DESIGN & DEVELOPMENT OF INTELIGENT SPEED LIMITER FOR MOTORBIKES

CHAPTER 01 – INTRODUCTION

1.1 RATIONAL OF THE PROJECT

Most of the people in the world love to drive fast. Faster vehicles tend to accidents than slower vehicles. In every country or state there are speed limit signs in different locations (public places like Schools and Hospitals, Busy Roads, major junctions, Narrow roads etc.) where the speed limit is set by the government to minimize road traffic and accidents. Speed limits are normally indicated on a traffic sign near above mentioned places. But most of the drivers do not follow these speed limits at all. So these vehicles should force to drive within or below a minimum speed limit whenever they are within that area.

The following project will be concerned with the automatic speed control of a vehicle in areas where the speed limit is set by the government. Whenever the vehicle is within the special area, current speed of the vehicle is compared with the pre-programmed speed limit in that area. If current speed is higher than the pre-programmed speed, the speed of the vehicle is decreased to some cutoff and kept constant until the vehicle moves out of the special area. After that the vehicle can accelerate by itself.

1.2 PROBLEM IDENTIFICATION

The number of road accidents is increasing day by day. The main reason for this is careless driving of the drivers. So, many people get killed and badly injured because of this. These deaths and injuries results in significant social and economic costs. Most of the fatal road accidents occur due to over speeding. Speeds should be adopted to road, traffic and weather conditions. Speed limits are set by government considering above mentioned factors and speed limit signs are showed in different places.

Many drivers exceed the posted speed limits. Sometimes it may be intentionally, sometimes it may be unintentionally as driver is unaware of the speed limit. So, speed choice of the vehicle is affected by the characteristics of the driver.

1.3 AIM

Introducing a mechanism to control the speed of the motorbikes automatically in special zones where speed limits are set by the government.

1.4 OBJECTIVES

The main objectives are;

- Develop a system to measure the speed of the motorbike.
- Develop a PIC microcontroller based intelligent vehicle speed limiter.
- Develop a strong wireless communication between vehicle and data transmitters.
- Implement a control system to reduce the power of the motorbike automatically.
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- To study on how to make the vehicle speed automatically decelarate.
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1.5 PROJECT SCOPE AND LIMITATIONS

Intelligent speed limiter for motorbike recognizes special areas where speed limits are set by government and keeps the speed of the motorbike within or under that set speed.

- Rider can't override the system in case of an emergency.
- Weather conditions may affect the wireless communication between motorbike and transmitters.

Engine capacity

Chapter 2: Literature Survey

This chapter is concentrated on the technological background, previously designed intelligent speed limiter techniques and application about those techniques. Furthermore, related software solutions and approaches which can be used during implementation.

2.1 Literature mapping

2.2 Speed limit signs

According to Miyata, S. (2017), Speed limit signs are used to represent the maximum legal speed for vehicles in public roads. They are used to limit traffic speeds, reduce accidents, minimize harmful environmental effects of traffic and improve efficiency of fuel usage. Speed limits are generally set by the legal bodies of the national government and forced by regional police. The speed limit in every location is denoted on a close by traffic sign. In most of the countries signs display speed limits in kilometers per hour (kmph) while others display in miles per hour (mph).

Speed limit signs are posted at different locations such as near hospitals, schools, narrow roads, highways, intersections etc.

According to Oke, S., Bamigbaiye, A., Oyedokun, O. and Charles-Owaba, O. (2006), speed limit sign does not display the maximum speed drivers should travel. It is the maximum speed authorized when circumstances are perfect. It is important to drive at or below the speed indicated. Any speed which is insecure for the existing circumstances is illegal. Drivers who surpass the posted speed limits are involved in about one-third of critical accidents.

2.3 SPEED DETECTION

According to A. Ramase, N. Kamble, J. Kamble (2018), the real speed of the motorbike can be calculated using an inductive proximity sensor. These sensors can detect metal objects without any physical contact. A small metal piece needs to be attached to the wheel and proximity sensor must be placed closed to the motorbike’s frame. Whenever the wheel rotates, metal object coincide with sensor and sensor gives high signal. The signal is analog and need to be converted into digital. Then by measuring the wheel diameter and multiplying it by 2π, circumference of the wheel can be obtained. Finally by dividing that circumference value from time taken to rotate the wheel one round, speed of the motorbike can be calculated. This is a high speed, low cost method but performance can be affected by temperature and humidity.

According to Jahan. A, Hoq. I, and Westerfeld. D (2013), GPS module can be used to measure the speed of the motorbike. The speed calculating formula is speed equals distance travelled divided by the time taken. GPS receiver does the same to calculate speed. It can calculate the distance travelled by using two GPS locations. GPS receiver has a very accurate clock inside it to measure the time taken to travel between two GPS points. Then GPS receiver can perform a calculation applying these numbers and decide the speed of the vehicle. GPS module produces all these information using output strings. Ground speed is given in knots. By converting it in to kilometers per hour exact speed of the vehicle can be measured. This method is easy to use and accurate. GPS signals can become weak in bad weather conditions.

As stated by ggn(), hall effect sensors operates with the 'Hall effect' law. This law describes that when a conductor with current travelling one way was introduced vertical to a magnetic field, a voltage could be determined at right angles to the current pathway. Using this law, Hall effect sensors can be able to notice the presence of magnet nearby it. There are two types of hall sensors, analog and digital. The digital hall sensor can only notice if a magnet is present or not (0 or 1) while an analog sensor can provide different outputs based on the magnetic field like how powerful and how far the magnet is. A digital hall sensor is used in this work. A tiny piece of magnet is attached to the wheel and Hall sensor is placed perpendicular to that magnet. As the magnet gets into line with the sensor, it will count 1 round. Then by calculating the circumference of the wheel and time taken to rotate the wheel one round, speed can be calculated. High temperature affects the sensitivity and accuracy of the hall sensor.

According to sdfsfsfdsfsdfsdf(), speed of a motorbike can be measured using an Infrared sensor. There are two types of IR sensors, active and passive. Passive sensors detect energy released by objects in the area of view and they do not use an infrared source. Active sensors comprise of two parts, IR source and IR detector. Active IR sensor is used in this work. IR source is a light emitting diode which produce infrared radiations. IR receiver is a photodiode or a phototransistor. In this work also IR transmitter is attached to the wheel and IR detector is installed in the motorbike’s frame near transmitter. When the wheel is rotating, there will be an instant that IR LED and photodiode come face to face. By calculating number of detections made by transmitter and receiver in a second and measuring circumference of the wheel, speed can be determined. The main drawbacks of this method are data transmission rate is slow and performance can be affected by environmental conditions like rain, dust and fog.

2.4 WIRELESS COMMUNICATION

According to B. Chavan, A. Makandar, F. Khan (2014), a radio communication device consists of radio frequency transmitter and receiver. Radio frequency transmitters perform by transmitting information (speed limits) to a receiver. Radio frequency receiver module receives the modulated radio signal and demodulates it. In this project, the transmitter is tuned at 433 MHz with a range of about 400 foot outdoors which will go through most walls. The receiver also has to be operated at 433 MHz. Transmitter is placed near places where speed should be limited. The signals frequently transmit information at the rate of 1Kbps - 10Kbps where receiver which is mounted inside motorbike can grab when it is within the transmitter’s range. This data include designated speed limits. Transmitter antenna shaft should be positioned away from metal objects in order to protect it from detuning. The main drawback of this beacon technology is the motorbike must be within the range of the exact beacons to follow the speed limit. More number of beacons are needed for various speed limits due to this reason.

According to V. Priyadarshni, P. Krishna and K. Ravi (2016), The Global Positioning System (GPS) receiver continuously observes various satellites and evaluate mathematical statements to decide the accurate position of the receiver and its deviation. Minimum four satellites are in perspective of the receiver for it to process four obscure amounts. Most of the receivers have trackers algorithm which helps in calculating various satellite timings, by making benefit of fact that immediate receivers position can be close to each other. After all these calculations made by the satellite the receivers position can be identified very easily. This process depends on a technique called Trilateration. In despite of its popularity, GPS is accountable to numerous crucial issues identified with the accuracy of the determined position. GPS receiver is installed within the motorbike in order to get the exact location. GPS doesn’t work when the receiver is grounded and the signal can become weak when trees, buildings, heavy clouds comes in between the satellites and receiver.

According to Torresen,J, Jorgen W. Bakke and Lukas Sekanina (2016), image processing is a technique which used to extract useful information from an image after perform some operations on it. A camera is mounted at the front of the motorbike facing forward to capture the traffic signs on the road. The standard procedure for detecting and recognizing traffic speed signs consists of three steps. First step is color segmentation. It is applied to highlight desirable signs in an image and restrict the search area in the image. Second step is template matching which is applied to shape detection. In third step, particular signs are identified using template matching. A color image is usually converted from RGB (Red, Green, Blue) color space into HSV (Hue, Saturation, Value) color space. From this conversion, color segmentation becomes easier.

As stated by Gomes. S, Papa. P, (2017), a traffic sign detection system consists of four stages. First stage is color based filtering to filter out image areas that have color features similar to the color found in signs known to the system. Using this filter color input image is converted into binary image. In next stage, the boundaries of the image areas are smoothed using close and open morphological applications. Then shape analysis is executed to evaluate the similarity between the area and a given shape. In the final stage, the holes within the areas are analyzed.

The speed of this system varied between 20 to 30 frames per second. The main drawbacks of image processing technique are performance can be affected by bad weather conditions (| fog, rain, snow) and it is difficult to capture quality images in nighttime.

According to Muthuraman. S, Vidyapeetham. A (2016), ZigBee is one of modern protocols to form radio sensor networks. There are two categories of ZigBee in terms of hardware, XBee series 1 and XBee series 2. XBee series 1 is used in this work and it creates V2I (vehicle to infrastructure) communication. XBee has to be configured using XCTU software. XBee transmitters send the data which includes information about the speed limits to the XBee receiver which installed within the motorbike. This module's reading range is 1.2 km outdoor. XBee transfers data at a rate of 250 kbps and operates at frequency between 868 MHz to 2.4 GHz. ZigBee is an efficient wireless communication method due to it's wide range and low power consumption.

According to Parivallal. V, Nandagopal. H (2012), Radio frequency identification (RFID) system consists of tag, reader and database. Tags have the circuitry required to collect power from electromagnetic fields created by interrogator, the essential memory components, plus various control circuits. There are two types of tags, active and passive. Passive tags powered by energy from RFID reader's while active tags are powered by a battery and hence read at a bigger range from the RFID reader. The simplest tags comprise only ROM (Read Only Memory), while complex tags also include RAM (Random Access Memory) and nonvolatile PROM (Programmable Read Only Memory) or EEPROM (Electrically Erasable Programmable Read Only Memory). ROM generally comprises the identification sequence for the transponder and commands for it's operating system. In this work active RFID tags which comprise a distinctive code corresponding to the designated speed limit are placed in the road and RFID reader is installed within the motorbike. Active tags can be read from a distance of 600 m away. RFID tags operates at frequency between 100 KHz to 2.45 GHz and transfers data at a rate of 8 kbps.

The advantage of RFID is its low cost for tags and can be attached to the traffic signals easily.

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According to cdcddfdfdfgfgf (), Point in polygon rule can be used to determine whether a certain point in a plane lies within, outside or on the border of a polygon. In this work GPS is used as wireless communication method and speed zones where speed limit signs are located defined as polygons. Ray casting algorithm is used in here to detect in which bounding polygon or speed zone the motorbike in located in. This algorithm is created on a simple inspection that if a point travels along a ray from infinity to the search point and if it intersects the border of a polygon numerous occasions, then it alternately travels from the outside to inside, then from inside to outside. Therefore after every two boundary crossings the travelling point goes outside. By taking GPS co-ordinate values of vertices that describe polygon and doing some calculations, it can be detected whether motorbike is within the speed limiting zone or not.

As stated by fdfdmbmkfgglhl(), Winding number algorithm can be used to determine whether point is inside a polygon. GPS is used as wireless communication method in this work also. Winding number of a closed arc in the plane around a fixed point is an integer, demonstrating the entire number of times that arc moves anticlockwise around the point. The winding number varies on the location of the arc. Point lies within the polygon if winding number is non zero. By gaining GPS co-ordinates and doing necessary calculations, motorbike's presence within the speed limiting zone can be identified. This algorithm uses inverse trigonometric functions, thus causes it complex and slower than ray casting algorithm.

According to fdfdsfdfed(), speed limiting zones can be defined as circles. GPS is used as wireless communication technique. Each circle has a set speed limit. Motorbike's presence inside a circle can be determined by taking GPS co-ordinates of center, length of radius and performing suitable calculations. If the distance between the center of the given circle and motorbike's current location is less than the radius of the circle, then the motorbike is within the circle. If that distance is equal to the radius then motorbike is on the perimeter of the circle. If the distance is greater than the radius motorbike is outside the circle. This method is simple and easy to use. Faster than winding number method.

2.6 POWER REDUCTION

According to Bob Simpkin, Frank Lai, Mark Fowkes(2007), engine power of a car can be reduced by limiting the throttle passed to the engine, irrespective of the throttle demand from the driver. But when it comes to motorcycle, rider's throttle demand should not suddenly override as control of transmitted power to the road wheels is a critical factor in maintaining the dynamic stability of a motorcycle. So, for a motorcycle power reduction should be delivered smoothly. Power reduction of a motorcycle engine can be achieved by changing the ignition, fuel supply and air supply.

- Ignition

An ignition system in a motorbike generates a spark to ignite a fuel-air mixture in combustion engines. The spark should be capable enough to jump a gap at the spark plug electrodes. Altering the ignition timing can lead to a small reduction in power.

- Fuel

Small reductions in the fuel supply could be used to bring a small reduction in power but larger reductions would lead to incorrect fuel/air mixtures and rough or unbalanced engine running.

- Air

A reduction in air entering the engine can be achieved by connecting a second throttle. However, air reduction without a similar reduction in fuel delivery would lead to an unstable, misfiring engine that could unbalance the rider.

According to Saivignesh. H, Mohamed. M, Nagaraj. M (2015), it is important to have a smooth, progressive power reduction that does not unsettle the rider. This excluded modifying only the ignition and the most practical solution is reducing both air and fuel together. Advantage of combined reduction in air and fuel, without modification of ignition is that there is no possibility of damaging the engine. In an internal combustion motorbike engine, the throttle is a means of controlling an engine's power by regulating the amount of air and fuel entering the engine. Throttle of a motorbike with a carburetor is the same as with any internal combustion engine. The cable connected to the throttle opens both air and fuel valves inside the carburetor, allowing the suction of the pistons to draw more air and fuel to the engine, providing more

power. So, by controlling the throttle cable power reduction can be achieved smoothly. A servo motor is used in this work to control the throttle cable. Servo motor is a brushless DC motor. It works on the pulse width modulation (PWM) principle. It has a closed loop system where it uses positive feedback to control movement and last point of the shaft. In this project, a servo motor of 12 Kg-cm torque is attached to the throttle cable. When servo motor receives the signal to close the throttle, it rotates and pulls back the throttle cable. Force needed to shut the throttle against the rider's desires was way higher than that needed to maintain it in its present position. When the speed reduces below set limit motor rotates and open the throttle, thus rider can regain the control of the throttle.

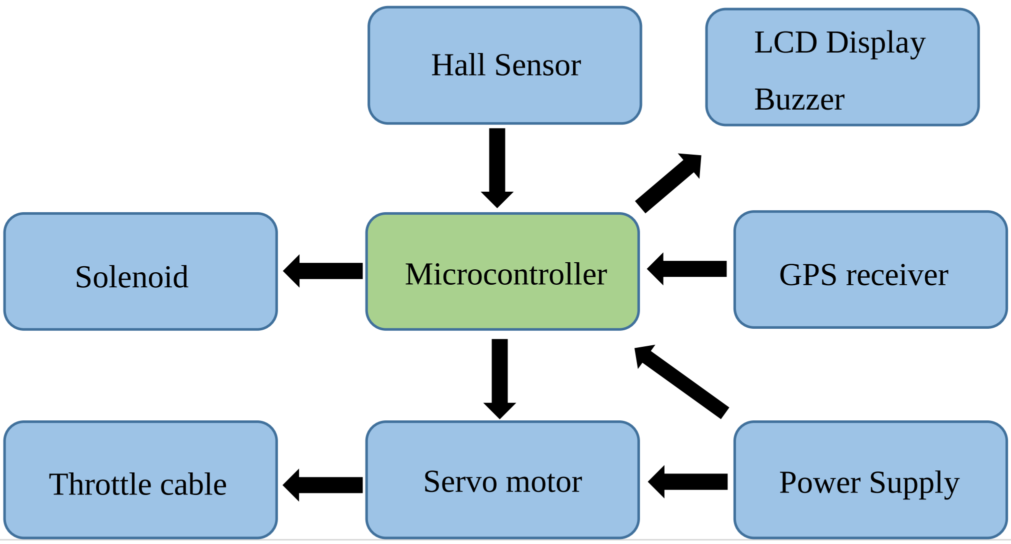
As stated by Pushkar P., Kunjan .A, 4Siddharth S. Goyal, Akash B. Pandey (2014), speed of the motorbike can be reduced by controlling the brake system. Two stepper motors are used in this work. Stepper motor is a brushless DC motor that rotates in steps. It can accurately positioned excluding any feedback, which denotes an open loop controller. One stepper motor of 10 Kg-cm torque is fixed to the clutch cable and other of 2Kg-cm torque fixed to the brake lever. Both six wire motors are operating in unipolar mode. When the speed of the motorbike increases beyond the designated limit, stepper motors turn specific number of predefined steps at a predefined speed thus engaging the brake and clutch. Then the motors get locked until speed of the motorbike reaches below the set speed. When it reaches below speed limit, motors retract, thus disengaging brake lever and clutch. However the stability of the motorbike is affected in a negative way when automatic braking take place.

According to (Thirukkovulur, A.K.,H.Nandagopal,and V.Parivallal

CHAPTER 3 – METHODOLOGY

This chapter explains about three conceptual designs and their methodologies to achieve the objectives of the project.

3.1 CONCEPTUAL DESIGN 1



In this design a Hall Effect sensor is used to calculate the speed of the motorbike. Hall effect sensor can measure the magnitude of a magnetic field. A small magnet needs be attached to the wheel and Hall effect sensor is attached to the frame of the motorbike. The number of rotations made by wheel and time taken doing it, is measured by the sensor. After performing some calculations from this data, speed of the motorbike can be measured using a microcontroller.

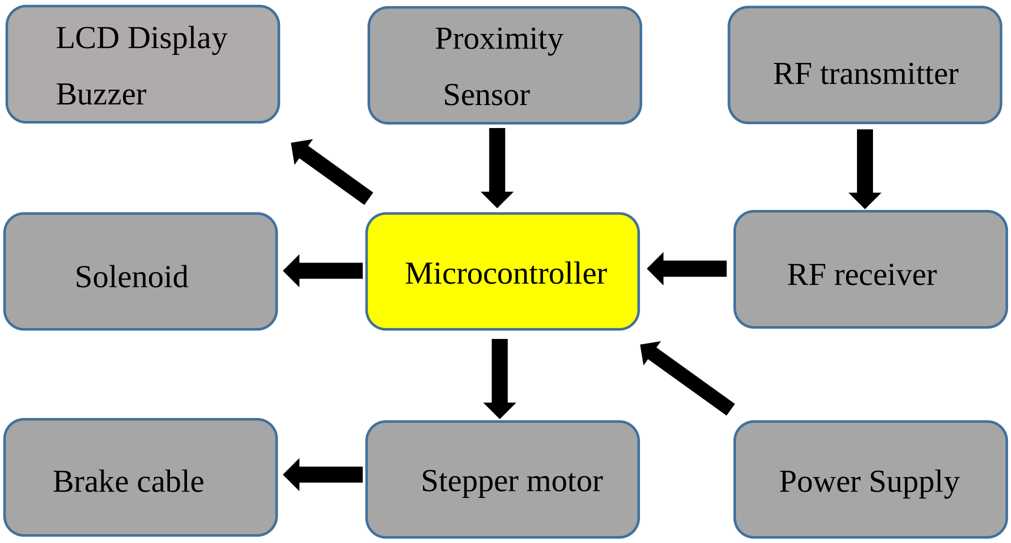
Motorbike's location is determined using a Global Positioning Satellite (GPS) system. Therefore a GPS receiver is installed inside the motorbike to detect satellite signals. The co-ordinates (latitude and longitude values) of the locations where the speed limit signs are placed, are programmed to the microcontroller.

When motorbike enters to a speed limiting zone buzzer activates and LCD displays the set speed limit of that zone. Power supply needed for both microcontroller and servo motor provides by motorcycle's battery.

Power reduction of the engine is done by adjusting the throttle cable (accelerator cable) which opens/closes both air valve and fuel valve inside the carburetor. A servo motor is used for this throttle cable adjusting purpose. The servo motor arm is connected to the throttle cable with the help of a mechanical actuator and servo motor's range of motion is equivalent to the range of motion of the motorbike's twist grip.

If the motorbike exceeds the designated speed limit in that GPS beacon, mechanical actuator is activated and cut the connection between twist grip and throttle. Then servo motor is activated and pulled back the throttle cable, closing the throttle and slowing the motorbike. The throttle then remained closed until motorbike's speed is below the speed limit set in that beacon. When the motorbike is below the designated speed limit, servo arm rotated back and mechanical actuator connects twist grip and throttle. Then rider re-gains the control of the throttle.

3.2 CONCEPTUAL DESIGN 2



In this design an inductive proximity sensor is used to measure the motorbike's speed. A small metal piece needs be attached to the wheel and sensor is attached to the frame of the motorbike. Radio Frequency (RF) signals are used as the wireless communication method. RF transmitters are programmed according to relevant speed limits and has to be installed in places where the speed limit signs are located. RF receiver is installed within the motorbike. Whenever the vehicle passes nearby RF transmitter, receiver inside the motorbike detects the speed limit transmit by the transmitter and then microcontroller compares it with the current speed of the motorbike.

When motorbike enters to a speed limiting zone buzzer activates and LCD displays the set speed limit of that zone. Power supply needed for both microcontroller and servo motor provides by motorcycle's battery.

PIC18F series high end PIC microcontroller is used in this design which has 16 bit instruction word length. This microcontroller has a CPU speed of 10 MIPS and a large RAM size.

Speed reduction is achieved by controlling the motorbike's braking system. A mechanical actuator is fixed to the throttle cable. A stepper motor is connected to the rear brake cable of the motorbike. When motorbike is above the designated speed limit, mechanical actuator is activated and cut off the connection between throttle and twist grip. So rider loses the control of the throttle. Then servo motor arm rotated and pulled back the brake cable over one second. Microcontroller compares new speed with designated speed and continues pulling brake cable over one second until speed reduced below the designated speed limit.

3.3 CONCEPTUAL DESIGN 3

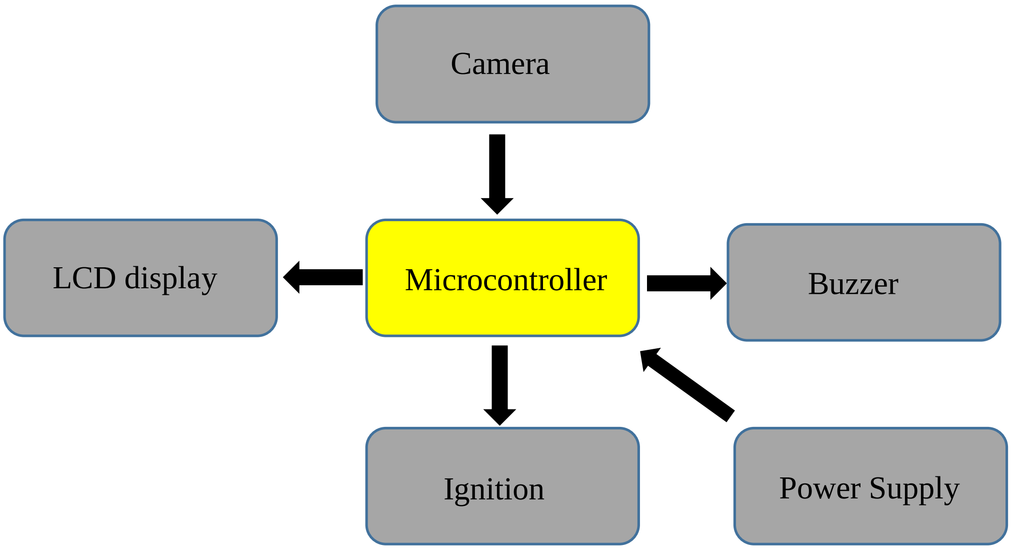


Image processing technique is used in this design to detect speed limits. A camera is mounted at the front of the motorbike facing forward to capture the images of traffic signs. Captured images are processed by the microcontroller according to a prepared algorithm. Images are analyzed and identified by comparing with sample images in the database.

Raspberry pi 3 model B is going to use as the microcontroller. It consists of a 1.2 GHz, 64 bit quad core processor.

Buzzer and LCD screen get activated once motorbike enters to a speed limiting zone. External power supply is used in this design to power up microcontroller and servo motor.

Speed reduction is achieved by altering the ignition timing by means of an electronic circuit.

As in the conceptual design 1, speed reduction of the motorbike is done by adjusting the throttle cable with the help of a servo motor.

3.4 Design selection

Standard project selection techniques are used to pick the optimum design by comparing significant features and parameters.

3.4.1 SWOT analysis

The SWOT analysis is used to identify strengths, weaknesses, opportunities and threats of proposed conceptual designs.

	Conceptual design 1	Conceptual design 2	Conceptual design 3
Strengths	▪Accurate speed detection. ▪Strong wireless communication between transmitter and receiver. ▪Smooth power reduction can be achieved by controlling throttle cable.	▪Accurate speed detection. ▪High reliable speed limiting location detection.	▪Design is simple as less hardware parts are required than other designs. ▪Faster than other designs.
Weaknesses	▪ Design is complex	▪Difficult to install RF transmitters near every speed limit sign board practically.	▪Relatively high initial cost ▪Difficult to capture images during night time and bad weather conditions
Opportunities	▪Easy to install the system within the motorbike. ▪Availability of numerous designing software.	▪Wireless communication is not affected with weather conditions.	▪Easy to install the system within the motorbike.

Threats	▪GPS receiver takes small time to connect with the satellite when power up.	▪Power reduction is not smooth. ▪Stability of the motorbike could be reduced while power reduction.	▪Power reduction is not smooth. ▪Unequal and alternate power delivery could unbalance the rider.

According to SWOT analysis and scoring method, the most appropriate design to implement Intelligent motorbike speed limiter is first conceptual design.

When considering Hall sensor, it gives precise speed and less vulnerable to bad weather conditions when compared with proximity and infrared sensor.

When detecting speed limiting zones GPS receiver gives the most practical solution when compared with installing RF transmitters all over the country. Image processing method is also good but it gives less accurate outputs during poor climate conditions.

Power reduction by controlling throttle cable with the use of a servo motor is way more practical than controlling brake cable or changing ignition timing. It reduces speed without unsettling the rider.

When comparing microcontrollers, Raspberry pi is the advanced one among others. But it is quite expensive when compared with PIC and Atmega microcontrollers.

Atmega microcontroller is not expensive and can be programmed using many languages and designing software. Though conceptual design 1 has some issues, it is the optimum design for Intelligent motorbike speed limiter system.

4.2 SOFTWARE DESIGN- PROGRAMMING DEVELOPMENT

4.2.1 DESIGN FLOW CHART

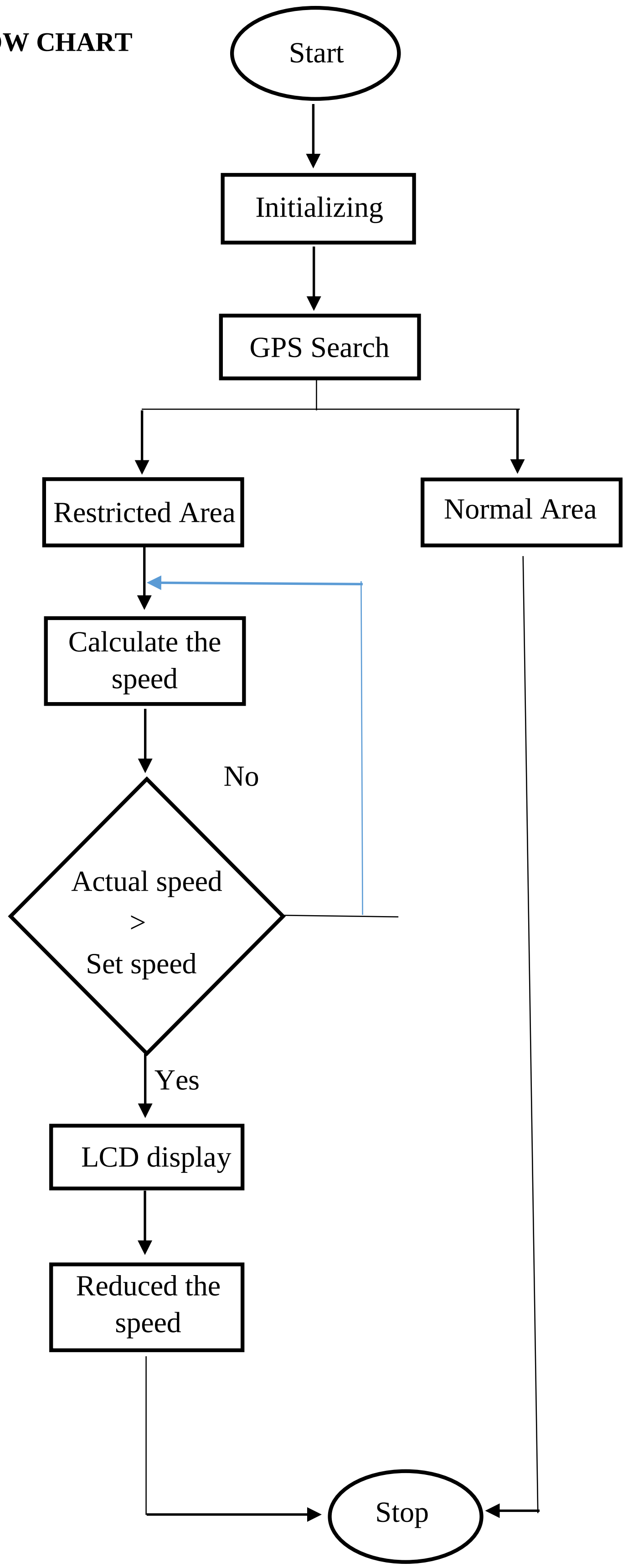


Figure 3.5. 1 Design flow chart

4.3 SPEED MEASUREMENT

Digital hall sensor is used for speed detection. Each time the magnet (which attached to the wheel) crosses the sensor, it will sense it and send the data to the microcontroller.

By running a nonstop timer using *millis()* function, time taken for the wheel to finish two rotations can be calculated by means of the following formula. Two rotations are taken to minimize error.

$$Time\ \ taken\ for\ two\ rotations = millis() - pevtime$$

A disrupt will be received by microcontroller every time the magnet is sensed. In this place, rpm (revolution per minute) of the motorbike is calculated.

$$RPM = \frac{1000}{Time\ taken\ for\ two\ rotations} \times 60$$

Where, $\frac{1000}{Time\ taken\ for\ two\ rotations}$ offers the revolution per seconds (rps) and to convert into rpm it is multiplied by 60.

Then speed of the motorbike is calculated using following equation.

$$Speed = Radius\ of\ the\ wheel\ \times RPM\ \times 0.37699$$

Radius of the wheel should be taken in meters. Then speed of the motorbike can be obtained in kilometers per hour (kmh^{-1}).

Wireless communication

GPS module is used as the wireless communication method. GPS receiver uses a sequence of satellites and ground stations to compute exact area where it is located. These GPS satellites transmit data signal over radio frequency (1.1 to 1.5 GHz) to the collector. With the assistance of this received data, a ground station or GPS module can process its location and time. GPS receiver receives data signals from GPS satellites and measures its distance from satellites. This is done by calculating the time needed for the signal to transmit from satellite to the receiver.

GPS Distance calculation;

$$Distance = Speed \ \times Time$$

Where,

Speed = Speed of Radio signal. Approximately equal to the speed of light 3×10^8

Time = Time required for a signal to transmit from the satellite to the receiver.

Travel time cam be determined by subtracting the sent time from the received time.

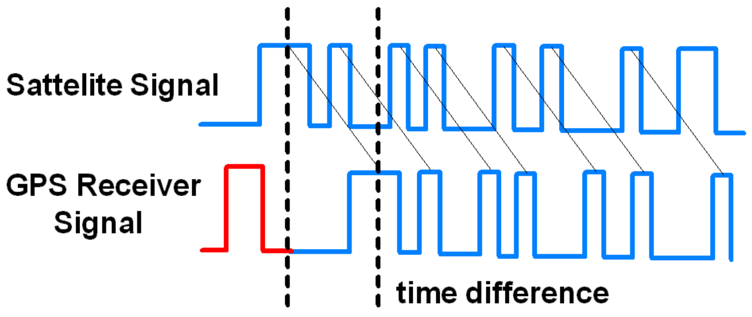
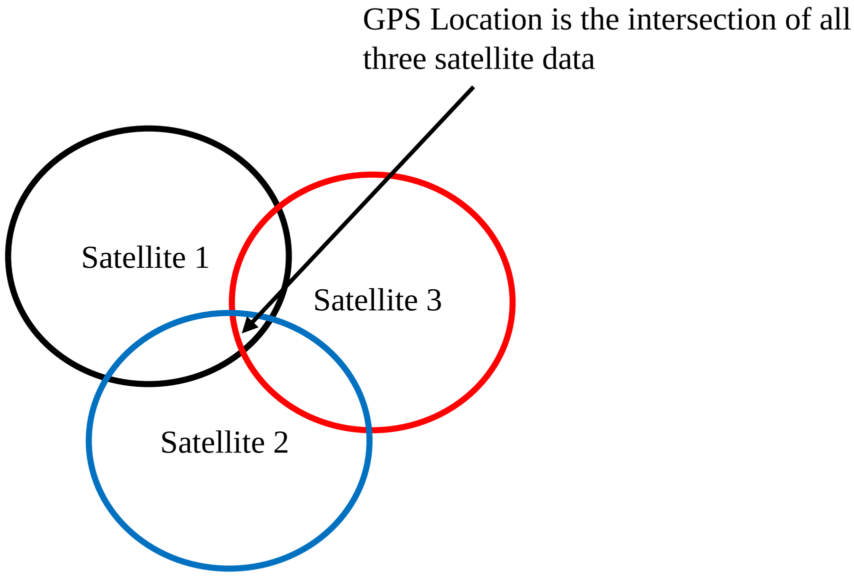


Figure - GPS Signal Time Difference

To decide distance, both the satellite and GPS receiver create the equivalent pseudocode signal simultaneously. The satellite transmits the pseudocode; which is collected by the GPS receiver. These two signals are then compared and the difference between the signals is the travel time.

Now, if the receiver recognizes the distance from three or more satellites and their position (which is sent by the satellites), then it can calculate its position, speed and elevation by using Trilateration method.

Trilateration is an advanced version of triangulation. Data from a solitary satellite offers a broad location of a point inside a large circular zone on the Earth's surface. Including information from a second satellite enables the GPS to limit the particular area of that point down to a zone where the two areas of the satellite data overlap. Including information from a third satellite gives a precise position of the point on the Earth's surface. Each satellite is at the midpoint of a sphere and where all satellites intersect is the location of the GPS receiver. When the location of the GPS receiver changes, the radius of the each circle will too change.



GPS receiver module provides output in standard (National Marine Electronics Association) NMEA string format. This NMEA string output from GPS receiver includes various parameters separated by commas like longitude, latitude, altitude, time etc. Every string starts with '$' and ends with carriage return/line feed sequence.

For this project, the Recommended Minimum Specific GNSS Data (GPRMC) output message is used. An example of RMC output string is:

$GPRMC, 01542555, A, 40.91466, N, 73.116300, E, 0.10, 329.72, 16122019, *19, <CR><LF>

RMC Data String	Data Format
$GPRMC	Message ID
01542555	UTC time in hhmmss.ss
A	A=Valid data
40.91466	Latitude
N	N/S Indicator
73.116300	Longitude
E	E/W Indicator
0.10	Speed in Knots
329.72	Course over ground
16122019	Date in ddmmyyyy
*19	Checksum
<CR>	Carriage return
<LF>	Line feed

Table

Parsing Data from GPS output string

GPS outputs data in several ways. For this task, Recommended Minimum GPRMC standard output is used. Output data is sent out from GPS as an array character. In order to recover the data from GPS, first of all, variables and ports have to be initialized.

Then all the data that sent from GPS can be retrieved through serial ports. Then a list of character array will be used as a global variables. At this point, each of the parameters of the

GPS output string is declared as character arrays. The character arrays are declared to be adequately long to hold the parameters.

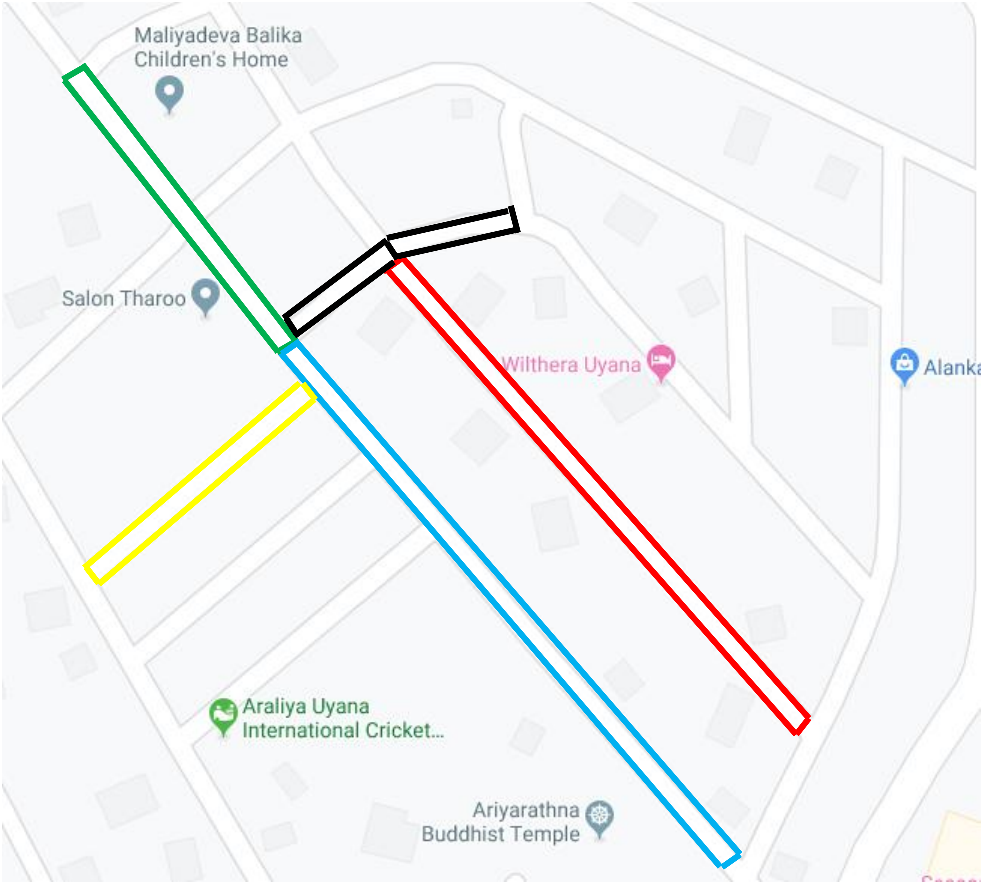
A function called *clear_infomation()* will execute at the starting of the program to confirm that those character array are not containing any preceding information or data. Then *read_GPS()* function will be executed which will read the data from GPS through serial port. Once the

program examines character ‘$’, ‘G’, ‘P’, ‘R’, ‘M’, ‘C’ and ‘,’ in order, all the characters after that will be positioned in char[32] as time until another ‘,’ found as an character. In this the next information which is data validation character ‘A’ is place in the variable named validate. In this manner, information for location co-ordinates and speed are assigned to their allocated character arrays. A pseudo code of the Data parsing is given below.

```
int position=0;
while{position != 6} {
data = UDR1;
if (data ==‘$’) position++;
if (data == ‘G’) position++;
if (data == ‘P’) position++;
if (data == ‘R’) position++;
if (data == ‘M’) position++;
if (data == ‘C’) position++;
if(data ==’,’) position++; }
// place all the character to time char array
until another a character found which is equal to ‘,’
position = 0 ;
while (data ! == ‘,’) {
time[position] = data;
data = UDR1;
position ++; }
```

Test Location

The roads in Kurunegala city are selected to test the system. The following figure shows the path of the motorbike where different speed limits are assigned for different locations which are specified in different colors.



- 15 kmph
- 25 kmph
- 45 kmph
- 60 kmph
- 80 kmph

Determination of Speed Zones

Different speed zones are marked on above map as polygons. After the speed zones are marked, the microcontroller uses the location co-ordinates obtained from the GPS and compares it with the hardcoded values of location co-ordinates of the different polygons representing each speed zone.

The following table indicates the latitude and longitude co-ordinates of the test location roads obtained from Google Maps.

Region	Speed (kmph)	Location Co-ordinates (Latitude, Longitude)
1	15	(7.500719, 80.363028); (7.500655, 80.363075); (7.500894, 80.363409); (7.500995, 80.363327); (7.501107, 80.363927); (7.501181, 80.363914)
2	25	(7.499362, 80.362707); (7.499437, 80.362659); (7.500086, 80.363416); (7.499998, 80.363479)
3	45	(7.500225, 80.363411); (7.500177, 80.363345); (7.501162, 80.362566); (7.501205, 80.362639)
4	60	(7.498325, 80.364944); (7.498392, 80.364992); (7.500219, 80.363407); (7.500163, 80.363354)
5	80	(7.498796, 80.365215); (7.498889, 80.365265); (7.500517, 80.363788); (7.500458, 80.363728)

Then these polygons can be defined in the *setupSpeedZones()* function.

```
// Road 3
speedZones[3] = &SpeedZone(45);
speedZones[3] - > setVertices (4, (Vertex[4]) {
vertex ( 7.500225, 80.363411);
vertex ( 7.500177, 80.363345);
vertex ( 7.501162, 80.362566);
vertex ( 7.501205, 80.362639) } );
```

In here '[3]' indicates the third region and '(45)' indicates the set speed limit. 'Vertex[4]' is the number of vertices of the polygon. Then latitude and longitude values of the four vertices are given.

The function *getspeedlimt()* use to check if the present GPS position is inside each speed limiting zone starting with the first one. If the polygons overlap with each other, the first polygon discovered will be the one that is used for limit the speed. To determine the location of the vehicle, the software code determines if the location co-ordinates obtained from the GPS falls within the parameterized polygons. This can be determined using ray casting algorithm.

Ray Casting algorithm

It is easy to find whether a point is inside or outside a polygon by testing how many times a ray, beginning from the point and leaving any fixed path, intersects the edges of the polygon. The ray will intersect polygon's edge an even number of occasions if the point is on the outside of the polygon. The ray will intersect polygon's edge an odd number of occasions if the point is on the inside of the polygon.

A pseudocode can be simply;

```
count ←—— 0
foreach side in polygon;
  if ray_intersects_segment (P,side) then
      count ←—— count + 1
if is_odd (count) then
   return inside
else
   return outside
```

If motorbike is within the restricted zone, then current speed is compared with set speed limit.

Angular position of the accelerator

The speed of the motorbike varies according to the accelerator's (twist grip throttle) position. An incremental rotary position encoder is used here to detect the angular position of the accelerator. The twist grip of the selected motorbike can be twisted from 0 to 90 degrees. That means when twist grip at 90 degrees throttle valve is fully opened. When twist grip turns, the encoder relays give the displacement pulses to the microcontroller.
The angular position of the accelerator can be expressed as,

$$\propto = \frac{\boldsymbol{P}}{\boldsymbol{PPR}} \times \mathbf{360}$$

Where, P = number of pulses

PPR = pulses per revolution

Speed reduction

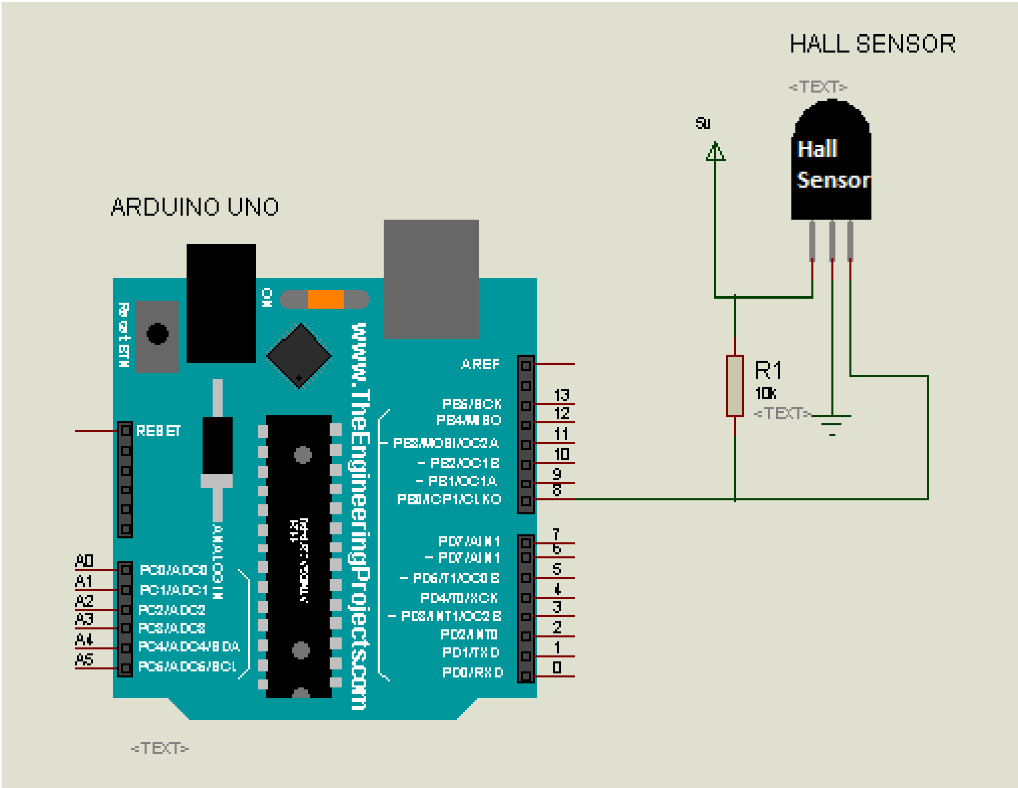
A servo motor is used to control the throttle of the motorbike. Servo motor is operated by sending an electrical pulse of changeable width called pulse width modulation (PWM). There is a maximum pulse, minimum pulse and a recurrence pace. Usually a servo motor can only turn 90 degrees in both way for a sum of 180 degrees. Servo motor anticipates a pulse every 20 milliseconds and the duration of the pulse will decide how much the motor rotates. Servo motor has a feedback circuit to confirm that servo arm reaches the required position.

The range of motion of motorbike's twist grip is equivalent to the servo motor's range of motion. That means if twist grip is turned 45 degrees clockwise by the rider, servo motor also turns 45 degrees clockwise and opens the throttle to increase the speed. Then if rider released the twist grip for 30 degrees angle, servo motor also rotates 30 degrees anticlockwise and closes the throttle to decrease the speed.

Whne the motor is

4.3 Hardware design

Hall sensor interfacing with Arduino

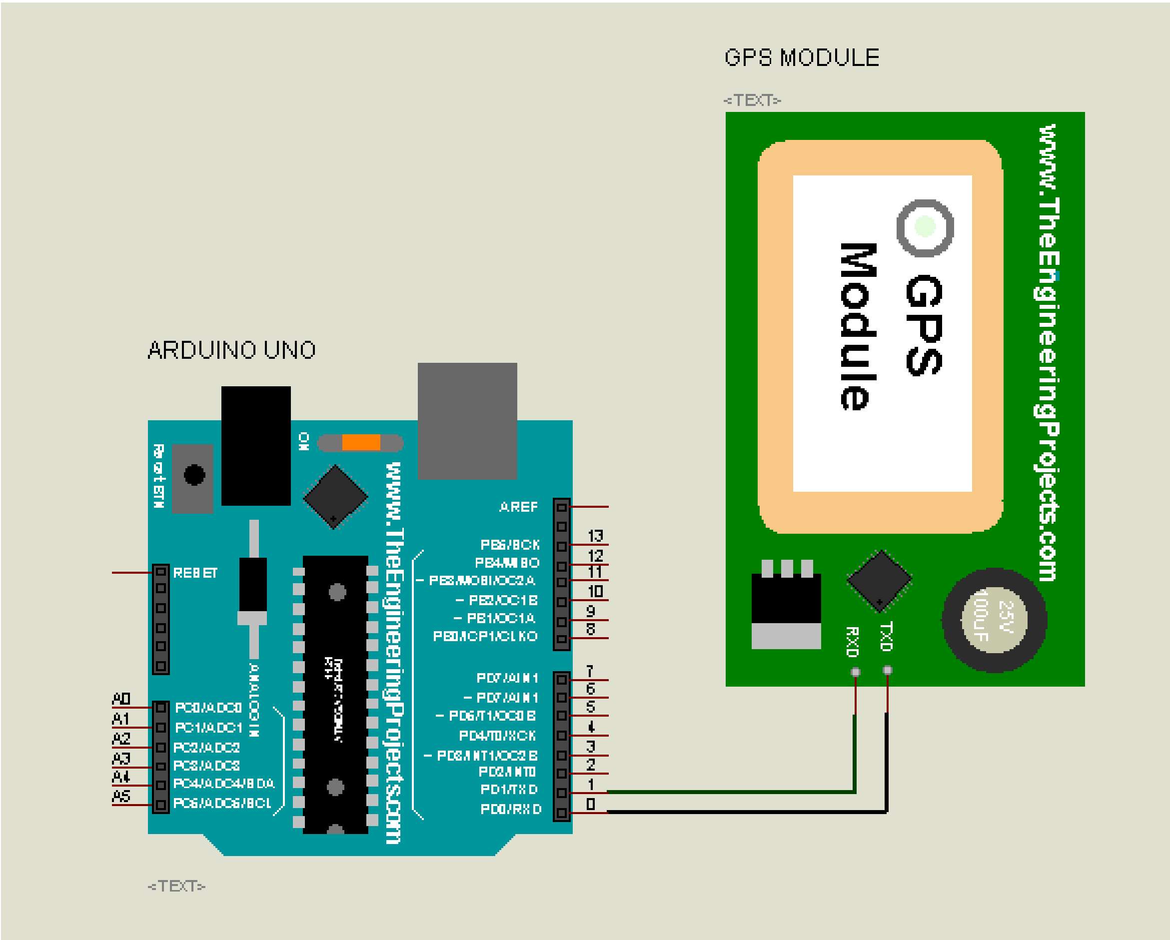


The digital hall sensor 49 E726S model is selected to detect the speed of the motorbike. It can sense both north and south polarity of a magnetic field.

It has 3 pins, Vcc(+5V), GND, and remaining pin connected to the PB0 digital pin of the Arduino. The hall sensor pin which is connected to PB0 pin of the Arduino provides the output whenever the magnet attached to the motorbike's wheel coincide with it. A 10 kohm resistor is connected between the Vcc (+5V) and output pin, to pull the output of the Hall sensor to 5V.

GPS module interfacing with Arduino

The GPS receiver is the key device of this system and NEO-6M GPS receiver is used for this project. This GPS has 50 channels and can track up to 22 satellites. This receiver has a pretty decent startup time, -161dBm navigation sensitivity and an accuracy of 5-10m which is sufficient for this project. The GPS receiver supports 4800bps to 230400bps baud rate and has a 1µs update rate. The NEO-6M GPS module has four pins: Pin1 (GND), Pin2 (VCC), Pin3 (RX), and Pin4 (TX). The RX pin is used to receive instructions from the Microcontroller and the TX information is operated to transmit GPS output information to the Microcontroller.

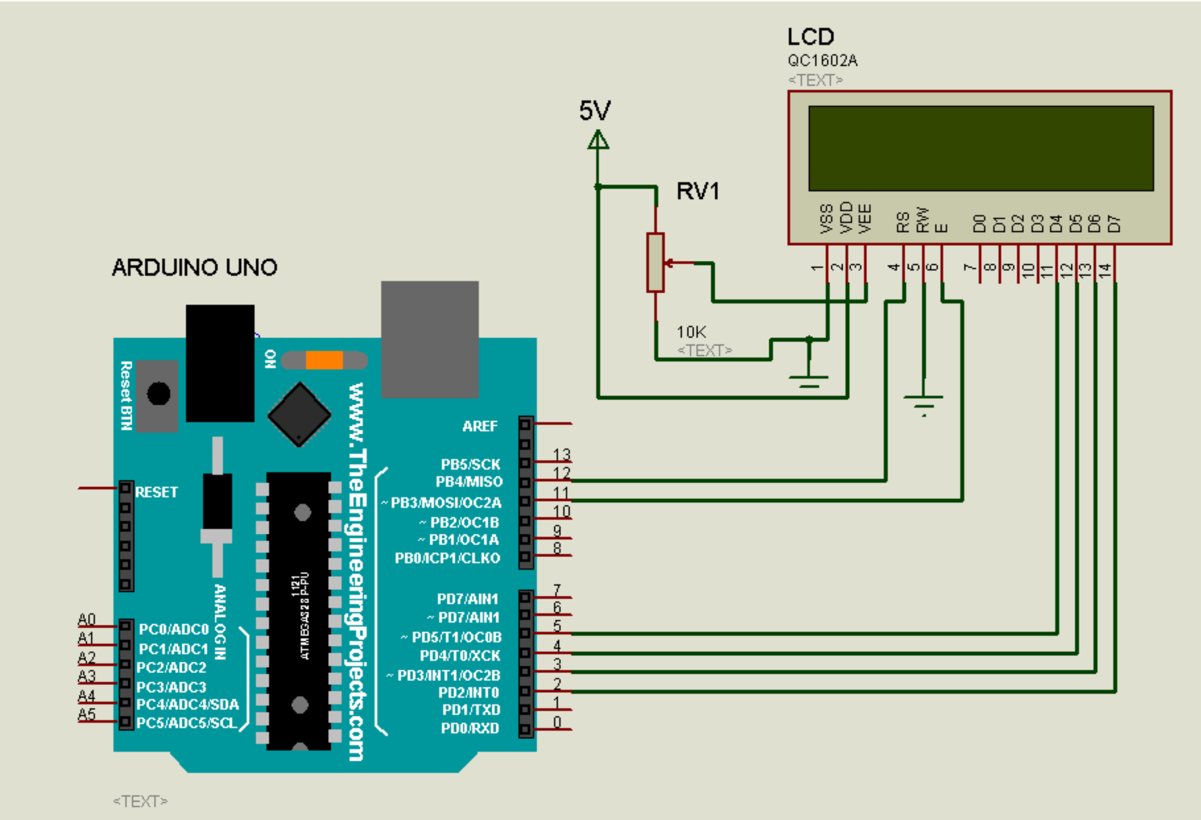


Following table shows the pin-outs of the NEO-6M GPS.

Pin Number	Pin Description	Connection to
1	Ground (GND)	GND
2	Reference Voltage (VCC)	+5V
3	Receive Channel (RX)	PD1/TXD

4	Transmit Channel (TX)	PD0/RXD

LCD Screen interfacing with Arduino

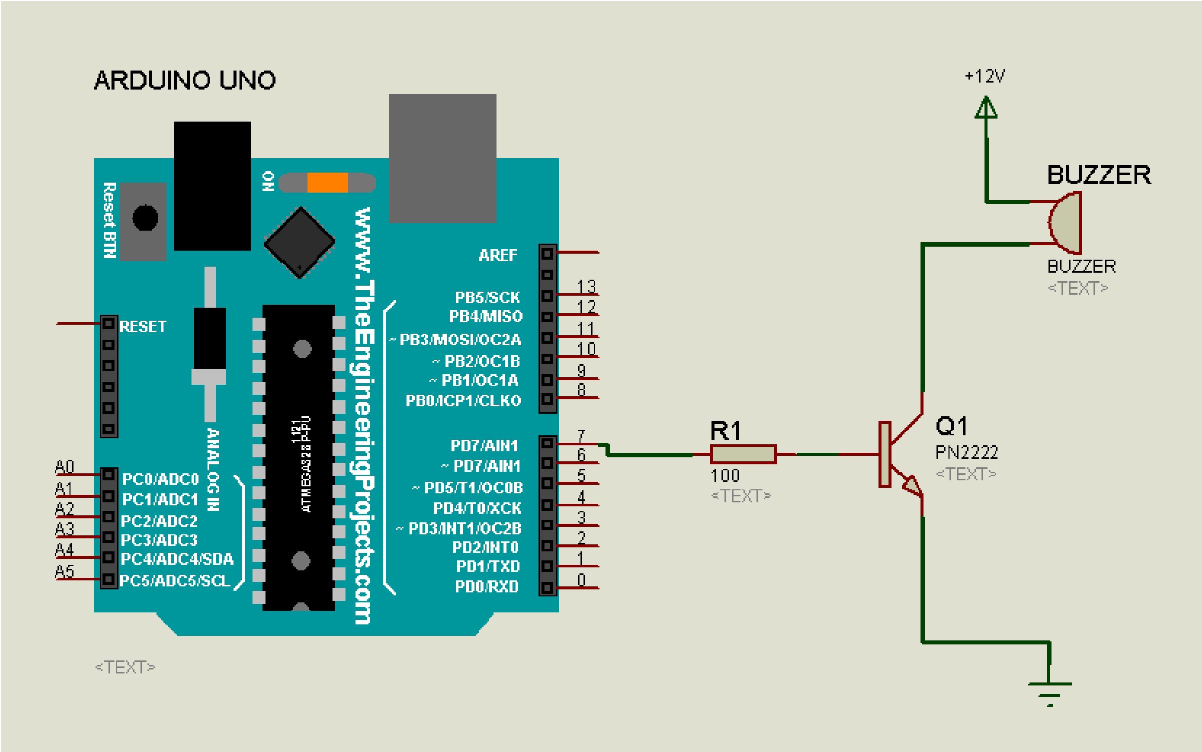


The LCD screen is the output of the system and displays the location co-ordinates, the recommended speed at the current location, and the current speed of the vehicle. The LCD module used in this project is QC1602a that has 2 lines with 16 characters per line. A 10Kohm potentiometer meter is used to adjust the contrast of the display. The LCD and Arduino are interfaced with the 4-bit method in this work. Thus there are four input lines, D4 to D7 of the LCD. Table IV gives the pin-outs.

Pin Number	Pin Description	Connection to
1	VSS	GND

2	VDD	+5V
3	VEE	Variable resistor
4	Register Select (RS)	PB4
5	Read/Write (RW)	GND
6	Enable (E)	PB3
7	D4	PD5
8	D5	PD4
9	D6	PD3
10	D7	PD2

Buzzer interfacing with Arduino



Piezo buzzer is used to alarm the rider when motorbike's speed exceeds the designated speed of the zone. When a piezo buzzer exposed to a fluctuating electric field it compress, then create a sound in consonance with the frequency of the signal. A NPN transistor is used to connect the buzzer to the Arduino. The transistor lets the buzzer to be powered from a separate voltage to the Arduino.