Sudan University of Science and Technology

College of Engineering

School of Electrical and Nuclear Engineering

Line Following Robotic Vehicle

روبوت متتبع مسار مركبة

A Research Submitted In Partial Fulfillment for the Requirments of the Degree of B.Sc. (Honor) In Electrical Engineering

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الآية

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قال تعالي :

(اللَّهُ الَّذِي سَخَّرَ لَكُمُ الْبَحْرَ لِتَجْرِيَ الْفُلْكُ فِيهِ بِأَمْرِهِ وَلِتَبْتَغُوا مِنْ فَضْلِهِ وَلَعَلَّكُمْ تَشْكُرُونَ * وَسَخَّرَ لَكُمْ مَا فِي السَّمَاوَاتِ وَمَا فِي الْأَرْضِ جَمِيعًا مِنْهُ إِنَّ فِي ذَٰلِكَ لَآيَاتٍ لِقَوْمٍ يَتَفَكَّرُونَ)

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DEDICTION

Our humble effort we dedicate to our parents, without their help , understand ing , support and most of all love a completion of this work would not have been possible .

ACKNOWLEDGMENT

We would like to express our special thanks of gratitude to our teachers for their able guidance and support in completing this research.

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Abstract

Interest in robots is increasing dramatically in today's world, and the field of use of these robots is expanding to include the fields of medicine, industry, hospitality and hotel, security, in addition to business. Most international companies are using robots in the field of storing, packaging and distributing their products, which leads to raising production efficiency and multifunctionality. And rotating the wheel economy, the project aims to control the flow of a car that follows a certain path using an open source microcontroller (Arduino Uno). The car is equipped with optical resistance sensors installed in the front, lower side, where the transmitter sends rays to the surface and then these rays are reflected, and from the intensity of the reflected light determines the color of the surface on which the car is traveling, and by using DC motors the direction and movement of the car is controlled in total.

The aims of this research is to:

-understand the basics of the robot system.

-understand the hardware and software control units used in robotic system.

-operate the robotic system.

المستخلص

يتزايد الاهتمام بالروبوتات بشكل ملفت في عالم اليوم، ويتوسع مجال استخدام هذه الروبوتات ليشمل مجالات الطب، الصناعة، الفندقة والضيافة، إضافة إلي الأعمال التجارية ، فمعظم الشركات العالمية أصبحت تستخدم الروبوتات في مجال تخزين و تغليف و توزيع منتجاتها ، مما يؤدي الي رفع كفاءة الإنتاج وتعدد الوظائف ، وتدوير عجلة الاقتصاد،

يهدف المشروع الي التحكم في سير سيارة تتبع مسار معين باستخدام المتحكم الدقيق مفتوح المصدر (Arduino Uno) .

السيارة تمتلك مجموعة من حساسات المقاومة الضوئية مثبتة في الجانب الأمامي السفلي، حيث يرسل جهاز الإرسال الأشعة إلي السطح ومن ثم تنعكس هذه الأشعة ، ومن شدة الضوء المنعكس تحدد لون السطح الذي تسير عليه السيارة ، وباستخدام محركات
التيار المستمر يتم التحكم في اتجاه وحركة السيارة .

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CHAPTER ONE

Introduction

1.1 General Concepts

Line follower is a machine that can follow a path. The path can be visible like a black line on a white surface.Sensing a line and maneuvering the robot to stay on course, while constantly correcting wrong moves using feedback from the sensor forms a simple yet effective system. It can be used in automobile, industrial automations, guidance.

As technology becomes increasingly important in today's world, it is invaluable to not only learn how to use technology, but also to understand how to create it. Since being the engineer one should have sound knowledge of the other discipline.Most of the projects have limted scope to only specific discipline.This would limit ones innovation and creativity. This project inspires to make connections across several disciplines rather than learning topics in isolation as it combines mechanical, electronic, electrical and programming skills.

- It gives visual grasp of math and science.
- It builds logical thinking.
- It brings out innovation and creativity.
- It enhances problem solving skills.

How ants always travel in a line, following ani nvisible route in search of food, or back home. How on roads the lanes is followed to avoid accidents and traffic jams. Ever thought about a robot which follows line? A perfect or near perfect mimic of nature? After all the purpose of robotics is to recreate in terms of machines what one see around to solve a problem or fulfill a requirement.

- The area will be benefitted from the project
- Industrial automated equipment carriers

- Entertainment and small household applications.
- Tour guides in museums and other similar applications.
- Second wave reconnaissance operations.

1.2 Problem Statement

In the industry carriers are required to carry products from one manufacturing plant to another which are usually in different buildings or separate blocks. Conventionally, cars or trucks were used with human drivers. Unreliability and inefficiency in this part of the assembly line formed the weakest link. The research is to automate this sector, using carts to follow a line instead of laying railway tracks which are both costly and an inconvenience.

1.3 Objectives

The objectives of the Line Following Robotic vehicle(LFRV) include :

- Move forward searching for a black line on a white surface .

1.4 Methodology

A model of line following robotic has been done using a controller , LDR sensor and DC motor.

1.5 Project layout

This research consists of an abstract and five chapters, where chapter one deals with an introduction that consists of problem statement , objective research and thesis organization .

Chapter two contains the previous studies of literature review and general cirçuit designed (motors, information's about the main components of sensors, power supplies and micro controllers).

Chapter three include detailed description of the components used in the design ,and the role of each one, with block diagram explaination how all components work together.

Chapter four is about the operation and how the (LFRV) response in the different cases.

Chapter five include the conclusion and recommendations.

CHAPTER TWO

Robotic System

2.1 Introduction :

Project design miniature robot (car) moves in the predetermined path. Controls the movement by microcontroller and three sensors, two of which sensors photo sensors and last sensor is distance sensor, track consists of one line, the line in black and sides white. Photo sensors detection line and send a signal to microcontroller, when photo sensors detect black color it means that the robot is moving in the right track, and when the robot move over white color the sensors send a signal to the microcontroller that robot on the verge of going out of the specified path, which is sending a signal to the front motor turn to the right or left, distance sensor detects for obstacles when the existence of any obstacle in front of it is sending a signal to microcontroller, which in turn send a signal to the back motor to stop and when the demise of the obstacle microcontroller sending a signal to the back motor to re-move the robot, and at the end of the specified path based optical sensors sending a signal to the microcontroller, which sends the signal to the back motor to stop.

2.2 Line Following Robot :

Line Following Robot has been in use since the 1950's.

Line Following Robotic Vehicles (LFRVs) are driver-less industrial trucks, usually powered by electric
motors and batteries .

Driverless transport system like LFRV’s may also be considered as one of the possible solutions for reducing cost, easy adaptability to internal requirements and interface problems, move flexibility, high speed to minimize transmit time.

An LFRV is a material handling system that uses independently operated, self-propelled vehicle that are guided along defined pathways on the floor. The vehicles are powered by on board batteries that allow operation for several hours between recharging .

LFRV is a mobile robot that follows a specific path in the floor consequently; it is driverless vehicles which have been used widely on industrial field to move materials around a manufacturing facility or a warehouse LFRV s are employed in nearly every industry including, pulp, paper, metals, newspaper and general manufacturing.

Transferring material or finished product and storing them on a bed is one example of LFRV use in factories. Moreover, some LFRV s use forklifts to lift objects for storage.

LFRV uses predefined path for guidance purpose in warehouse or factory.

Two main technologies LFRV uses for guidance ,which are magnetic wire and colored tapes. In wire guidance, a wire emitting radio waves fixed in a slot cut in factory floor and a detecting sensor placed on the bottom of the robot facing the floor.

The sensor detects the radio waves being transmit from the wire and follows Its.

Tape guidance technology can be in two types: magnetic or colored. LFRV uses proper sensor to detect the tape , which uses colored tape.

Using color or magnetic guidance has advantage over wired guidance, as it is easy in installation and can be relocate from place to another flexibly. Additionally, it is considered a "passive" system since it does not require the guide medium to be energized as wire does .

All LFRV s in working environments linked through Radio Frequency (RF) module to a control unit. The control unit can be Personal Computer (PC) or Personal Digital Assistant (PDA) as long as it has windows mobile like PCs. LFRV takes task manipulation orders from the control unit, and communicating to other LFRV s in working area through it.

With all advantages LFRV s have, it still has one main problem that is lack to be fully mobile. It is categorized under mobile robots since it can move through working place but in fact, the guidance path limits this movement to specific area in workspace .

2.2.1 Types of Line Following Robots :

Depending on Number of Wheels :

- Two Wheels
- Three Wheels
- Four Wheels
- Six Wheels

Depending on Number of Sensors :

- Two Line Sensors
- Four sensors :
- Six sensors:

2.2.2 The path :

The definition of pathways is generally accomplished using wires embedded in the floor or by reflective paint on the floor surface. Sensors on the vehicle that can follow the guide wires or paints achieve guidance. The term guidance refers to the ways by which the LFRV pathways are defined and the vehicle control system that follows the pathways.

When paint strips are used to define the vehicle pathways, the vehicle possesses an optical sensor system that is capable of scanning the paint.

The strips can be taped, sprayed or painted on the floor. The paint guidance system is useful in an environment where electrical noises would render the guidance wire system unreliable or when the installation of the guide wire system in the floor surface would not be appropriate.

One problem with the paint strip guidance is that the paint strip must be maintained and kept clean and unscratched. In the case of wire guidance systems, wires are embedded in a small channel cut into the surface of the floor. The channel should be thick enough . A frequency generator is then used to provide the guidance signal carried. The signal is of relatively low voltage, low current.

2.2.3 Shape of The Path :

Track component by way of black width larger than the width robot used, aspects track white, choose black and white, because of black can
absorb light significantly reverse color white, which reflects light in large quantities, track shape depends on the use of robot or depends on who uses it.

2.3Arduino:

Arduino is an open-source project that created microcontroller-based kits for building digital devices and interactive objects that can sense and control physical devices.

The project is based on microcontroller board designs, produced by several vendors, using various microcontrollers. These systems provide sets of digital and analog input/output (I/O) pins that can interface to various expansion boards (termed shields) and other circuits. The boards feature serial communication interfaces, including Universal Serial Bus (USB) on some models, for loading programs from personal computers. For programming the microcontrollers, The arduino project provides an integrated development environment (IDE) based on a programming language named Processing, which also supports the languages C and C++.

The first arduino was introduced in 2005, aiming to provide a low cost, easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats, and motion detectors.

Arduino boards are available commercially in preassembled form, or as do-it-yourself kits. The hardware design specifications are openly available, allowing the arduino boards to be produced by anyone. Adafruit Industries estimated in mid-2011 that over 300,000 official Arduinos had been commercially produced, and in 2013 that 700,000 official boards were in users' hands .

2.4 Brushed DC motor :

All self-commutated DC motors are by definition run on DC electric power. Most DC motors are small PM types. They contain a brushed internal mechanical commutation to reverse motor windings' current in synchronism with rotation .

DC machines are defined as follows :

Armature circuit - A winding where the load current is carried, such that can be either stationary or rotating part of motor or generator.

Field circuit - A set of windings that produces a magnetic field so that the electromagnetic induction can take place in electric machines.

Commutation: A mechanical technique in which rectification can be achieved, or from which DC can be derived, in DC machines.

-Types of brushed DC motor :

-DC shunt-wound motor

-DC series-wound motor

-DC compound motor (two configurations):

- Cumulative compound
- Differentially compounded

-PM DC motor (not shown)

-Separately excited (not shown).

2.5 Servo motor :

A servomotor is a motor, very often sold as a complete module, which is used within a position-control or speed-control feedback control system mainly control valves, such as motor-operated control valves. Servomotors are used in applications such as machine tools, pen plotters, and other process systems. Motors intended for use in a servomechanism must have well-documented characteristics for speed, torque, and power. The speed vs. torque curve is quite important and is high ratio for a servo motor. Dynamic response characteristics such as winding inductance and rotor inertia are also important; these factors limit the overall performance of the servomechanism loop. Large, powerful, but slow-responding servo loops may use conventional AC or DC motors and drive systems with position or speed feedback on the motor. As dynamic response requirements increase, more specialized motor designs such as coreless motors are used. AC motors' superior power density and acceleration characteristics compared to that of DC motors tends to favor PM synchronous, BLDC, induction, and SRM drive applications.

A servo system differs from some stepper motor applications in that the position feedback is continuous while the motor is running; a stepper system relies on the motor not to "miss steps" for short term accuracy, although a stepper system may include a "home" switch or other element to provide long-term stability of control

2.6 Stepper motor :

Stepper motors are a type of motor frequently used when precise rotations are required. In a stepper motor an internal rotor containing PMs or a magnetically soft rotor with salient poles is controlled by a set of external magnets that are switched electronically. A stepper motor may also be thought of as a cross between a DC electric motor and a rotary solenoid. As each coil is energized in turn, the rotor aligns itself with the magnetic field produced by the energized field winding. Unlike a synchronous motor, in its application, the stepper motor may not rotate continuously; instead, it "steps"—starts and then quickly stops again—from one position to the next as field windings are energized and de-energized in sequence. Depending on the sequence, the rotor may turn forwards or backwards, and it may change direction, stop, speed up or slow down arbitrarily at any time.

Simple stepper motor drivers entirely energize or entirely de-energize the field windings, leading the rotor to "cog" to a limited number of positions; more sophisticated drivers can proportionally control the power to the field windings, allowing the rotors to position between the cog points and thereby rotate extremely smoothly. This mode of operation is often called microstepping. Computer controlled stepper motors are one of the most versatile forms of positioning systems, particularly when part of a digital servo-controlled system.

A linear motor is essentially any electric motor that has been "unrolled" so that, instead of producing a torque (rotation), it produces a straight-line force along its length.

Linear motors are most commonly induction motors or stepper motors. Linear motors are commonly found in many roller-coasters where the rapid motion of the motorless railcar is controlled by the rail. They are also used in maglev trains, where the train "flies" over the ground. On a smaller scale, the 1978 era HP 7225A pen plotter used two linear stepper motors to move the pen along the X and Y axes.

2.7 Sensors:

Sensors are used in everyday objects such as touch-sensitive elevator buttons (tactile sensor) and lamps which dim or brighten by touching the base, besides innumerable applications of which most people are never aware.

With advances in micromachinery and easy-to-use micro controller platforms, the uses of sensors have expanded beyond the most traditional fields of temperature, pressure or flow measurement .

2.7.1 Photo-resistor (LDR) :

A photo-resistor (or light-dependent resistor, LDR, or photocell) is a light-controlled variable resistor. The resistance of a photo-resistor decreases with increasing incident light intensity; in other words, it exhibits photoconductivity. A photo-resistor can be applied in light-sensitive detector circuits, and light- and dark-activated switching circuits.

A photo-resistor is made of a high resistance semiconductor. In the dark, a photo-resistor can have a resistance as high as several mega-ohms (MΩ), while in the light, a photo-resistor can have a resistance as low as a few hundred ohms. If incident light on a photo-resistor exceeds a certain frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electrons (and their hole partners) conduct electricity, thereby lowering resistance. The resistance range and sensitivity of a photo-resistor can substantially differ among dissimilar devices. Moreover, unique photo-resistors may react substantially differently to photons within certain wavelength bands.

A photoelectric device can be either intrinsic or extrinsic. An intrinsic semiconductor has its own charge carriers and is not an efficient semiconductor, for example, silicon. In intrinsic devices the only available electrons are in the valence band, and hence the photon must have enough energy to excite the electron across the entire band gap. Extrinsic devices have impurities, also called do pants, added whose ground state energy is closer to the conduction band; since the electrons do not have as far to jump, lower energy photons (that is, longer wavelengths and lower frequencies) are sufficient to trigger the device. If a sample of silicon has some of its atoms replaced by phosphorus atoms (impurities), there will be extra electrons available for conduction. This is an example of an extrinsic semiconductor.

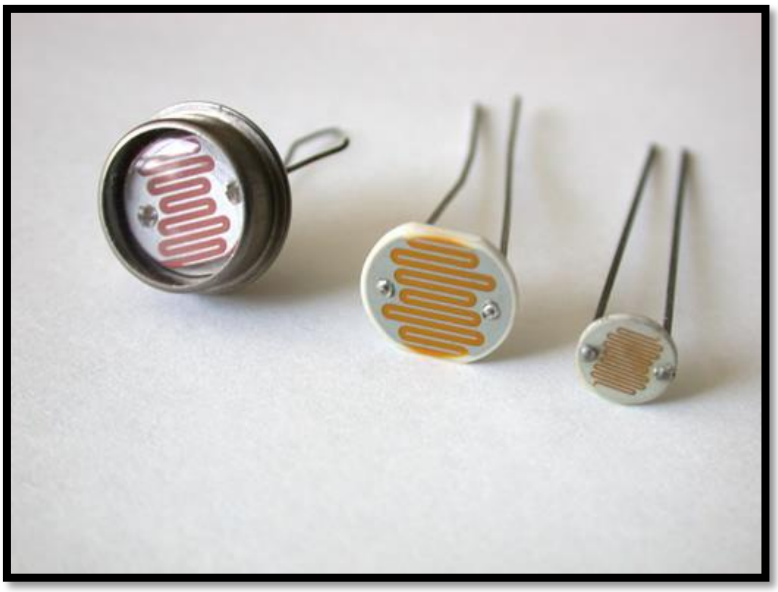


figure (2.1) Photo-resistor Sensor

2.7.2 Light-emitting diode(LED) :

A light-emitting diode (LED) is a two-lead semiconductor light source. It is a p–n junction diode, which emits light when activated When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor.

An LED is often small in area (less than 1 mm2) and integrated optical components may be used to shape its radiation pattern

figure (2.2) The Light-emitting diode Sensor

2.7.3 Photo-detector Sensors :

Photo-detectors may be used in different configurations. Single sensors may detect overall light levels. A 1-D array of photo-detectors, as in a spectrophotometer or a Line scanner, may be used to measure the distribution of light along a line. A 2-D array of photodetectors may be used as an image sensor to form images from the pattern of light before it.

2.8 Classifications of Photo-detectors by their mechanism for detection:

-Photoemission: Photons cause electrons to transition from the conduction band of a material to free electrons in a vacuum or gas.

-Photoelectric: Photons cause electrons to transition from the valence band to the conduction band of a semiconductor.

-Photovoltaic: Photons cause a voltage to develop across a depletion region of a photovoltaic cell.

-Thermal: Photons cause electrons to transition to mid-gap states then decay back to lower bands, inducing phonon generation and thus heat.

-Polarization: Photons induce changes in polarization states of suitable materials, which may lead to change in index of refraction or other polarization effects.

-Photochemical: Photons induce a chemical change in a material.

-Weak interaction effects: photons induce secondary effects such as in photon drag detectors or gas pressure changes in Golay cells.

2.9 line tracing with a light chassis:

Aim in this paper is to propose a low cost line tracing system implemented with a light chassis, DC Motors, infrared Proximity sensors and manually developed controller board.

Controller board contains microcontroller, motor driver and MAX232 circuit. Software side we are controlling the robot using C program using Serial Port Communication. Motion control is based on the differential drive mechanism.

- **Microcontroller used :**

Microcontroller Philips P89V51RD2 and it has some advantages :

-It has a vast 64 KB programmable flash

memory and 1024 bytes of RAM.

-Easily Available.

- Cheap compared to other microcontrollers.

-Easy process of burning It can withstand temperatures between the ranges 00 C to 700 C.

- It also has a built in Analog to Digital Converter.

We used 3 I R sensors to detect the white line.

2.9.1 Line Follower Using LDR & LED :

Line follower robot is a robotic car that can follow a path. The path can be visible like a black line on the white surface as in figure (2.3).The basic principle of the line follower robot actually almost the same as the light follower robot, but instead of tracking the light the LFR sensor is used to track the line. Therefore by differentiating the line color and its surrounding (black over white or vice verse) any light sensitive sensor could be used to navigate the robot to follow this track.

For the line follower robot the line sensors are made using LDR and white LED.A1K resistor across the LED.A series connection of 10K resistor and 10K variable are with the LDR as on figure (2.4) . It is powered by 9V battery.

Figure (2.3) LFRV Using LDR And LED Sensor

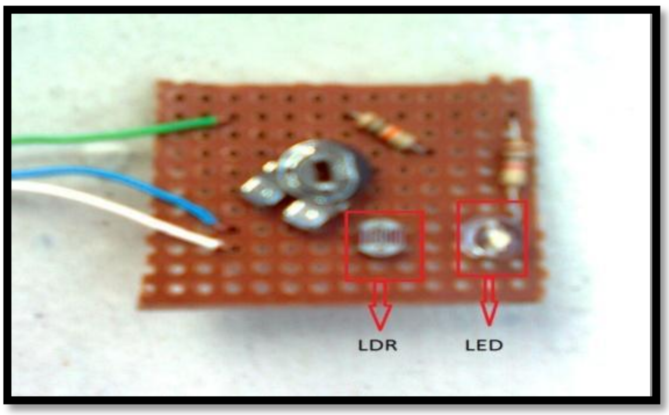


Figure (2.4) LDR And LED Sensor

CHAPTER THREE

Line Follower Components

3.1 The line following compromised from :

-Arduino UNO .

-LDR Sensors.

-DC Motors .

-IC L293D.

-Bread Board and Jump Wiring .

3.2 Arduino UNO :

An Arduino board consists of an Atmel 8-, 16- or 32-bit AVR microcontroller (although since 2015 other makers' microcontrollers have been used) with complementary components that facilitate programming and incorporation into other circuits. An important aspect of the Arduino is its standard connectors, which let users connect the CPU board to a variety of interchangeable add-on modules termed shields. Some shields communicate with the Arduino board directly over various pins, but many shields are individually addressable via an I^2C serial bus—so many shields can be stacked and used in parallel. Before 2015, Official Arduinos had used the Atmel megaAVR series of chips, specifically the ATmega8, ATmega168, ATmega328, ATmega1280, and ATmega2560. In 2015, units by other producers were added. A handful of other processors have also been used by Arduino compatible devices. Most boards include a 5 V linear regulator and a 16 MHz crystal oscillator (or ceramic resonator in some variants), although some designs such as the LilyPad run at 8 MHz and dispense with the onboard voltage regulator due to specific form-factor restrictions. An Arduino's microcontroller is also pre-programmed with a boot loader that simplifies uploading of programs to the on-chip flash memory, compared with other devices that typically need an external chip programmer. This makes using an Arduino more straightforward by allowing the use of an ordinary computer as the programmer. Currently, optiboot bootloader is the default bootloader installed on Arduino UNO.

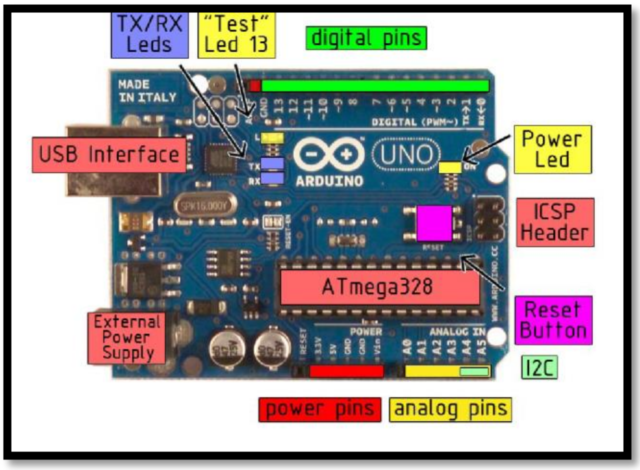
At a conceptual level, when using the Arduino integrated development environment, all boards are programmed over a serial connection. Its implementation varies with the hardware version. Some serial Arduino boards contain a level shifter circuit to convert between RS-232 logic levels and transistor–transistor logic (TTL) level signals. Current Arduino boards are programmed via Universal Serial Bus (USB), implemented using USB-to-serial adapter chips such as the FTDI FT232. Some boards, such as later-model Uno boards, substitute the FTDI chip with a separate AVR chip containing USB-to-serial firmware, which is reprogrammable via its own ICSP header. Other variants, such as the Arduino Mini and the unofficial Boarduino, use a detachable USB-to-serial adapter board or cable, Bluetooth or other methods, when used with traditional microcontroller tools instead of the Arduino IDE, standard AVR in-system programming (ISP) programming is used.

An official Arduino Uno Revision 2 with descriptions of the I/O locations

The Arduino board exposes most of the microcontroller's I/O pins for use by other circuits. The Diecimila,[a] Duemilanove,[b] and current Uno[c] provide 14 digital I/O pins, six of which can produce pulse-width modulated signals, and six analog inputs, which can also be used as six digital I/O pins. These pins are on the top of the board, via female 0.1-inch (2.54 mm) headers. Several plug-in application shields are also commercially available. The Arduino Nano, and Arduino-compatible Bare Bones Board and Boarduino boards may provide male header pins on the underside of the board that can plug into solderless breadboards.

Many Arduino-compatible and Arduino-derived boards exist. Some are functionally equivalent to an Arduino and can be used interchangeably.

Many enhance the basic Arduino by adding output drivers, often for use in school-level education, to simplify making buggies and small robots. Others are electrically equivalent but change the form factor, sometimes retaining compatibility with shields, sometimes not. Some variants use different processors, of varying compatibility



Figure(3.1) Components of Arduino Uno

The Arduino project provides the Arduino integrated development environment (IDE), which is a cross-platform application written in the programming language Java. It originated from the IDE for the languages Processing and Wiring. It is designed to introduce programming to artists and other newcomers unfamiliar with software development. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and provides simple one-click mechanism to compile and load programs to an Arduino board. A program written with the IDE for Arduino is called a "sketch".

The Arduino IDE supports the languages C and C++ using special rules to organize code. The Arduino IDE supplies a software library called Wiring from the Wiring project, which provides many common input and output procedures. A typical Arduino C/C++ sketch consist of two functions that are compiled and linked with a program stub main() into an executable cyclic executive program:

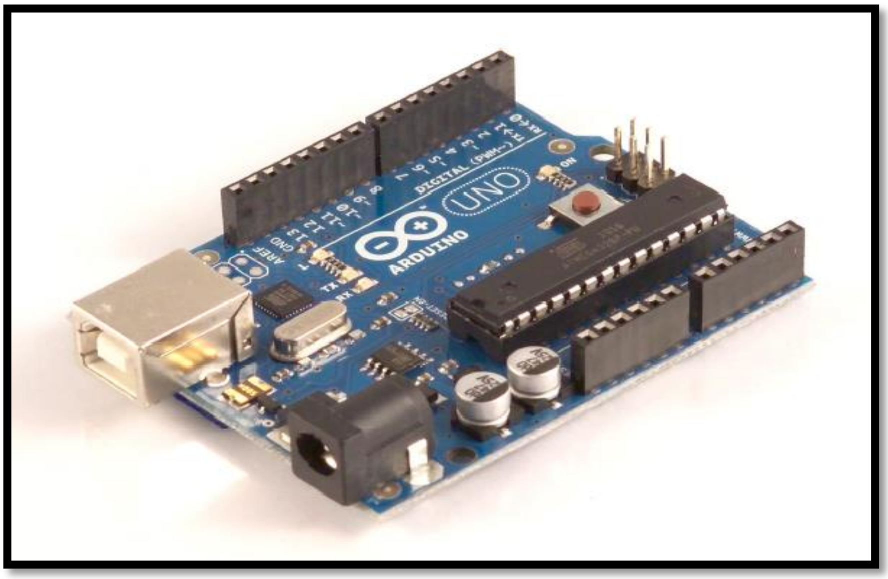
- setup(): a function that runs once at the start of a program and that can initialize settings.
- loop(): a function called repeatedly until the board powers off.

After compiling and linking with the GNU toolchain, also included with the IDE distribution, the Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal coding that is loaded into the Arduino board by a loader program in the board's firmware.

- **Other IDE:**

Arduino programs may be written in any programming language with a compiler that produces binary machine code. Atmel provides a development environment for their microcontrollers, AVR Studio and the newer Atmel Studio, which can be used for programming Arduino.

Arduino can be controlled using C/C++ interpreter Ch without the binary code. Two textbooks “Learning Arduino with Ch Programming for the Absolute Beginner” and “Learning Arduino with C Programming” are freely available.



Figure(3.2) Arduino Uno

- **Sample program:**

The bare minimum code to start a sketch program consists of two functions setup()and loop().

```
void setup() {
 // put your setup code here, to run once at startup
}
void loop() {
 // put your main code here, to run repeatedly
}
```

Most Arduino boards contain an LED and a load resistor connected between pin 13 and ground which is a convenient feature for many tests.

A typical program for a beginning Arduino programmer blinks a light-emitting diode (LED) on and off. This program is usually loaded in the Arduino board by the manufacturer. In the Arduino environment, a user might write such a program as shown:

Power LED (red) and integrated LED on Line 13 (green) on Arduino compatible board, made in China

```
#define LED_PIN 13         // Pin number attached to LED
void setup() {
  pinMode(LED_PIN, OUTPUT);
 }
   // Enable pin 13 for digital output.
void loop() {
  digitalWrite(LED_PIN, HIGH);  // Turn on the LED.
  delay(1000);          // Wait one second. (1000 milliseconds)
  digitalWrite(LED_PIN, LOW);   // Turn off the LED.
  delay(1000);          // Wait one second.
```

- **Program Code :**

```
/*------- Arduino Line Follower Code-----*/
/*-------Defining Inputs------*/
#define LS  3              // left sensor
#define RS  3             // right sensor

/*--------defining Outputs------*/
#define   LM1  8         // left motor
#define   LM2   9        // left motor
#define   RM1   10        // right motor
#define   RM2   11        // right motor
#define   en1   6
#define   en2   5
Void setup()
{
pinMode(LS,   INPUT);
pinMode(RS,   INPUT);
pinMode(LM1,   OUTPUT);
pinMode(LM2,   OUTPUT);
pinMode(Rm1,   OUTPUT);
pinMode(RM2,   OUTPUT);
pinMode(en1,      OUTPUT);   pinMode(en1,    OUTPUT);
analogWrite(en1,150);  analogWrite(en2, 150);
}

Void loop()
{
If(!digitalread(LS)  && !digitalread(RS))    //Move Forward
{
digitalWrite(LM1,   HIGH);
```

```
digitalWrite(LM2,   LOW);
digitalWrite(RM1,   HIGH);
digitalWrite(RM2,   LOW);
}
If((digitalRead(LS))  && !digitalRead(RS))    // Turn right
{
digitalWrite(LM1,   LOW);
digitalWrite(LM2,   LOW);
digitalWrite(RM1,   HIGH);
digitalWrite(RM2,   LOW);
}
If(!digitalRead(LS)  &&  (digitalRead(RS)) )     // turn left
{
digitalWrite(LM1,   HIGH);
digitalWrite(LM2,   LOW);
digitalWrite(RM1,   LOW);
digitalWrite(RM2,   LOW);
}
If((digitaRead(LS))  &&  (digitalRead(RS)))    //  stop
{
digitalWrite(LM1,   LOW);
```

- Development :

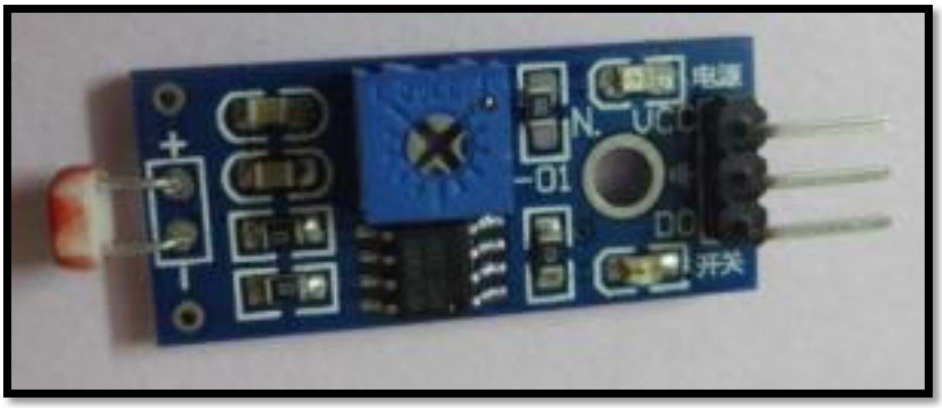
Arduino is open-source hardware. The hardware reference designs are distributed under a Creative Commons Attribution Share-Alike 2.5 license and are available on the Arduino website. Layout and production files for some versions of the hardware are also available. The source code for the IDE is released under the GNU General Public License, version Nevertheless an official Bill of Materials of Arduino boards has never been released by the staff of Arduino.

Although the hardware and software designs are freely available under copyleft licenses, the developers have requested that the name "Arduino" be exclusive to the official product and not be used for derived works without permission. The official policy document on use of the Arduino name emphasizes that the project is open to incorporating work by others into the official product. Several Arduino-compatible products commercially released have avoided the Arduino name by using -duino name variants.

- Applications :
- Xoscillo, an open-source oscilloscope
- Scientific equipment such as the Chemduino
- Arduinome, a MIDI controller device that mimics the Monome
- OBDuino, a trip computer that uses the on-board diagnostics interface found in most modern cars
- Ardupilot, drone software and hardware
- ArduinoPhone, a do-it-yourself cellphone
- GertDuino, an Arduino mate for the Raspberry Pi
- Water quality testing platform
- Homemade CNC using Arduino and DC motors with close loop control by Homofaciens
- DC motor control using Arduino and H-Bridge

3.2 LDR sensor :

LDR sensor module is used to detect the intensity of light. It is associated with both analog output pin and digital output pin labelled as AO and DO respectively on the board. When there is light, the resistance of LDR will become low according to the intensity of light. The greater the intensity of light, the lower the resistance of LDR. The sensor has a potentiometer knob that can b e adjusted to change the sensitivity of LDR towards light.



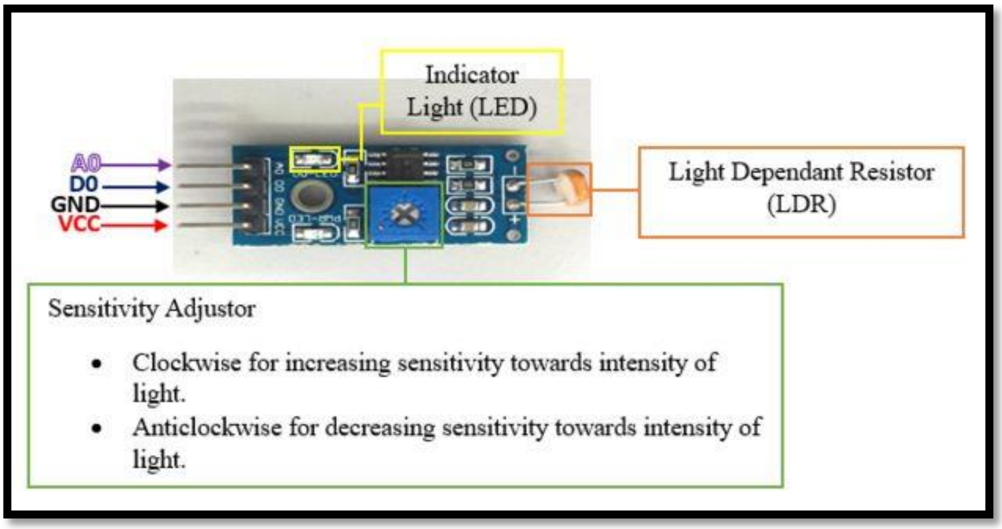
Figure(3.3) LDR Sensor Module

- Uses high quality light dependent resistor.
- Potentiometer to adjust light brightness threshold.
- Digital Output
- Fixed bolt hole for convenient installation
- Uses LM393 wide voltage comparator
- LED indicator – ON when ambient light is more than threshold
- Operating Voltage is 3.3-5 V
- Dimensions: 3.2cm x 1.4cm

- **Description :**

The module has 3 pins- Vcc, GND, DO(digital output).

This module is used to detect ambient light. If the ambient light intensity is less than the threshold value set using the potentiometer, DO outputs HIGH(1) value and when the ambient light intensity

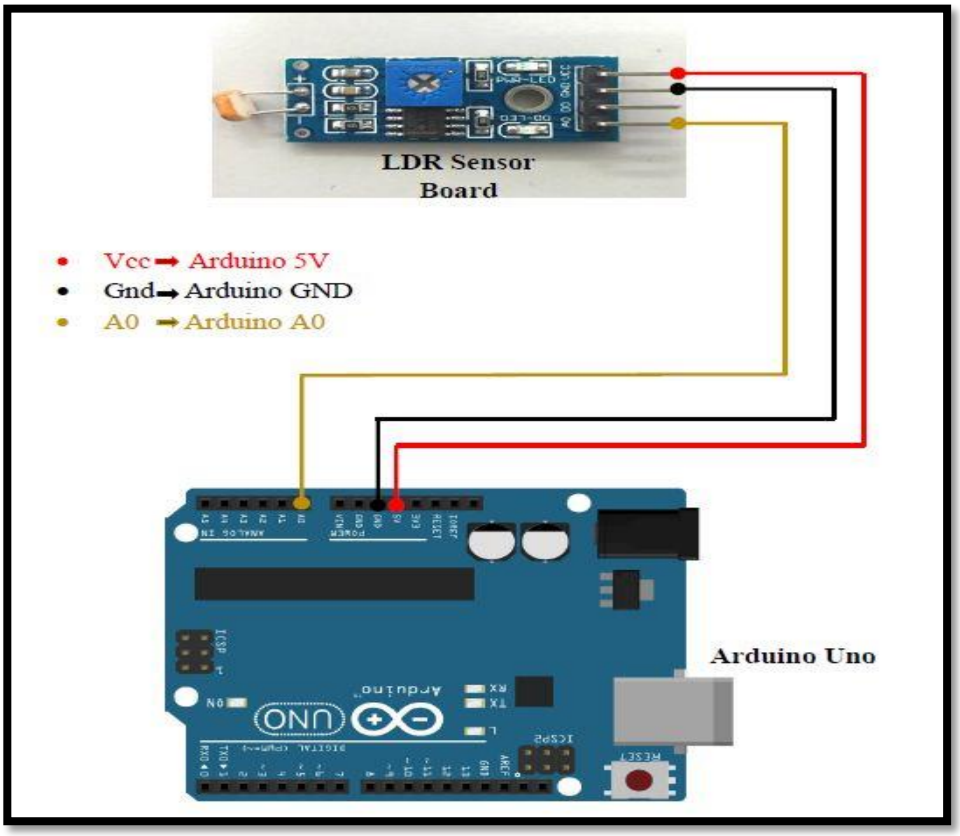


Figure(3.4) LDR Sensor Module

is more than the set threshold, DO outputs a LOW(0) value

- **usage :**
- Photosensitive resistor module most sensitive to environmental light intensity is generally used to detect the ambient brightness and light intensity.
- Module light conditions or light intensity reach the set threshold, DO port output high, when the external ambient light intensity exceeds a set threshold, the module D0 output low;
- Digital output D0 directly connected to the MCU, and detect high or low TTL, thereby detecting ambient light intensity changes;
- Digital output module DO can directly drive the relay module, which can be composed of a photoelectric switch;
- Analog output module AO and AD modules can be connected through the AD converter, you can get a more accurate light intensity value .
- **Pin details :**
  - VCC = 3.3V to 5V DC
  - GND = Ground
  - DO = Digital Output
  - AO = Analog Output

- **Sample Hardware Installation :**



Figure(3.5) Installation Between Arduino And LDR Sensor

3.3 DC Motors :

Motion is one of the primary differentiators between a robot and a computer. More robots get their motion from DC (Direct Current) motors than from any other mechanism (see Figure3.6) .

Figure(3.6) DC Motor

This chapter details the different varieties of DC motors and their characteristics. If you don't find this subject interesting, you can skim this chapter and move on to the next. Motors won't be selected and attached to the line-following robot circuit until the next chapter.

- **DC Motors operation:**

In an electric motor, electricity is converted to motion by magnetism. Most people have played with a pair of magnets. Placing the magnets facing each other causes the magnets to attract and pull together. Turning one of the magnets around causes the pair to repel each other and push apart.

One magnet can attract with enough strength to drag the other magnet across a surface. This technique can be improved by adding a third magnet. The first magnet attracts the second magnet, while the third magnet repels from the rear.

When magnets are mounted around a pole, the combination of pulling and pushing can result in a rotating motion. A magnet on the shaft or pole is attracted to a magnet mounted nearby, while simultaneously being repelled by another magnet mounted on the opposite side. As soon as the shaft rotates to the magnet pulling it, the shaft magnet flips polarity and starts pushing away.

The key to making this mechanism operate is that flowing electricity can create a magneticfield. Instead of physically flipping over a magnet to change from attract to repel, the flow of electricity can be flipped forwards and backwards.

- **Looking Inside an Iron -Core Permanent-Magnet DC Brush Motor :**

An iron-core permanent-magnet DC brush motor (see Figure3.7) consists of two major sections: the stationary parts (stator) and the rotating parts (rotor). The cap, also called the endcap or assembly, at the end of the motor is connected to the stator and doesn't move.

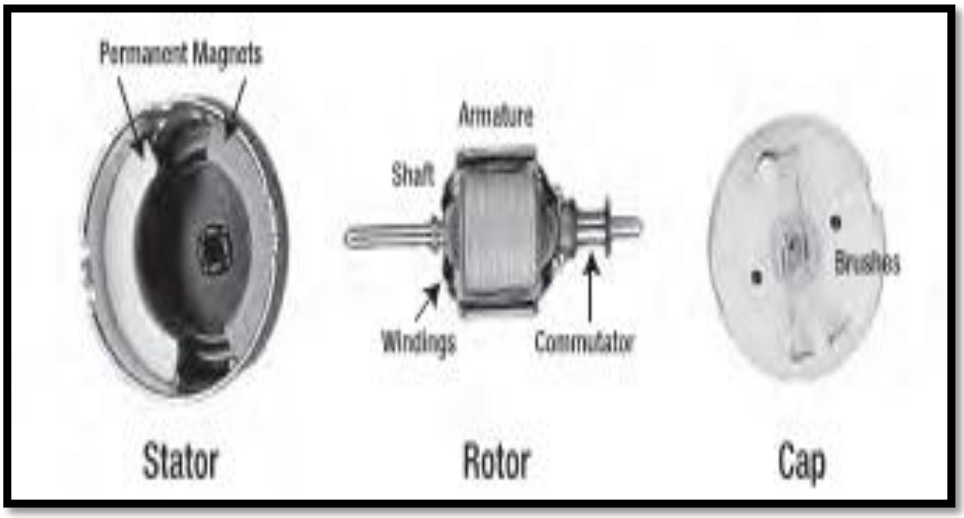


Figure (3.7) stator-Rotor-Cap of motor

- **Stator:**

The classic stator (the stationary part) includes two permanent magnets mounted opposite each other in a metal can (see 3.8). The term “permanent magnets” indicates that the magnets remain magnetized even when the electricity is turned off. The magnetic field created by the electricity is going to push and pull against these two permanent magnets.

Figure(3.8) classic stator

A pai r of perman ent magnets removed from the metal can. The clip inthe foreground keeps the magnets from s liding together. At high enough temperatures (Curie temperature), permanent magnets lose theirmagnetic field, resulting in reduced performance or even complete failure. Therefore , it's important not to abuse amotor by allowing it to overheat during use. Provide for adequate ventilation and, if possible, mount the motor body against other metal object s to provide a large thermal path to wick away the heat.

Interestingly, the metal container that makes up the body of the motor acts as a return path for the magnetic field. As such, less of the magnetic field is "leaked" into nearby components.

- **Rotor :**

The rotor (the rotating part) is built around a shaft. The shaft sticks out the end of the motor body so that wheels, belts, fan blades, or gears can be connected to it.

To limit friction, only a small portion of the rotor touches the motor body. High-quality motors and large motors often include ball bearings at those locations to improve carrying strength and decrease friction.

- **Rotor Windings :**

In the middle of the shaft is an armature containing many windings of wire (see Figure 3.9). The wire carries the electricity around and around an iron core in an oval loop. This increases the magnetic field that pushes and pulls against the permanent magnets on the stator.

Figure (3.9) Rotor Windings

Motor shaft and armature with wire windings and an iron-based core Besides generating and transmitting the magnetic field, the iron core also dissipates and evenly distributes heat, allowing for hard running. However, the relatively heavy iron core makes it more difficult to start or stop the shaft because of inertia.

Note: Almost all motors have three or more windings. Motors with only two windings wouldn't necessarily rotate in the same direction at power up, nor would they necessarily rotate all the way around. For example: Initially the shaft would rotate toward the first magnet, but then the windings reverse, so it might rotate back the way it came.

Hopefully, inertia would carry the rotor around in the direction it was already going.

- **Rotor Brushes:**

The "brush" term in "DC brush motor" indicates that the motor has brushes. The brushes connect directly to the battery or other power source. As stated earlier, the brushes press against the commutator to make the connection between the battery and the armature windings. The brushes must press firmly (see Figure 3.10) or else the electrical connection breaks and the electrical flow ceases.

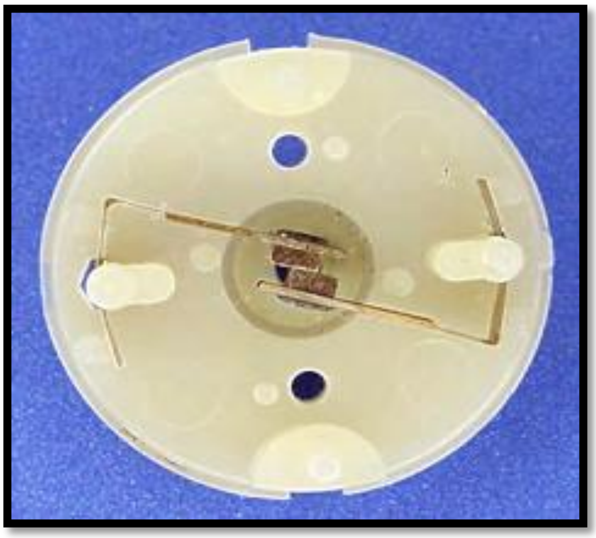


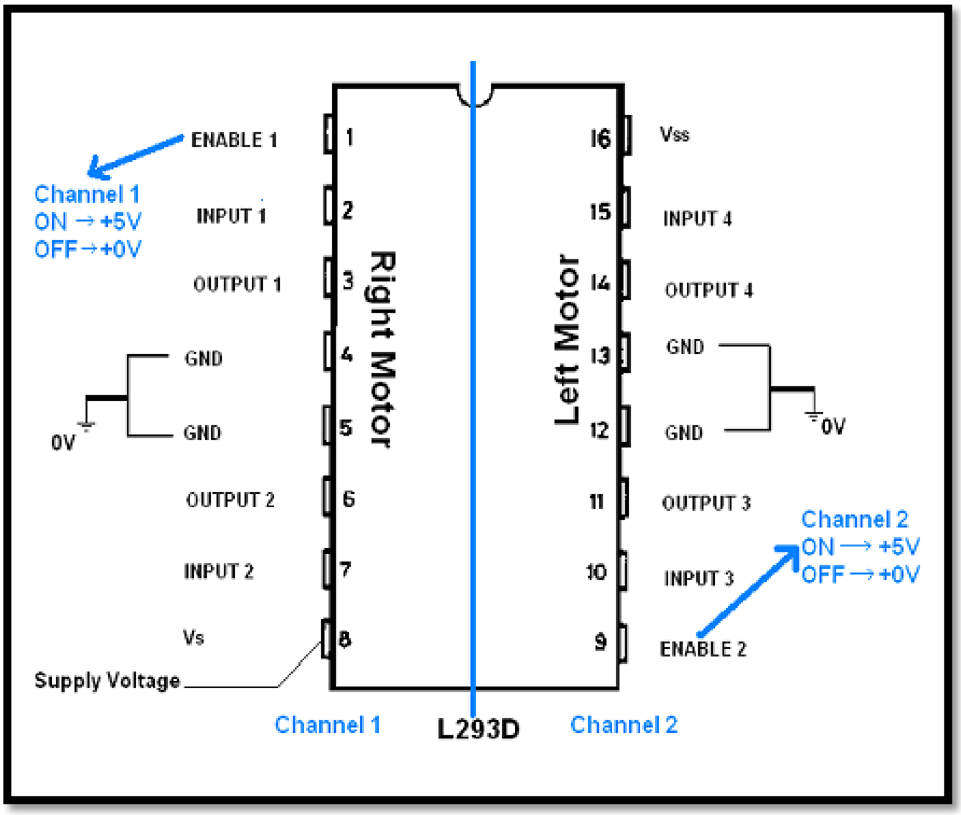
Figure (3.10) Rotor Brushes

Brushes with pads pressed against each other because the motor shaft has been removed

There are a couple of downsides to brushes. First, the pressing of the brushes against the rotor adds friction, thus slowing down the motor and increasing heat. Second, the constant making and breaking of contacts generates electrical noise (like television static when a vacuum cleaner is run) and causes sparking. Last, but most important, the brushes wear out. Even the most well-made, well-maintained brush motor is eventually going to encounter brush failure. Brush degeneration is caused more by sparking than by friction. High-end brush motors have capacitors to absorb sparks and the motors are designed to be serviceable to replace the brushes.

3.4 IC L293D :

This is a motor driver IC that can drive two motor simultaneously. Lets see how we use this IC.



Figure(3.11) Figure. Pin Details of L293D

- **Motor Driver usage:**

From microcontroller we cannot connect a motor directly because microcontroller ca not give sufficient current to drive the DC motors. Motor driver is a current enhancing device, it can also be act as Switching Device. Thus we insert motor driver in between motor and microcontroller. Motor driver take the input signals from microcontroller and generate corresponding output for motor.

- **Points regarding L293D :**
  - Supply voltage (Vss) is the Voltage at which we wish to drive the motor.
  - Logical Supply Voltage will decide what value of input voltage should be considered as high or low .So if we set Logical Supply Voltage equals to +5V, then -0.3V to 1.5V will be considered as Input Low Voltage and 2.3 V to 5V will be considered as Input High Voltage.
  - L293D has 2 Channels .One channel is used for one motor.
  - Channel 1 - Pin 1 to 8
  - Channel 2 - Pin 9 to 16
  - Enable Pin is use to enable or to make a channel active. Enable pin is also called as Chip Inhibit Pin.
  - All Input (Pin No. 2, 7,10and15) of L293D IC is the output from microcontroller (ATmega16A).
  - All Output (Pin No. 3, 6,11and 14) of L293D IC goes to the input of Right and Left motor.
    - **Output Connection :**
  - OUTPUT 1 (Pin No 3) --- Negative Terminal of Right Motor
  - OUTPUT 2 (Pin No 6) --- Positive Terminal of Right Motor
  - OUTPUT 3 (Pin No 10) --- Positive Terminal of Left Motor
  - OUTPUT 4 (Pin No 14) --- Negative Terminal of Left Motor

3.5 bread board and jump wiring:

The board and wiring used to connect all components together.

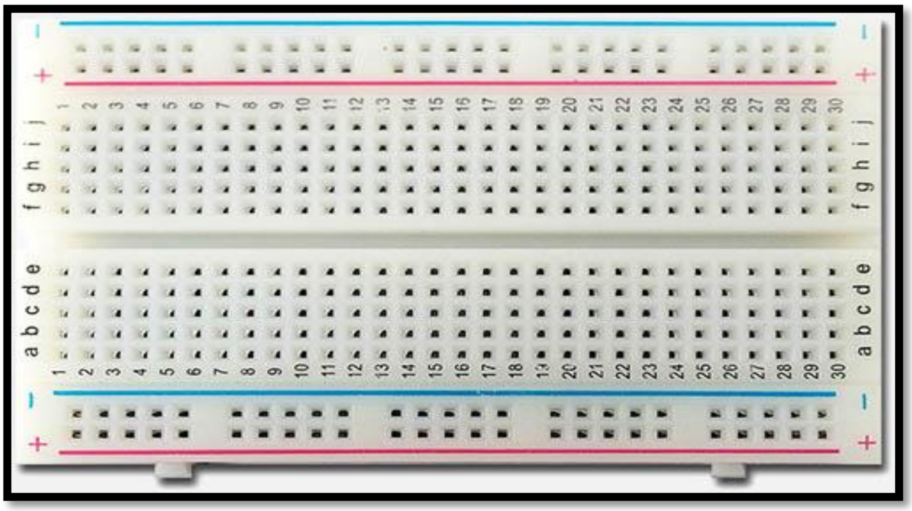


figure (3.12) **Bread board ,** A **bread board** is a solderless device for temporary prototype with electronics and test circuit designs. Most electronic components in electronic circuits can be interconnected by inserting their leads or terminals into the holes and then making connections through wires where appropriate

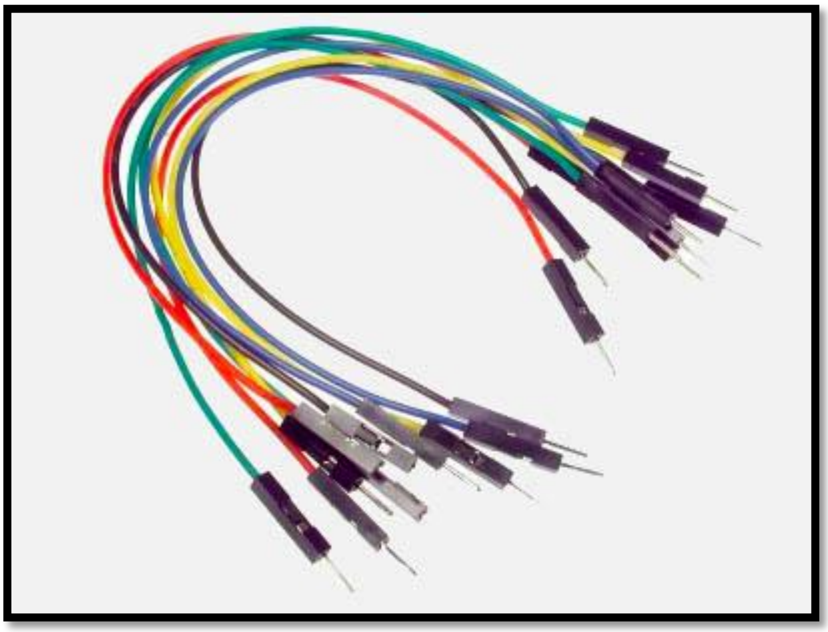


figure (3.13) Jump wiring . A jump wire (also known as jumper wire, or jumper) is an electrical wire, or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering.

Individual jump wires are fitted by inserting their "end connectors" into the slots provided in a breadboard, the header connector of a circuit board, or a piece of test equipment.

Block Diagram:

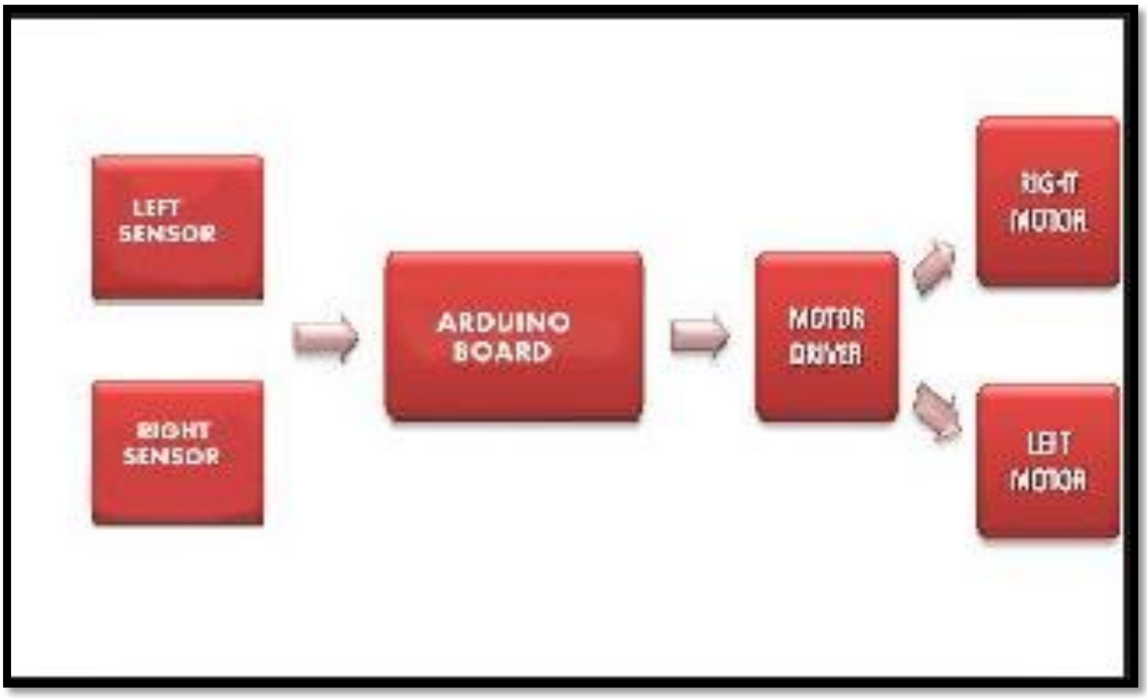


figure (3.14) block Diagram , A block diagram is a diagram of a system in which the principal parts or functions are represented by blocks connected by lines that show the relationships of the blocks. They are heavily used in engineering in hardware design, electronic design, software design, and process flow diagrams.

Block diagrams are typically used for higher level, less detailed descriptions that are intended to clarify overall concepts without concern for the details of implementation. Contrast this with the schematic diagrams and layout diagrams used in electrical engineering, which show the implementation details of electrical components and physical construction .

CHAPTER FOUR

Line Follower Robot Implementation

4.1 Introduction:

The line follower is a self operating car that detects and follows a line that is drawn on the floor. The path consists of a black line on a white surface (or it may be reverse of that .

The control system used must sense a line and maneuver the robot to stay on course, while constantly correcting the wrong moves using feedback mechanism, thus forming a simple yet effective closed loop System. The robot is designed to follow very tight curves.

4.2 Basic Design And Requirements :

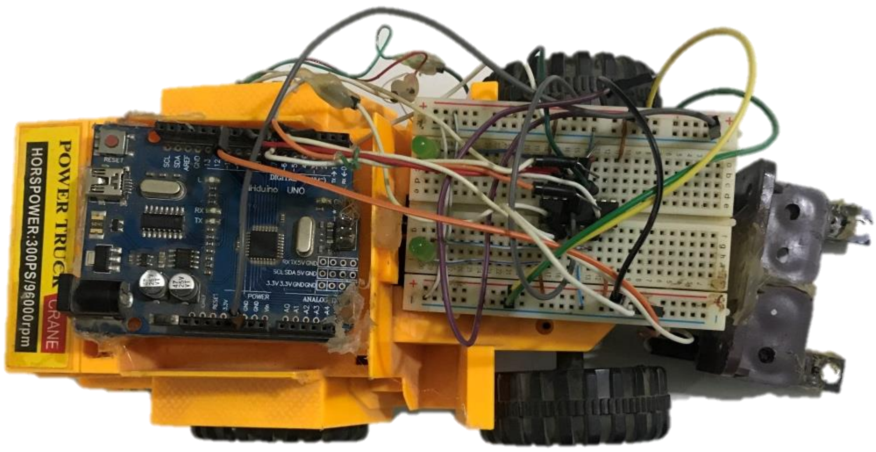
- A sensor to detect the line on the surface . we used LDR module sensor, it is cheap and easy to build and use.
- A microprocessor to run the code that takes inputs from the sensor and control the motion of robot. we used a cheap single chip computer called an Arduino-uno.
- The Arduino cannot drive the motors (used to actually make the car run) directly, so a motor driver is used. A motor driver in our case is 16pin chip called L293D. It can drive 2 DC motors.
- Battery to power the whole thing .
- A chassis to hold everything .

4.3 System Description:

- **Components Connecting :**

A 4 wheels car with 2 DC motors and gears used as the main body of LFRV ,2 LDR sensors connected under the front side of the car, the distance between two sensors is enough to put the linr between them, and the distance between sensors and the line is about 2 cm and this is the best range for sensor sensitivity .

figure (4.1) Side view of bread board and Arduino connected up to the car



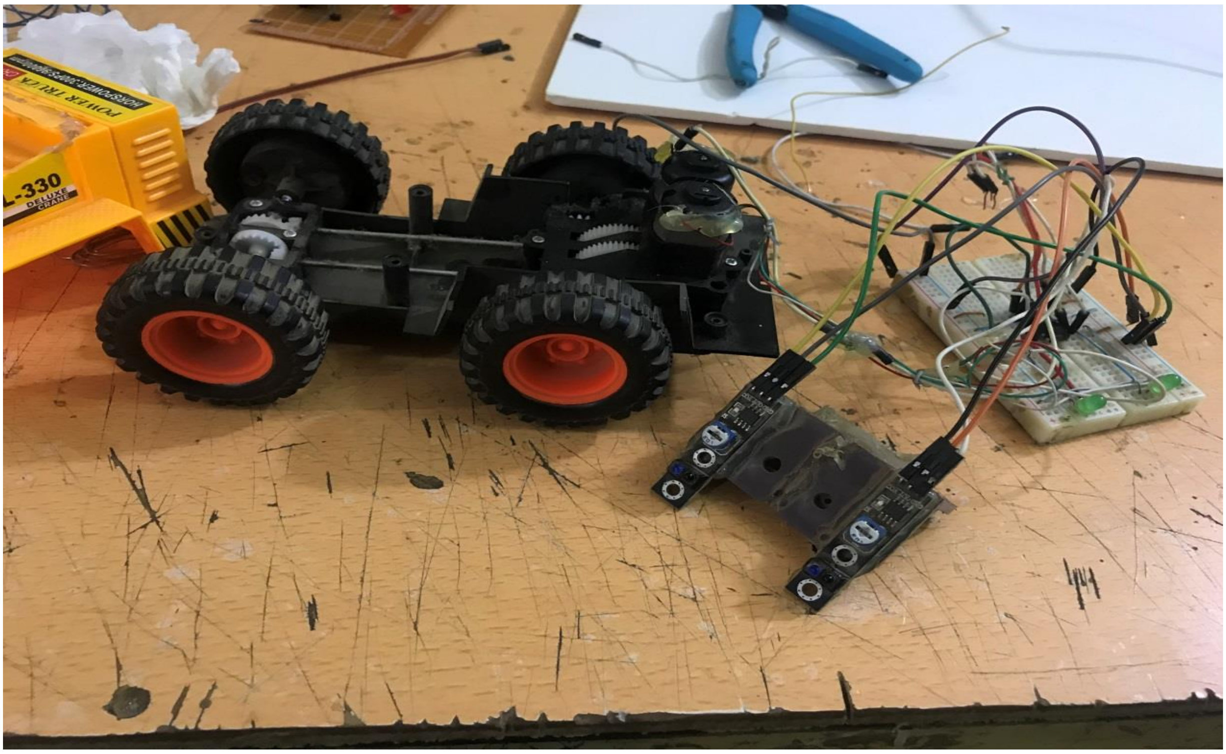


figure (4.2) The bread board and Arduino connected up to the car

- All components connected as shown figure below:

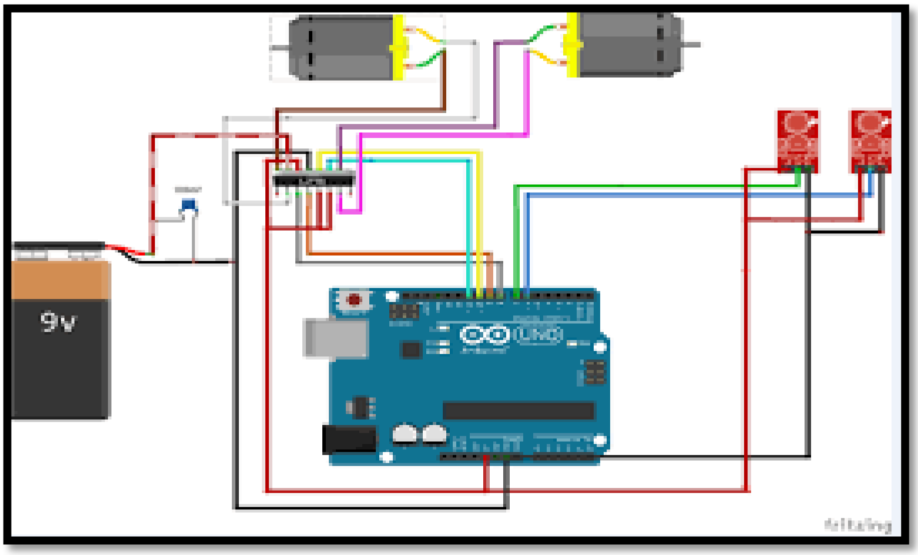


figure (4.3) System connection

4.4 System Operation :

Operation of system has been divided to two sections shown below:

4.4.1 Input section:

Sensors :

Arrangement of sensors:

An array of sensors arranged in a straight row pattern is bolted under the front of the Car. It is used to locate the position of line below the car.

We only used 2 sensors, If we have lesser number then our car movement is not smooth and it may face problems at sharp turns. If we used higher number of sensors car movement will become smooth and reliable for sharp turns

- **The distance between each sensors depend on :**

1. Number of sensors used .
2. Width of straight line (distance between sensors should be more than width of line).

- **Line Tracking :**

We put the car up the black line to be between the 2 sensors, so the sensors sense both white sides of the line ,while the sensor read white color ,the DC motor which connected with it keep running, and when there a turn in the line ,one sensor read black color and stop the motor connected with ,while the other sensor still sensing white color and keep the other motor running caused in turning of the car until the other sensor sense a white color by the end of the turn, and car move straight again.

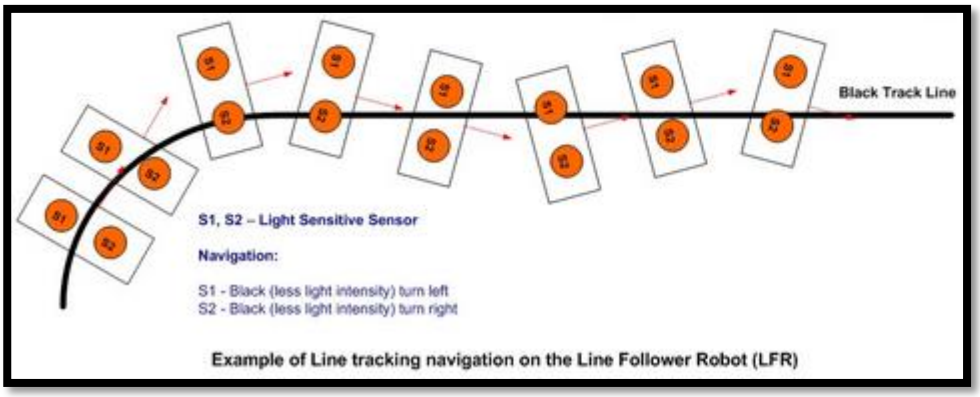


figure (4.4) **Line Tracking**

Line end:

When both LDR sensors sense black color, both DC motor stop and the car stop according to that ,this state represent the end of the line.

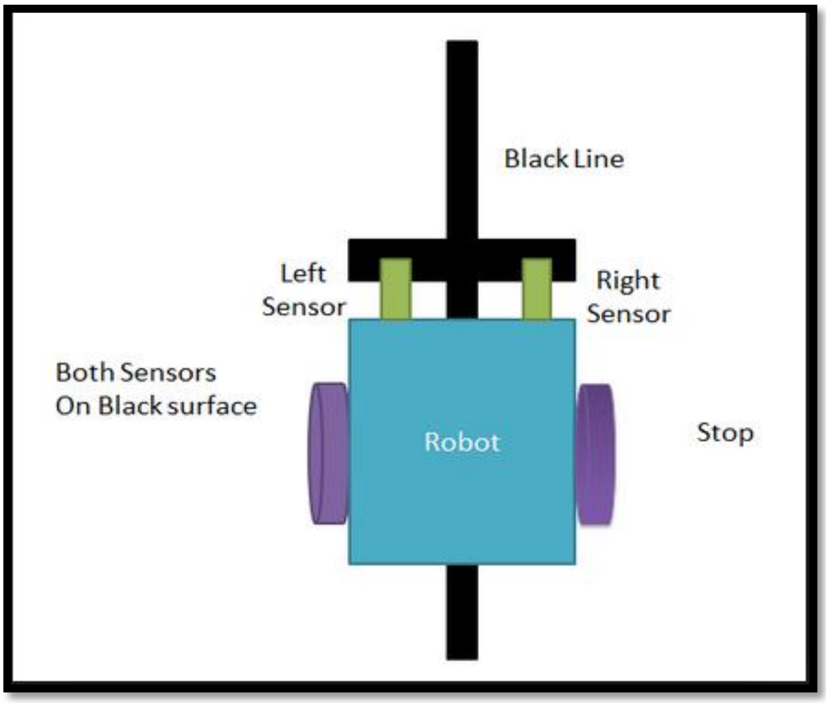


figure (4.5)

4.4.2 Output Section :

For moving a robot we have two dc motors attached to wheels gears. DC motors are most easy to control. One dc motor requires only two signals for its operation If we want to change its direction just reverse the polarity of power supply a cross it. we vary speed by varying the voltage across motor.

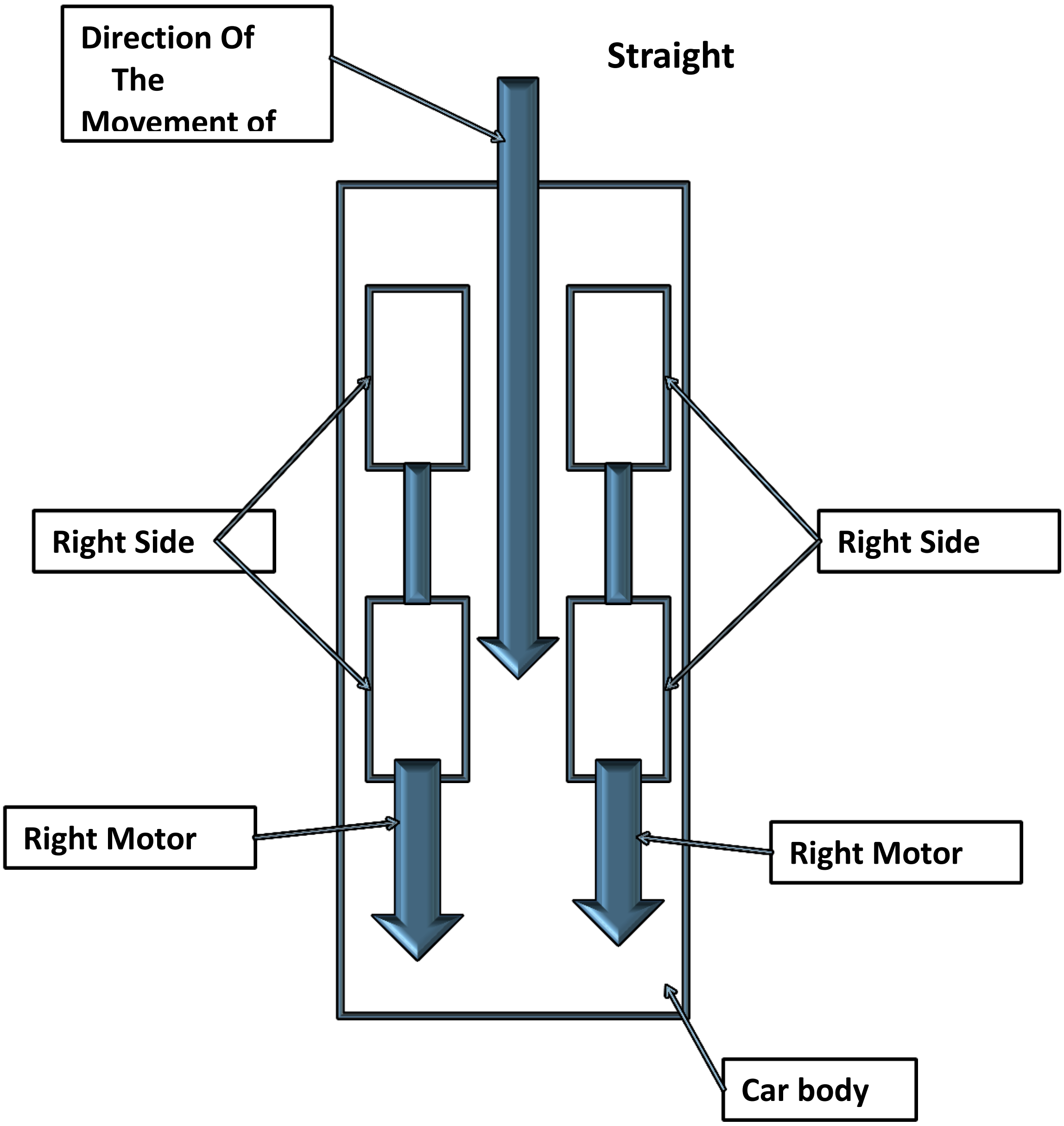
- **Use of gears:**

The DC motors don't have enough torque to drive a robot directly by connecting wheels in it. Gears used to increase the torque of dc motor on the expense of its speed.

- **The reason for used two motors:**

By using two motors we can move our robot in any direction. This steering Mechanism of robot is called as differential drive.

Let's check how it works :



Figure(4.6) Direction of movement ,The differential drive is a two-wheeled drive system with independent actuators for each wheel. The name refers to the fact that the motion vector of the robot is the sum of the independent wheel motions. The drive wheels are usually placed on each side of the robot and toward the front.

Table (4. 1) Movement Description

Left Motor	**Right Motor**	**Car Movement**
Straight	Straight	Straight
Stop	Straight	Left
Straight	Stop	Right

CHAPTER FIVE

Conclusion and Recommendation

5.1. Conclusion

The line following robot is automobile system that has ability to recognize it's path , move and change the robot's position toward the line in the best way to remain in track.

This research report presents a photodiode sensor based line follower robot. The robot will confirm the output production line control of the industrial application can be increased without any losses of delay time.

In this robot 9v battery is used to run DC motors. The distance covered by the motor is directly proportional to speed . Speed is reduced due to half drain batteries. This robot cannot take high load, if we use it in real time scenario in hospitals. More power supply will be needed to carry high load.

This robot is a prototype .When it will be actually implemented in real time, there will be practical errors but those can be solved with better components and more time .Once it will be fixed it will be helpful application for health care centers Due to structure and technical lacuna of the robot ,it is not possible to transport high load goods. However in future if the center of gravity and other technical aspects are taken off, it is also possible to transport high load goods.

Efficiency of robot is dwindled due to drain of the battery, also taking sharp turns would be possible if radius of curvature is properly adjusted.

On addressing above limitations high tech top notchrobot would be able to design.

5.2 Recommendations

In the process of development of the line follower, most of the useful feature is identified and many of them was implemented . But due to the time limitations and other factor some of these cannot be added.

So the development features in brief:

Use of color sensor.

Use of ccd camera for better reconigsation and precise tracking the path

Use PID controller to improve response of the system

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