Project report submitted in partial fulfillment for the Degree of B. Tech in Applied Electronics & Instrumentation Engineering under Maulana Abul Kalam Azad University of Technology

GESTURE CONTROL INTERFACE OF A ROBOT-CAR USING RASPBERRY PI

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CERTIFICATE OF APPROVAL

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It is to be understood that by this approval, the undersigned do not, necessarily endorse or approve any statement made, opinion expressed or conclusion drawn therein, but approve the project only for the purpose for which it is submitted.

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RECOMMENDATION

I hereby recommend that the project report titled "**Gesture Control Interface of Robot-Car using Raspberry Pi**" prepared by **Afreen Bano**, AEIE2015/042, **Mitun Kundu**, AEIE2015/033, **Ayan Jana**, AEIE2015/028 and **Suman Kumar Pal**, AEIE2015/013 be accepted in partial fulfillment of the requirement for the Degree of Bachelor of Technology in Applied Electronics &Instrumentation Engineering, RCC Institute of Information Technology.

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ABSTRACT

The integration of more and more functionality into the human machine interface (HMI) of vehicles increases the complexity of device handling. Thus optimal use of different human sensory channels is an approach to simplify the interaction with in-car devices. Using this idea, a car-robot can be implemented whose navigation can be done wirelessly with the help of a Raspberry Pi.

Robots are currently playing a big role in our lives. There are different type of robots: wheeled robots, flying robots, factory building robots. The current way to control this robots are by using a keyboard, joystick or pre-programmed commands. This project is about to introduce a new way to control a robot and it is by using gestures. This project is to build a remote control robot(car), which is controlled from a distance using only gestures.

The project has two components a car and a control station. The control station is computer which has gesture recognition hardware so that it can detect the commands and send them to the car. The control station is the micro computer Raspberry Pi 3B. The data from the hand movements with the help of the accelerometer are fed into the Encoder HT 12E through the Raspberry Pi. Then the values are transmitted with the help of Tx 434. Rx 434 receives the values in the receiver part, where it is decoded by a Decoder HT 12D and sent to the motor driver L293D. Thus motors are controlled with the data obtained from the motor driver.

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CHAPTER I: INTRODUCTION

Gesture recognition is a topic in science and language technology with the goal of interpreting human gestures via mathematical algorithms. Gestures can originate from any bodily motion or state but commonly originate from the face or hand. Users can use simple gestures to control or interact with devices without physically touching them. Many approaches have been made using cameras and computer vision algorithms to interpret sign language. However, the identification and recognition of posture, gait, proxemics, and human behaviors is also the subject of gesture recognition techniques. Gesture recognition can be seen as a way for computers to begin to understand human body language, thus building a richer bridge between machines and humans than primitive text user interfaces or even GUIs (graphical user interfaces), which still limit the majority of input to keyboard and mouse and interact naturally without any mechanical devices. Using the concept of gesture recognition, it is possible to point a finger at this point will move accordingly. This could make conventional input on devices such and even redundant.

1.1 ROBOT

A robot is usually an electro-mechanical machine that can perform tasks automatically. Some robots require some degree of guidance, which may be done using a remote control or with a computer interface. Robots can be autonomous, semi-autonomous or remotely controlled. Robots have evolved so much and are capable of mimicking humans that they seem to have a mind of their own.

1.2 HUMAN MACHINE INTERACTION

An important aspect of a successful robotic system is the Human-Machine interaction. In the early years the only way to communicate with a robot was to program which required extensive hard work. With the development in science and robotics, gesture based recognition came into life. Gestures originate from any bodily motion or state but commonly originate from the face or hand. Gesture recognition can be considered as a way for computer to understand human body language. This has minimized the need for text interfaces and GUIs (Graphical User Interface).

1.3 GESTURE

A gesture is an action that has to be seen by someone else and has to convey some piece of information. Gesture is usually considered as a movement of part of the body, esp. a hand or the head, to express an idea or meaning.

1.4 OBJECTIVE OF THE PROJECT

The integration of more and more functionality into the human machine interface (HMI) of vehicles increases the complexity of device handling. Thus optimal use of different human sensory channels or gestures is an approach to simplify the interaction with in-car devices. Using this idea, a car-robot can be implemented whose navigation can be done wirelessly with the help of a Raspberry Pi.

Hand gesture recognition is an essential way for Human-Robot Interaction (HRI). Sign language is the most intuitive and direct way to communication for impaired or disabled people.

The goal of this project is to capture simple hand gestures from the Glove and use that input to wirelessly control a modified RC car. Controlled variable includes steering using an accelerometer sensor. Testing showed that users were able to wear the glove and control the car with only a small amount of instruction.

CHAPTER II: LITERATURE REVIEW

2.1 GESTURE CONTROLLED CAR-ROBOT

Gesture recognition technologies are much younger in the world of today. At this time there is much active research in the field and little in the way of publicly available implementations. Several approaches have been developed for sensing gestures and controlling robots. Glove based technique is a well-known means of recognizing hand gestures. It utilizes a sensor attached to a glove that directly measures hand movements.

A Gesture Controlled robot is a kind of robot which can be controlled by hand gestures and not the old fashioned way by using buttons. The user just needs to wear a small transmitting device on his hand which includes a sensor which is an accelerometer in our case. Movement of the hand in a specific direction will transmit a command to the robot which will then move in a specific direction. The transmitting device includes a Comparator IC for assigning proper levels to the input voltages from the accelerometer and an Encoder IC which is used to encode the four bit data and then it will be transmitted by an RF Transmitter module.

At the receiving end an RF Receiver module will receive the encoded data and decode it by using a decoder IC. This data is then processed by a microcontroller and passed onto a motor driver to rotate the motors in a special configuration to make the robot move in the same direction as that of the hand.

2.2 APPLICATION

The applications of the accelerometer based gesture controlled robot include:

- Military applications to operate robots
- Medical applications for the purpose of surgery
- Construction field
- In industries to control trolley and lift

- Gesture controlling is very helpful for handicapped and physically disabled people to achieve certain tasks, such as driving a vehicle.
- Gestures can be used to control interactions for entertainment purposes such as gaming to make the game player's experience more interactive or immersive.

2.3 LITERATURE REVIEW

A hand-gesture-based control interface was introduced for navigating a car-robot in [1]. A 3-axis accelerometer is adopted to record a user’s hand trajectories. The trajectory data is transmitted wirelessly via an RF module to a computer. The received trajectories are then classified to one of six control commands for navigating a car-robot. The classifier adopts the dynamic time warping (DTW) algorithm to classify hand trajectories. Simulation results show that the classifier could achieve 92.2% correct rate.

A novel, non-contact, pointing interface is being developed for control of non-safety critical systems inside a vehicle with the aims of improving safety, decreasing manufacturing cost and improving the ease of driver migration between different cars in [2]. A driver operates the interface via an onscreen cursor using pointing gestures to be identified by a computer vision system. This paper describes the vision subsystem responsible for detection and tracking of the driver’s hands. To be robust, it must detect and track under varying lighting conditions with no prior assumptions concerning the colour of the hands or clothing. Adaptive foreground and background models are used for segmentation and a robust geometrical hand model is employed for tracking. The system is demonstrated working at speeds close to real-time on a standard PC using image sequences captured inside a car.

The integration of more and more functionality into the human machine interface (HMI) of vehicles increases the complexity of device handling in [3]. Thus optimal use of different human sensory channels is an approach to simplify the interaction with in-car devices. This way the user convenience increases as much as distraction may decrease. In this paper a video based real time hand gesture recognition system for in-car use is presented. It was developed in course of extensive usability studies. In combination with a gesture optimized HMI it allows intuitive and effective operation of a variety of in-car multimedia and infotainment devices with hand poses and dynamic hand gestures.

Envision to add context awareness and ambient intelligence to edutainment and computer gaming applications in general was implemented in [4]. This requires mixed-reality setups and ever-higher levels of immersive human-computer interaction. Here, the focus is on the automatic recognition of natural human hand gestures recorded by inexpensive, wearable motion sensors. To study the feasibility of this approach, an educational parking game was chosen with 3-D graphics that employs motion sensors and hand gestures as its sole game controls. The implementation prototype is based on Java-3D for the graphics display and on the CRN Toolbox for sensor integration. It shows very promising results in practice regarding game appeal, player satisfaction, extensibility, ease of interfacing to the sensors, and – last but not least – sufficient accuracy of the real-time gesture recognition to allow for smooth game control. An initial quantitative performance evaluation confirms these notions and provides further support for the setup.

The primary and secondary driving task together with Human Machine Interface (HMI) trends and issues which are driving automotive user interface designers to consider hand gesture recognition as a realistic alternative for user controls are described in [5]. A number of hand gesture recognition technologies and applications for Human Vehicle Interaction (HVI) are also discussed including a summary of current automotive hand gesture recognition research.

Hand gesture recognition is an essential way for Human-Robot Interaction (HRI) . Sign language is the most intuitive and direct way to communication for impaired or disabled people. Furthermore, emotional interaction with human beings is desirable for robots. In this paper [6], hand gesture recognition and emotion recognition of an integrated system will be described which has ability to track multiple people at the same time, to recognize their facial expressions, and to identify social atmosphere. Consequently, robots can easily recognize hand gesture and facial expression with emotion variations of different people, and can respond properly. A combining hand gesture recognition algorithm which combines two distinct recognizers has been studied. These two recognizers collectively determine the hand's gesture via a process called combinatorial approach recognizer (CAR) equation.

Automobiles are becoming increasingly important in daily life. However, people usually need to cost lots of efforts and time to get their required services. On one hand, an automobile itself consists of many physical processes to achieve its traditional functionality; on the other hand, it is being integrated with more and more sensors and actuators, which makes it a typical cyber-physical system. In order to provide friendly and human-centric services for users, the Intelligent Cyber-Physical System for automobiles (iCPS-Car) for automobiles was proposed in [7]. iCPS-Car integrates people, cars and cyber spaces together and provides natural interaction manners, and personalized and continuous services.

It was attempted to narrow down the gap between real world and synthetic environment in [8]. For that purpose, an immersive driving car simulation was developed that combines tangible tool with mixed reality environment. As tangible tool, a real physical mini car was deployed that employ arduino sensor inside. To provide an immersive sensation among user and arduino mini car, a camera belonging to a smart phone was employed in front of our car that will create real-driving-sensation since the user will feel like he is sitting and driving inside the car. As car controller, a natural user interface (NUI) controller was implemented that employ widely used RGBD sensor, Kinect.

Multiple devices while driving steals drivers' attention from the road and is becoming the cause of accidents in 1 out of 3 cases. Many research efforts are being dedicated to design, manufacture and test Human-Machine Interfaces that allow operating car devices without distracting the drivers' attention. A complete system for controlling the infotainment equipment through hand gestures is explained in this paper. The system works with a visible-infrared camera mounted on the ceiling of the car and pointing to the shift-stick Area, and is based in a combination of some new and some well-known computer vision algorithms in [9]. The system has been tested by 23 volunteers on a car simulator and a real vehicle and the results show that the users slightly prefer this system to an equivalent one based on a touch-screen interface.

Humans and machines do not interface well. In an attempt to bridge the gap between humans and the systems they interact with, a plethora of input methods have been devised: keyboards, mouse, joysticks, game controllers and touch screens are just a few examples. Unfortunately, none of these devices remove the barrier between man and machine. With the Magic Glove control system in [10], the aim to remove this obstruction by allowing the user to control a hardware device using natural gestures. The Magic Glove takes advantage of a multitude of sensors to capture hand movements and uses this information control a device – in this case, a modified RC car. The goal of this paper is to capture simple hand gestures from the Magic Glove and use that input to wirelessly control a modified RC car. Controlled variables include speed, steering, lights and sounds using a combination of flex, force and gyroscopic sensors. Multiple variables are controlled simultaneously as Magic Glove outputs a constant control signal.

This paper [11] presents a method for two-hand pose recognition based on skeleton information, aiming at the problem of low recognition rate and poor robustness in the field of human computer interaction by single hand. This method consists of two steps: two-hand positional information extraction and gesture recognition. In the first step, we utilize the Kinect depth image to acquire the position of both hands. The second step is the highlight of the proposed method, it locates the palms by hand nodes, extracts the right hand movement information which is trained by a Hidden Markov Model. This method has been verified by a experimental car control system and demonstrated good robustness in complex background environment.

To ensure safety and usability of advanced in-car cockpit solutions, prospective evaluation during early prototyping stages is important, especially when developing innovative human-cockpit-interactions. In this context, highly realistic test environments will help to provide reliable and valid findings. Nevertheless, real car driving studies are difficult to control, manipulate, replicate and standardize. They are also more time consuming and expensive. One economizing suggestion is the implementation of immersive driving environments within simulator studies to provide users with a more realistic awareness of the situation in [12]. This paper discusses research investigating the influence of immersive driving environments. Three interaction modalities (touch, spin controller, free-hand gestures) and two levels of immersivity (low, high) are examined to examine this methodology.

The recently developed Kinect sensor has opened a new horizon to Human-Computer Interface (HCI) and its native connection with Microsoft's product line of Xbox 360 and Xbox One video game consoles makes completely hands-free control in next generation of gaming in [13]. Games that requires a lot of degree of freedoms, especially the driving control of a car in racing games is best suitable to be driven by gestures, as the use of simple buttons does not scale to the increased number of assistive, comfort, and infotainment functions. In this paper, Mamdani type-I fuzzy inference system based data processing module is proposed which effectively takes into account the dependence of actual steering angle with the distance of two palm positions and angle generated with respect to the sagittal plane. The FIS output variable controls the duration of a virtual "key-pressed" event which mocks the users pressing of actual keys assigned to control car direction in the original game. The acceleration and brake (deceleration) of the vehicle is controlled using the relative displacement of left and right feet.

The notion of developing thought controlled devices (games, robots, cars etc.) is becoming increasingly popular with the introduction of low cost commercial headsets that record neuro electric activity and the extensive research in the area of Brain Computer Interfaces (BCIs). In this paper [14], we study the feasibility of using a commercial low cost EEG amplifier which has only limited number of electrodes, to develop a motor control BCI system. The objective is to extract brain activity responsible for direction specific imagined and executed motor activity, which can be used to identify the motor task performed by the user using the simultaneously recorded EEG.

Recently it is issued that the interaction technology for driver's gesture recognition in vehicular environment. Drivers want to control the multimedia system, air conditioning system and other applications which are equipped in head unit on dash board through the simple hands motion. But, limited under the safety driving condition, gesture cognition while being in car has many problems due to specific condition on road. In car, according to vehicle status such as forward and backward moving or horizontal tilting, data errors of the motion sensors are caused and unexpected driver's motion will be registered. In this paper [15], it is proposed the system model for the gesture interaction between users and vehicle are defined and the data processing process including specific hardware structure is adopted in order to reduce the motion sensing errors.

The past few years has shown a sudden spurt in the field of human computer interaction. The days of using a mouse to control a computer is almost obsolete and people now prefer to use touch screens and more recently, air gestures, for the same. However, the use of gestures is not limited to computers alone. It finds its application in controlling televisions and other home appliances as well. This paper [16] explores one such application where in air gestures could be used to control automobiles. The paper describes a novel method to not only give directions but also password-protect and use special features of the vehicle, using gestures. The complete algorithm was developed using video processing on MATLAB 2011b and was found to be 3.6 times faster than its predecessor algorithms. The same was tested in real-time as well, using a robot prototype and satisfactory results were obtained.

In this contribution [17], a novel approach to transform data is presented from time-of-flight (ToF) sensors to be interpretable by Convolutional Neural Networks (CNNs). As ToF data tends to be overly noisy depending on various factors such as illumination, reflection coefficient and distance, the need for a robust algorithmic approach becomes evident. By spanning a three-dimensional grid of fixed size around each point cloud we are able to transform three-dimensional input to become processable by CNNs. This simple and effective neighborhood-preserving methodology demonstrates that CNNs are indeed able to extract the relevant information and learn a set of filters, enabling them to differentiate a complex set of ten different gestures obtained from 20 different individuals and containing 600.000 samples overall.

In this paper [18], we introduce a hand-gesture-based control interface for navigating a car-robot. A 3-axis accelerometer is adopted to record a user's hand trajectories. The trajectory data is transmitted wirelessly via an RF module to a computer. The received trajectories are then classified to one of six control commands for navigating a car-robot. The classifier adopts the dynamic time warping (DTW) algorithm to classify hand trajectories. Simulation results show that the classifier could achieve 92.2% correct rate.

A research platform has been designed for a perceptually guided robot, which also serves as a demonstrator for a coming generation of service robots in [19]. In order to operate semi-autonomously, these require a capacity for learning about their environment and tasks, and will have to interact directly with their human operators. Thus, they must be supplied with skills in the fields of human-computer interaction, vision, and manipulation. GripSee is able to autonomously grasp and manipulate objects on a table in front of it. The choice of object, the grip to be used, and the desired final position are indicated by an operator using hand gestures.

Gesture interfaces are gaining relevance for human-machine communication, since it is expected that they make interaction more intuitive. Particularly vision based approaches are widely preferred. This paper [20] describes a novel vision based real-time gesture recognition system, designed for operating in an automotive environment. It is used within an application for retrieving traffic news and e-mails from a message storage. Image processing and pattern matching techniques, specially adapted to the complex environmental conditions, represent the systems basics.

2.4 FEASIBILITY

The Raspberry Pi 3 Model B is the third generation Raspberry Pi. This powerful credit-card sized single board computer can be used for many applications and supersedes the original Raspberry Pi Model B+ and Raspberry Pi 2 Model B.

Whilst maintaining the popular board format the Raspberry Pi 3 Model B brings a more powerful processor, which is 10 times faster than the first generation Raspberry Pi.

Additionally it adds wireless LAN & Bluetooth connectivity making it the ideal solution for powerful connected designs.

MPU6050 sensor module is complete 6-axis Motion Tracking Device. It combines 3-axis Gyroscope, 3-axis Accelerometer and Digital Motion Processor all in small package. Also, it has additional feature of on-chip Temperature sensor. It has I2C bus interface to communicate with the microcontrollers.

One of the main reasons as to why ADXL345 was not used is because this is an analog in nature and it only serves as an accelerometer and not as a gyroscope. MPU 6050 uses I2C to communicate with the Raspberry Pi 3B.

To reduce the cost of the project, only one microcomputer or controller has been used. Raspberry Pi is being used in the transmitter side and RF module is used for transmission of data.

Software:

The programming language that was used in the Raspberry Pi for the project was Python.

Python is an interpreted, high-level, general purpose programming language. Python has a design philosophy that emphasizes code readability, notably using significant whitespace. It provides constructs that enable clear programming on both small and large scales.

Python features a dynamic type system and automatic memory management. It supports multiple programming paradigms, including object-oriented, imperative, functional and procedural. It also has a comprehensive standard library.

Hardware:

Accelerometer was chosen as a sensing device because it can measure the minute movements. MPU 6050 is a six DOF (Degrees of Freedom) accelerometer which means it gives six values as output – three from accelerometer and three from gyroscope. However, only the accelerometer values were used for this project.

Raspberry Pi is a single board microcomputer which has significantly more processing power that most of the microcontrollers out there. It has GPIO pins, but it lacks the hardware control and other peripherals found in a number of microcontrollers.

CHAPTER III: BLOCK DIAGRAM

The gesture controlled robot works on the principle of an accelerometer(MPU 6050) which records the hand movements and sends the data to the Raspberry Pi which assigns proper voltage levels (either 3.3V or 0V). The Raspberry Pi is being used in the BCM mode. The information is then fed to an Encoder (HT 12E) which makes it ready for RF transmission.The RF module used here is RF434. On the receiving end, the information is received by the RF receiver and then passed on to the decoder (HT 12D). The data from the encoder goes into the motor driver IC (L293D) which triggers the motors in different configurations to move the bot in different specific directions. The block diagram for the entire system is given below:

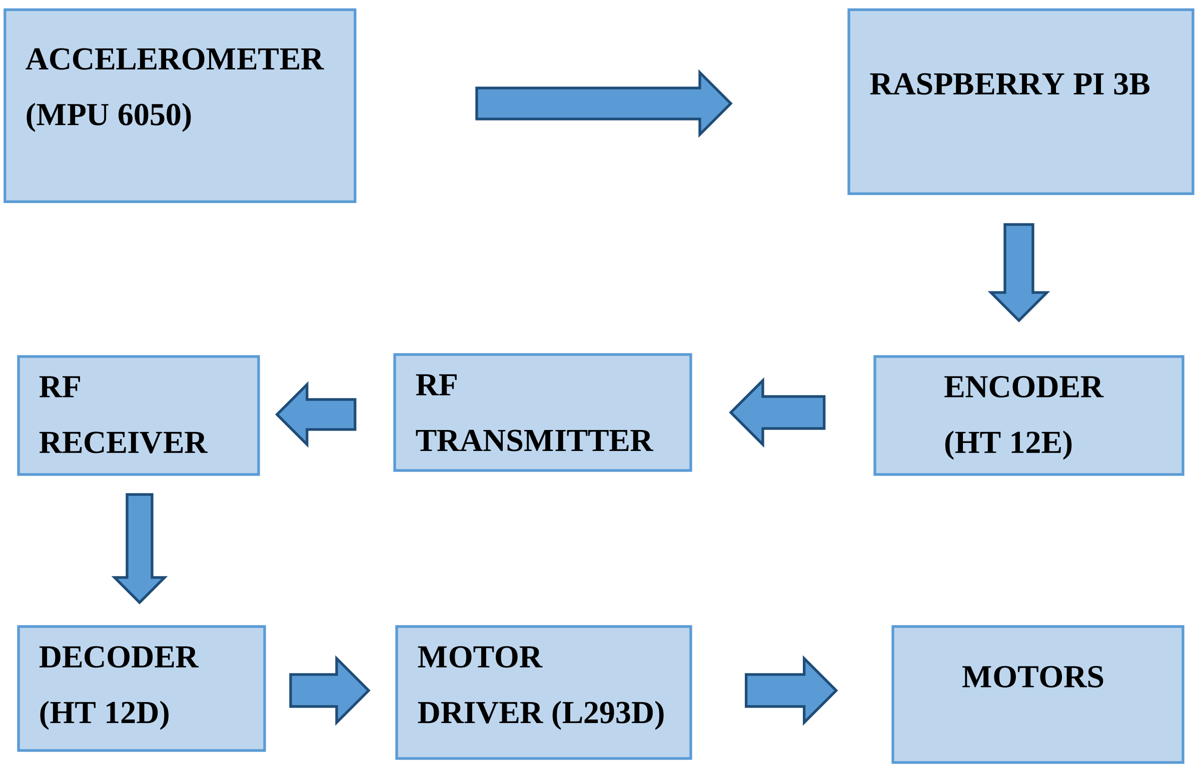


Figure 3.1: Block diagram of the system

The entire system can be divided into two parts – one being the transmitter part which includes:

- Accelerometer
- Raspberry Pi
- Encoder
- RF transmitter

The other being the receiver part which includes:

- RF receiver
- Decoder
- Motor driver
- Motors.

3.1 ACCELEROMETER (MPU 6050)

An accelerometer is an electromechanical device that will measure acceleration forces. These forces may be static, like the constant force of gravity pulling at your feet, or they could be dynamic - caused by moving or vibrating the accelerometer.

It is a kind of sensor which records acceleration and gives an analog data while moving in X,Y,Z direction or may be in X, Y direction only depending on the type of the sensor.

MPU6050 sensor module is complete 6-axis Motion Tracking Device. It combines 3-axis Gyroscope, 3-axis Accelerometer and Digital Motion Processor all in small package. Also, it has additional feature of on-chip Temperature sensor. It has I2C bus interface to communicate with the microcontrollers.

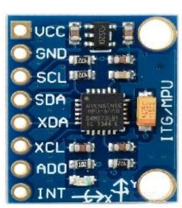


Figure 3.2: MPU 6050

Table 3.1: MPU 6050 pinout:

Pin Number	Symbol	Function
1	VCC	Provides power for the module, can be +3V to +5V. Typically +5V is used
2	GND	Connected to Ground of system
3	SCL	Used for providing clock pulse for I2C Communication
4	SDA	Used for transferring Data through I2C communication
5	XDA	Auxiliary Serial Data pin. This pin is used to connect other I2C interface enabled sensors SDA pin to MPU6050
6	XCL	Auxiliary Serial Clock pin. This pin is used to connect other I2C interface enabled sensors SCL pin to MPU6050
7	AD0	I2C Slave Address LSB pin. This is 0th bit in 7-bit slave address of device. If connected to VCC then it is read as logic one and slave address changes
8	INT	Interrupt digital output pin

3.2 RASPBERRY PI

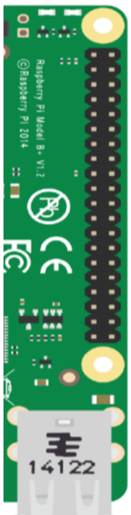
The Raspberry Pi 3 Model B is the third generation Raspberry Pi. This powerful credit-card sized single board computer can be used for many applications and supersedes the original Raspberry Pi Model B+ and Raspberry Pi 2 Model B.

Whilst maintaining the popular board format the Raspberry Pi 3 Model B brings a more powerful processor, which is 10 times faster than the first generation Raspberry Pi.

Additionally it adds wireless LAN & Bluetooth connectivity making it the ideal solution for powerful connected designs.

Figure 3.3: Raspberry Pi 3B

Raspberry Pi 3B pinout:



Peripherals	GPIO	Particle	Pin #			Pin #	Particle	GPIO	Peripherals
3.3V			1	×	×	2	5V		
I2C	GPIO2	SDA	3	×	×	4	5V		
	GPIO3	SCL	5	×	×	6	GND		
Digital I/O	GPIO4	D0	7	×	×	8	TX	GPIO14	UART
GND			9	×	×	10	RX	GPIO15	Serial 1
Digital I/O	GPIO17	D1	11	×	×	12	D9/A0	GPIO18	PWM 1
Digital I/O	GPIO27	D2	13	×	×	14	GND		
Digital I/O	GPIO22	D3	15	×	×	16	D10/A1	GPIO23	Digital I/O
3.3V			17	×	×	18	D11/A2	GPIO24	Digital I/O
SPI	GPIO10	MOSI	19	×	×	20	GND		
	GPIO9	MISO	21	×	×	22	D12/A3	GPIO25	Digital I/O
	GPIO11	SCK	23	×	×	24	CE0	GPIO8	SPI (chip enable)
GND			25	×	×	26	CE1	GPIO7	
DO NOT USE	ID_SD	DO NOT USE	27	×	×	28	DO NOT USE	ID_SC	DO NOT USE
Digital I/O	GPIO5	D4	29	×	×	30	GND		
Digital I/O	GPIO6	D5	31	×	×	32	D13/A4	GPIO12	Digital I/O
PWM 2	GPIO13	D6	33	×	×	34	GND		
PWM 2	GPIO19	D7	35	×	×	36	D14/A5	GPIO16	PWM 1
Digital I/O	GPIO26	D8	37	×	×	38	D15/A6	GPIO20	Digital I/O
GND			39	×	×	40	D16/A7	GPIO21	Digital I/O

Figure 3.4: Raspberry Pi 3B pinout

3.3 ENCODER (HT 12E)

HT12E is an encoder integrated circuit of 212 series of encoders. They are paired with 212 series of decoders for use in remote control system applications. It is mainly used in interfacing RF and infrared circuits. The chosen pair of encoder/decoder should have same number of addresses and data format.

Simply put, HT12E converts the parallel inputs into serial output. It encodes the 12 bit parallel data into serial for transmission through an RF transmitter. These 12 bits are divided into 8 address bits and 4 data bits.

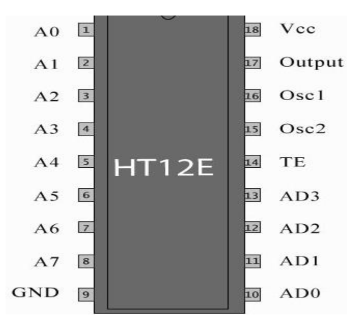


Figure 3.5: HT 12E pinout

Table 3.2: HT 12E pinout:

Pin Number	Name	Function
1	A0	8 bit Address pins for input
2	A1	
3	A2	
4	A3	
5	A4	
6	A5	
7	A6	
8	A7	
9	GND	Ground (0V)
10	AD0	4 bit Data/Address pins for input
11	AD1	
12	AD2	
13	AD3	
14	TE	Transmission enable; active low
15	Osc2	Oscillator input
16	Osc1	Oscillator output
17	Output	Serial data output
18	Vcc	Supply voltage; 5V (2.4V-12V)

3.4 RF MODULE (Tx 434/Rx 434)

An RF module (radio frequency module) is a (usually) small electronic device used to transmit and/or receive radio signals between two devices. In an embedded system it is often desirable to communicate with another device wirelessly. This wireless communication may be accomplished through optical communication or through radio frequency (RF) communication.

RF communications incorporate a transmitter and a receiver. They are of various types and ranges.This RF module comprises of an RF Transmitter and an RF Receiver. The transmitter/receiver (Tx/Rx) pair operates at a frequency of 434 MHz. An RF transmitter receives serial data and transmits it wirelessly through RF through its antenna connected at pin4. The transmission occurs at the rate of 1Kbps - 10Kbps.The transmitted data is received by an RF receiver operating at the same frequency as that of the transmitter.

Figure 3.6: RF 434 module

Table 3.3: Tx 434 pinout:

Pin Number	Name	Function
1	GND	Ground (0V)
2	Data	Serial data input pin
3	Vcc	Supply voltage; 5V
4	ANT	Antenna output pin

Table 3.4: Rx 434 pinout:

Pin Number	Name	Function
1	GND	Ground (0V)
2	Data	Serial data output pin
3	Data	Linear output pin
4	Vcc	Supply voltage; 5V
5	Vcc	Supply voltage; 5V
6	GND	Ground (0V)
7	GND	Ground (0V)
8	ANT	Antenna input pin

3.5 DECODER (HT 12D)

HT12D is a decoder integrated circuit that belongs to 212 series of decoders. This series of decoders are mainly used for remote control system applications, like burglar alarm, car door controller, security system etc. It is mainly provided to interface RF and infrared circuits. They are paired with 212 series of encoders. The chosen pair of encoder/decoder should have same number of addresses and data format.

In simple terms, HT12D converts the serial input into parallel outputs. It decodes the serial addresses and data received by, say, an RF receiver, into parallel data and sends them to output data pins. The serial input data is compared with the local addresses three times continuously. The input data code is decoded when no error or unmatched codes are found. A valid transmission in indicated by a high signal at VT pin.

HT 12D pinout:

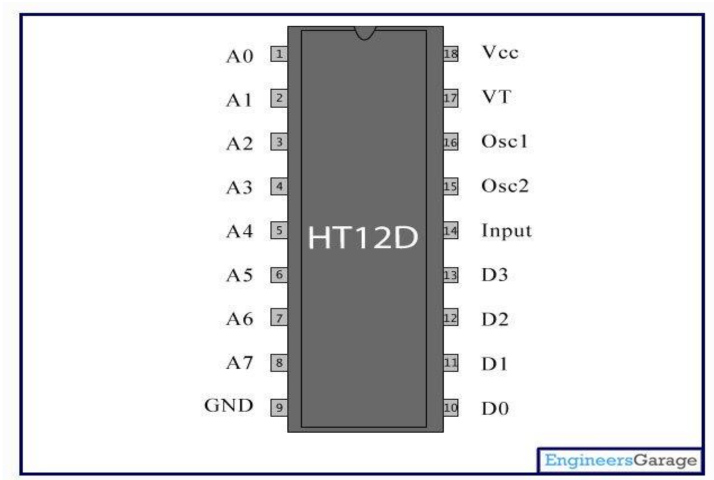


Figure 3.7: HT 12D pinout

Table 3.5: HT 12D pinout:

Pin Number	Name	Function
1	A0	8 bit address pins for input
2	A1	
3	A2	
4	A3	
5	A4	
6	A5	
7	A6	
8	A7	
9	GND	Ground (0V)
10	D0	4 bit data/address pins for output
11	D1	
12	D2	
13	D3	
14	Input	Serial data input
15	Osc2	Oscillator output
16	Osc1	Oscillator input
17	VT	Valid transmission; active high
18	Vcc	Supply voltage; 5V(2.4V-12V)

3.6 MOTOR DRIVER (L293D)

L293D is a dual H-bridge motor driver integrated circuit (IC). Motor drivers act as current amplifiers since they take a low-current control signal and provide a higher-current signal. This higher current signal is used to drive the motors.

L293D contains two inbuilt H-bridge driver circuits. In its common mode of operation, two DC motors can be driven simultaneously, both in forward and reverse direction. The motor operations of two motors can be controlled by input logic at pins 2 & 7 and 10 & 15. Input logic 00 or 11 will stop the corresponding motor. Logic 01 and 10 will rotate it in clockwise and anticlockwise directions, respectively.

Enable pins 1 and 9 (corresponding to the two motors) must be high for motors to start operating. When an enable input is high, the associated driver gets enabled. As a result, the outputs become active and work in phase with their inputs. Similarly, when the enable input is low, that driver is disabled, and their outputs are off and in the high-impedance state.

L293D pinout:

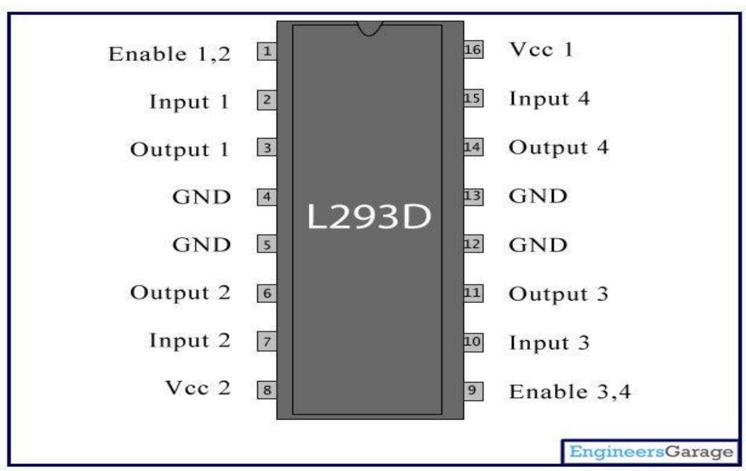


Figure 3.8: L293D motor driver pinout

Table 3.6: L293D pinout:

Pin Number	Name	Function
1	Enable 1,2	Enable pin for Motor 1; active high
2	Input 1	Input 1 for motor 1
3	Output 1	Output 1 for motor 1
4	GND	Ground (0V)
5	GND	Ground (0V)
6	Output 2	Output 2 for motor 1
7	Input 2	Input 2 for motor 1
8	Vcc 2	Supply voltage for motors; 9V-12V
9	Enable 3,4	Enable pin for Motor 2; active high
10	Input 3	Input 1 for motor 2
11	Output 3	Output 1 for motor 2
12	GND	Ground (0V)
13	GND	Ground (0V)
14	Output 4	Output 2 for motor 2
15	Input 4	Input 2 for motor 2
16	Vcc 1	Supply voltage; 5V

3.7 DC MOTORS

A machine that converts DC power into mechanical power is known as a DC motor. Its operation is based on the principle that when a current carrying conductor is placed in a magnetic field, the conductor experiences a mechanical force.

DC motors have a revolving armature winding but non-revolving armature magnetic field and a stationary field winding or permanent magnet. Different connections of the field and armature winding provide different speed/torque regulation features. The speed of a DC motor can be controlled by changing the voltage applied to the armature or by changing the field current.

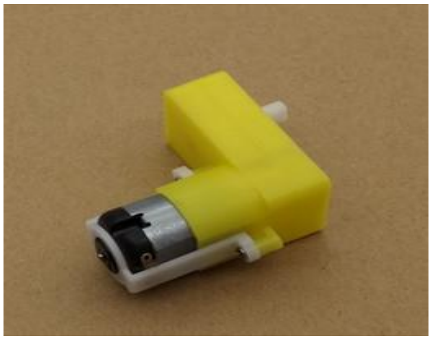


Figure 3.9: A DC motor

CHAPTER IV: METHODOLOGY

The accelerometer MPU6050 measures movement in all three directions i.e. in X, Y and Z directions with the help of a program written using Python. It transmits output in the form of voltage levels which is being fed into the GPIO pins of the Raspberry Pi. GPIO (General Purpose Input/Output) is a powerful feature of the Raspberry Pi.

Any of the GPIO pins can be designated (in software) as an input or output pin and used for a wide range of purposes.

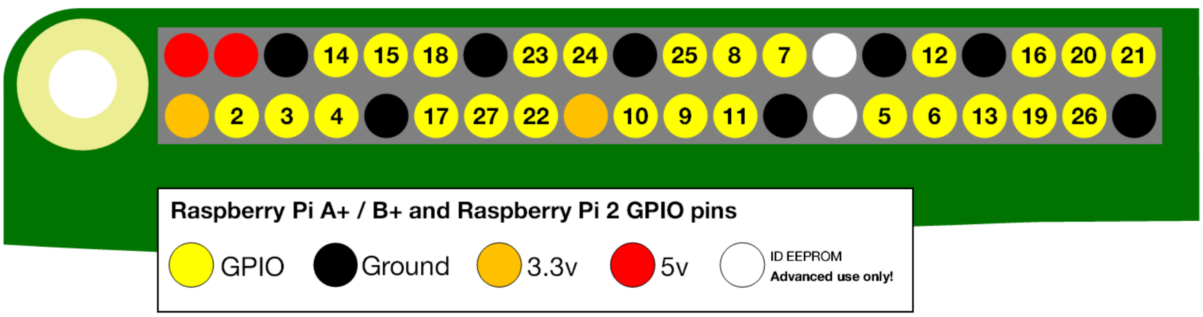


Figure 4.1: GPIO pin out of Raspberry Pi

Two 5V pins and two 3V3 pins are present on the board, as well as a number of ground pins (0V), which are not configurable. The remaining pins are all general purpose 3V3 pins, meaning outputs are set to 3V3 and inputs are 3V3-tolerant.

A GPIO pin designated as an output pin can be set to high (3V3) or low (0V).

A GPIO pin designated as an input pin can be read as high (3V3) or low (0V). This is made easier with the use of internal pull-up or pull-down resistors. Pins GPIO2 and GPIO3 have fixed pull-up resistors, but for other pins this can be configured in software.

As well as simple input and output devices, the GPIO pins can be used with a variety of alternative functions, some are available on all pins, others on specific pins:

- PWM (pulse-width modulation) –

Software PWM available on all pins, Hardware PWM available on GPIO12, GPIO13, GPIO18, GPIO19

- SPI -

SPI0: MOSI (GPIO10); MISO (GPIO9); SCLK (GPIO11); CE0 (GPIO8), CE1 (GPIO7)

SPI1: MOSI (GPIO20); MISO (GPIO19); SCLK (GPIO21); CE0 (GPIO18); CE1 (GPIO17); CE2 (GPIO16)

- I2C -

Data: (GPIO2); Clock (GPIO3)

EEPROM Data: (GPIO0); EEPROM Clock (GPIO1)

- Serial -

TX (GPIO14); RX (GPIO15)

The code to find out about the GPIO pinout from the Pi itself is:

>>pinout

4.1 Configuration of MPU 6050

- Installing smbus:

>>sudo apt-get install python-smbus i2c-tools

- Enabling the I2C in RPi:

>>sudoraspi-config

- Then including the i2c specification lines by these commands:

>>sudonano /etc/modules

These lines were added:

i2c-bcm2708

i2c-dev

- Rebooting the Pi:

>>sudo reboot

- The interfacing was tested by using this following command. This would show the address of the sensor connected to our pi:

>>sudo i2c detect -y 1

The port address of MPU 6050 is detected at 0x68.

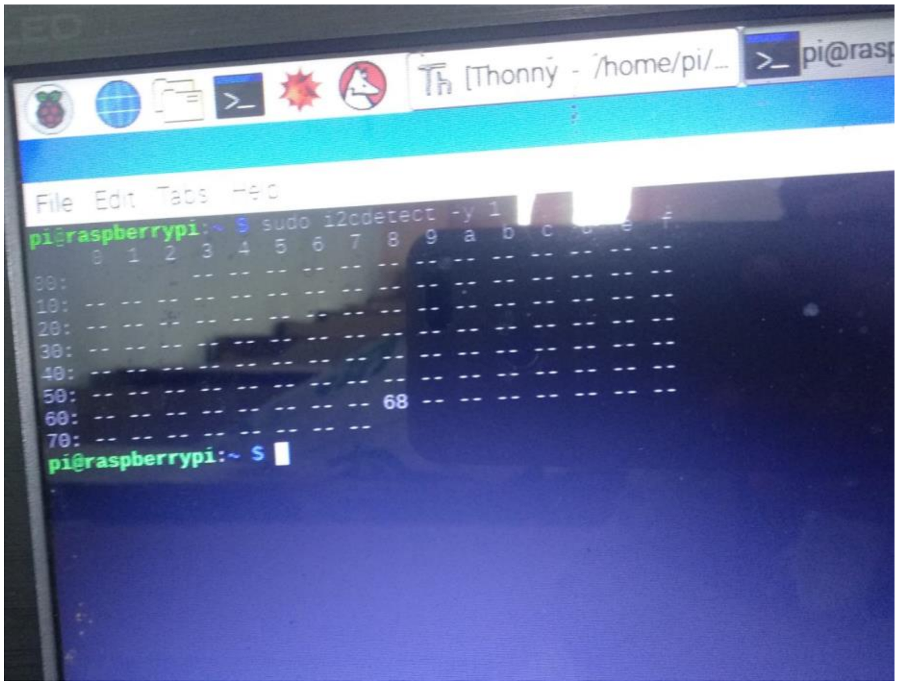


Figure 4.2: Port address of MPU 6050 in Raspberry Pi

4.2 Determining the real time parameters of MPU 6050(Accelerometer)

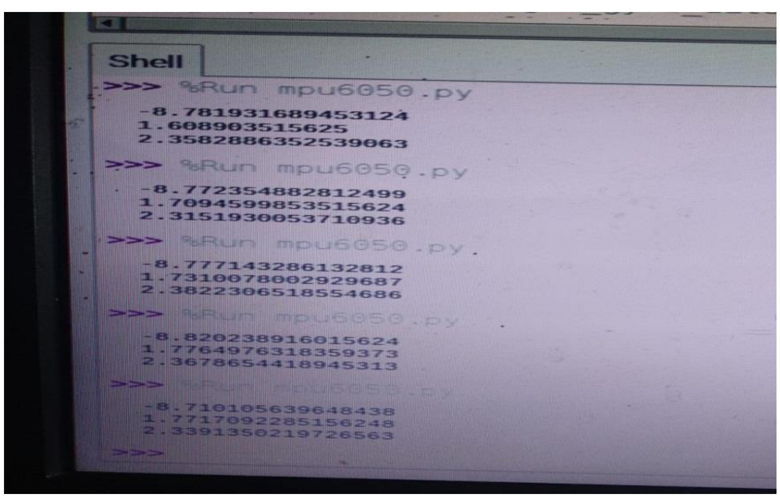


Figure 4.3: X, Y, Z direction values in MPU 6050

After calibrating the MPU 6050 with the help of the Python program in Raspberry Pi, the following conditions were checked for direction with respect to the movement:

Table 4.1: Conditions to check direction of MPU 6050:

Case	Condition	Comments
I	Z>8	Stop
	Z<8	Check for direction with respect to movement
II	X<-2	Forward direction
	X>3	Backward direction
	Y>0	Right direction
	Y<0	Left direction

All the conditions mentioned above were calibrated and the conditions for X and Y direction of the MPU 6050 will only be considered if the condition for the Z direction is satisfied.

Depending upon the conditions found in MPU 6050, the values of four data pins (GPIO pins) of Raspberry Pi are set or reset.

Table 4.2: Logics provided by Raspberry Pi to Encoder:

Data Pins				Motor 1		Motor 2		Comments
D1	D2	D3	D4	D1	D2	D3	D4	
1	0	1	0	1	0	1	0	Forward
0	1	0	1	0	1	0	1	Reverse
1	0	0	1	1	0	0	1	Left
0	1	1	0	0	1	1	0	Right

4.3 Encoding & Transmission

This binary logic from the Raspberry Pi go to the encoder (HT 12E). The four data pins act as parallel input to the encoder. The encoder converts it into serial 4-bit data. This data is generated at the output pin of the encoder.

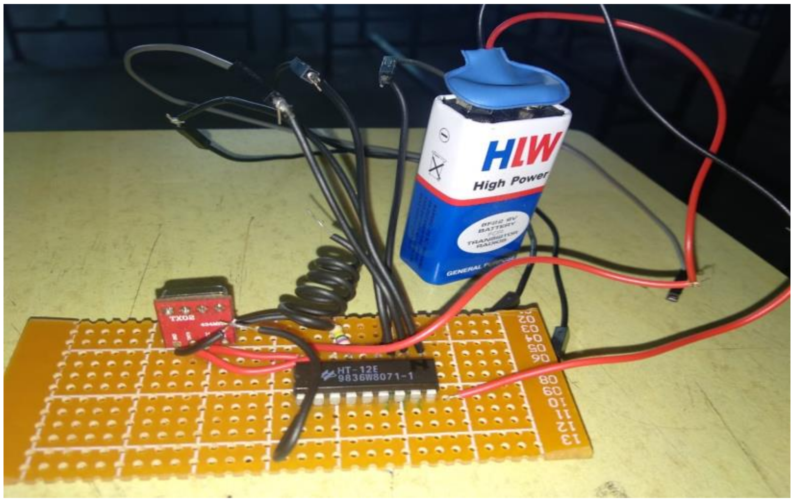


Figure 4.4: Encoder and Transmitter connection

The serial output act as input to the RF transmitter (Tx434). The data is transmitted wirelessly to the RF receiver (Rx434).

4.4 Receiving & Decoding

The serial data received at the receiver (Rx434) is generated at the data pin and it is wired to the decoder (HT 12D). The decoder converts the 4-bit serial data to 4-bit parallel data. The 4-bit set or reset logics are generated at the four output pins of the decoder.

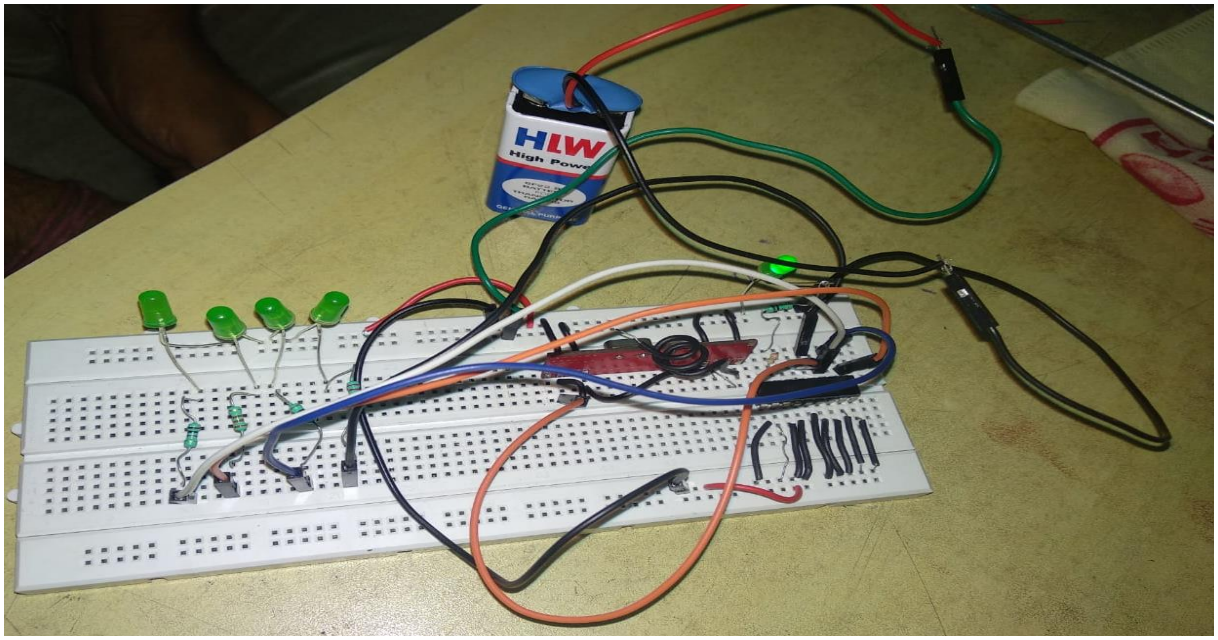


Figure 4.5: Receiver and Decoder connection

4.5 Motor Configuration

The four 1-bit data from the decoder are wired to the four input pins of the motor driver (L293D) respectively. The power is provided by two 9V DC power supplies.

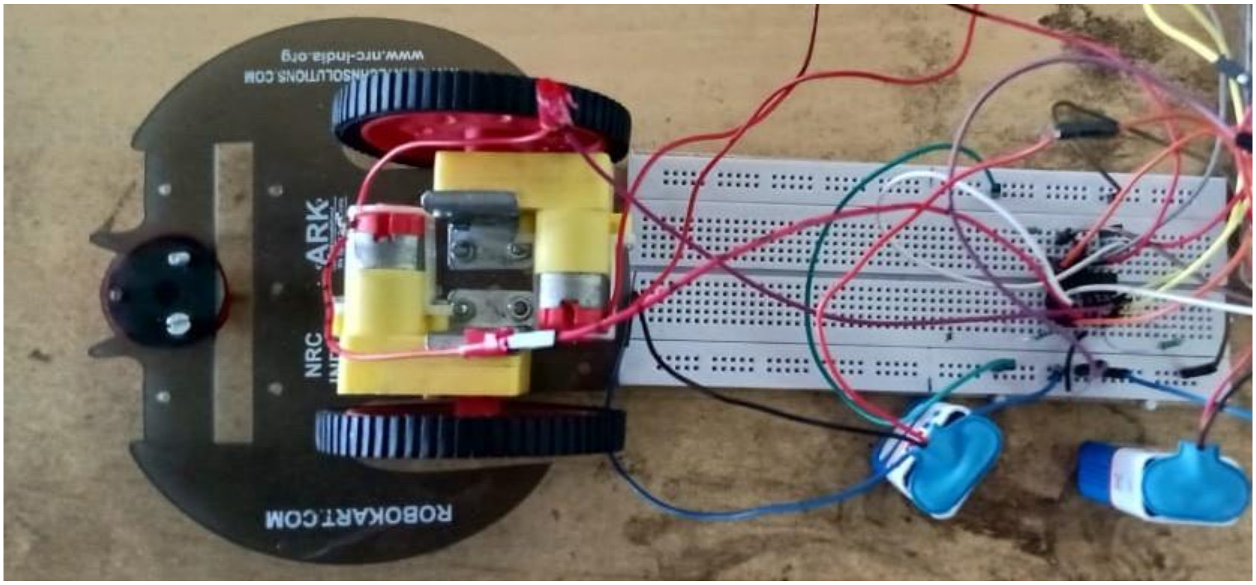


Figure 4.6: Connection of Motors with Motor driver

Decoder Output A1A2B1B2	Motor A A1A2	Motor B B1B2	Robot Motion
1010	10	10	Forward
0101	01	01	Backward
1001	10	01	Right
0110	01	10	Left

Figure 4.7: Motor configuration

CHAPTER V: RESULTS & DISCUSSION

Upon soldering the circuit for both transmitter end and receiver end, the final circuit looked like the following:

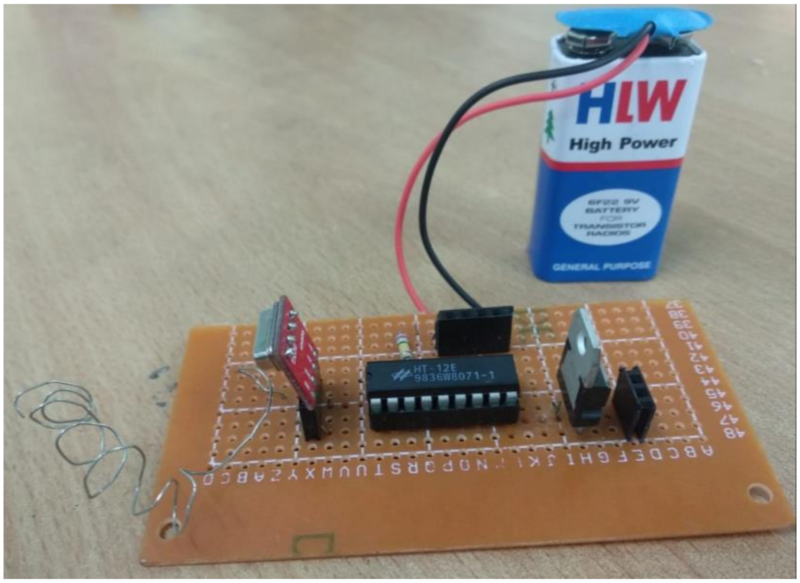


Fig. 5.1: Encoder and Transmitter connection in a vero board

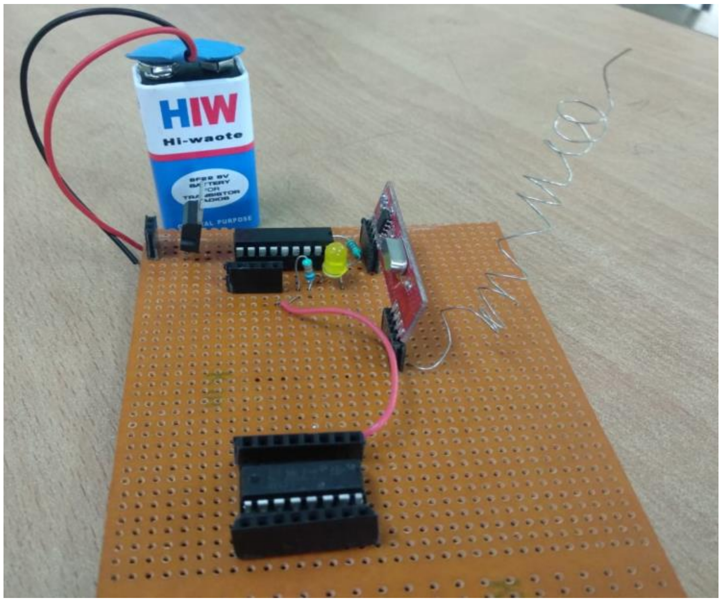


Fig. 5.2: Receiver and Decoder connection in vero board

Based on the hand movements, the accelerometer orientation was as follows:

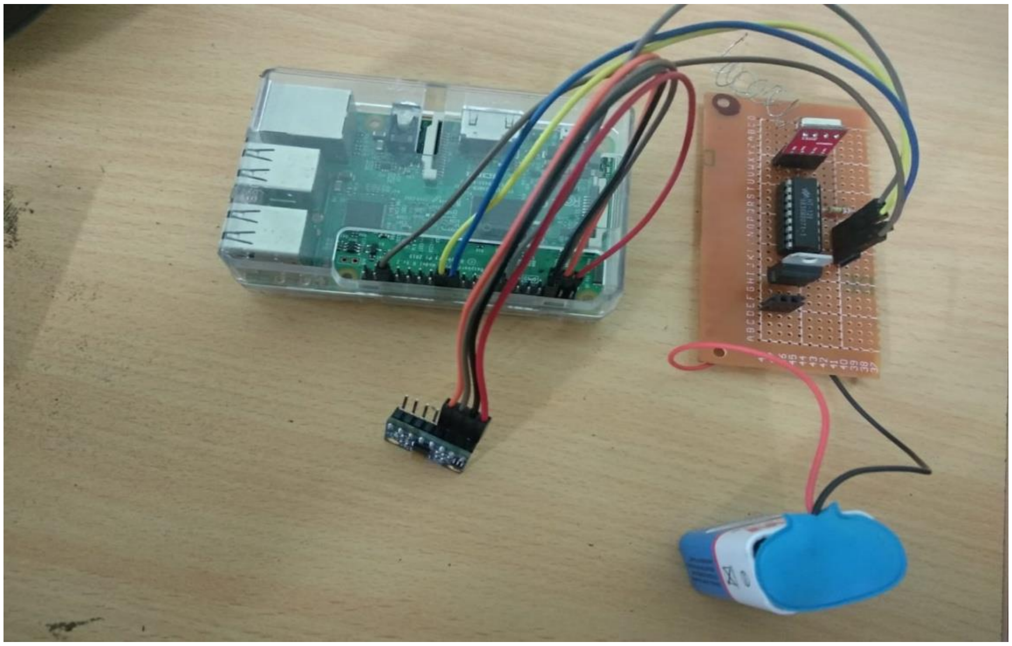


Fig. 5.3: Transmitter End

Table 5.1: Accelerometer Reading Results:

Direction	**Accelerometer Orientation**
Forward	+y
Reverse	-y
Left	-x
Right	+x
Stop	Rest

The comparator code of the Raspberry Pi generates 4-bit data, which is fed to the motors from the decoder.

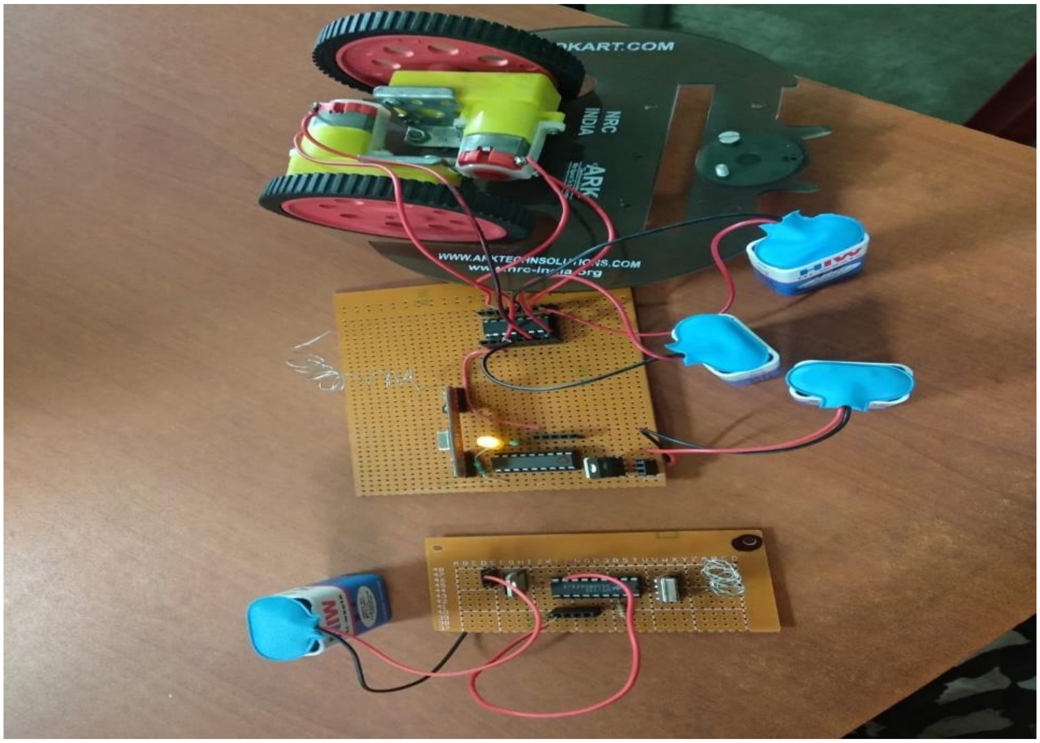


Fig. 5.4: Receiver End

Table 5.2: Motion induced by Accelerometer Orientation:

Data Pins				**Motor 1**		**Motor 2**		**Car Movement**	**Accelerometer Orientation**
D1	D2	D3	D4	D1	D2	D3	D4		
1	0	1	0	1	0	1	0	Forward	+y
0	1	0	1	0	1	0	1	Reverse	-y
1	0	0	1	1	0	0	1	Left	-x
0	1	1	0	0	1	1	0	Right	+x

CHAPTER VI: CONCLUSION

The main objective of the project was to build a robot-car that would run with the help of the hand gestures obtained from the Accelerometer MPU 6050 using wireless RF communication. A Raspberry Pi model 3B was used as a microcontroller. The car is showing proper movements for the pre-determined and calibrated different hand gestures. The data from the hand movements with the help of the accelerometer are fed into the Encoder HT 12E through the Raspberry Pi. Then the values are transmitted with the help of Tx 434. Rx 434 receives the values in the receiver part, where it is decoded by a Decoder HT 12D and sent to the motor driver L293D. Thus motors are controlled with the data obtained from the motor driver.

The car only moves when the accelerometer is moved in a specific direction as per the given calibrated values of the accelerometer.

6.1 Limitations & Future work:

- The 9V batteries used offer only a limited amount of power to the system. Some alternate source of power would be more helpful in place of batteries.
- The RF module (RF 434) has a limited range of operation (around 500 feet). This problem can be solved by utilizing a GSM module for wireless transmission. The GSM infrastructure is installed almost all over the world. GSM will not only provide wireless connectivity but also quite a large range.
- Thirdly, an on-board camera can be installed for monitoring the robot from farawayplaces. All we need is a wireless camera which will broadcast and a receiver module which will provide live streaming.

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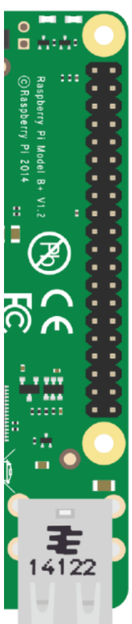
APPENDIX

Raspberry Pi 3B datasheet:

Raspberry Pi 3B pinout:



Peripherals	GPIO	Particle	Pin #			Pin #	Particle	GPIO	Peripherals
3.3V			1	X	X	2	5V		
I2C	GPIO2	SDA	3	X	X	4	5V		
	GPIO3	SCL	5	X	X	6	GND		
Digital I/O	GPIO4	D0	7	X	X	8	TX	GPIO14	UART
GND			9	X	X	10	RX	GPIO15	Serial 1
Digital I/O	GPIO17	D1	11	X	X	12	D9/A0	GPIO18	PWM 1
Digital I/O	GPIO27	D2	13	X	X	14	GND		
Digital I/O	GPIO22	D3	15	X	X	16	D10/A1	GPIO23	Digital I/O
3.3V			17	X	X	18	D11/A2	GPIO24	Digital I/O
SPI	GPIO10	MOSI	19	X	X	20	GND		
	GPIO9	MISO	21	X	X	22	D12/A3	GPIO25	Digital I/O
	GPIO11	SCK	23	X	X	24	CE0	GPIO8	SPI (chip enable)
GND			25	X	X	26	CE1	GPIO7	
DO NOT USE	ID_SD	DO NOT USE	27	X	X	28	DO NOT USE	ID_SC	DO NOT USE
Digital I/O	GPIO5	D4	29	X	X	30	GND		
Digital I/O	GPIO6	D5	31	X	X	32	D13/A4	GPIO12	Digital I/O
PWM 2	GPIO13	D6	33	X	X	34	GND		
PWM 2	GPIO19	D7	35	X	X	36	D14/A5	GPIO16	PWM 1
Digital I/O	GPIO26	D8	37	X	X	38	D15/A6	GPIO20	Digital I/O
GND			39	X	X	40	D16/A7	GPIO21	Digital I/O

MPU 6050 datasheet:

Features:

Gyroscope Features:

The triple-axis MEMS gyroscope in the MPU-60X0 includes a wide range of features:

- Digital-output X-, Y-, and Z-Axis angular rate sensors (gyroscopes) with a user-programmable full-scale range of ±250, ±500, ±1000, and ±2000°/sec

- External sync signal connected to the FSYNC pin supports image, video and GPS synchronization
- Integrated 16-bit ADCs enable simultaneous sampling of gyros
- Enhanced bias and sensitivity temperature stability reduces the need for user calibration
- Improved low-frequency noise performance
- Digitally-programmable low-pass filter
- Gyroscope operating current: 3.6mA
- Standby current: 5µA
- Factory calibrated sensitivity scale factor
- User self-test

Accelerometer Features:

The triple-axis MEMS accelerometer in MPU-60X0 includes a wide range of features:

- Digital-output triple-axis accelerometer with a programmable full scale range of ±2g, ±4g, ±8g and ±16g
- Integrated 16-bit ADCs enable simultaneous sampling of accelerometers while requiring no external multiplexer
- Accelerometer normal operating current: 500µA
- Low power accelerometer mode current: 10µA at 1.25Hz, 20µA at 5Hz, 60µA at 20Hz, 110µA at 40Hz
- Orientation detection and signaling
- Tap detection
- User-programmable interrupts
- High-G interrupt
- User self-test

MPU 6050 pinout:

Pin Number	Symbol	Function
1	VCC	Provides power for the module, can be +3V to +5V. Typically +5V is used
2	GND	Connected to Ground of system
3	SCL	Used for providing clock pulse for I2C Communication
4	SDA	Used for transferring Data through I2C communication
5	XDA	Auxiliary Serial Data pin. This pin is used to connect other I2C interface enabled sensors SDA pin to MPU6050
6	XCL	Auxiliary Serial Clock pin. This pin is used to connect other I2C interface enabled sensors SCL pin to MPU6050
7	AD0	I2C Slave Address LSB pin. This is 0th bit in 7-bit slave address of device. If connected to VCC then it is read as logic one and slave address changes
8	INT	Interrupt digital output pin

HT12D datasheet:

Features:

- Operating voltage: 2.4V~12V
- Low power and high noise immunity CMOStechnology
- Low standby current
- Capable of decoding 12 bits of information
- Binary address setting
- Received codes are checked 3 times
- Address/Data number combination
- 8 address bits and 4 data bits

HT 12D pinout:

Pin Number	Name	Function
1	A0	8 bit address pins for input
2	A1	
3	A2	
4	A3	
5	A4	
6	A5	
7	A6	
8	A7	
9	GND	Ground (0V)
10	D0	4 bit data/address pins for output
11	D1	
12	D2	
13	D3	
14	Input	Serial data input
15	Osc2	Oscillator output
16	Osc1	Oscillator input
17	VT	Valid transmission; active high
18	Vcc	Supply voltage; 5V(2.4V-12V)

HT12E datasheet:

Features:

- Operating voltage
- 2.4V~12V for the HT12E
- Low power and high noise immunity CMOS technology
- Low standby current: 0.1A (typ.) at VDD=5V

HT 12E pinout:

Pin Number	Name	Function
1	A0	8 bit Address pins for input
2	A1	
3	A2	
4	A3	
5	A4	
6	A5	
7	A6	
8	A7	
9	GND	Ground (0V)
10	AD0	4 bit Data/Address pins for input
11	AD1	
12	AD2	
13	AD3	
14	TE	Transmission enable; active low
15	Osc2	Oscillator input
16	Osc1	Oscillator output
17	Output	Serial data output
18	Vcc	Supply voltage; 5V (2.4V-12V)

RF 434 datasheet:

Transmitter Tx 434 pinout:

Pin Number	Name	Function
1	GND	Ground (0V)
2	Data	Serial data input pin
3	Vcc	Supply voltage; 5V
4	ANT	Antenna output pin

Receiver Rx 434 pinout:

Pin Number	Name	Function
1	GND	Ground (0V)
2	Data	Serial data output pin
3	Data	Linear output pin
4	Vcc	Supply voltage; 5V
5	Vcc	Supply voltage; 5V
6	GND	Ground (0V)
7	GND	Ground (0V)
8	ANT	Antenna input pin

L293D datasheet:

L293D pinout:

Pin Number	Name	Function
1	Enable 1,2	Enable pin for Motor 1; active high
2	Input 1	Input 1 for motor 1
3	Output 1	Output 1 for motor 1
4	GND	Ground (0V)
5	GND	Ground (0V)
6	Output 2	Output 2 for motor 1
7	Input 2	Input 2 for motor 1
8	Vcc 2	Supply voltage for motors; 9V-12V
9	Enable 3,4	Enable pin for Motor 2; active high
10	Input 3	Input 1 for motor 2
11	Output 3	Output 1 for motor 2
12	GND	Ground (0V)
13	GND	Ground (0V)
14	Output 4	Output 2 for motor 2
15	Input 4	Input 2 for motor 2
16	Vcc 1	Supply voltage; 5V