefore, when doing research, factors such as the scaling factor and number of blocks (M) have to be changed on the go. In order to achieve this, a computer communication is used. The UART communication pins of a microcontroller are used for this purpose. As modern mobile computers lack RS232 communication capability, a TTL to USB converter is used so that the system can be directly connected to the USB port of the computer. Furthermore, fatigue level data of the drivers can be stored and analysed using the computer.

3.2.4 THE ALGORITHM

1. When the system is powered up, it reads the speed of the vehicle.
2. If the mean speed is greater than a set level and also its variability is lower than a critical value, the fatigue detection system turns on
3. If one of the indicator lamps is turned on, the fatigue detection becomes inactive. It is activated again if indicator lamp is turned off and condition in 2 is met
4. Steering wheel angle is read. Then arithmetic mean of 3 angle values is taken in order to reduce noise. Then an array of 10 elements is populated with these values. This is done using an interrupt as the time interval between two angle reading is critical for this application
5. Amp_theta value is calculated using the values in the angle-data-array in the main thread.
6. A warning is shown on the LCD and a buzzer sounds if the Amp_theta value is greater than a critical value
7. UART communication begins with a peripheral interrupt by a push button

CHAPTER 4

COMPONENT SELECTION

4.1 MEASURING STEERING ANGLE

In vehicles that are equipped with electronic stability control (ESC), a steering wheel angle sensor is built in to the steering wheel. For vehicles that do not have such sensors, several options are available. One option is to use an optical encoder.

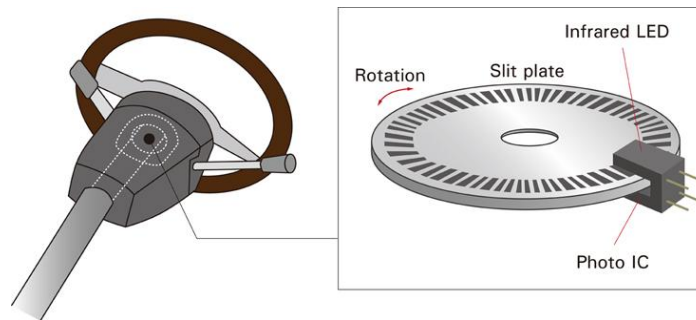


Figure 2 - Steering wheel angle sensor (Source –[4])

Using a magnetic encoder is another option. Finally, for every option to be feasible, the sensor should be easily fixable to the steering system without complex modifications.

However these sensors are expensive. Therefore, for this demonstration, a low-cost solution, a potentiometer is used to measure the steering angle. This method will not be feasible for a real vehicle since this requires costly modification to the existing steering system.

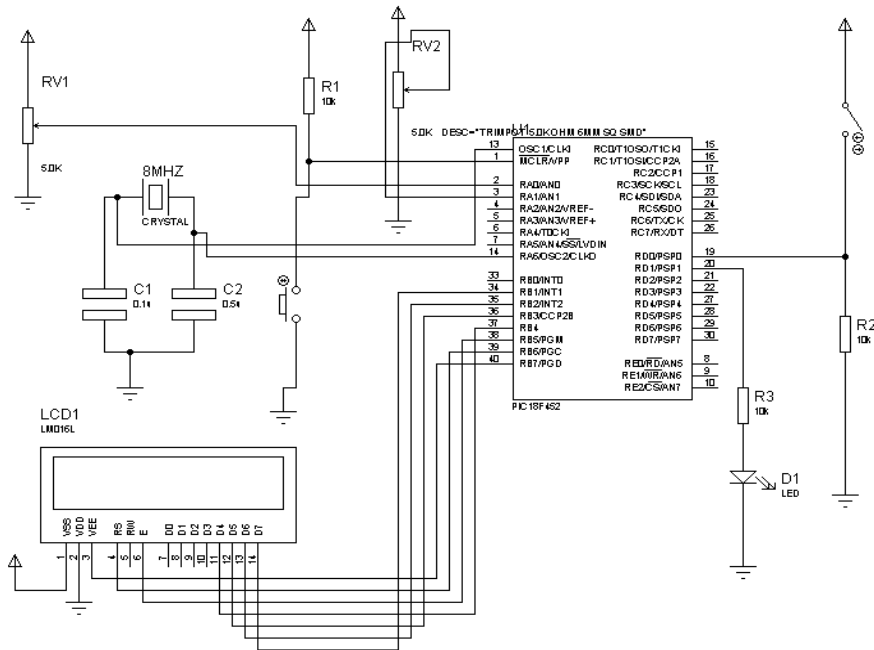
4.2 MICROCONTROLLER

The microcontroller that is used is PIC18f452. The algorithm of this project needs a significant amount of arithmetic manipulations including multiplications and divisions. This PIC microcontroller contains a hardware multiplier [4]. Therefore, it would be faster to execute heavy mathematic calculations on this microcontroller. In the source code, interrupts are used. One stack level is reserved for interrupts. Also, one stack level is reserved for each *(multiplication) and / (division) [5]. PIC16 family becomes useless as it a stack with only 7 levels. In contrast, PIC18f452 contains a 31-level stack.

4.3 OTHER COMPONENTS

- ❖ UART TTL to USB converter
- ❖ LCD display

- #### 4.4 CONTROL CIRCUIT



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CHAPTER 5

CONCLUSION

This project report proposed driver fatigue detection system based on steering wheel angle and angular velocity. The algorithm that is used to detect driver fatigue is a time-based one and it detects delayed feedback of the driver using steering angle and angular velocity. The large variations of the steering angle towards the mean position are resulted from a fatigue driver who is about to fall asleep. The output value of the algorithm exceeds certain value, a warning message is shown on the LCD and the buzzer is activated to alert the driver. So this steering based fatigue detection system can be used to warn drivers at drowsy situations.

But the formula which is used in this system is only suitable for vehicles travelling along straight lines. Therefore, when the driver takes a bend, overtake or turn, the system will give warnings erroneously. To eliminate this drawback partially, our system automatically turns off the warning system while one indicator lamp of the vehicle is turned on. And also this fatigue detection system would be ideal for detecting fatigue on a highway because the speed of the vehicle does not vary significantly on highways.

As this project is in research level, the cut-off levels may be different from person to person. Therefore scaling factor and number of blocks have to be changed on the go. To achieve this, a computer communication is used. UART TTL to USB converter is used for this purpose, so that the system can be directly connected to the USB port of the computer. According to that fatigue level data of the drivers can be stored and analysed using the computer

5.1 POSSIBILITIES OF FUTURE DEVELOPMENT

As future development;

- ❖ This system can develop according to detect fatigue level changes for different people at different driving conditions
- ❖ Detect bends on road and avoid triggering the alarm
- ❖ Calibration of the system according to the driver

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ANNEXES

SOURCE CODE

```
void sedCalculator();

void highwayMode();

void speedData();

// FloatToStr should have a char array of length characters of the float +5 elements

// LCD module connections

sbit LCD_RS at RD7_bit;

sbit LCD_EN at RD6_bit;

sbit LCD_D4 at RB5_bit;

sbit LCD_D5 at RB4_bit;

sbit LCD_D6 at RB3_bit;

sbit LCD_D7 at RB2_bit;


sbit LCD_RS_Direction at TRISB7_bit;

sbit LCD_EN_Direction at TRISB6_bit;

sbit LCD_D4_Direction at TRISB5_bit;

sbit LCD_D5_Direction at TRISB4_bit;

sbit LCD_D6_Direction at TRISB3_bit;

sbit LCD_D7_Direction at TRISB2_bit;


int adcArray[10];

int adcArrayIndex_in;

int lastADC;

unsigned int area;

int numSamples;      // Make these global otherwise they resets every time this function is called!!!!!!!!!!

int numElements;

unsigned int elements;
```

```

unsigned int sed;

int totalSamples;


//highwayMode variables

int speedIndex;

unsigned int speed;

unsigned int speedArray[10];

unsigned int speeddataIndex;

unsigned int speedMean;

unsigned int speedVar;

bit speedDataReady;


//Ment to be changed dynamically via computer

int elementCalcSize=4;

int scalingFactor=1;


void interrupt() iv 0x000008 ics ICS_AUTO{

    int diff;

    int sqr;

    int deviation;

    unsigned int tmp1;

    unsigned int tmp2;

    unsigned short test;

    int ADCsmooth=0;

    int i=0;


    INTCON.GIE=0;

```

```

if(INTCON.TMR0IF){    // this code is invoked 32us after TMR0 is enabled

INTCON.TMR0IE=0;

INTCON.TMR0IF=0;


while(1){

ADCON0.CHS0=0;    //select channel 0 for steering angle read

for(i=0;i<5;i++){

asm{

    bsf    ADCON0,GO    //Start A/D conversion

    Wait:

    btfsc  ADCON0,GO    //Wait for conversion to complete

    goto   Wait

    }

    ADCsmooth+=ADRESH*4 + ADRESL/64 - 512;

}

if(adcArrayIndex_in==10){

    ADCsmooth=0;

    adcArrayIndex_in=0;

    break;

}

adcArray[adcArrayIndex_in] = ADCsmooth/5;

ADCsmooth=0;

adcArrayIndex_in++;

}

speedDdata();

speedDataIndex=0;

speedDataIndex++;

```

```

    }

}

/*

void kernelMode(){

char read;

    if (UART1_Data_Ready()) {    // If data is received,

        read=uart1_Read();

        switch(read){

            case('1'):PORTD.RD1=1;

            break;

            case('0'):PORTD.RD1=0;

            break;

            case('a'): uart1_write('a');

            break;

            case('s'): uart1_write('s');

            break;

            case('d'): uart1_write('d');

            break;

            case('g'): uart1_write('g');

            break;

            case('h'): uart1_write('h');

            break;

            case('j'):  uart1_write('j');

            break;

            case('k'): uart1_write('k');

            break;

        }

    }

}

```

```
} */
```

```
void speedData(){
```

```
    int i;
```

```
    ADCON0.CHS0=1; // select channel 1 for read speed
```

```
    for(i=0;i<3;i++){
```

```
        asm{
```

```
            bsf    ADCON0,GO    //Start A/D conversion
```

```
            Wait1:
```

```
            btfsc  ADCON0,GO    //Wait for conversion to complete
```

```
            goto   Wait1
```

```
        }
```

```
        speed+=ADRESH;
```

```
    }
```

```
    speed/=3;
```

```
    speedArray[speedIndex]=speed;
```

```
    speedIndex++;
```

```
    if(speedIndex==9){
```

```
        speedIndex=0;
```

```
        speedDataReady=1;
```

```
    }
```

```
}
```

```
void sedCalculator(){
```

```

float foo=0;

int i;

float temp1;

float temp2;

float temp3;

char out[15];


for(i=0;i<10;i++){

    if((lastADC<0 && ADCarray[i]>0) || (lastADC>0 && ADCarray[i]<0)){

        temp1=area*numSamples;

        temp2=temp1*0.00027;

        elements+=(int)temp2;

        numElements++;

        totalSamples++;

        numSamples=1;

        area=0;

        IntToStr(numElements,out);

        LCD_out(2,1,out);

    }else{

        temp1=abs(lastADC) + abs(ADCarray[i]);

        temp2=temp1*0.00027;

        area+=(int)temp2;

        numSamples++;

        totalSamples++;

    }

}

if(numElements==elementCalcSize){

    foo = 1000/totalSamples;

    temp1=scalingFactor*elements;

    sed=(int)(temp1*foo);

```

```

        elements=0.0;

        numElements=0;

        totalSamples=0;

        IntToStr(sed,out);

        LCD_out(1,1,out);

    }

    lastADC=ADCArray[i];

}

}

void highwayMode(){

    int i;

    int speedSum=0;

    char out[10];

    speedVar=0;

    speedDataReady=0;

    for(i=0;i<10;i++){

        speedSum+=speedArray[i];

    }

    speedMean=speedSum*0.1;

    for(i=0;i<10;i++){

        IntToStr(speedArray[i],out);

        LCD_out(1,4,out);

        delay_ms(200);

        speedVar+=abs(speedMean-speedArray[i]);

    }

}

}

void main() {

```

```

char out[15];

char output[15];

int i=0;

unsigned long int speedVariability;

int tmp=0;


TRISD=0;

PORTD=0;

TRISB.RB0=1;

adcArrayIndex_in=0;

speedIndex=0;


area=0;

numSamples=0;      // Make these global otherwise they resets every time this function is called!!!!!!!!!

numElements=0;

elements=0;

sed=0;

totalSamples=0;

lastADC=0;


speed=0;

speedDataIndex=0;

speedMean=0;

speedVar=0;

speedDataReady=0;


Lcd_Init();          // Initialize LCD

Lcd_Cmd(_LCD_CLEAR);    // Clear display

Lcd_Cmd(_LCD_CURSOR_OFF); // Cursor off

```

```

TRISA = 0b00001011;

ADCON0= 0b10000001; //Fosc/32 [7-6], A/D ch0 [5-3], a/d on [0]

ADCON1= 0b00000100; //AN0,AN1,AN3 are analog inputs

delay_us(50);


T0CON = 0b11000111; //TMR prescaler is 1:256

INTCON= 0b10100000;

TMR0H = 0b11111111;


delay_ms(100);


while(1){

    INTCON.TMR0IE=0;

    sedCalculator();

    if(speedDataReady==1){

        highwayMode();

    }

    INTCON.TMR0IE=1;

    delay_ms(100);

}

}

```