Control and Microprocessor Lab
LINE FOLLOWING CAR

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Contents

0.1 List of Components

0.1.1 Wheel Smart Robot Car Chassis Kit (un-assembled)

The mechanical structure is very simple and easy to install. An excellent platform for Line Following robots and Maze Solving Robots. The chassis has enough room for all the necessary electronics. This robot chassis together with tiva microprocessor makes an ideal DIY project Kit.
This car chassis comes with encoder disks, you can use two encoders with these disks to measure the speed and velocity of the robot car. It gives you the freedom to implement multiple kind of line following algorithms like PID.
Specifications:
Voltage: DC 6V
Current: 120MA
Reduction rate : 48:1
RPM (With tire): 240

Tire Diameter: 66mm
Car Speed(M/minute): 48
Motor Weight (g): 50
Motor Size: 70mm*22mm*18mm
Noise: ¡65dB Tire Size
Tire Size Center hole: Long 5.3MM, 3.5MM
wide Diameter: 66MM
Width: 26MM
DC Gear Motor
No load speed (6V): 200$RPM\pm$10
No load current (6V): 200 mA
No load speed (3V): 90$RPM\pm$10
No load current (3V): 150 mA
Voltage: 3-6 V
Reduction ratio is 1:48

0.1.2 Channel TCRT5000 Line Following Line Tracking Array Module:

5 channel TCRT5000 line tracking sensor module is a sensor board designed for use with line following robots. It has 6 road high sensitive infrared distance sensor, for the recognition of black and white line accurately.
Specifications:
1. Digital Signals Output
2. 5V DC Input
3. Infrared Tracking Sensor

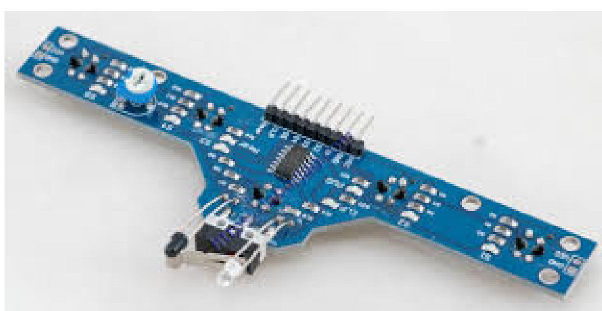

Figure 1: 5 Channel Sensor array

0.1.3 Capacitors:

A device used to store an electric charge, consisting of one or more pairs of conductors separated by an insulator. We used 10uF it to reduce the ripples that voltage source produces.

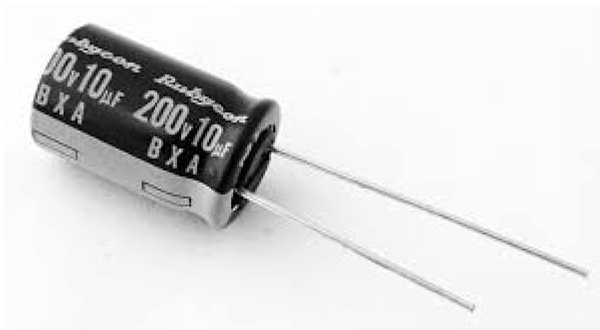

Figure 2: Capacitors

0.1.4 4n35 Optocoupler:

The 4N35 is an optocoupler that consists of a gallium arsenide infrared LED and a silicon NPN phototransistor. When the input signal is applied to the LED in the input terminal, the LED lights up. After receiving the light signal, the light receiver then converts it into electrical signal and outputs the signal directly or after amplifying it into a standard digital level. They are also known as optoisolators since they separate two circuits optically. These are used to couple two circuits without any ohmic contact. They allow one of the circuits to switch another one while they are completely separate. The first circuit is connected to IR diode while the other circuit with the photo transistor.

Figure 3: Opto coupler

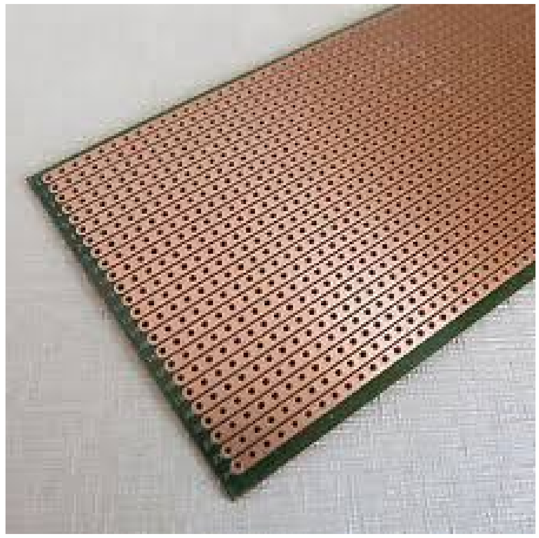

Figure 4: Vero Board

0.1.5 Jumper Wires :

A jumper wire is a short insulated wire with bare (stripped of insulation) ends. You use jumper wires to connect two points in a breadboard circuit.

0.1.6 Veroboard Breadboard Style:

As with other stripboards, in using Veroboard , components are suitably positioned and soldered to the conductors to form the required circuit.

0.1.7 L298H Bridge Motor Driver Module

The L298 is an integrated monolithic circuit in a 15-lead Multiwatt and PowerSO20 packages. It is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads such as relays, solenoids, DC and stepping motors.This module is based on the very popular L298 Dual H-Bridge Motor Driver Integrated Circuit. The circuit will allow you to easily and independently control two motors of up to 2A each in both directions. 12V supply is given to it using LM2596 DC to Dc Buck Module and 5V power is connected to 4N35 optocoupler 4th pin. It's 1st and 4th pins are used to move the robot forward and 2nd and 3rd pins are used to move it backward.
Specifications:
Motor supply: 7 to 24 VDC
Control Logic: Standard TTL Logic Level

Output Power: Up to 2A each

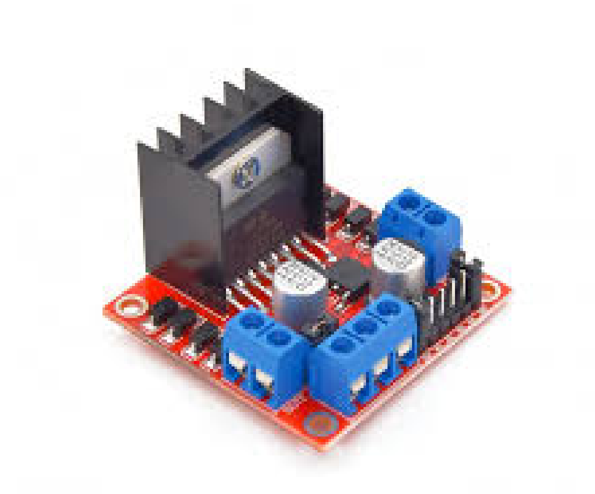

Figure 5: Motor Driver

0.1.8 Li-ion Battery Pack:

Provides excellent continuous power to the devices like RC boat, model car, remote control, electric toys, razor, cordless phone, flashlight, DIY power bank, emergency lighting, LED lamp, security facilities, electric tools, etc.

Figure 6: Lithium ion batteries

0.1.9 LM7805 voltage regulator:

The voltage regulator IC 7805 is actually a member of the 78xx series of voltage regulator ICs. 7805 is a three terminal linear voltage regulator IC with a fixed output voltage of 5V which is useful in a wide range of applications Some of the important features of the 7805 IC are as follows:
It can deliver up to 1.5 A of current (with heat sink).
Has both internal current limiting and thermal shutdown features.
Requires very minimum external components to fully function

Figure 7: Voltage Regulator

0.2 Budget

List of Components	Quantity	Amount(Rupees)
3 Wheel Smart Robot Car	1	500
Tracking Array Module	1	450
LM7805 voltage regulator	1	20
10uF Capacitors	2	20
TLP4N35 Optocouplers	2	30
Jumpers	3	90
Veroboard breadboard style	1	80
L298H Bridge Motor Driver Module	1	200
TP4056 1A Standalone Linear Li-Ion Battery Charger	1	60
18650 Cell	4	680

Figure 8: Budget

0.3 Block Diagram

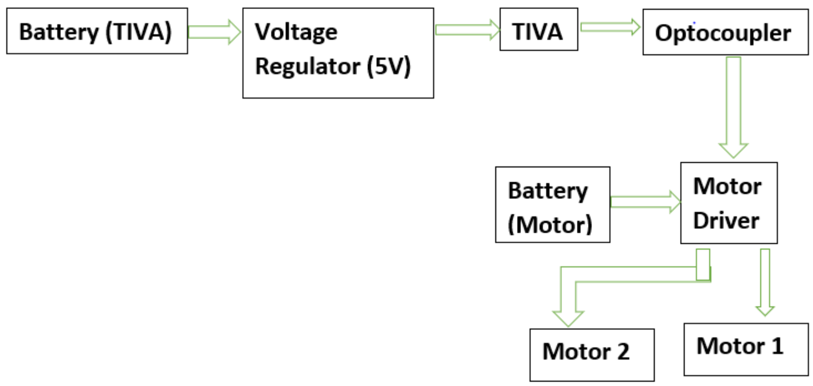

Figure 9: block diagram

0.4 Working

0.4.1 Phase 1

In the 1st phase we assembled Wheel Smart Robot Car Chassis Kit first.Then we made Optocoupler circuit using 4n35 optocoupler and capacitors on a veroboard. We then mounted L298H Motor Driver Module on the body of car and gave connetions to both motors.We used a voltage regulator supply for 5V supply of Tiva Board and a Buck Module for 9V supply for L298H Motor Driver Module.We used 5 Li-on batteries , 2 for Tiva board supply and 3 for Motor Driver Module.We used battery stands for the batteries.The connections were made with the jumper wires.Then we fixed Channel TCRT5000 Line Following Array Module at the bottom of front side of car.We gave connection to Line Following Array Module from Tiva Board.Then we tested that whether the car motors were working.

0.4.2 Phase 2

In the 2ND phase we used If-Else conditions in our tiva micro controller for the line following car.PWM signal are generated through tiva using the information of sensor array.The speed of each motor is adjusted by adjusting the duty cycle. The motor speeds are controlled by adjusting the mean voltage supplied to the armature by using PWM. Although, the motor speed increases with increase in applied voltage, the relationship is non-linear. The dynamic load on the motors, the robot weight and inertia, further increases the non-linearity. Although both motors are similar, slight mechanical differences in the motors usually results in the motors rotating at different speeds even when equal power is applied. This causes the robot to drift towards the right or left instead of moving forward. Due to the non-linearity in the speed of the motors, the robot path deviation is different at different motor speeds. The constraints due to the motors remain as one of the most significant and defining characteristic which affects the performance of the entire system. IR sensors, which are used as the line sensors are themselves non-linear, i.e. the sensor values are just an indication of surface reflectivity. The sensor value is lower when over a white surface and higher when over a dark surface. The actual values are heavily dependent on the external lighting conditions even though sensor array is shielded. Further, there is appreciable difference between the readings of various sensors due to various factors like placement, manufacturing differences, etc

0.4.3 Phase 3

In the third phase we used pid.The introduction of PID significantly improve the performance of the car The output of the IR line sensor array is fed to the microcontroller which calculates the error term from sensor values.
The proportional value is approximately proportional to the car's position with respect to the line. That is, if the car is precisely centered on the line, we expect a proportional value of exactly 0. The integral value records the history of car's motion. It is a sum of all of the values of the proportional term that were recorded since the robot started running.
The derivative is the rate of change of the proportional value.
The proportional term (P) , the integral term (I) and the derivative term (D) are the measures of the errors encountered while the robot follows a line. Kp , Ki and Kd are the proportional , integral and derivative constants that are then multiplied to the errors to adjust the robot's position.
If the car is perfectly in the center the error will zero.But if the car is at is on the left or the right side of the line there will be error in the reading and this error will be multiplied with the Kp, Kd and Ki. If the car is on the left side of the line then following formulation will be used and vice versa for the car on the right side of the line
Motor Speed = Kp * Error + Kd * (Error - Last Error);
Last Error = Error;
Right Motor Speed = Right Base Speed + MotorSpeed;
LeftMotorSpeed = Left Base Speed - MotorSpeed;
The next step is to tune the PId that is to select the error constant. This can be done by selecting different values of Kp ,Kd, and Ki. The duty cycle of each motor is also adjusted so that any manufacturing defect may be minimized.In this phase after applying pid control the car follows the line more accurately with minimal error