A project report on

OPTIMISATION OF PURE PURSUIT FOR PATH PLANNING AND TRACKING IN AUTONOMOUS VEHICLES

Submitted in partial fulfillment for the award of the degree of

Master of Technology

In

Automotive Electronics

by

SUNIL L (19MEA0019)

Under the guidance of

Dr. Ganesan K

Senior Professor, TIFAC-CORE,

Vellore Institute of Technology

VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

School of Electronics Engineering

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DECLARATION

I hereby declare that the thesis entitled "OPTIMISATION OF PURE PURSUIT FOR PATH PLANNING AND TRACKING IN AUTONOMOUS VEHICLES" submitted by me, for the award of the degree of Master of Technology VIT is a record of bonafide work carried out by me under the supervision of Dr. Ganesan K, Vellore Institute of Technology.

I further declare that the work reported in this thesis has not been submitted and will not be submitted, either in part or in full, for the award of any other degree or diploma in this institute or any other institute or university.

PLACE: VELLORE

DATE : **SUNIL L**

CERTIFICATE

This is to certify that the thesis entitled "OPTIMISATION OF PURE PURSUIT FOR PATH PLANNING AND TRACKING IN AUTONOMOUS VEHICLES" submitted by Mr.SUNIL L (19MEA0019), School of Electronics Engineering, VIT University, Vellore for the award of the degree of Master of Technology in Automotive Electronics, is a record of bonafide work carried out by him under my supervision, as per the VIT code of academic and research ethics.

The contents of this report have not been submitted and will not be submitted either in part or in full, for the award of any other degree or diploma in this institute or any other institute or university. The thesis fulfills the requirements and regulations of the University and in my opinion meets the necessary standards for submission.

DR . K. GANESAN

PLACE: VELLORE **SENIOR PROFESSOR TIFAC CORE**

DATE : **VELLORE INSTITUTE OF TECHNOLOGY**

ABSTRACT

Autonomous and semi-autonomous vehicle are becoming the fore coming of automotive. Simultaneous localization and mapping is one of the standing problems in the autonomous field. VSLAM is an emerging new feature, which works to identify the immediate area and can mapped to a projected surface. The SLAM is achieved by applying numerous iterations of matrices to have an accurate result. This mainly chains the vehicle where and how its headed thus by keeping away from running out of the track it is supposed to move. SLAM and VSLAM both uses Dijkstra's algorithm for path planning but due to its area searching inefficiency, furthermore optimization have to be done. ASTAR is another type of algorithm which is predecessor of Dijkstra's but it also has some limitation due to its computation. Optimalization in a way to reduce the computation time and resources. We consider limited resources as to boost up the efficiency in real time environments to meet up the stringent conditions. We further developed way of accessing the given area in higher nodal cost and also minimized the program execution.

Keywords: Dijkstra's Algorithm, Pure pursuit, Relays, Inertial Measurement Unit, , Computational Neural Networks, A star Algorithm.

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ACKNOWLEDGEMENT

It is my pleasure to express with deep sense of gratitude to Dr. Ganesan K, Senior professor, TIFAC-CORE, Vellore Institute of Technology, for his constant guidance, continual encouragement, and understanding; more than all, he taught me patience in my endeavour. My association with him is not confined to academics only, but it is a great opportunity on my part of work with an intellectual and expert in the field of Automotive.

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It is indeed a pleasure to thank my friends who persuaded and encouraged me to take up and complete this task. At last but not least, I express my gratitude and appreciation to all those who have helped me directly or indirectly toward the successful completion of this project.

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ABBREVIATIONS

CNN	Convolution Neural Networks
GPS	Global Positioning System
LQR	Linear Quadratic Regulator
VSLAM	Visual Simultaneous and Mapping
SLAM	Simultaneous and Mapping
AV	Autonomous Vehicles
IMU	Inertial Measurement Unit
MPU	Magnetic Pickup
I2C	Inter-Integrated Circuits
GPIO	General Purpose Input/output
PWM	Pulse width Modulation
RPM	Rotation per Minute
D *	Dynamic A Star

CHAPTER 1

1.1 INTRODUCTION

Self-driving cars are the upcoming emerging feature in automotive domain. Every industrialist is slowly adopting themselves to autonomous vehicles and development is seen in regular discipline. Autonomous vehicles are not commercialized prevalently around the globe. Some countries have adopted it in selected areas. The AV's can be used effectively in industries having ware house. There it can be used as mode of transportation. Generally, AV's are more efficient in indoor than outdoor. Any AV's has several modules with which the processing happens in a chain. If AV's are commercialized it may lead to vast reduction in men power for transportation in all aspects. Since outdoor environment is not standard in all parts of any country it is hard to make it work with zero error. Unless uniform markings and standard signs are followed it is going to be a tough task to have completely efficient self-driving vehicle.

1.2 OBJECTIVE

Autonomous and semi-autonomous vehicle are becoming the fore coming of automotive. Simultaneous localization is one of the standing problems in the autonomous field. VSLAM is an emerging new feature, which works to identify the area which are near and can mapped to a projected surface. The SLAM is achieved by applying numerous interactions of matrices to have an accurate result. This mainly chains the vehicle where and how its headed thus by keeping away from running out of the track it is supposed to move. The final work is to test it on real time scenarios by embedding this module to raspberry pi which will be the controller and will be processing the ZCAM data. All these steps are need to be trained for different environment and topology.

VSLAM uses Dijkstra's algorithm to track path but due to its inefficient, furthermore optimization have to be done. ASTAR is another type of algorithm which is predecessor of Dijkstra's but it also has some limitation due to its computation. Optimization in a way to reduce the computation time and resources.

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1.3 PROPOSED WORK

This system is expected to depict a path plan and track it via a compatible algorithm. The main proposed plan is to make the map of localized area and steer the vehicle in desired path. Initiating with mapping around the nearby areas and proceed with path tracking, then steering along the line. As first and foremost, I initiated to use the Dijkstra algorithm which works moderate even with stringent conditions. Dijkstra allows us to coordinate along with the desired path which has been provided by the algorithm. After verifying the countless efforts of pros and cons subjected to be tested in a toy car it gave us reasonable level of output. But that it isn't enough us to steer a vehicle on its own. So plan have been modified to match the criteria based on the tolerances and even specified the given data more precise by using Pure Pursuit algorithm.

1.4 RESEARCH CONTRIBUTION

The subjected module contains the Arduino and raspberry pi controller powered by 5V separately from either power banks and USB respectively.

1. Detection of angle from IMU controller which drives the algorithm fore look ahead.
2. Hall effect sensors are being used to detect when the vehicle has moved to a feet of 3 such that it detects the movement of vehicle and plot it in maps.
3. Developing the system that detects and responds to the above said.
4. Optimization of Dijkstra algorithm
5. Applying the given data in the pure pursuit algorithm with marked dimensions.

1.5 CHRONOLOGY OF MODULE WORK CONTRIBUTION

- ✧ HARDWARE MODULE
- ✧ SOFTWARE MODULE
- ✧ TESTING PHASE

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CHAPTER 2

LITERATURE SURVEY

(Best Routes Selection Using Dijkstra & Floyd-Warshall Algorithm-2017)-Risald et al.,

This paper talks about the pith of calculation for nearby reasonability particularly like traffic during while patient is more awful and gone before to be medical clinic. In those cases conditions can be helpful to track down the ideal way to take patients structure direct A toward point B in given time. The way taken by the application will preferably low thickness traffic direct that needs toward be associated through courses. Close to courses may contain emergency clinic and it assume to be given every one of the subtleties to the applications to continue the arranging map. On the off chance that the course contains deterrent with no implication and sudden factors like impacts or catastrophic events, at that point the course might be redone to approach by clinic. Consolidating two calculations can veil the deficiences of every calculation, by and large while joining the calculations and information parsing takes less time while contrasting the principles of calculation and may not prompt absolute practical arrangements.

(Improvement of Dijkstra Algorithm and its application in Route Planning-2010)-Dong Kai et al.,

The paper consolidates of the old style Dijkstra's calculation to its own qualities decreases the looking through size of calculation and improves running productivity. The outcomes show that the improvement of calculation is sensible and effective.Through the examination of qualities and shortcomings of the exemplary Dijkstra's calculation, we can track down that the principle downsides can be summed up as two focuses: stockpiling structure and looking through region. In this way, the paper has improved these two focuses, in particular the improvement of information stockpiling structure and the looking through space of confined calculations. Furthermore, its legitimacy is acquired by investigating the test results.

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(Analysis of QOS VLAN based on Dijkstra Algorithm on OSPF-2018)-M. Nurr Alfarni et al.,

This prompts the principle router execution overburdened which makes the organization net-frame down. It is important to change the organization, particularly in the correspondence convention on the switching by utilizing convention Open Shortest Path First(OSPF). OSPF is a connection state-based directing convention that uses Dijkstra's calculation to track down the best way is taken as a correspondence medium. Making ways made by considering different parts of the boundaries that influence network traffic. OSPF can limit down on network foundation brought about by the weight of an enormous traffic to keep up the solidness of traffic on correspondence lines, transmission capacity has a very goo class dependent on the standard TIPHON. From the consequences of the QOS boundaries likewise acquired a diminishing in defer esteem by 31% on foundation with the OSPF convention. This demonstrates that the organization traffic is more steady when utilizing OSPF convention.

(An Improved Dijkstra's Algorithm for Shortest Planning on 2-D-2019)-Li Wenzheng et al.,

This paper presents a property on 2D eight neighbor framework map and portrays an improved Dijkstra's calculation which can accelerate the first Dijkstra's calculation by a few significant degrees and that's just the beginning, and furthermore presents the use with the A* calculation for somewhat known conditions. We accept this property on 2D eight-neighbor network map is exceptionally valuable, and we will attempt to discover more application areas for this property in our future work. This group tried out different foundation of IDA on various perspectives 2-D in eight neighbor network and results appears its paces up the Dijkstra's calculation by numerous significant degrees, the outcomes got during the calculation bargain can be effortlessly seen in A* incomplete circumstances.

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(Design of a Modified Dijkstra;s Algorithm for finding Alternate Routes for Shortest-Path Problems with Huge Costs-2020)-Omoniyi et al.,

The traditional Dijkstra's calculation is a ravenous system. It is utilized to track down the most limited way in a diagram. It is worried about briefest way arrangement without formal consideration for reaching destiny. Nonetheless, all things considered, circumstances, the supposed briefest way got from utilization of the old style calculation might be at an immense cost for the nodal that the arrangement may not be valuable for functional purposes. Consequently in this investigation, another system that deals with the value of the arrangement, all things considered, circumstances is proposed.

(Novel Pure-Pursuit Trajectory Following Approaches & their Practical Applications-2019)-Erno Horvath et al.,

Pure pursuit calculation is a famous direction following calculation, broadly utilized in versatile autonomous technology and vehicular control for various reasons. The activity is basic and clear as it relies just upon the kinematic model of the objective mechanical framework. The calculation can be tuned by picking look-ahead distance of points of the reference direction. In this paper, we propose three upgrades to the first pure pursuit calculation, meaning to deal with dynamic choice of look-ahead distance by choosing different objectives, altering look-ahead distance as indicated by the bends and changing sidelong deviation. Our work was inspired by a continuous self-ruling vehicle research at our college.

(Path tracking Control of Wheeled Mobile robot based on Improved Pure -Pursuit Algorithm-2018)-Sun Quinpeng et al.,

In this journal, our proposed dynamic guiding VO has been tried to keep away from static impediments in office circumstances with restricted movement. Global path pursue was performed by utilizing PRM for developing a way from starting situation to target position by a given guide. PRM was picked to limit computational time in worldwide way arranging measure. While neighborhood way arranging was done by consolidating Pure Pursuit of way following and changed directing VO of hindrance aversion.

CHAPTER 3

3.1 HARDWARE MODULE

The hardware setup has been fitted with toy car which is a prototype. This car is expected to move autonomously by getting the information from the sensors and feeding it into the upcoming module via pipelining method approach. In this prototype the Hall effect sensors are been placed at rear wheels and the IMU sensor placed along its orientation with respect to the vehicle's integrity. So the it can give us a hit when the vehicles completes one rotation. For more accuracy multiple hall effect sensors can be placed and projecting information into the algorithm arises. All these are 12V motors and controlled using an Arduino controller.

Initially there were built in motor drivers that were specifically fabricated to control this toy car (prototype). But those drivers cannot supply enough power to the motor while the vehicle was filled with supposed pay load with our specific modified criteria's. Also over power caused the drivers to malfunction because it doesn't includes any kind of fuse unfortunately which starts affecting the vehicle's angular displacement and wear & tear in motors.

So these motor drivers are now replaced with relays. These relays are capable of supplying the necessary power to the motor and also to withstand sudden and continuous spikes in our given power supply. After all been installed the sensor element of the vehicle such Hall effect and IMU starts giving closer range to accuracy prediction which basically needed to map the displacement of the vehicle's along its angle and speed.

3.2 PATH PLANNING & TRACKING H/W MODULE

- ✧ IMU SENSOR
- ✧ HALL EFFECT SENSOR
- ✧ RASPBERRY PI MODULE
- ✧ ARDUINO BOARD

- ✧ RELAY UNIT
- ✧ DISPLAY & INPUT

3.3 THE INERTIAL MEASUREMENT UNIT SENSOR

3.3.1 INTRODUCTION OF IMU SENSOR

The raspberry pi module which controls the IMU sensor draws power from power banks provided. Its been positioned in such a way that matches the orientation of the vehicle integrity. The flow connection for IMU interfaced with Raspberry pi module are made and pins are been configured optimized.

For more accuracy we have used the *IMU 9250* sensor which depicts the angle even more closer to our stringent conditions. The algorithm is designed in such a way that distinguishes the given region of angle when its been moved in 3 dimensions.

The sensor MPU-9250 is a SiP that incorporates 2 chips: the MPU-6500, which contains a 3-hub spinner, a 3-pivot accelerometer, and its been installed with Digital Motion Processor fit for preparing complex Motion Fusion calculations; and the AK8963, the market driving 3-hub computerized compass. A solitary plan can uphold the MPU-9250 or MPU-6500, giving clients the adaptability to help either gadget in various item. Upgrades incorporate supporting the accelerometer low force mode with just 6.4μA of and it gives improved compass information goal of 16-bits . The full scale estimation scope of ±4800μT lightens compass arrangement challenges on complex PCB's.

3.3.2 BLOCKS OF IMU SENSOR

- ✧ ACCELEROMETER
- ✧ GYROSCOPE

3.3.3 ACCELEROMETER WORKING PRINCIPLE

An Accelerometer that measures the changing rate of velocity of an particular object with respect to time also known as acceleration. With an accelerometer, you are able to identify out the angle the sensor is tilted at with respect to the ground, and vice versa.

An accelerometer that contains microscopic crystals that can under go stress when vibrations occur from system. From that stress, a voltage is been created which creates a reading on any acceleration. Its measured in m/s^2 But as accelerometer sensors express measurements in "g",which is 9.8 m/s^2.

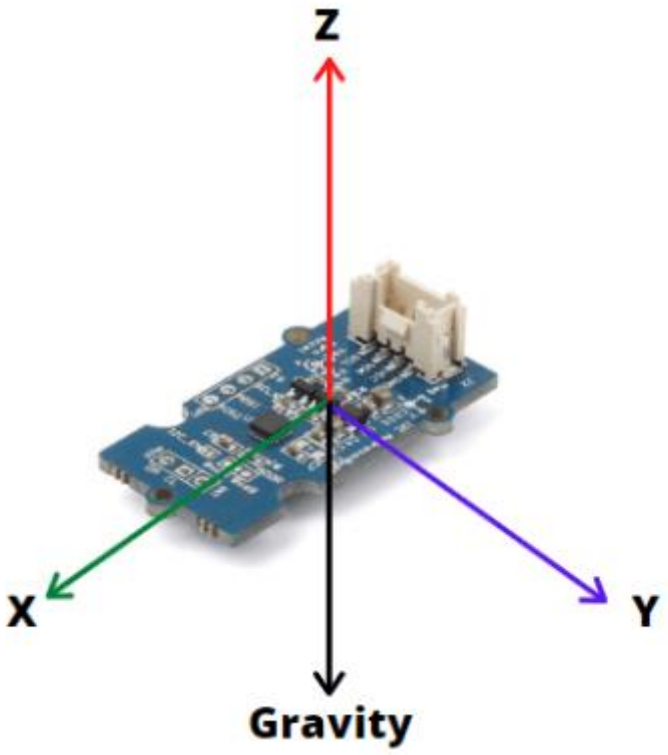

Fig.3.1 The illustration of accelerometer principle.

3.3.4 GYROSCOPE WORKING PRINCIPLE

At the point when a mass is moving a specific way with a defined speed and when an external angular rate will be applied as demonstrated with the forward green a power will happen which the sensor will recognize. As demonstrated underneath, named by the blue and red bolt, this will cause opposite removal of the mass. The removal will cause an adjustment of capacitance which will be estimated, handled and it will relate to a specific rakish rate.

The yields of the gyrator are in degrees each second, so to get the precise position, we simply need to incorporate the angular speed. In the wake of applying rationales in code we get precise position which we subject to polygon work later. By getting different boundaries from this sensor we get steady yield which will decide the direction and nature of the way which we wanna execute in ensuing codes. IMU which represents Inertial Measurement Unit is characterized as a 9-pivot sensor that actions direction, speed, and gravitational powers by joining Accelerometer, Gyroscope, and Magnetometer into 1 which we consolidate as sensor.

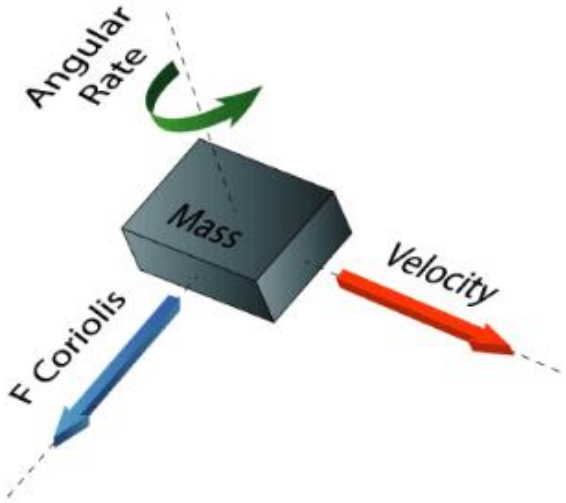

Fig.3.2 The illustration of gyroscope principle.

3.4 IMU INTERFACING WITH RASPBERRY PI MODULE

- ✧ **RASPI CONFIG COMMAND**
- ✧ **ENABLE I2C BUS**
- ✧ **INTERFACE PINS BY LOGIC CODE**
- ✧ **SOURCE LIBRARY AND OUTPUT**

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3.4.1 RASP-PI CONFIG COMMAND

This is initial step for confining the IMU sensor with raspberry PI module. Initially our raspberry Pi doesn't have enough supported libraries and its files. So initiating raspberry Pi for IMU sensor with this command will give us access to open port for sensor and read as well as write.

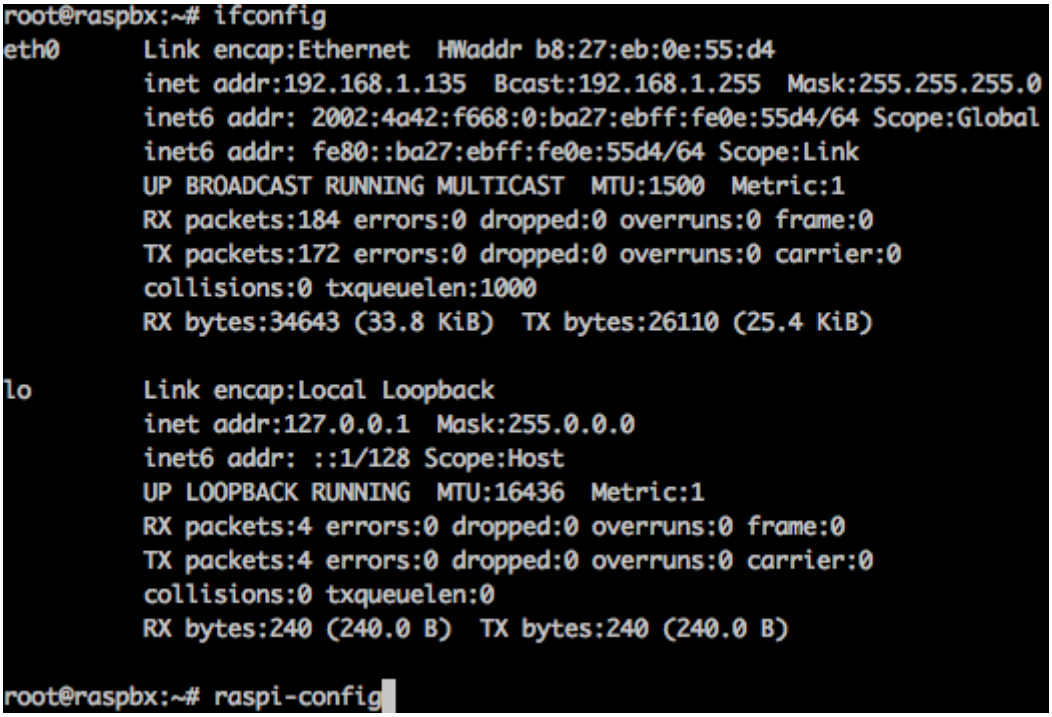


Fig.3.3 The configuring of raspberry pi command.

3.4.2 ENABLE I2C BUS

Our raspberry Pi and IMU sensor comprises I2C buses which are logically which can take data in particular packet from one end to other or multiple. This is not enabled defaultly, for additional usage such as interfacing we need to enable this pin with modes from the Pi module for accessing it. Whenever there is access package such SiC these may carry

additional lines of instructions for enabling the access across all given ports. Once its opened we can transfer contents in form of packets.

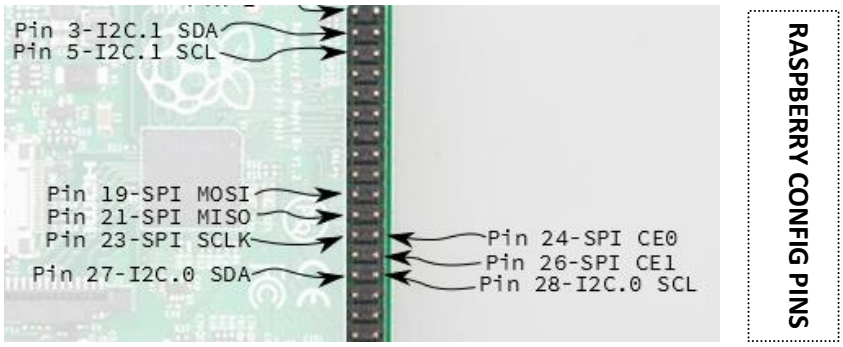


Fig.3.4 The illustration of raspberry pin configuration.

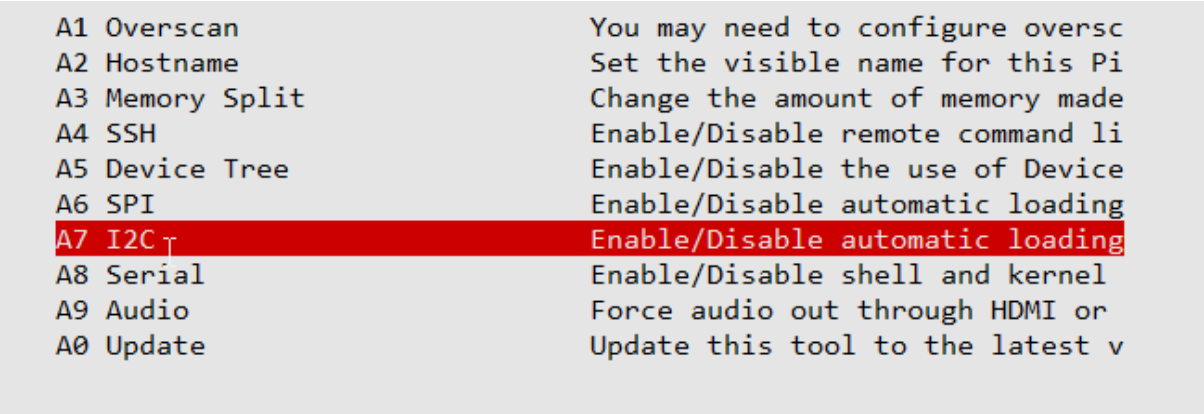


Fig.3.5 Enabling I2C pins.

3.4.3 INTERFACE PINS BY LOGIC CODE

Raspberry Pi module has set of pins that can accept or pass any information which we dictate. Similarly IMU sensor has its own set of instructions to give out multiple data all at once. Combining these two our data extraction might be intolerable, for this we use our own code logic to dictate where the packets of data might be useful while entering or exiting. These vital Pins are not been touched on any cause. Since the vital pins are the one which we drive the board and other important components which we access inside the module.

GRD SRC - being the vital Pins remaining other packet pins are subjected to form logic pins.

MPU9250	Raspberry Pi
SDA	SDA
SCL	SCL
VCC	3 V
Gnd	Gnd

Table 3.1 The illustration of raspberry pin configuration.

3.4.4 SOURCE LIBRARY AND OUTPUT

Initially Raspberry Pi and IMU dosn't have appropriate filed and libraries with dependencies. Since we are interfacing the two modules we need to download libraries which acts as dependencies which parsing the data from one end point to other and vice versa. These data are fetched from upcoming instructions set which are been given by these dependencies and access to all kind of packets which has been transmitting in the buses. The library are sources and installed which can be extracted in IMU and Pi module for further communication across two modules, After error rectification and parsing of data may indicate established bus along with port are connecting without any hassle.

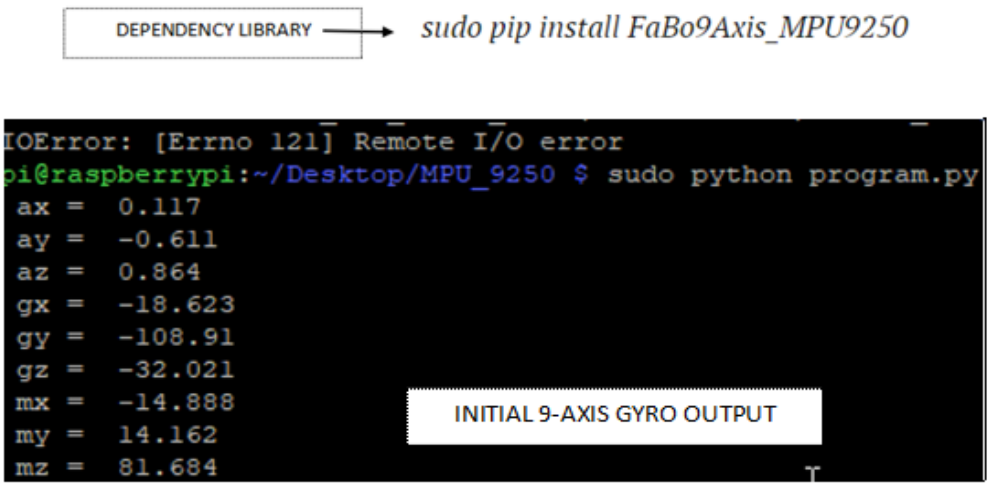


Fig.3.6 The illustration of raspberry pin configuration.

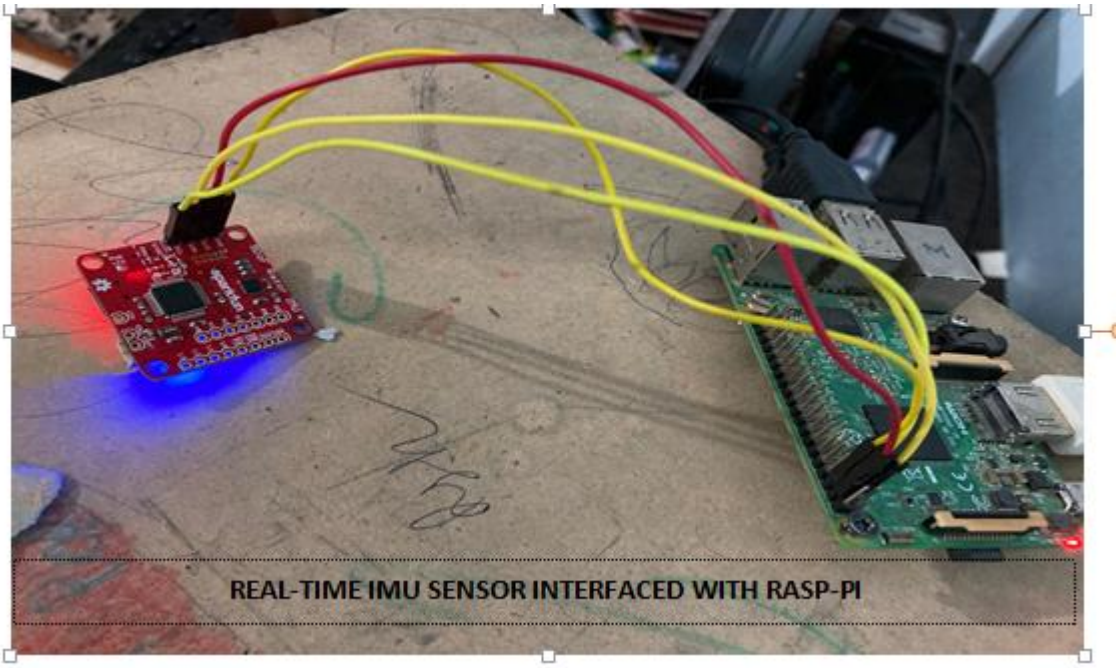


Fig.3.7 The real time configuration of raspberry with MPU sensor.

3.5 THE HALL EFFECT SENSOR

- ✧ **INTRODUCTION OF HALL EFFECT SENSOR**
- ✧ **PRINCIPLE OF HALL EFFECT**
- ✧ **HALL DETECTION**
- ✧ **INTERFACING HALL EFFECT WITH RASP-PI**
- ✧ **LOGIC CODE AND DEPENDENCIES**

3.5.1 INTRODUCTION OF HALL EFFECT SENSOR

One of the main uses of magnetic sensors is in automotive systems for the sensing of position, distance and speed. The firing angle of spark plugs w.r.t. Angular position of crank shaft, the position of the car seats and seat belts for air-bag control.

Magnetic sensors are fabricated to respond to a wide range of positive and negative magnetic fields in a variety of different applications and one type of magnet sensor whose output signal is a function of magnetic field flux enclosed around it is called the Hall Effect Sensor.

Hall Effect Sensors are sensors which are triggered by an outside magnetic field. We realize that an magnetic field has two significant attributes motion polarity, (B) and extremity (North and South Poles). The yield signal from a Hall impact sensor is the capacity of magnetic field density around the device. At the point when the magnetic transition density around the sensor surpasses a specific pre-set edge, the sensor identifies it and creates a yield voltage called the Hall Voltage, VH.

3.5.2 PRINCIPLE OF HALL EFFECT

When the device is placed within a magnetic field, the flux lines puts a force on the semiconductor material which deflects the charge carriers, electrons & holes, to either side of the semiconductor material. This movement of charge carriers is a result of the magnetic force they experience passing through the semiconductor material.

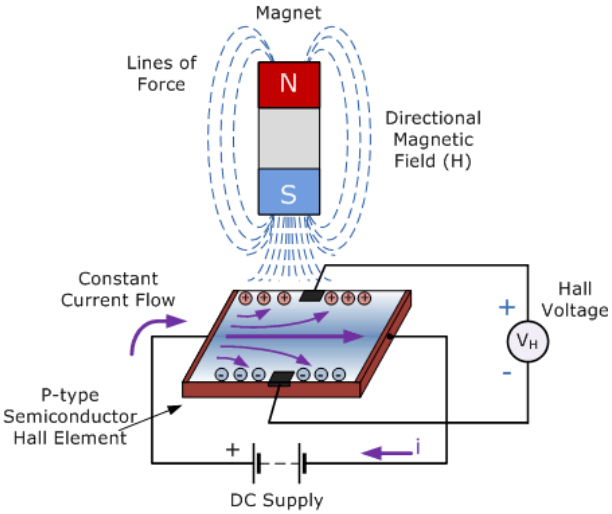


Fig.3.8 The principle of hall effect sensor.

As these electrons and openings move side wards a potential contrast is created between the different sides of the semiconductor material by the development of these charge transporters. At that point the development of electrons through the semiconductor material is influenced by the presence of an outside attractive field which is at right points to it and this impact is more prominent in a level rectangular molded material.

"To generate a potential difference across the device the magnetic flux lines must be perpendicular, (90') to the current flow and be of the correctly placed polarity, generally a south pole"

The Hall effect provides information regarding the type of magnetic pole and magnitude of the magnetic field. For e.g., a south pole would trigger the device to produce a voltage output while a north pole would have no variation. Generally, Hall Effect sensors and switches are fabricated to be in the open condition when there is no magnetic flux present. They only turn close condition when required to a magnetic field of viable strength and polarity orientation.

3.5.3 HALL DETECTION

- ✧ HEAD-ON DETECTION
- ✧ DIMENSIONAL DETECTION
- ✧ DYNAMIC DETECTION

3.5.3.1 HEAD-ON DETECTION

This detection needs that the magnetic field is about 90 degrees to to the hall effect sensing device and that for detection, it approaches the sensor straight on towards the active face. A sort of "head-on" approach.

Linear devices can also distinguish between polarity of magnetic fields. Non-linear devices can be made to produce the output "ON" at a designed air gap distance away from the magnet for indicating positional detection. The Head on detection is mostly used viable form of sensing technique because this uses limited energy source of whats given into the system to get its output for given time reference frame.

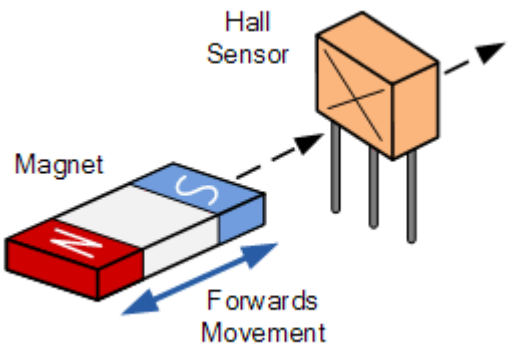


Fig.3.9 Head on Detection for hall effect sensor.

3.5.3.2 DIMENSIONAL DETECTION

The second detecting arrangement is "sideways detection". This requires getting the magnet across the substance of the Hall impact component in a sideways motion. Sideways or slide-by location is helpful for distinguishing the presence of an attractive field as it gets across the essence of the Hall component inside a fixed air hole distance for instance, tallying rotational magnets or the speed of turn of engines.

Contingent on the situation of the attractive field as it passes by the zero field Center line of the sensor, a direct yield voltage addressing both a positive and a negative yield can be delivered. This takes into consideration directional development discovery which can be vertical just as even.

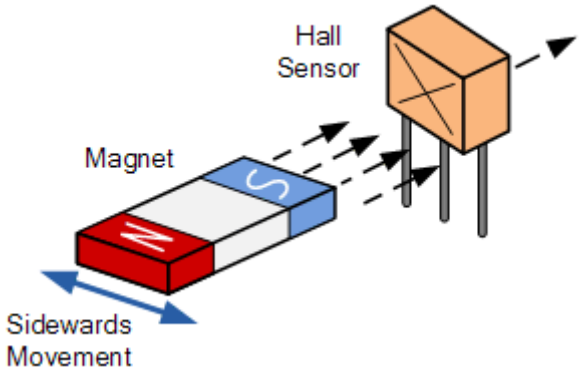


Fig.3.10 Dimensional detection for hall effect sensor.

3.5.3.3 DYNAMIC DETECTION

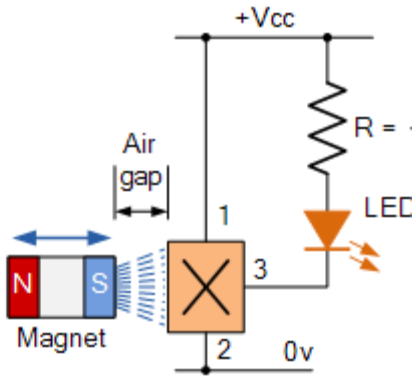


Fig.3.11 Dynamic detection for hall effect sensor

In a persistent development the Hall Effect Sensor is situated in such a manner it identifies the attractive field around it brought about by the development in the objective at some specific distance with given air-hole. The objective will be moving with higher speed yet at the hour of location around the corridor sensor time is been punched and exposed to computation to discover the speed of moving focuses with straightforward mathematical estimation.

3.5.4 INTERFACING HALL EFFECT SENSOR WITH RASP-PI

The hall effect is been placed adjacent to the wheels to detect whether the vehicles move in given direction. The magnetic pole of north is being detected by the receiver side of the sensor to register that the sensor is been made a hit. So it registers the vehicle has been moved to a distance of 3 feet. It's been made possible by devising an algorithm that register these criteria of displacements as per our requirement.

SDA	→	SDA
SCL	→	SCL
VCC	→	3 V
Gnd	→	Gnd

VITAL PINS BYPASSED

Table 3.2 Interfacing vital pins with raspberry pi & sensor

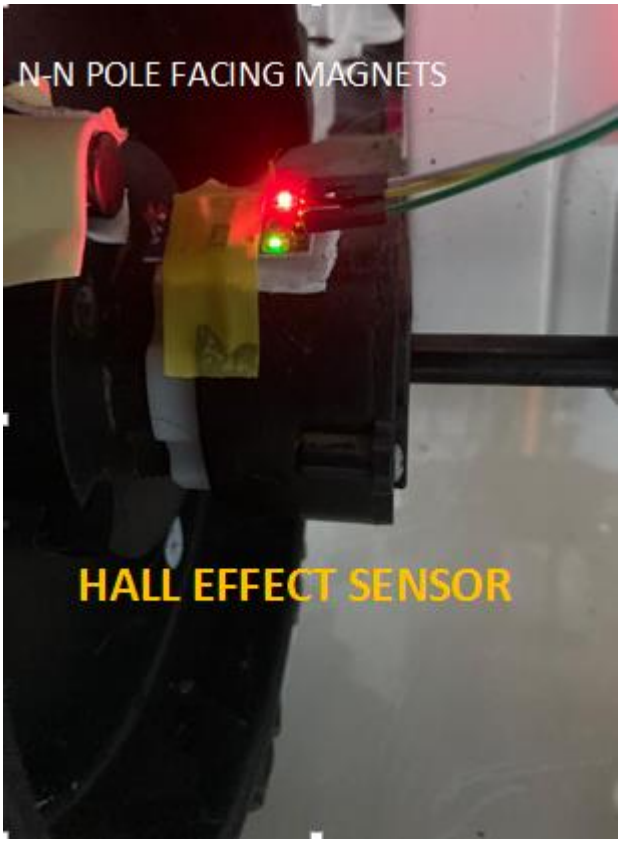


Fig.3.12 Interfacing vital pins with raspberry pi & sensor

The Hall Effect sensor coordinated with Raspberry module has set of pins that can acknowledge or pass any data which we direct. Essentially IMU sensor has its own arrangement of guidelines to give out different information at the same time. Joining these two our information extraction may be excruciating, for this we utilize our own code rationale to direct where the parcels of information may be valuable while entering or leaving. These fundamental Pins are not been addressed any reason. Since the essential pins are the one which we drive the board and other significant segments which we access inside the module.

GRD SRC - being the indispensable Pins staying other parcel pins are exposed to frame rationale pins. Since IMU sensor previously taking principle part of the pins, we need to reconfigure the pins in a manner the parcels they move ought not be bother. Pins are reconfigured and given need in rationale code to start the information stream and input.

3.5.6 LOGIC CODE AND DEPENDENCIES

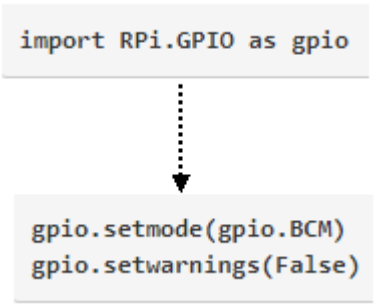


Fig.3.13 Inputs and outputs initiating with Rasp-Pi sensor

We start the code by importing the RPI.GPIO library which allows us write python scripts to interact with the raspberry pi GPIO pins.Next we set the numbering configuration for the Raspberry pi's GPIO that we will like to use and disable GPIO warnings to allow free flow execution of the code.

```
if(cu>2):
  gyro = mpu9250.readGyro()
  gz = int(gyro['z'])
  gz=gz-pgz
  #print(gz)
  #print(gpio.input(hallpin))
  hs=int(gpio.input(hallpin))
  if(prv!=hs):
      #print("state change")
      if(hs==0):
       #  print("hit")
         if(gz>0):
```

Fig.3.14 Declaring output for hall sensor

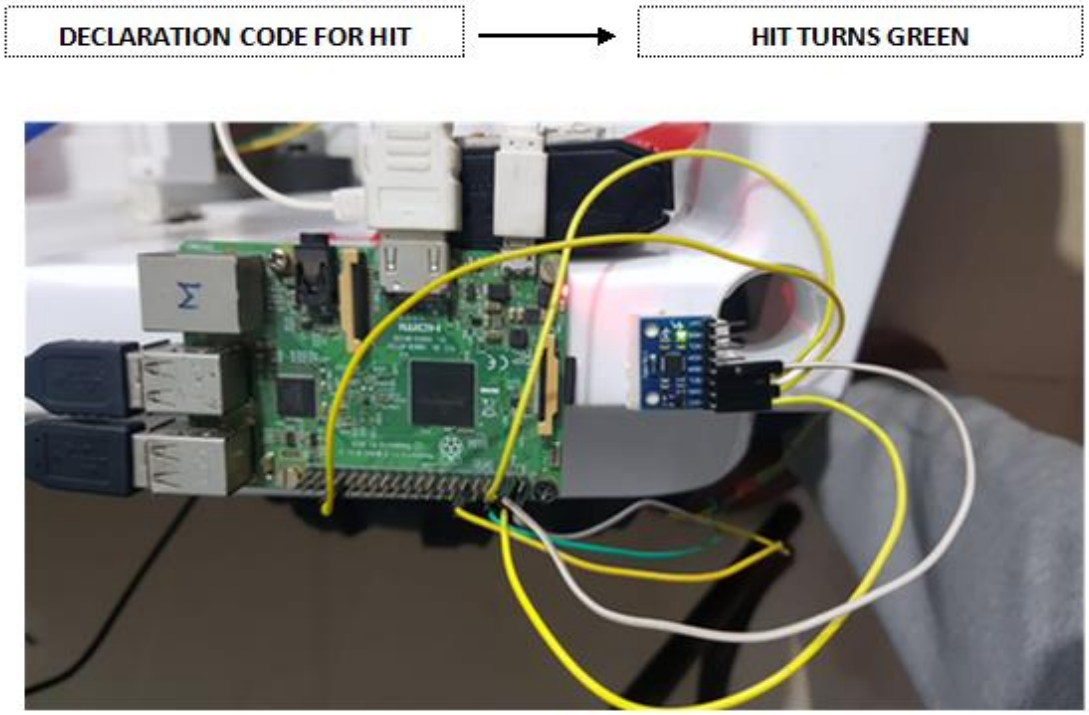


Fig.3.15 Real time output for interfacing HALL & Ras-pi

The primordial Hall Effect Sensor sensing detection for our dynamic output is been triggered by green led indicator.

3.6 RASPBERRY MODULE

Raspberry Pi is a micro processing unit which has its own memory and processor built in. This runs on python or other open source software that are compatible with this module, is being used for various application which are in budding stage or prototype. In this prototype there is an IMU sensor placed at the back end of the vehicle to sense the angle through which the vehicle is getting deviated. This sensor is controlled using this raspberry controller. Similarly Hall effect sensor is also being placed in Rasp-pi to get the data transaction and processed as per given logic code and display it in the monitor wired or wirelessly.

The Vital Pins are never been subjected to tamper apart from all the usage pins. These pins are frequently interchanged or soldered according to our usage. The Logic code determines which data should be processed in given time and where to pass it via I2C buses. Entire module of execution and interface is been explained above until Rasp-pi command execution.

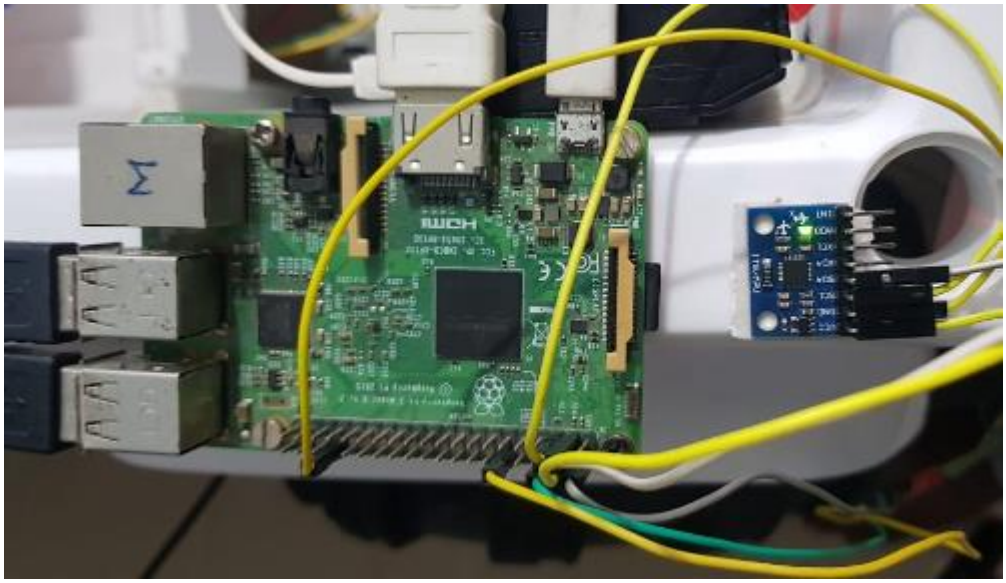


Fig.3.16 Raspberry and Hall to trigger Green Hit.

3.7 ARDUINO MODULE

Arduino UNO is a controller that is capable of performing various operations. This controller basically runs in its own language which is similar to C. One of the frequent reasons for using this is controlling a motor. The speed of the rear wheels are controlled using this controller. If a motor drive is used then the concept of PWM can be used. Since in our case a motor drive is insufficient to supply the necessary power it is not done. Still the RPM is controlled by having different delay times while running. Also the front motor is controlled using the same board.

3.8 INITIATING ARDUINO MODULE FOR RELAYS

Generally for usage of third party applications for other purposes requires a software or dependency which haven't been installed earlier. To rectify this the Arduino UNO comes with default package and we need to enable com ports and transfer the package via set of defined instructions.

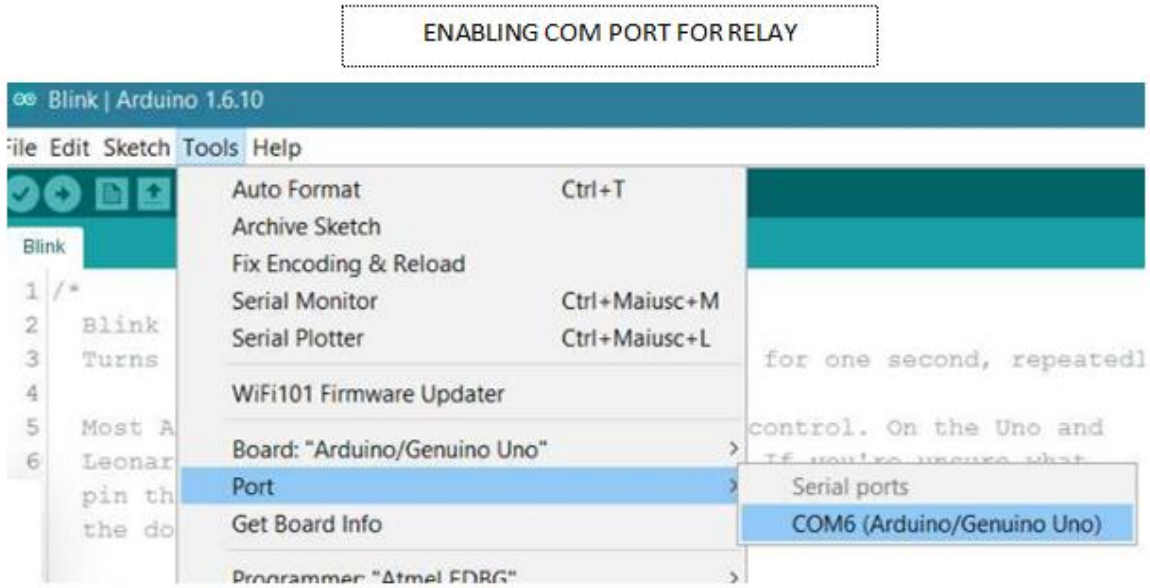


Fig.3.17 Com ports for Arduino.

After enabling com port we can access the Arduino module without any hassles.

3.9 RELAY MODULE

Relay Unit utilized here is a 5V 10A two channel hand-off module which has benefits in the two different ways by separating the circuit during over supply and furthermore by providing the vital current. Likewise the engine drive which is by and large prudent to drive the engines constrained by any regulator couldn't supply the necessary amperes, while the hand-off module provided the current required drive the engine with adequate force.

3.9.1 PURPOSE OF RELAYS

Usually when we drive a system it require power at specific quantity in given time. In our case the over driven of arduino board cant give enough power output to the specified motors. For this purpose we introduced a bridge that acts of power factor to the load i.e. Motors. When the set of instruction is been made out using delays it automatically calls the motors with specific voltage in given time delay. During this phase the power which runs across the entire board comes with its own drawback that the entire power has some back emf that is been leaking throughout the board in the form of heat. To rectify this we introduced the relays for stopping this further. The relays gets the specified stringent voltage and delay from the arduino controller. Then it makes its circuitry to prevent the back emf occurs in the transmission path and thus is controls the given amount of voltage and current in stringent conditions. It enables us to drive the motors without any hassel as depicted by algorithm to steer the wheels in its path.

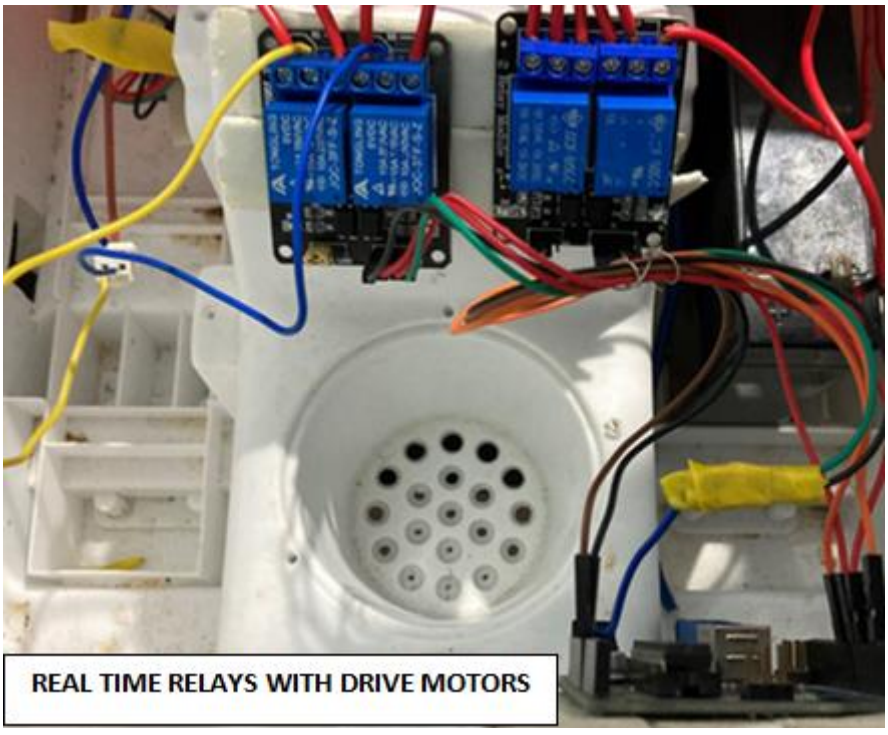


Fig.3.18 Relay for steer module and bypassing emf unit.

3.10 DISPLAY AND INPUT

The closest form of input and output for controlling a mini computer with specified hardware goes for monitor and keyboard. While other sources can be input and output example monitoring via CNC view & outputs shall be transferred to data card and can processed later.

This autonomous vehicles should run autonomously, for that we need live monitoring and control unit with specified instruction inputs. Live monitoring can be captured via HDMI to monitor control cable. Similarly inputs control can be given wirelessly or via keyboard connected with CPU for program execution of all software modules that runs synchronously.

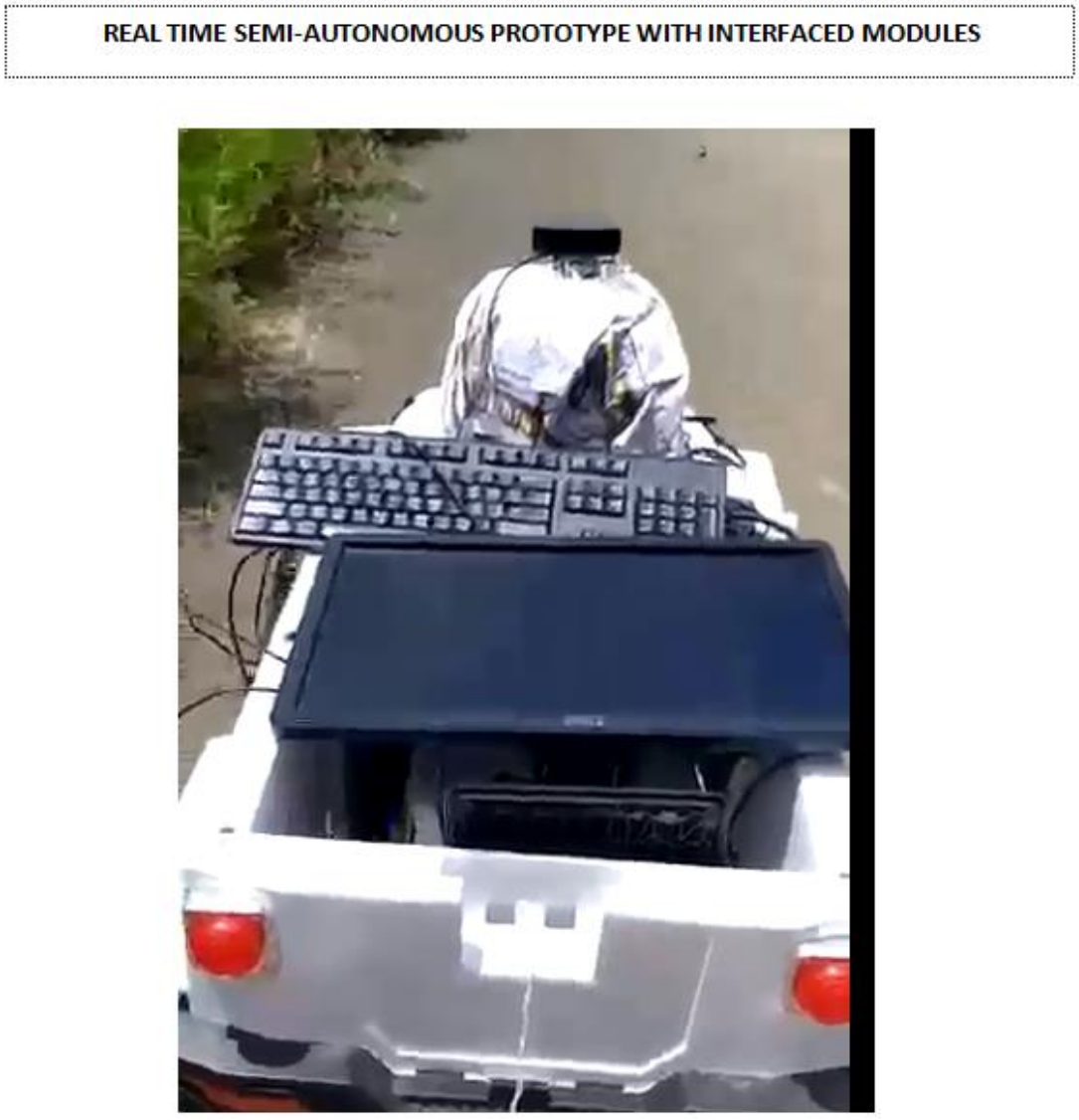


Fig.3.19 Real time Input and output for modules.

CHAPTER 4

4.1.SOFTWARE MODULE

The scope of autonomous vehicle is to run autonomously without any intervention once everything is been set. Like wise our prototype module en-comprising autonomous with subjecting our stringent set conditions for carrying out our tasks. Basically autonomous vehicles has numerous methods and modules. Those modules has to sync perfectly and run across all the modules in any given time slot. Another important aspect is to keep track of whats the data flow between modules and when it flows. If there is any error between parsing of packets from one point to other, we need to rectify it by using error detection and correction algorithm. The modules must sync together to produce autonomous movement in vehicle. After movement all other algorithms takes their place and produce output so that the vehicle keeps moving on its values until its been terminated.

4.2 INTRODUCTION TO SOFTWARE MODULE

Initially we began with toy car as a prototype for converting it into autonomous vehicles manipulation. For this we had set stage for subdividing into categories for modules. The vital modules for initiating autonomous are the one which steers the vehicles in given path, the one which carries the information for path planning and tracking algorithms through various subjections trajectories which corresponding the nearest path algorithm, the one which takes cares of objective in its path and its gives command to other modules to follow when it detects objects in its path.

4.3 FLOW OF ALGORITHM HIERARCHY

The flow of algorithms shall be initiated all modules together performing their tasks. The path planning and tracking algorithm is the foundation for algorithms to work on it while it gives the space from where to start and stop in this 3-Dimension space. The algorithm uses the coordinates to locate from where its been starting and where its currently in active. It also finds numerous way of trajectories to get to destination by having logical shortest path. Once it defines the boundaries and way to approach the destination, the steering module kicks in

with its set of instructions and commands. The steering module is initiated the algorithm checks for the view and angle from camera and compares the loading data from its recorded data by CNN. The Computational Neural Networks segregates the given data set into multiple set of various scenarios for given situation. If the set of particular scenario is been recorded by cam it segregates into possible scenario by manipulating external factors such as light, grass growth, orientation, seasons, ambiance etc..Whenever the situation is been called algorithm changes is behaviour and mode corresponding to the given set of instruction pursued by CNN and its dependent algorithm. So the path planning algorithm and steering algorithm should sync properly to give its final output by initial position to final position by steering along the given line of trace.

After determining the initial position and set the destination to final position using coordinates the path planning and tracking algorithm gives line of trace or map for which the autonomous vehicles to be carried within in it. We shall set some boundary limits to steer in the particular line of sight which will be constantly monitored by CNN. The particular CNN checks the data given by the camera and it senses any other obstacle is been carried out rather than the desired output. If suppose, the vehicles has steered in wrong direction due to external factors or delay, the CNN constantly monitors and instructs the steering module to steer in given path i.e. Left, right or maintain same. This can be carried out by differences in voltage given by the arduino board which is been monitored by algorithm run by CPU. Claiming that the vehicle has started moving based on given stringent conditions, supposedly an object or obstacle is objecting the vehicles to proceed forward.

This is where the obstruction module kicks in and says alternate path and to avoid collision. The basic collision detection is constantly inline for the vehicles to avoid any collision. Once a object or obstacle is been identified the obstruction modules helps to render the path in such a way the obstacle is been let out of the path predicted by the path planning algorithm. The information is fed-back into path planning algorithm to check if any alternate route that the vehicle can avoid that obstacle. If it isn't that case using collision detection it tries to cross the path without any collision. If that option is not available it immediately sends information to server that the situation should be fixed. The constant monitoring modules are CNN, Collison avoidance, path updation, steering module. Hence the data must flow to and fro at

all given times. So these datas should collide between them and should not make any interference among them. In such a way algorithms and its timing slot have been set. The pins which govern the vital functions such as ground, power, SCH, SHD should not be tampered at any cause, which may produce the delay for bypassing set instructions which they should be carried out. These instruction should run without any delay of interference, if suppose a pin has been tampered by rough terrain, the instruction set jumps to next instruction leaving that set of instruction that does not pass through the algorithms will gives error after some while and may cause halt in programs at any given point. Ensuring the contact point and algorithms are tamper proof any such deviation from the predicted stringent conditions.

4.4 MODULES OF PROTOTYPE

- ✧ **STEERING MODULE**
- ✧ **PATH TRACKING AND PLANNING MODULE**
- ✧ **OBSTRUCTION VISION MODULE**

Since autonomous prototype comprises modules everything has to sync coordinately to give the output desired set by our logic codes and CNN training. Primarily after updating our modules with path planning and tracking algorithm it responds to it environment. The steering module takes control of where to steer and how to steer in given time in specific angle. The obstruction module takes care of what lies a ahead of its path, and how to overcome or take multiple trajectories to avoid the collision. These data flows has to sync perfectly with each other to establish across modules ensuring the flow of data reaching the correct algorithm in its given time. These data flows must not get tampered along with any other data that flowing with vital informations such as voltage and current that drives other modules.

CHAPTER 5

5.1 INTRODUCTION ON PATH PLANNING ALGORITHM

Fundamentally the path planning calculation involves briefest way calculation & close to token calculation, Dijkstra calculation, pure pursuit algorithm.Path-planning is a significant crude for self-ruling versatile robots that allows robots to track down the most limited – or in any case ideal – way between two focuses. In any case ideal ways could be ways that limit the measure of turning, the measure of slowing down or whatever a particular application requires. Calculations to track down a most brief way are significant in advanced mechanics, yet in addition in network steering, computer games and quality sequencing.

Way arranging requires a guide of the situations and the robot to know about its area concerning the guide. We will accept for the present that the robot can limit itself, is outfitted with a guide, and equipped for staying away from impermanent obstructions on its way. Step by step rules to make a guide, how to restrict a robot, and how to manage obstructive position data will be significant foci .

5.2 THEORY AND ALGORITHM FOR PLANNING PATH

- ✧ Map representations algorithms
- ✧ Basic path-planning algorithms ranging from Dijkstra, A*, D*, RRT
- ✧ Coverage path planning.

We had tried various algorithms initiating with Dijkstra’s for path planning. We devised algorithm specifically for our environment in term of certain modifications which can be enabled in further process and operations inside certain logic loop. This modified algorithm depicts the usage of certain limitation within confined space of map. For more accuracy we have tested the range of area under minimal conditions such as defined space, and constant light ambient conditions necessary for the loop to identify itself over several other iterations.

5.2.1 MAP REPRESENTATION ALGORITHMS

To design plan a path, we some way or another need to address the situation in the PC. We separate between two reciprocal methodologies: discrete and ceaseless approximations. In a discrete estimate, a guide is sub-partitioned into lumps of equivalent (e.g., a matrix or hexagonal guide) or varying sizes (e.g., rooms in a structure). The last guides are otherwise called topological guides.

Discrete guides loan themselves well to a diagram portrayal. Here, each lump of the guide relates to a vertex (otherwise called "node"), which are associated by edges, if a robot can explore from one vertex to the next. For instance a guide is a topological guide, with crossing points as vertices and streets as edges. Computationally, a diagram may be put away as a contiguousness or occurrence list/lattice. A ceaseless estimate requires the meaning of internal (deterrents) and external limits, ordinarily as a polygon, while paths can be encoded as successions of genuine numbers. Discrete map planning are the predominant portrayal in advanced mechanics.

As of now the most well-known map is the occupancy matrix map. In a matrix map, the situation is discretized into squares of discretionary goal, for example 1cm x 1cm, on which hindrances are stamped. In a probabilistic inhabitance framework, network cells can likewise be set apart with the likelihood that they contain an obstruction. This is especially significant when the situation of the robot that detects a snag is unsure.

Inconveniences of matrix maps are their huge memory prerequisites just as computational opportunity to navigate information structures with enormous quantities of vertices. An answer for the last issue are topological guides that encode whole rooms as vertices and use edges to show safe associations between them. There could be no silver shot, and every application may require an alternate arrangement that could be a mix of various guide types.There exist additionally every conceivable blend of discrete and constant portrayal. For instance, guides for GPS frameworks are put away as topological guides that store the GPS directions of each vertex.

In our own special case we utilized Dijkstra calculation to get the briefest way from starting to end. Drawn nearer by nodal cost overhead rationale circle and investigate ahead calculation to decide whats the nearest highlight the objective. These followed by the ways which can be drawn as a line of follow from guide A toward point B by correcting the directions along to the perspective from its unique position.

5.2.2 A* ALGORITHM AND LOGIC

Taking a gander at the situation for our current circumstance the calculation plays out a ton of calculations that are "clearly" not going the correct way. They are clear since we have a higher perspective of the situation, seeing the area of the obstruction, and we know the surmised course of the objective. The last additional information that we have can be encoded utilizing a heuristic capacity, a fancier word for a "rule of thumb". For instance, we could offer need to nodes that have a lower assessed distance to the objective than others. For this, we would check each node not just with the genuine distance that it took us to arrive (as in Dijkstra's calculation), yet additionally with the assessed cost "as the crows flies", for instance by ascertaining the Euclidean distance or the distance between the vertex we are taking a gander at and the objective vertex. This calculation is known as A*. Contingent upon the climate, A* may achieve search a lot quicker than Dijkstra's calculation.

A* calculation, then again, tracks down the most ideal way that it can take from the source in arriving at the objective. It realizes which is the best way that can be taken from its present status and how it needs to arrive at its destination.Now that A*, we should comprehend a touch of hypothesis about it as it is fundamental for assist you with seeing how this calculation functions. A*, as we as a whole know at this point, is utilized to track down the most ideal way from a source to an objective. It advances the way by ascertaining minimal separation from one hub to the next.

$$F = G + H$$

- F – F is the parameter of A* which is the sum of the other parameters G and H and is the least cost from one node to the next node. This parameter is responsible for helping us find the most optimal path from our initiate to terminate.

- G – G is the cost of moving from one node to the other node. This parameter changes for every node as we move up to find the most optimal path.
- H – H is the heuristic/estimated path between the current code to the destination node. This cost is not actual but is, in reality, a guess cost that we use to find which could be the most optimal path between our source and destination.

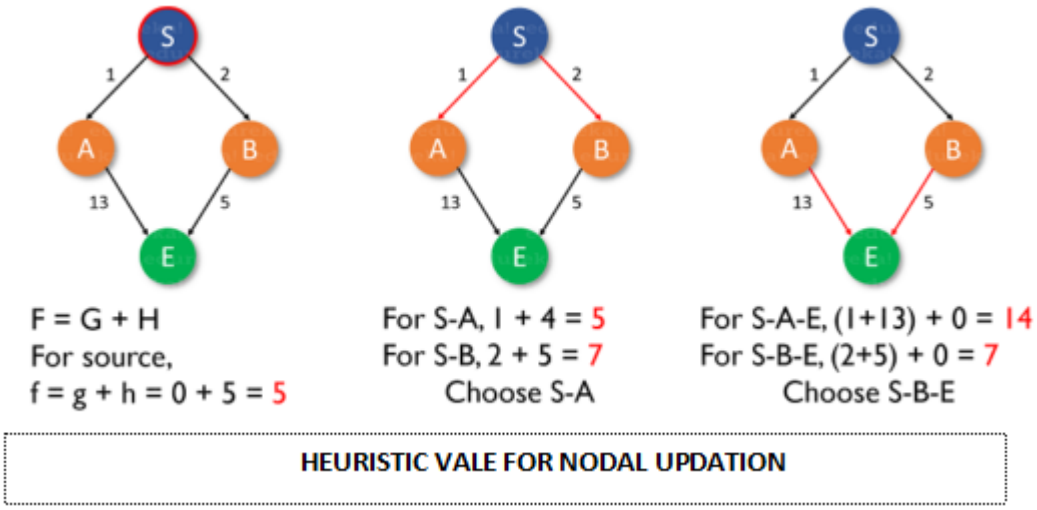


Fig.5.1 Nodal Updation to nearest neighbors.

5.2.3 FLOW OF A* ALGORITHM

- Add start node to list
- For all the neighbouring nodes, find the least cost F node
- Switch to the closed list
- For 8 nodes adjacent to the current node
- If the node is not reachable, ignore it. Else
- If the node is not on the open list, move it to the open list and calculate f, g, h.

- ✧ If the node is on the open list, check if the path it offers is less than the current path and change to it if it does so.
- ✧ Stop working when
- ✧ You find the destination
- ✧ You cannot find the destination going through all possible points conjecture.

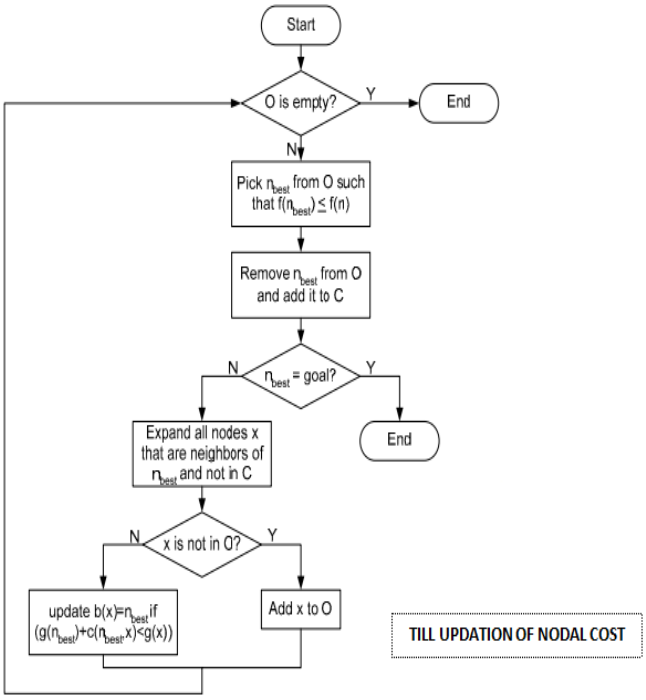


Table 5.1 Flow Algorithm of A star.

Dynamic Weighting[15] uses the cost function $f(n) = g(n) + (1 + \varepsilon w(n))h(n)$, where $w(n) = \begin{cases} 1 - \frac{d(n)}{N} & d(n) \leq N \\ 0 & \text{otherwise} \end{cases}$, and where

NODAL WEIGHT COST UPDATION FUNCTION.

Fig.5.2 Dynamic Weights for Nodal Updates.

```
if __name__ == '__main__':

    maze = [[0, 1, 0, 0, 0, 0],
            [0, 0, 0, 0, 0, 0],
            [0, 1, 0, 1, 0, 0],
            [0, 1, 0, 0, 1, 0],
            [0, 0, 0, 0, 1, 0]]

    start = [0, 0] # starting position
    end = [4,5] # ending position
    cost = 1 # cost per movement

    path = search(maze,cost, start, end)
    print(path)
```

Fig.5.3 Area update for A star Algorithm.

A* star terminating with its cost updation function to set values for matrices and ends up looking like set of values that are non colliding with its path of obstacle.

```
print('\n'.join([''.join(["{:" ">3d}'
      for row in path]))
```

Printing output when cost of nodal become 0

```
  0 -1 -1 -1 -1 -1
  1  2  3  4  5 -1
 -1 -1 -1 -1  6  7
 -1 -1 -1 -1 -1  8
 -1 -1 -1 -1 -1  9
```

Fig.5.4 output of modified A star Algorithm.

CONS

Despite the fact that being the best pathfinding calculation around, A* Search Algorithm doesn't create the most optimal way consistently, as it depends vigorously on heuristics/approximations. These may influence the delivering of the information as it streams from different modules and it might cross up sync when the information stream traffic is higher from the modules that are adjusted. Some of the time A* may require significant investment intricacy dependent on the wellspring of the objective and the source and the given destination with accordance to the given time frame at the particular timeline as depicted.

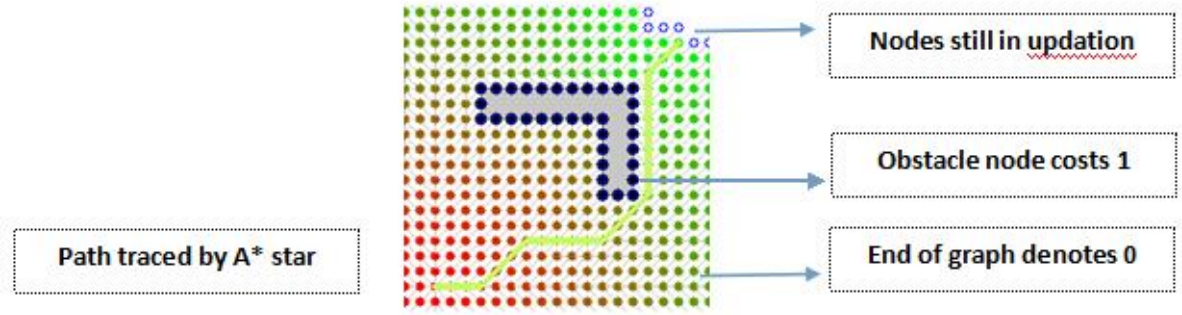


Fig.5.5 Path traced by Algorithm.

5.3 D* ALGORITHM

Stands for "*Dynamic A* Search*"

Dynamic: Arc cost boundaries can change during the critical thinking measure—rethinking online. Initially designs utilizing the Dijkstra's calculation and permits brilliantly storing middle information for fast rethinking An augmentation of A* that resolves the issue of costly rethinking when deterrents show up in the way of the robot, is known as D*. Not at all like A*, D* begins from the objective vertex and can change the expenses of parts of the way that incorporate a hindrance. This permits D* to rethink around an obstruction while keeping up the majority of the generally determined way.

5.4 RRT ALGORITHM

A* and D* become computationally costly when either the inquiry space is huge, e.g., because of a fine-grain goal needed for the errand, or the elements of the hunt issue are high, for example when getting ready for an arm with numerous levels of opportunity. A later advancement known as Rapidly-Exploring Random Trees (RRT) resolves this issue by utilizing a randomized methodology that focuses on rapidly investigating an enormous space of the pursuit space with iterative refinement. For this, the calculation chooses an irregular point in the climate and associates it to the underlying vertex. Ensuing irregular focuses are then associated with the nearest vertex in the arising diagram. The chart is then associated with the objective hub, at whatever point a point in the tree approaches sufficient given some edge. Albeit for the most part an inclusion calculation (see additionally underneath), RRT can be utilized for way arranging by keeping up the expense to-begin each additional point, and

biasing the determination of focuses to once in a while falling near the objective. . Most as of late, varieties of RRT have been suggested that will in the end track down an ideal arrangement. By the by, despite the fact that RRT rapidly discovers some arrangement, smooth ways ordinarily require extra pursuit calculations that beginning from an underlying appraisal given by RRT.

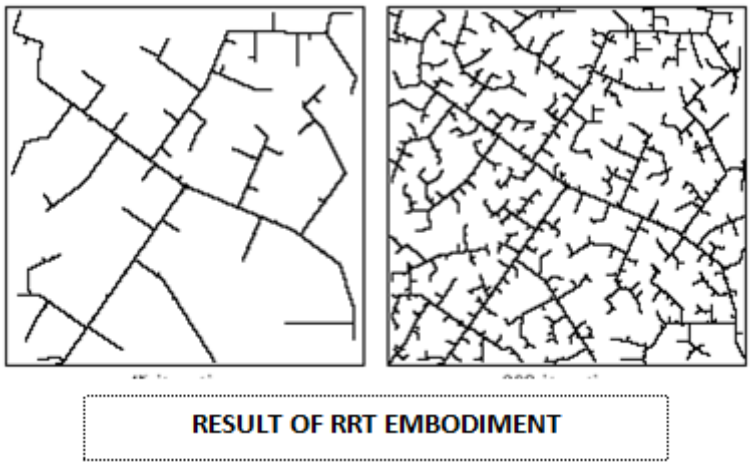


Fig.5.6 Image produced when Algorithm branches numerous iterations**.**

To manage the actual encapsulation of the robot, which muddles the way arranging measure, the robot is decreased to a point-mass and every one of the snags in the climate are developed by half of the longest augmentation of the robot from its middle. This portrayal is referred to as arrangement space as it diminishes the portrayal of the robot to its x and y facilitates in the plane. Most arranging calculations additionally don't think about the direction of the robot. On the off chance that this is wanted, an extra measurement should be brought into the setup space.

5.5 COVERAGE PATH PLANNING

When the climate has been discretized into a graph (note, a chart is just a single conceivable portrayal), we can utilize different calculations from diagram hypothesis to design alluring robot directions. For instance, floor inclusion can be accomplished by playing out a depth first search (DFS) or a breadth first-search (BFS) on a diagram where every vertex has the size of the inclusion device of the robot. "Inclusion" isn't just fascinating similar calculations can be utilized to play out a thorough inquiry of a setup space, for example, in the model seen where we plotted the blunder of a controller arm in arriving at an ideal situation over its arrangement space. Tracking down a base in this plot utilizing a thorough inquiry tackles the

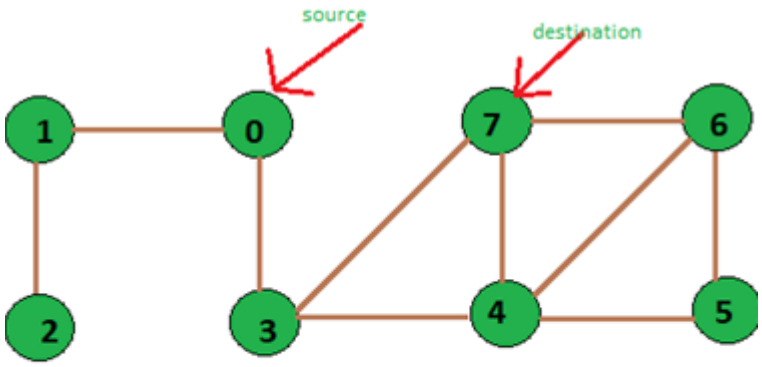
backwards kinematics issue. Essentially, a similar calculation can be utilized to deliberately follow all connections on a site till an ideal profundity (or really following the whole internet).

5.5.1 GRAPH TRAVERSALS

Graph crossing implies visiting each vertex and edge precisely once in an obvious request. While utilizing certain diagram calculations, you should guarantee that every vertex of the chart is visited precisely once. The request in which the vertices are visited are significant and may rely on the calculation or question that you are settling. During a crossing, it is significant that you track which vertices have been visited. The most well-known method of following vertices is to stamp them.

5.5.2 BREADTH FIRST SEARCH

There are many ways to traverse graphs. BFS is the most commonly used approach. BFS is a traversing algorithm where you should start implying from a selected node (source or starting node) and traverse the graph layer-wise thus searching the neighbour nodes (nodes which are directly connected to source node). You must then move towards the next-level neighbour nodes.




```
Shortest path length is : 2
Path is::
0 3 7
```

Fig.5.7 Weighted Nodal information parsing through each nodes.

5.6 DIJKSTRA'S ALGORITHM AND ITS LOGIC

The issue to track down a "shortest" path starting with one vertex then onto the next through an associated chart is of interest in different spaces, most unmistakably in the web, where it is utilized to track down an ideal course for an information parcel. The expression "most shortest " alludes here to the base combined edge cost, which could be actual distance (in a mechanical application), delay (in a systems administration application) or some other metric that is significant for a particular application.

One of the most punctual and predecessor calculations is Dijkstra's calculation. Beginning from the underlying vertex where the way should begin, the calculation denotes all immediate neighbors of the underlying vertex with the expense to arrive. It at that point continues from the vertex with the least expense for the entirety of its neighboring vertices and imprints them with the expense to get to them by means of itself if this expense is lower. When all neighbors of a vertex have been checked, the calculation continues to the vertex with the following most minimal expense. A more definite portrayal of this calculation is given here. When the calculation arrives at the objective vertex, it ends and the robot can follow the edges pointing towards the least edge cost.

The traditional Dijkstra's calculation is an greed methodology. It is utilized to track down the most brief way in a diagram. It is worried about most limited way arrangement without formal thoughtfulness regarding the sober mindedness of the arrangement. Notwithstanding, all things considered, circumstances, the purported most brief way got from use of the traditional calculation might be at a tremendous expense for the degree that the arrangement may not be helpful for viable purposes. Consequently in this examination, another system that deals with the handiness of the arrangement, all things considered, circumstances is proposed. This new altered calculation acquaints another segment with the traditional calculation in type of probabilities which characterize the situation with opportunity each edge of the diagram. These probabilities were produced arbitrarily in this investigation, and used to alter the old style Dijkstra's procedure. The altered Dijkstra's was then carried out on a 40-hub chart. The adjusted calculation created every one of the potential courses thus managed the cost of the distinguishing proof of the most limited way. The following stage in

this investigation is to figure the computational intricacy of the altered calculation and contrast it and the traditional Dijkstra's calculation.

5.6.1 CLASSICAL DIJKSTRA'S LIMITATIONS

The utilization of Dijkstra's calculation and A* calculation in the most limited way is fundamental will give a similar yield right away when being utilized on the town or local scale maps. A* examine the region just toward objective in light of the heuristic worth that included in the computation, while Dijkstra look by growing out similarly toward each path and normally winds up investigating a lot bigger region before the objective is found coming about making it more slow than A*. This can be demonstrated by the circle check of Dijkstra and A*, the more focuses (nodes) the higher the contrast between the loop the time.

At first while continuing to track down the most short way around there, we will in general define the limits with obstructions, along these lines preparing the estimations dependent on time it took to accumulate hub results from direct A toward point B will gives an opportunity to arrive at source to objective in some random time. I had attempted to limit the region with expanded deterrent so it might establish similar neighborhood climate for the model to perform under such conditions.

5.6.2 AMENDING LOGIC BY INTERCHANGING MATRICES

```
def get_motion_model():
    # dx, dy, cost
    motion = [[1, 0, 0],
              [0, 1, 1],
              [-1, 0, 1],
              [0, 1, -1],
              [1, -1, math.sqrt(2)],
              [-1, 1, math.sqrt(2)],
              [1, -1, math.sqrt(2)],
              [-1, 1, math.sqrt(2)]]

    return motion
```

Fig.5.8 Logic is been modified in classical Dijkstra to our conditions.

The above set guidance of line portrays the progressions that occurred inside the space of search projected which are been exposed to be expanded in productivity and region diminished. This progressions makes the projects execute the given region in inside given time frames. So the information stream that emerges from modules wont conflict making the

set guidance skip and cause loop chaos. The projected work works under 11secs for given deterrent in time period. At first the arrangement of condition set for prelude work is to have a fierce method of tracking down the most limited path from guide source toward objective. By modifying the rationale in such a manner to distinguish the way to objective productively yet not severely we can accomplish quicker calculation.

5.6.3 AMENDING LOGIC BY GEOMETRY MAINUPALTION

To improve the proficiency of diverse network route planning , many specialists and researchers have led some studies, Dijkstra's calculation is an examination area of interest. The Dijkstra's calculation has its own inadequacies when looking for an ideal way between two focuses, yet it enjoys indispensable benefits. Through the examination of qualities and shortcomings of the exemplary Dijkstra's calculation, we can track down that the primary disadvantages can be summed up as two focuses: storage structure and looking through region. In this way, the paper has improved these two focuses, in particular the improvement of information storage stockpiling structure and the looking through space of confined calculations. Also, its legitimacy is gotten by examining the exploratory outcomes.

Dijkstra's calculation is the most old style and full grown calculation for looking through a briefest way in the diagram, notwithstanding, this calculation has the exceptionally time intricacy and occupies a bigger extra space. To beat the deficiencies of Dijkstra's calculation, a lot of explores have been finished by numerous specialists and researchers, and their exploration results have individual characteristics and benefits, yet the hypothetical premise of related calculation is Dijkstra's algorithm[2~7]. Joining real traffic organization's dispersion trademark, this paper has improved the traditional Dijkstra's calculation to diminish the intricacy of existence and abatement the looking through size of the calculation, and improve this current calculation's running proficiency.

The numeral upsides of the framework ([,]) I j x are relating to the qualities between focuses I and j, with the worth is zero when start point and end point are a similar point, and the worth is ∞ when there is no immediate way between two focuses. At that point this network contains an enormous number of nothing and ∞, which builds the quantity of invalid cycles and takes the huge space away. Subsequently it is informal from the point of view of existence.

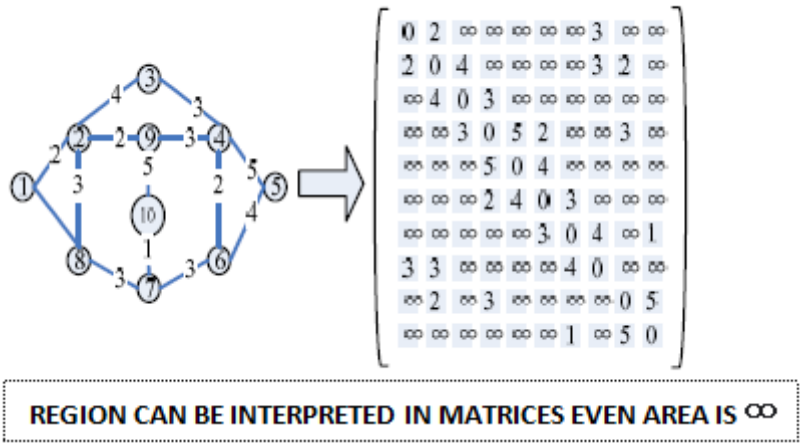


Fig.5.9 Interpretation of area under infinity.

5.6.3.1 STORAGE ADJACENCY LIST

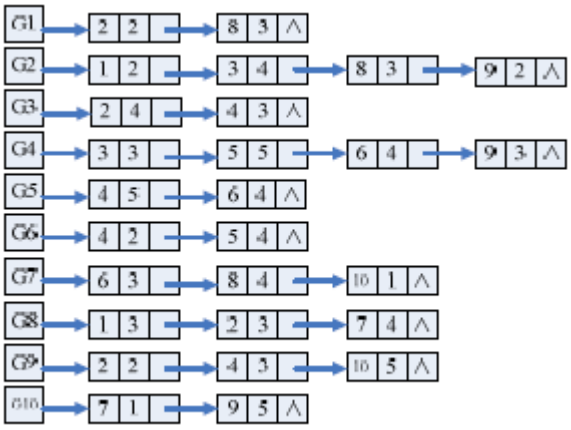


Fig.5.10 Storage adjacency configuration.

Step 1. The [ ] i D v of the node which directly interacts with the 0 v will be initialized to its weight, and the rest is maximum value which is allowed by the computer.

Step 2. The node which directly connects with the 0 v will be added to the path list.

Step 3. The node w that has the smallest weight is found, and deleted in path. If the remaining node is zero, then end.

Step 4. Modify the shortest path: compare [ ] i D v and [ ] (,) i D w + s w v among the weights of the rest nodes which directly connects with w. If the value of [ ] i D v is less than the value of [ ] (,) i D w + s w v and the value of [ ] i D v is ∞, then v = D w + s w v .

5.6.3.2 SPACE COMPLEXITY

- ✧ Analysis of Space Complexity Since list array MGragh is adopted, the space complexity is O(T) , where T is the edge number of directed graph. In the worst case , ifT = n2 , then the space complexity isO(n2) .

- ✧ Analysis of Time Complexity After the storage structure is improved, the time complexity of the processed algorithm's four steps is as follows: The time complexity of step 1 isO(n).

- ✧ Step 1 : The first cycle number is the node number that directly connects with 0 v , that is 1 n .The second cycle number is obtained when 1 n − adds the number of the nodes which directly links with vertexes the first time found and are at infinite distance from 0 v .

- ✧ To draw random declarations, until the node number is zero, then end. In the worst case, 0 v connects with every node, the cycle number is respectively (n −1), (n − 2), then the time complexity is (n −1) + (n − 2) +□+1, that isO(n^2) .

- ✧ The time complexity of step 4 isO(T) . IfT = n2 , and then the time complexity isO(n^2) . Therefore, the time complexity of Algorithm that improves storage structure is max{O(n),O(T),O(n2)}, that isO(n^2) .

- ✧ The time complexity is the same as classical Dijkstra's algorithm. But the nodes of given situation route network are large, besides the directed graph corresponding to road net is incomplete, then the degree of node is less than 5, so T << n2 . In this case, improved storage structure is very logical and diversly eliminates storage redundancy and multi-attempt computation.

5.6.4 RESTRICTED AREA SEARCH

Since the traditional Dijkstra's calculation is a complete inquiry measure, there should be excess. As indicated by qualities of Dijkstra's calculation and the spatial conveyance highlight of the genuine street organization, the calculation limits the looking through region sensibly. Since the straight line between two focuses is the most brief length, the course from start highlight objective point is by and large strike of the briefest way when we plan the course of the genuine street organization. Specifically the at last real most limited way between two focuses is by and large on the two sides of the association line, and ordinarily nearby. On the off chance that there is just one edge between two focuses, the actual edge is the most limited way. Notwithstanding, now and then perhaps there exists save way of brief distance in the two point's area. In particular, to enter the privilege voyaged path , ventured into the every possible outcome of the nearest path depicted by the algorithm in given standard.

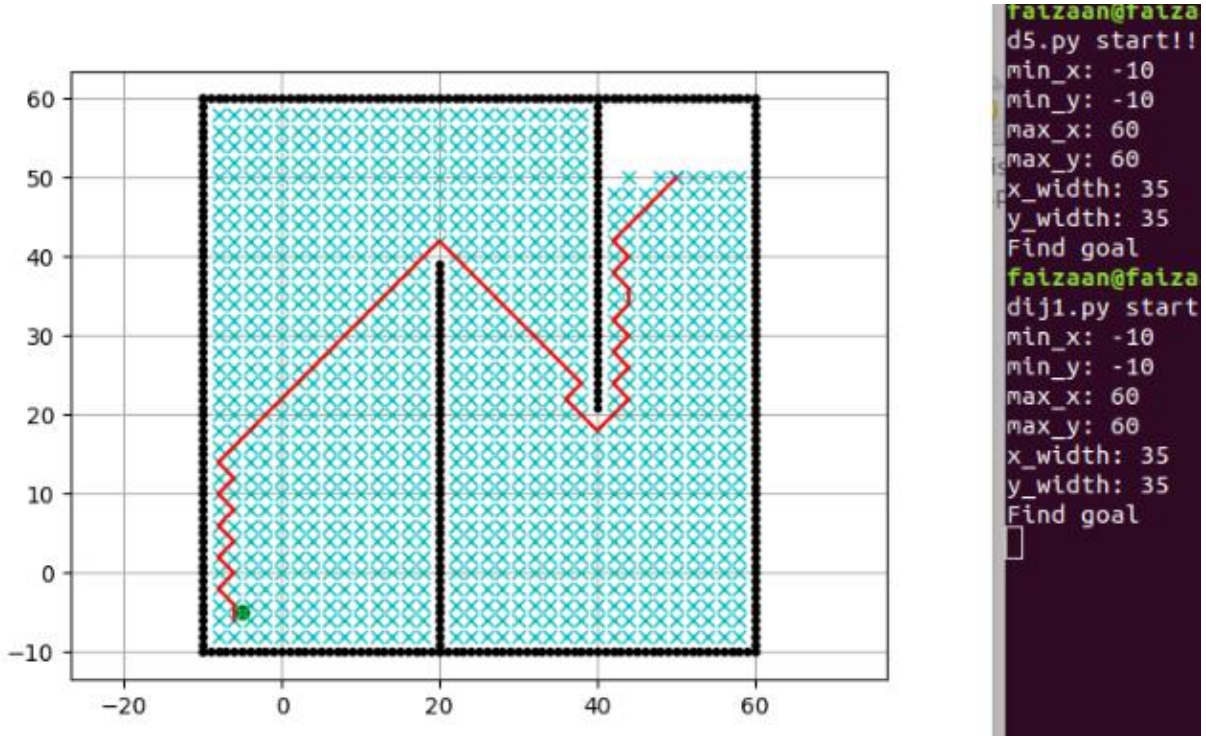


Fig.5.11 Classical Dijkstra Path Algorithm.

5.6.5 SEARCHING AREA ANALYSIS

- ✧ The searching area of the classical Dijkstra's algorithm is 2 A1 = π R
- ✧ The searching area of the restricted searching area algorithm is 2 [2] 2 1 2 A < T R + T
- ✧ Because the searching node is volumation to the searching area, their time complexity is respectively (2) 1 O A and (2) 2 O A , commonly two threshold of 1 T and 2 T are relatively small constant. Thus, the ratio of their time complexity can be approximately expressed as .

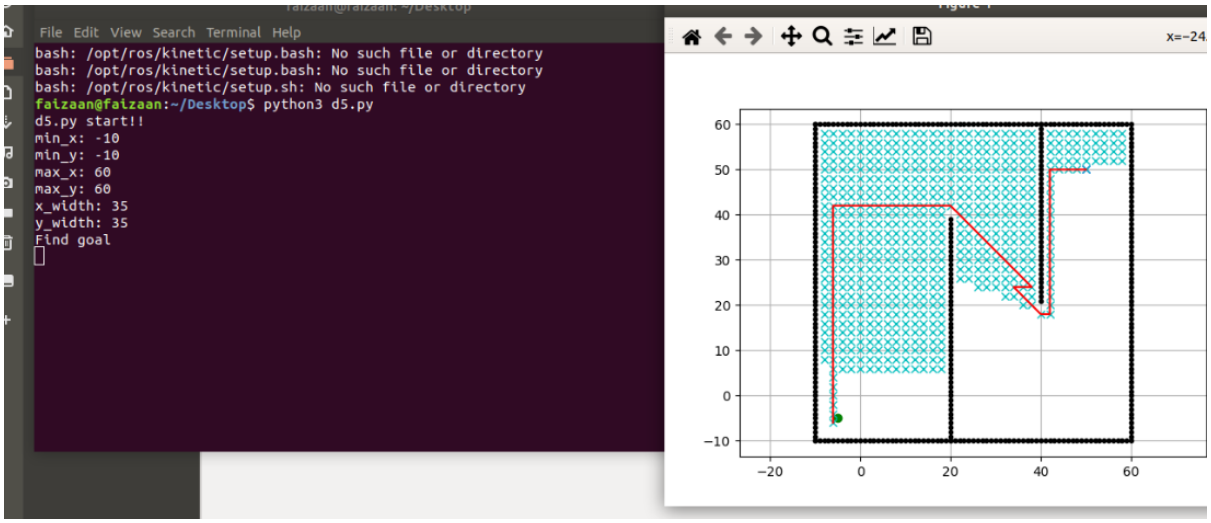


Fig.5.12 Optimized Dijkstra Path Algorithm reduced time complexity**.**

- ✧ By seeing , we can find that the searching area of the restricted searching area algorithm is smaller than that of the classical Dijkstra's algorithm. With the increase of the road network scale and distance of neighbor nodes, the difference of time complexity is more significant.
- ✧ Therefore, the improved algorithm restricting the searching area reasonably will reduce the scale of algorithm searching, minimize the complexity; and improve the efficiency of a system.

SEARCH ALGORITH FOR CLASSICAL DIJKSTRA

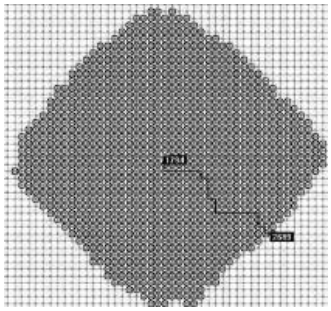
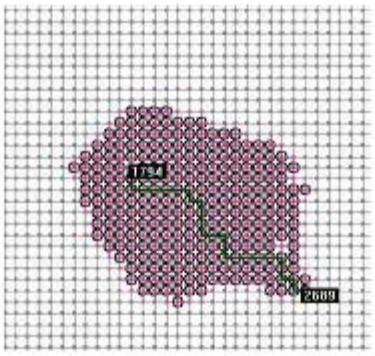


Fig.5.13 Classical area search.

$$O(A_1^2)/O(A_2^2) \approx A_1^2/A_2^2 \approx R^4/R^2 = R^2.$$



SEARCH ALGORITHM FOR IMPROVED AREA DIJKSTRA

Fig.5.14 Optimized Algorithm Iterations makes efficient Complexity.

Shockingly, the improved calculation itself limits looking through region; possibly the calculation in some cases can't look through the authenticated short way, and must be a rough briefest way. It is a faulty most limited way calculation, and decreases the exactness while advancing. However, in many conditions, the most limited way is in the rectangular inward. Generally talking, the benefit of the advancement calculation is clear and the improved calculation gets the motivation behind enhancement.

5.6.6 DIJKSTRA'S PLANNING ON 2D

Tracking down a shortest way from a subjectively chosen initiate point to a solitary objective position is valuable in certain areas, for example, in part known conditions or control

numerous mechanical technology from various beginning situations to move to the objective position. This paper examines a property on 2D eight-neighbor matrix map and presents an improved Dijkstra's calculation (or IDA for short) to tackle the issue. The property we investigated guarantees that each position just requirements to compute once to get the briefest distance to the objective situation in IDA, so it can save a lot of time with respect to the Dijkstra's calculation. We test the presentation of IDA on various sizes of 2D eight-neighbor brace maps, the outcomes show that IDA can accelerate the Dijkstra's calculation by a few significant degrees and the sky is the limit from there. In the interim, the outcomes get by our calculation can without much of a stretch be utilized by the A* calculation for halfway referred to conditions as Path Adaptive A* and Tree Adaptive A* does.

Algorithm 1: The improved Dijkstra's algorithm pseudo-code

```
Input: GridMap, goal
Output: distance to goal for all nodes in GridMap
g = Inf; label = 0;
g(goal)= 0 ;
label(goal) = 1 ;
add goal to PQ;
while PQ ≠Ø do
    current = remove_first(PQ);
    successors = get_successors(current);
    for next in successors do
        if label(next) ==0 then
            g(next) = g(current)+cost(current,next);
            label(next) = 1 ;
            add next to PQ;
        end if
    end for
end while
return g;
```

Fig.5.15 Optimized Algorithm Flow**.**

Case 1:

g(A) < g(B): We assume that cost ***(A,C) < cost(B,C) , we get g(A) + cost(A,C) < g(B) +cost(B,C)*** . So we are sure that ***g(C) = g(A) +cost(A,C)*** is the shortest distance for node C .

Case 2:

We assume that ***cost(A,C) > cost(B,C).*** As our definition, there are only two different distances for each move, ***1 or 2***^ . So we can get ***g(B) -g(A) >^2 -1.*** As node C is a neighbor node of node A and node B, and ***cost(A,C) >cost(B,C)*** , we can get that cost***(A,C) =^2*** &□ ***cost(B,C) =1.***□ □□□□

5.6.7 DIJKSTRA'S OPEN SHORT FIRST ALGORITHM

Describes the stages of quantitative research that are useful as guidelines in analyzing data and making the information that used to find out the problems.

5.6.7.1 DESIGN PHASE

- ✧ After the exploration issue is gotten, the order makes an examination plan, both boundary plan and examination boundary model which will control the exploration from starting to end.
- ✧ Describe the exploration model, depicting and disclose the exploration to be completed to work with comprehension of the examination to be done.
- ✧ Information recovery is finished utilizing a few diverse boundary tests.

5.6.7.2 EMPHRICIAL PHASE

- ✧ In this part are data collection, data extraction for analysis. Data collection is done by testing the infrastructure before and after using the OSPF protocol.

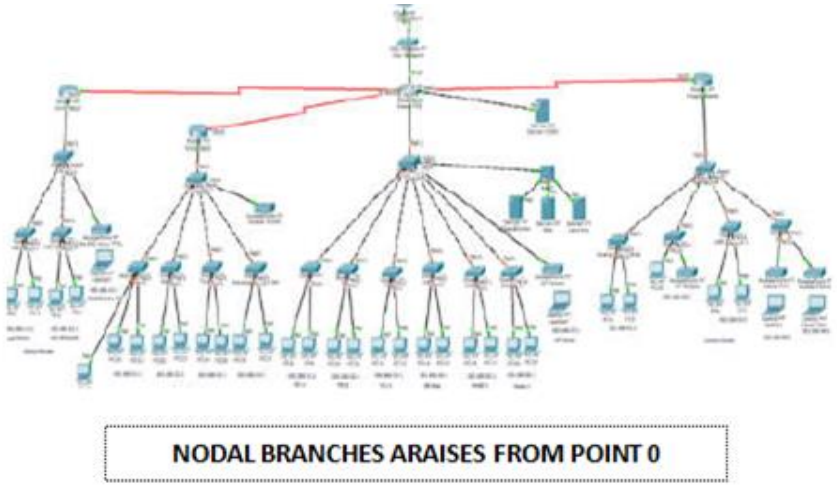


Fig.5.16 A vision of how Nodal path branch iterates.

CHAPTER 6

6.1 INTRODUCTION ON PATH TRACKING ALGORITHM

Pure pursuit is a tracking calculation that works by figuring the curvature and flow that will move a vehicle from its present situation to some objective position. The general purpose of the calculation is to pick an objective position that is some distance in front of the vehicle on the way. The name unadulterated pursuit comes from the similarity that we use to portray the strategy. We will in general consider the vehicle pursuing a point on the way some distance in front of it - it is seeking after that moving point. That similarity is regularly used to contrast this technique with the manner in which people drive. We will in general glance some distance before the vehicle and head toward that spot. This look-ahead distance changes as we drive to mirror the spot of the street and vision impediments.

6.2 THEORETICAL DEVIATIONS

The Pure pursuit approach is a technique for mathematically deciding the structure reference that will drive the vehicle to a picked way point, named the objective point. This objective point is a point on the way that is one look-ahead separation from the current vehicle position. A bend that joins the current point and the objective point is built. The harmony length of this bend is the look-ahead distance, and goes about as the third requirement in deciding a one of a kind circular segment that joins the two focuses. Believe the look-ahead distance to be undifferentiated from the distance to a spot before a vehicle that a human driver may look toward to follow the street.

6.3 ILLUSTRATION OF ALGORITHM

- ✧ Determine the point 0 location of the vehicle & find nodal closest path.
- ✧ Find the goal destination- import the goal coordinates to vehicle coordinates.
- ✧ Calculate the path curve & request the vehicle to steer the prototype to desired path.

✧ Track until nodal point gets=0,loop and assign coordinates w.r.t. CNN updation.

6.4 LINEAR QUADRATIC REGULATOR

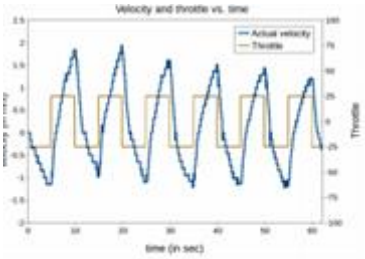
The LQR strategy thinks about a linearized model for the vehicle and figures the ideal contribution for the framework at a specific moment. It ensures asymptotic stable output by discovering the solving for the *Discrete Algebraic Ricatti* Equation and utilizing the answer for track down the ideal control activity. We weight the individual mistakes to choose the forcefulness of the control activity to limit the separate blunder. From our blend depicted in the past area, we keep boundary k = q1 as the lone critical tuning boundary for recreation investigation. Figure 18 shows the recreation results acquired on various courses by using this regulator. Different boundaries that impacted the regulator were:

✧ The max iteration for the iterative solution of DARE.

✧ The sampling time for the discrete-time model.

✧ The tolerance for the iterative solution.

While taking care of bends in the way following issue the LQR regulator had a good execution in smooth ways like on the roundabout course at ordinary speeds yet taking care of ways with fast changes in curve and flow and higher speeds got disturbed as at limit focuses the ideal control activity shoots up past immersion and potentially because of non-straight elements ruling around then. That is, unexpected changes in the way ebb and flow achieved an irritation that deferred the assembly of the vehicle further. Notwithstanding his, it was seen that the regulator very much dealt with steady shape ways at all speeds. On ways with an adjustment of concavity i.e., sinusoidal course, the regulator didn't follow the way with insignificant mistake however in any event gave power fluctuating speed.



Throttle complexity with velocity

Fig.6.1 Illustration of LQR.

6.5 MODEL PREDICTIVE CONTROLLER

The Model Predictive Controller utilizes a prescient technique where an inner model predicts the future conditions of the framework and dependent on the expectation it creates an ideal control activity that limits a quadratic target work while fulfilling certain requirements. This strategy assists us to create ideal control for the framework with limitations. For reference following, the technique is truly reasonable, thinking about the power and execution of the regulator. We utilize an inside point analyzer library for the enhancement cycle for our situation. Objectives for MPC:

- ✧ Objective function weights for respective error terms.
- ✧ Constraints for the control and state variables.
- ✧ Predicted model for the system.
- ✧ Prediction horizon. The basic strategy of tuning the MPC controller depends on the optimizer used and the way it works.

To begin with, we need to set the requirements for the state and control factors, and afterward we need to change the loads for the goal capacities. Like the LQR regulator, we can set different loads to be zero at first and offer load to simply the cross-track mistake or arbitrarily instate the loads for different boundaries. When we realize that the loads give an ideal control activity, at that point we can chip away at tweaking shows the exhibition of this regulator utilizing the expressed tuning technique.

When running MPC on ways with sudden changes in the span of curve and flow, we saw the advantage of having a regulator that predicts the future changes and streamlines the control activities as indicated by the changes. The regulator yields activities that can guarantee constant and smooth following execution. Nonetheless, on expanding the expectation skyline, the presentation is more influenced because of more extensive calculation time just as a more huge impact of things to come changes to current control activity. A general perception while utilizing MPC regulator was its heartiness as the exhibition didn't fluctuate a great deal with an adjustment of ways just as speeds. Being computationally weighty is the lone bad mark that was noticed for the regulator.

6.6 PROTOTYPE ADAPTIVE ALGORITHM WITH PURE PURSUIT

Once the modules are been called for path planning with set of libraries which are pre-imported while the module starts. Everything packs up with certain set of strains. Thus enables us to proceed the data which is been constantly flowing from the camera to the mainframe of the CPU for processing. After its been processed it sends the CNN that the system is in viable path. Then the data from the CPU is sent back to planning algorithm with respective coordinates only for checking that the vehicles is in its map. This can be achieved by pre-running the set of instructions for map area.

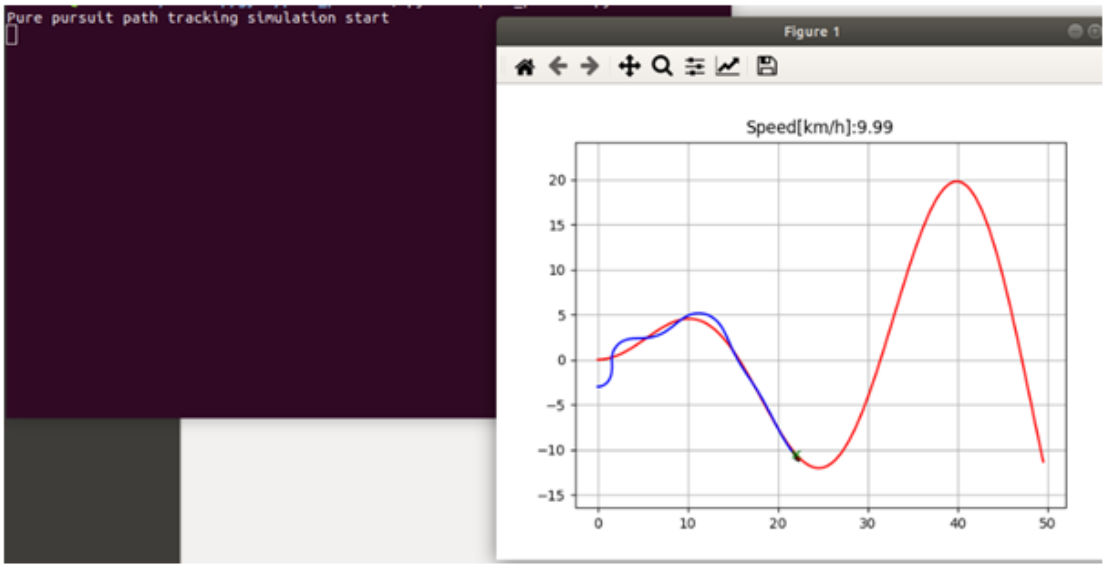


Fig.6.2 Pure-Pursuit in its Random Environment.

6.6.1 ROLE OF IMU SENSOR FOR PURE PURSUIT

When the initial module yet to begin the processing data of sets i.e. Map coordinates and its vital information are been stored and converted into 2-D format for the CNN to understand where its is current position. Again, sensors plays a vital role in determining the position and speed calculation of the vehicles. The data from the IMU sensor depicts how may coordinates the vehicles as moved from its last position and able to determine the current position by generating the curvature from point A to point B by using algorithms pre-loaded into it.

6.6.2 ROLE OF HALL EFFECT SENSOR FOR PURE PURSUIT

The *hall effect sensor* get the speed by manipulating the sensors hits and converts that hits into feet per second. These values are loaded along with coordinates to empower the algorithm which we already took data set of that area. After gaining the data set for the entire region the vehicles sets form position 0 and all sensors data's are been infused into the modules along with other modules. After datas are been injected in to the packet stream the process starts to undergo vital optimization first. The region of marking initial 0 has been recorded along with collision avoidance and ranging with steer module and RTC. With the help of algebraic expression it can find the speed of prototype.

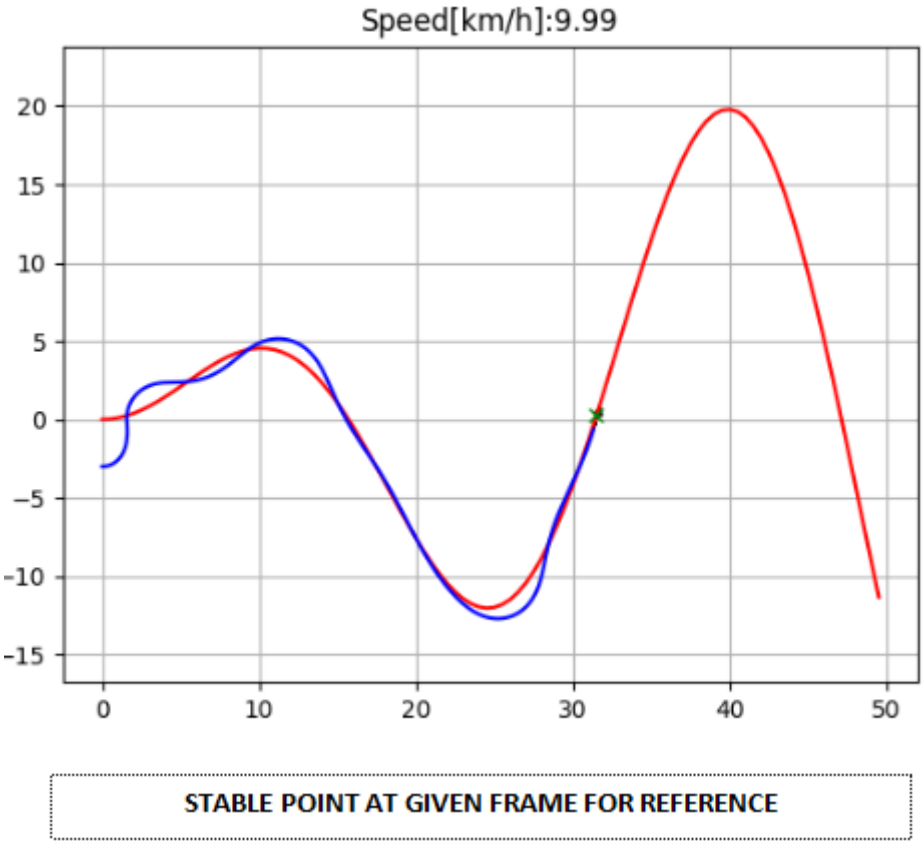


Fig.6.3 Pure-Pursuit in its stable point.

6.6.3 IMPORTING PLANNING ALGORITHM IN TRACKING ALGORITHM

This is one of the vital operations in the upcoming algorithm. Since this part decides how much data should flow in given track in given set of time. Further more it also decides the data to be manipulated under processed simulations results by CNN. The resulting set of results from CNN will compared by algorithm with the results given by this sandwiched program to produce the desired result output. The desired output shall be incorporated as limits and stringent values predicted but previous output. That previous output will be recorded in a data storage and then later called upon by CNN to compare the values which we got while tracking and planning of the prototype that has been moved in desired path prematurely. The data set collected during test phase will be saved and process by CNN and it will be indexed according to the desired situation on the given day. When the results of data from camera that matches with the output given by CNN after manipulated, the results may get triggered from indexed data and based on the applications processed by data, the result may vary. During this whole process in between the establishment of path planning and tracking is been done and routed by this incorporated program such that based on results from this program the CNN takes necessary actions.

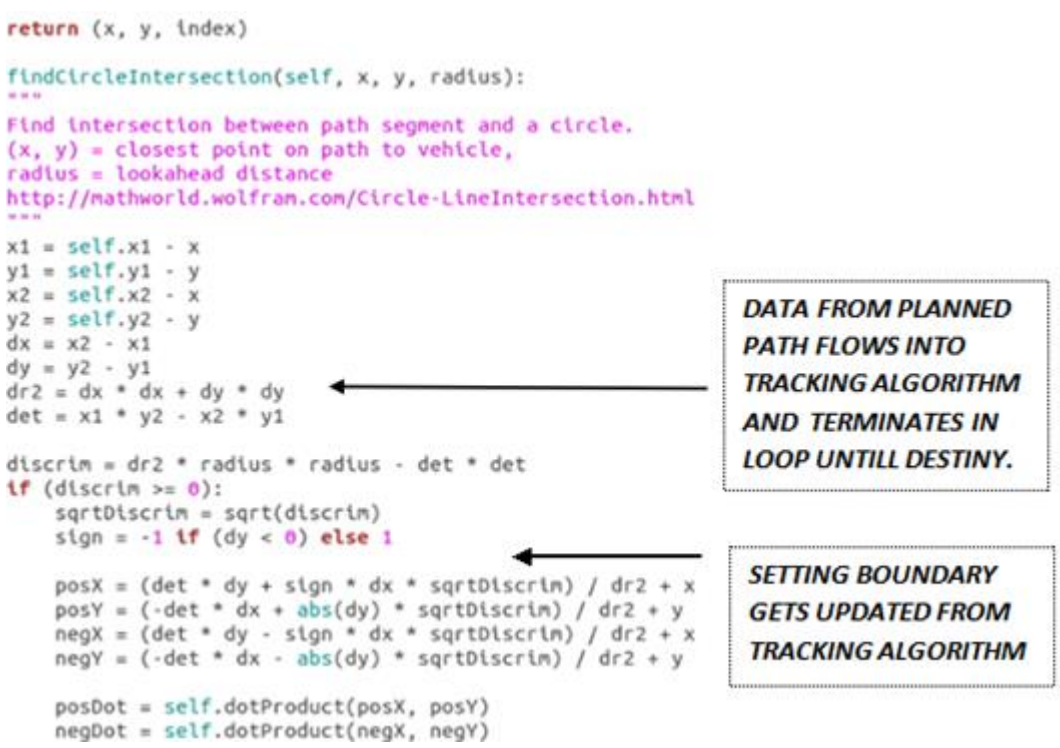


Fig.6.4 Calling function for importing Pure-Pursuit.

6.6.4 IMPORTING TO POLYGON FXN

This algorithm devised particularly for exporting the set of coordinates that are taken by combining the path planning and tracking along with sensors. This algorithm permeates set of data which can be process by the google polygon function. By exporting the coordinates to the desired set range of algorithm, this function can produce the output which we can see whether the data manipulated by the program as we predicted. It also serves the basic functionality for producing the cross check pattern for maintaining the vehicles in the correct path. n this program of function we can clearly see the data of coordinates is been continuously sent as package to the polygon function to produced an output and also for cross verifying.

```
    </style>
    <script>
      // This example creates a 2-pixel-wide red polyline showing the path of
      // the first trans-Pacific flight between Oakland, CA, and Brisbane,
      // Australia which was made by Charles Kingsford Smith.
      function initMap() {
        const map = new google.maps.Map(document.getElementById("map"), {
          zoom: 18,
          center: { lat: 12.970060, lng: 79.170196},
          mapTypeId: "satellite",
        });
        const flightPlanCoordinates = [
{lat: 12.970068209398805, lng: 79.17019614704714},
{lat: 12.970076418797612, lng: 79.170196},
{lat: 12.970084628196417, lng: 79.17019614704715},
{lat: 12.970092837595223, lng: 79.170196},
{lat: 12.970101046994028, lng: 79.17019614704716},
{lat: 12.970109256392833, lng: 79.170196},
{lat: 12.970117462040454, lng: 79.17019570595046},
{lat: 12.970125661437374, lng: 79.17019526498811},
{lat: 12.970133867084995, lng: 79.17019497093855},
{lat: 12.970141926881563, lng: 79.17019336325626},
{lat: 12.97014981946425, lng: 79.17019104084316},
{lat: 12.970157950208101, lng: 79.17018986822474}
                ];
        const flightPath = new google.maps.Polyline({
          path: flightPlanCoordinates,
          geodesic: true,
          strokeColor: "#FF0000",
          strokeOpacity: 1.0,
          strokeWeight: 2,
        });
        flightPath.setMap(map);
      }
```

SET OF DATA FROM SENSOR COORDINATES FLOWS IN TO FXN

Fig.6.5 Importing Coordinates into Pure-Pursuit.

CHAPTER 7

7.1 FLOW CHART OF MODULAR DATA FLOW & ACCESS

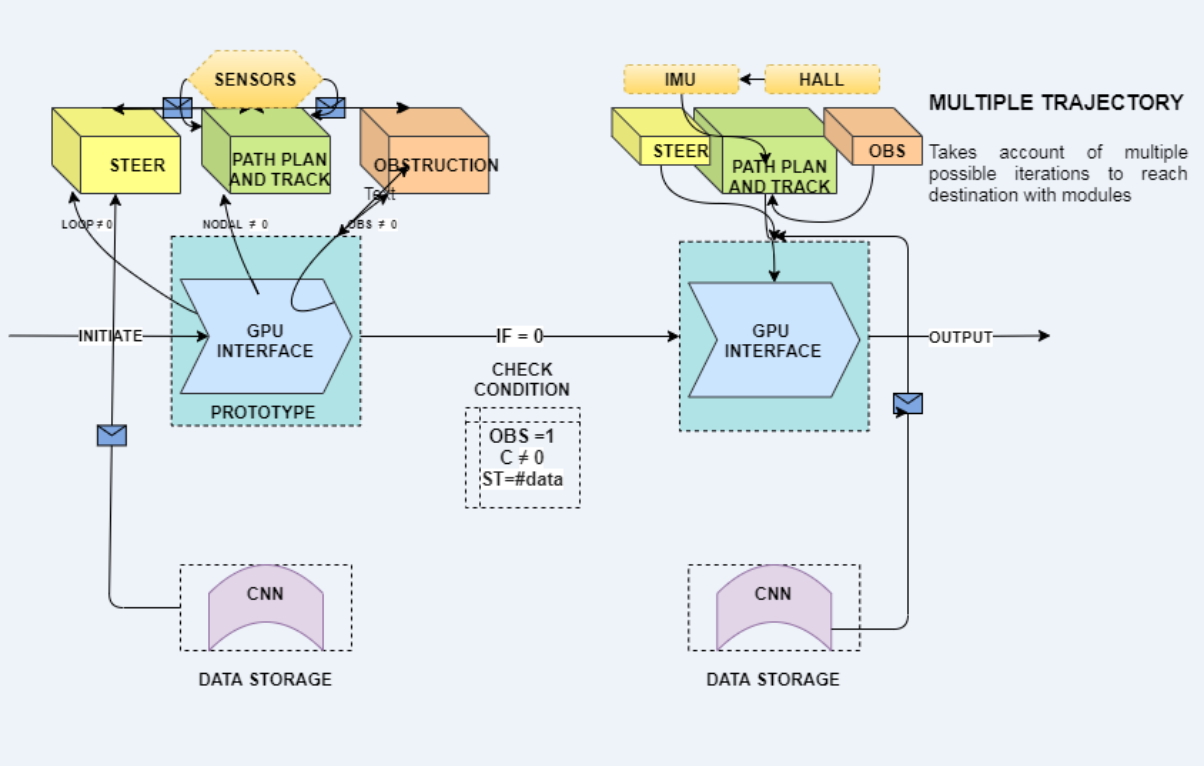


TABLE 7.1 DATA FLOW OF ALL MODULES.

This chart comprises the flow of data which takes place within modules and how data can flow from point A to point B without any obstruction. Also, it takes necessitous steps to takes action when the module detects obstruction too. Primarily the initiate stage of data flow arises from GPU interface which correspondingly handling all the data from all the modules together. Steer module gives data via its camera and its surrounding trained CNN data. The obstruction module detects if any object is present in the line of path. Prematurely path planning algorithms load maps in GPU and set coordinates as stage and over view with line of tracking.Sensing module senses all data and transfers all data to GPU for manipulation and output shall be as of scenario depicted by data set. Path planning loads maps and set stages for coordinates under right circumstances and navigation is carried out by GPS coordinates. The check condition keep on dog watching whats interpreting the data, once obstruction or steer angle is off axis from predicted.

CHAPTER 8

8.1 RESULTS

The modules are been integrated in such a way that it can diversify the datas that can flows into the respective modules while it can produce the data as stringent output with much more accuracy in its given environment. This is achieved by above discussed methods in optimizing the Dijkstra's algorithm with the area minimalization in the given time N with with given nodal cost at the particular environment. The stages of data which all the modules is collecting based on the code which we had written to execute the instruction set for each particular modules with respect to one another. The GPU renders the data from all the modules which can be elaborately discussed in the flowchart of the modules. If the respective path planning and tracking modules is been given the input with certain conditions from the environment such as obstruction modules triggers the input or steer modules deviates out from the predicted line of reference, this modules kicks in as to render the flowing data with comparing its own data coming the GPS coordinates. If the path is been deviated it instructs the steer modules to get back into track or if any obstruction is been visible it takes all possible outcomes of path depicted from the map.

FIGURE 8.1 GPS COORDINATE CONNECTED POLYGON FXN.

FIGURE 8.2 PROTOTYPE MODULES WHICH ARE INTERCONECTED

8.2 CONCLUSION

Thus we developed a prototype that can manipulate data that flows from the given three modules and renders an output to desired condition. The main objective of this project is to design and develop an autonomous robot or vehicles that can steer to the desired location once the values are been rendered. At this part of the stage the vehicles can manipulate to some extent and it got it output at the initial stages. Modular flow of data and giving activation to the surrounding has been performed, the prototype can able to move to few meter due to its limitations. The target acquisition and path set for destination and map reconstruction are yet to be optimized in the workflow. The prototype can able to receive the data wirelessly and process the iterations for given specification of coordinates. Data interpretation between the module of steering has been enhanced to better condition that it can manipulate data that flows via it.

8.3 FUTURE WORKS

- ✧ The prototype should manipulate the data that arises from the obstruction modules as well.
- ✧ Path planning and tracking algorithms are to be enhanced to maximum output wirelessly.
- ✧ Target acquisition and path planning and selecting en route are to be maximized and enhanced.
- ✧ Based on the geographical conditions these are to be developed for Indian road for better customization.
- ✧ The practicality of this prototype for Indian roads are been continuously challenged by various factors that interrupts the training to inhibit.
- ✧ Better functionality code and algorithm for the modules are yet to be processed.
- ✧ Autonomous vehicles initiation bigger challenge is how the training has to be done with given storage and computational power, this has to been over seen.

REFERENCES

1. ***(Best Routes Selection Using Dijkstra & Floyd-Warshall Algorithm-2017)-Risald et al.,***

2. ***(Improvement of Dijkstra Algorithm and its application in Route Planning)-Dong Kai et al.,***

3. ***(Analysis of QOS VLAN based on Dijkstra Algorithm on OSPF)-M. Nurr Alfarni et al.,***

4. ***(An Improved Dijkstra's Algorithm for Shortest Planning on 2-D)-Li Wenzheng et al.,***

5. ***(Design of a Modified Dijkstra;s Algorithm for finding Alternate Routes for Shortest-Path Problems with Huge Costs)-Omoniyi et al.,***

6. ***(Novel Pure-Pursuit Trajectory Following Approaches & their Practical Applications)-Erno Horvath et al.,***

7. ***(Path tracking Control of Wheeled Mobile robot based on Improved Pure -Pursuit Algorithm)-Sun Quinpeng et al.,***

8. ***(Towards Shortest Path Computation using Dijkstra's Algorithm-2020)- Neha et al.,***

9. ***(Shortest Path with Dynamic Weight Implementation using Dijkstra's Algorithm-2018)-Aditiya et al.,***

10. ***(Autonomous Indoor Vehicle Navigation using modified Steering Velocity Objects-2020)-M. Faud & Djoko et al.,***

11. ***(Path following controller for Autonomous Vehicles-2019)- Adam et al.,***

12. ***(GPS Tracking for Autonomous Vehicles-2018)- Yaseen, Darwiche et al.,***

13. ***(Visual Path Tracking Control for Park Scene-2017)- Whengfu & zhu et al.,***

14. ***(Map Matching when the map is wrong: Efficient on/off road Vehicle tracking and map learning -2019)- James Murphy & Albert et al.,***