Stair Climbing and Fire Fighting Robot

A Project Report Submitted
In Partial Fulfilment of the Requirements
For the Degree of

BACHELOR OF TECHNOLOGY
By

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Certificate

It is certified that the work contained in this report titled “Stair Climbing and Fire Fighting Robot" is the original work done by Aarti(2413055), Shounak Chakraborty(2413067),Shashank Sharma(2413072), Shweta Srikkanth(2413066) and has been carried out under our supervision.

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Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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<u>Approval Sheet</u>

This project report entitled **Stair Climbing and Fire Fighting Robot** by Aarti(2413055),Shounak Chakraborty(2413067), Shashank Sharma(2413072),Shweta Srikkanth(2413066) is approved for the degree of

BACHELOR OF TECHNOLOGY IN ELECTRONICS.

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SUPERVISOR

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Acknowledgement

It gives us a great sense of pleasure to present the report of the B. Tech Project undertaken during B. Tech. Final Year. We owe special debt of gratitude to our Professor **Dr. Rakhi Narang** and **Dr. Lalita Josyula** Department of Electronics, Sri Venkateswara College, University of Delhi for their constant support and guidance throughout the course of our work. Their sincerity, thoroughness and perseverance have been a constant source of inspiration for us. It is only their cognizant efforts that our endeavours have seen light of the day.

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We also do not like to miss the opportunity to acknowledge the contribution of all faculty members of the department and for their kind assistance and cooperation during the development of our project. Last but not the least, we acknowledge our friends for their contribution in the completion of the project.

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INTRODUCTION

In today's world, robots are increasingly being integrated into working tasks to replace humans. They are currently used in many fields of applications including office, military tasks, hospital operations, industrial automation, security systems, dangerous environment and agriculture. Several types of mobile robots with different dimensions are designed for various robotic applications. The robot has been designed for the purpose of aiding rescue people. Common situations that employ the robot are urban disasters, hostage situations, and explosions

In this project, we propose to design an autonomous robot that can climb stairs and extinguish fire. The robot is designed to reach un-accessible areas like stairs, uneven path and would douse fire for humans risking their life daily. In today's world, robots are increasingly being integrated into working tasks to replace humans. Several types of mobile robots with different dimensions are designed for various robotic applications. Therefore, in this work, we will try to come up with a product which will be a fusion of both stair climbing and Fire Fighting mechanism. Stair climbing method has been utterly studied by us and practically implemented. Thus, our approach is to combine Stair Climbing with Fire Fighting mechanism using flame sensors to detect fire and douse fire using water-pump or carbon-dioxide carrier. Thereafter, we have look forward to Image processing using Python which will capture the image of fire at larger scale instead of sensors which will make it more efficient and help in the surveillance.

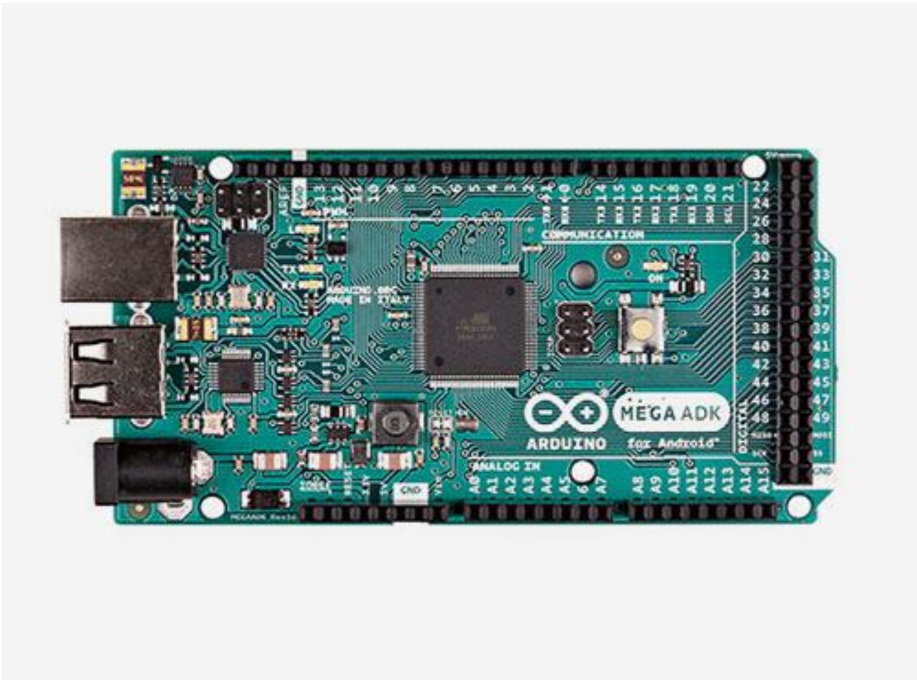
Keywords- Robotics, Mechanics, Arduino, Raspberry Pi2, Fire Fighting, Computer Vision, Python, WiFi Module.

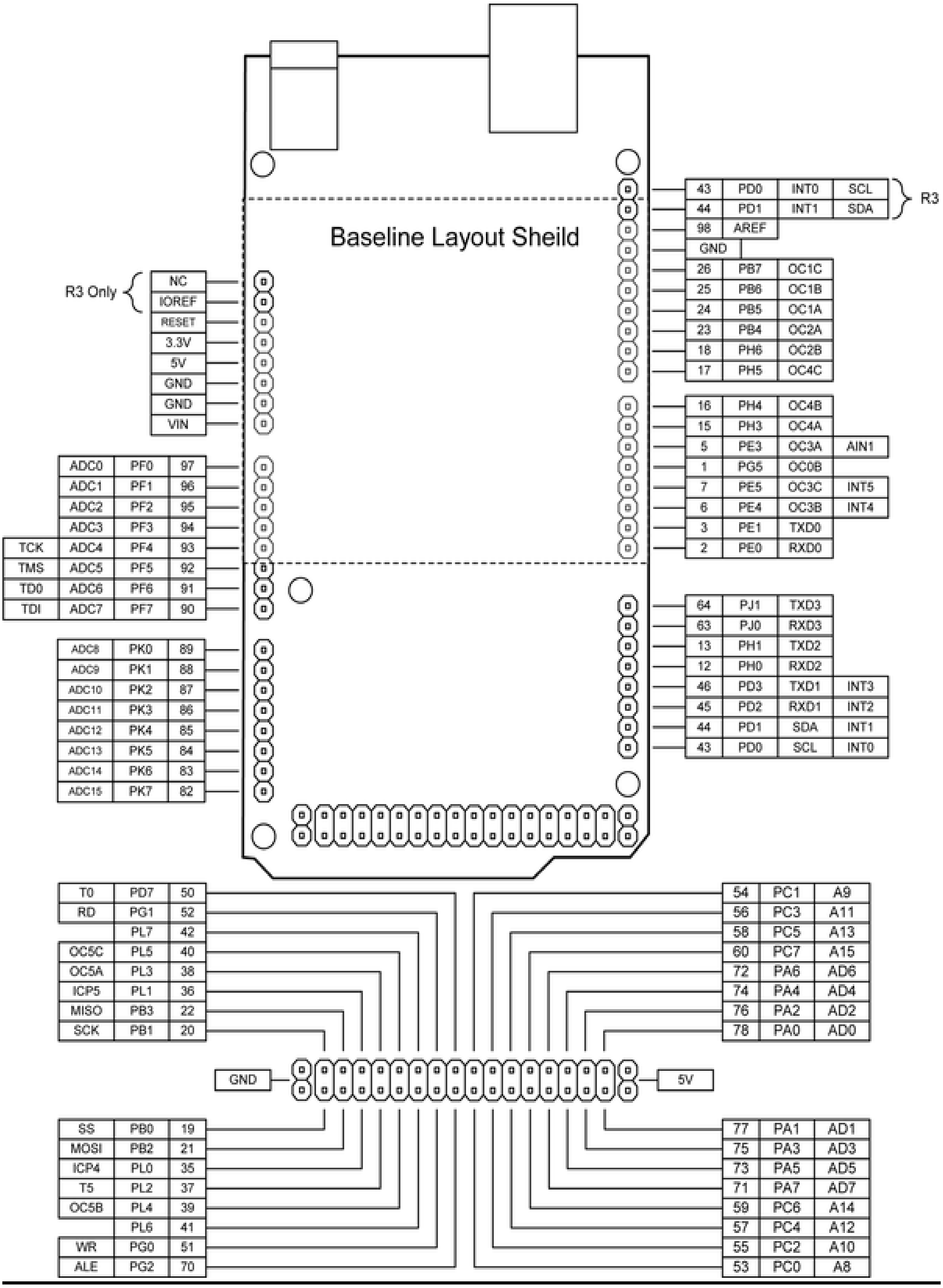
1 ARDUINO

1.1 INTRODUCTION

Arduino is an open source, computer hardware and software company, project, and user community that designs and manufactures microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical world. The project's products are distributed as open-source hardware and software, which are licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), permitting the manufacture of Arduino boards and software distribution by anyone. Arduino boards are available commercially in preassembled form, or as do-it-yourself kits.

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (*shields*) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++. In addition to using traditional compiler toolchains, the Arduino project provides an integrated development environment (IDE) based on the Processing language project.




Baseline Layout Sheild
R3
43 PD0 INT0 SCL
44 PD1 INT1 SDA
98 AREF
GND
26 PB7 OC1C
25 PB6 OC1B
24 PB5 OC1A
23 PB4 OC2A
18 PH6 OC2B
17 PH5 OC4C
16 PH4 OC4B
15 PH3 OC4A
5 PE3 OC3A AIN1
1 PG5 OC0B
7 PE5 OC3C INT5
6 PE4 OC3B INT4
3 PE1 TXD0
2 PE0 RXD0
64 PJ1 TXD3
63 PJ0 RXD3
13 PH1 TXD2
12 PH0 RXD2
46 PD3 TXD1 INT3
45 PD2 RXD1 INT2
44 PD1 SDA INT1
43 PD0 SCL INT0
R3 Only
NC
IOREF
RESET
3.3V
5V
GND
GND
VIN
ADC0 PF0 97
ADC1 PF1 96
ADC2 PF2 95
ADC3 PF3 94
TCK ADC4 PF4 93
TMS ADC5 PF5 92
TD0 ADC6 PF6 91
TDI ADC7 PF7 90
ADC8 PK0 89
ADC9 PK1 88
ADC10 PK2 87
ADC11 PK3 86
ADC12 PK4 85
ADC13 PK5 84
ADC14 PK6 83
ADC15 PK7 82
T0 PD7 50
RD PG1 52
PL7 42
OC5C PL5 40
OC5A PL3 38
ICP5 PL1 36
MISO PB3 22
SCK PB1 20
54 PC1 A9
56 PC3 A11
58 PC5 A13
60 PC7 A15
72 PA6 AD6
74 PA4 AD4
76 PA2 AD2
78 PA0 AD0
GND
5V
SS PB0 19
MOSI PB2 21
ICP4 PL0 35
T5 PL2 37
OC5B PL4 39
PL6 41
WR PG0 51
ALE PG2 70
77 PA1 AD1
75 PA3 AD3
73 PA5 AD5
71 PA7 AD7
59 PC6 A14
57 PC4 A12
55 PC2 A10
53 PC0 A8

1.2 ARDUINO MEGA ADK

The Arduino MEGA ADK is a microcontroller board based on the ATmega2560. It has a USB host interface to connect with Android based phones, based on the MAX3421e IC. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

1.3 TECHNICAL SPECIFICATIONS

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz
USB Host Chip	MAX3421E
Length	101.52 mm
Width	53.3 mm
Weight	36 g

1.4 POWER

The Arduino MEGA ADK can be powered via the USB connection or with an external power supply. The power source is selected automatically. The board can operate on an external supply of 5.5 to 16 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- **VIN**. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

- **5V**. this pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.
- **3V3**. A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND.** Ground pins.
- **IOREF**. This pin on the Arduino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs for working with the 5V or 3.3V.

1.5 MEMORY

The MEGA ADK has 256 KB of flash memory for storing code (of which 8 KB is used for the boot loader), 8 KB of SRAM and 4 KB of EEPROM

1.6 INPUT AND OUTPUT

Each of the 50 digital pins on the MEGA ADK can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- **Serial**: 0 (RX) and 1 (TX); Serial 1: 19 (RX) and 18 (TX); Serial 2: 17 (RX) and 16 (TX); Serial 3: 15 (RX) and 14 (TX). Used to receive (RX) and transmit (TX) TTL serial data. Pins 0 and 1 are also connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- **PWM**: 2 to 13 and 44 to 46. Provide 8-bit PWM output with the analogWrite() function.
- **Digital**: 7 (RST), 50 (MISO), 51 (MOSI), 52 (SCK).
- **LED**: 13.There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.
- **Analog pins** : The MEGA ADK has 16 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and analogReference() function.

There are a couple of other pins on the board:

- **AREF**. Reference voltage for the analog inputs. Used with analogReference().
- **Reset**. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

1.7 ATMEGA2560

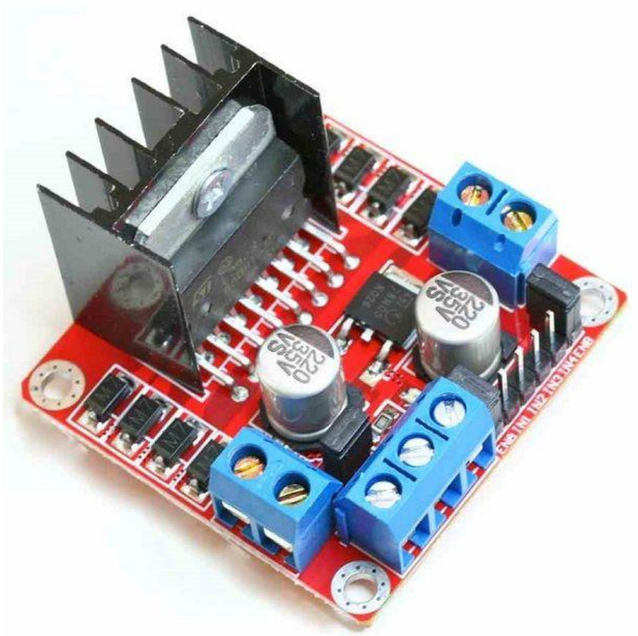
The ATmega640/1280/1281/2560/2561 provides the following features: 64K/128K/256K bytes of In-System Programmable Flash with Read-While-Write capabilities, 4Kbytes EEPROM, 8Kbytes SRAM, 54/86 general purpose I/O lines, 32 general purpose working registers, Real Time Counter (RTC), six flexible Timer/Counters with compare modes and PWM, four USARTs, a byte oriented 2-wire Serial Interface, a 16-channel, 10-bit ADC with optional differential input stage with programmable gain, programmable Watchdog

Timer with Internal Oscillator, an SPI serial port, IEEE® std. 1149.1 compliant JTAG test interface, also used for accessing the On-chip Debug system and programming and six software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next interrupt or Hardware Reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except Asynchronous Timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the Crystal/Resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low power consumption. In Extended Standby mode, both the main Oscillator and the Asynchronous Timer continue to run.

2 Motor Driver 2A Dual L298 H-Bridge

This dual bidirectional motor driver 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.

It is ideal for robotic applications and well suited for connection to a microcontroller requiring just a couple of control lines per motor. It can also be interfaced with simple manual switches, TTL logic gates, relays, etc.



Fig, L298 Motor Driver

The circuit incorporates 4 direction LEDs (2 per motor), a heat sink, screw-terminals, as well as eight Schottky EMF-protection diodes. Two high-power current sense resistors are also incorporated which allow monitoring of the current drawn on each motor through your microcontroller.

An on-board user-accessible 5V regulator is also incorporated which can also be used to supply any additional circuits requiring a regulated 5V DC supply of up to about 1A.

The circuit also offers a bridged mode of operation allowing bidirectional control of a single motor of up to about 4A.

2.1 Features:

- Motor supply: 6 to 35 VDC
- Control Logic: Standard TTL Logic Level
- Output Power: Up to 2 A each
- Current Sense Outputs
- Onboard Power Resistors Provided for Current Limit
- Enable and Direction Control Pins
- External Diode Bridge Provided for Output
- Heat sink for IC
- Power-On LED indicator
- 4 Direction LED indicators

Dimensions**:** 3 x 2.5"

An H bridge is an electronic circuit that enables a voltage to be applied across a load in either direction. These circuits are often used in robotics and other applications to allow DC motors to run forwards or backwards.

Most DC-to-AC converters (power inverters), most AC/AC converters, the DC-to-DC push–pull converter, most motor controllers, and many other kinds of power electronics use H bridges. In particular, a bipolar stepper motor is almost invariably driven by a motor controller containing two H bridges.

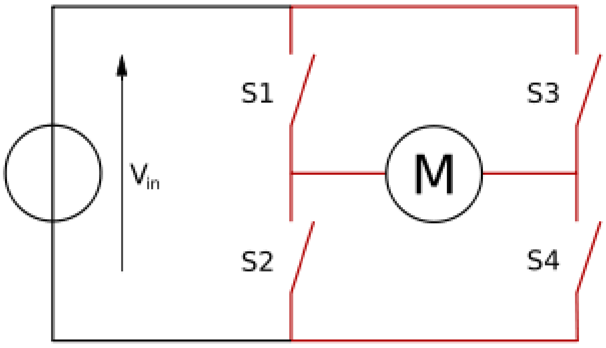
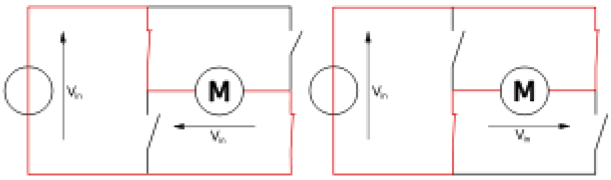


Fig. H-Bridge

The term H bridge is derived from the typical graphical representation of such a circuit. An H bridge is built with four switches (solid-state or mechanical). When the switches S1 and S4 (according to the first figure) are closed (and S2 and S3 are open) a positive voltage will be applied across the motor. By opening S1 and S4 switches and closing S2 and S3 switches, this voltage is reversed, allowing reverse operation of the motor.

Using the nomenclature above, the switches S1 and S2 should never be closed at the same time, as this would cause a short circuit on the input voltage source. The same applies to the switches S3 and S4. This condition is known as shoot-through.

The H-bridge arrangement is generally used to reverse the polarity/direction of the motor, but can also be used to 'brake' the motor, where the motor comes to a sudden stop, as the motor's terminals are shorted, or to let the motor 'free run' to a stop, as the motor is effectively disconnected from the circuit. The following table summarises operation, with S1-S4 corresponding to the diagram above.

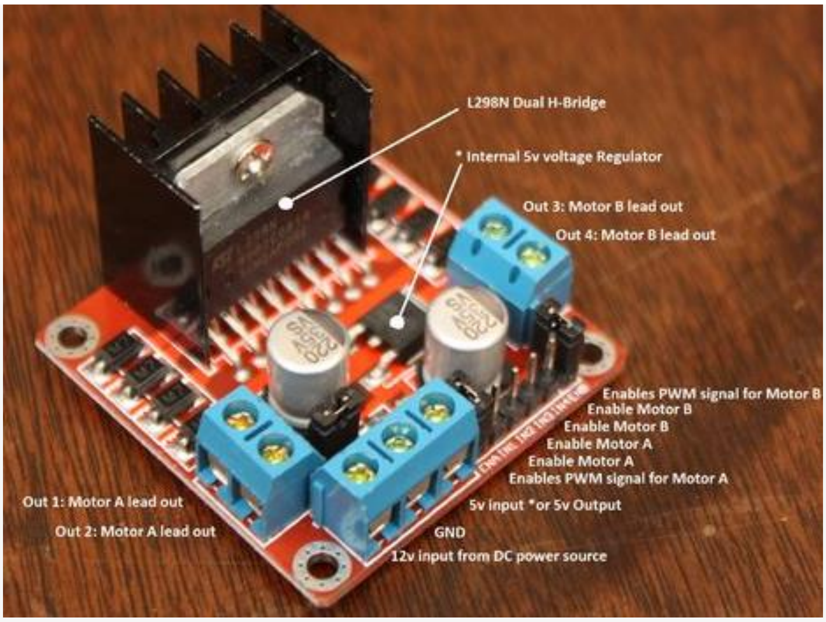


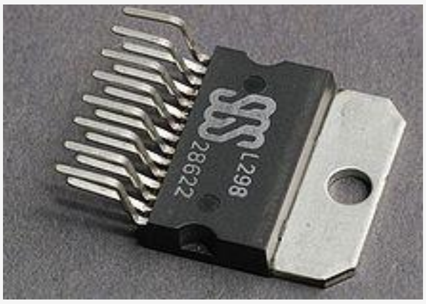
A way to build an H bridge is to use an array of relays from a relay board.

A "DPDT" ("Double Pole Double Throw") relay can generally achieve the same electrical functionality as an H bridge (considering the usual function of the device). However a semiconductor-based H bridge would be preferable to the relay where a smaller physical size, high speed switching, or low driving voltage (or low driving power) is needed, or where the wearing out of mechanical parts is undesirable. Another option is to have a "DPDT" relay to set the direction of current flow and a transistor to enable the current flow. This can extend the relay life, as the relay will be switched while the transistor is off and thereby there is no current flow. It also enables the use of PWM switching to control the current level.

3 CONNECTING L298 WITH ARDUINO

STEP 1: GETTING TO KNOW YOUR L298N DUAL H-BRIDGE MOTOR CONTROLLER MODULE:





3.1 Usage:

H-Bridge's are typically used in controlling motors speed and direction, but can be used for other projects such as driving the brightness of certain lighting projects such as high powered LED arrays.

3.2 HOW IT WORKS:

An H-Bridge is a circuit that can drive a current in either polarity and be controlled by *Pulse Width Modulation (PWM).

* Pulse Width Modulation is a means in controlling the duration of an electronic pulse. In motors try to imagine the brush as a water wheel and electrons as a the flowing droplets of water. The voltage would be the water flowing over the wheel at a constant rate, the more water flowing the higher the voltage. Motors are rated at certain voltages and can be damaged if the

voltage is applied to heavily or if it is dropped quickly to slow the motor down. Thus PWM. Take the water wheel analogy and think of the water hitting it in pulses but at a constant flow. The longer the pulses the faster the wheel will turn, the shorter the pulses, the slower the water wheel will turn. Motors will last much longer and be more reliable if controlled through PWM.

3.3 PINS:

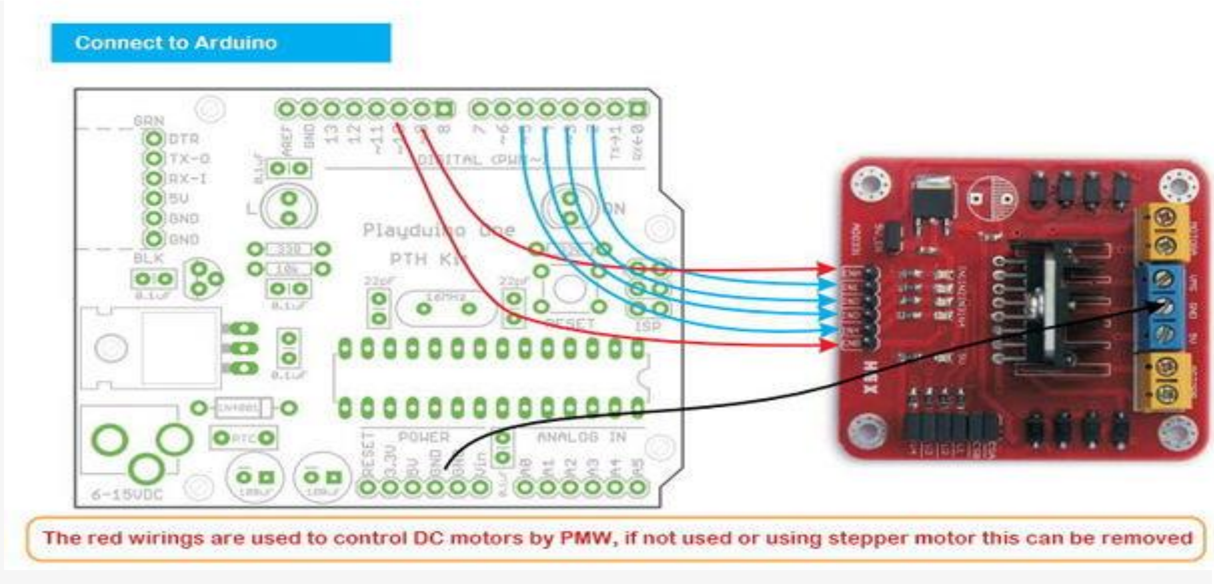
- Out 1: Motor A lead out
- Out 2: Motor A lead out
- Out 3: Motor B lead out
- Out 4: Mo (Can actually be from 5v-35v, just marked as 12v)
- GND: Ground
- 5v: 5v input (unnecessary if your power source is 7v-35v, if the power source is 7v-35v then it can act as a 5v out)
- ENA: Enables PWM signal for Motor A (Please see the "Arduino Sketch Considerations" section)
- In1: Enable Motor A
- In2: Enable Motor A
- In3: Enable Motor B
- In4: Enable Motor B
- ENB: Enables PWM signal for Motor B (Please see the "Arduino Sketch Considerations" section)

3.4 SPECIFICATIONS:

- Double H bridge Drive Chip: L298N
- Logical voltage: 5V Drive voltage: 5V-35V
- Logical current: 0-36mA Drive current: 2A (MAX single bridge)
- Max power: 25W
- Dimensions: 43 x 43 x 26mm
- Weight: 26g

*Built-in 5v power supply, when the driving voltage is 7V-35V

STEP 2: WIRING TO AN ARDUINO:



There are several different models of these L298N Dual H-Bridge Motor Controllers. The generic wiring schematic above should do the trick for most.

Two things to mention

- Make sure you have all of your grounds tied together; Arduino, Power source, and the Motor controller.
- The PWM Pins are unnecessary if you do not want to control PWM features.

STEP 3: ARDUINO SKETCH CONSIDERATIONS:

The Arduino code sketch is pretty straight forward. Since there isn't a library for the L298N Dual H-Bridge Motor Controller you just have to declare which pins the controller is hooked

The **"int dir(number)Pin(letter)"'** pins can be connected to any available digital pin you have available, as long as you declare the correct pin in your sketch. This makes the L298N Dual H-Bridge Motor Controller very versatile if your project is using a lot of Arduino pins.

The **int "speedPin(letter)"** pins need to be connected to a PWM pin on the Arduino if you want to enable speed control through PWM.

As a quick cheat I have included a list of PWM pins for the main two types of Arduino's I use:

- **ATMEGA – PWM:** 2 to 13 and 44 to 46. Provide 8-bit PWM output with the analogWrite() function.
- **UNO – PWM:** 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.

4 DC SERVO MOTOR

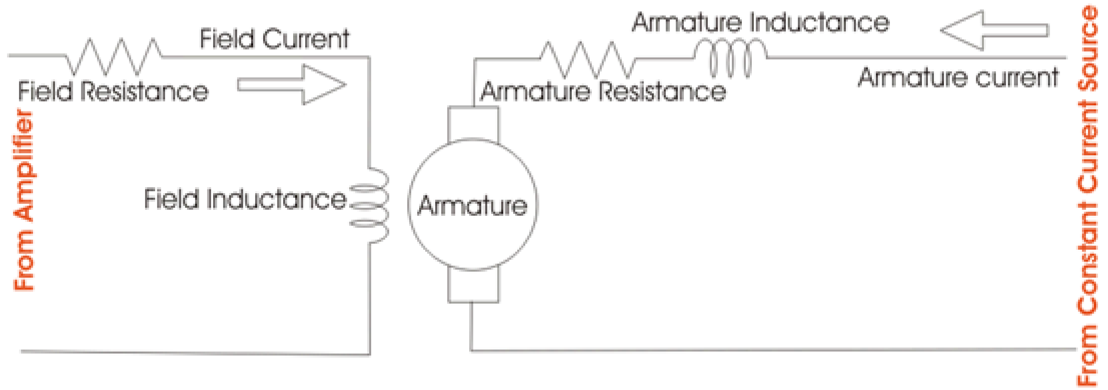
4.1 DC SERVO MOTOR THEORY

The motors which are utilized as **DC servo motors**, generally have separate DC source for field winding and armature winding.

The control can be archived either by controlling the field current or armature current. Field control has some specific advantages over armature control and on the other hand armature control has also some specific advantages over field control. Which type of control should be applied to the **DC servo motor**, is being decided depending upon its specific applications.

4.2 FIELD CONTROLLED DC SERVO MOTOR THEORY

The figure below illustrates the schematic diagram for a field controlled DC servo motor. In this arrangement the field of DC motor is excited be the amplified error signal and armature winding is energized by a constant current source.



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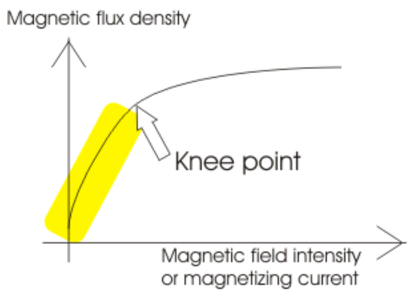
The field is controlled below the knee point of magnetizing saturation curve. At that portion of the curve the mmf linearly varies with excitation current. That means torque developed in the DC motor is directly proportional to the field current below the knee point of magnetizing saturation



curve.

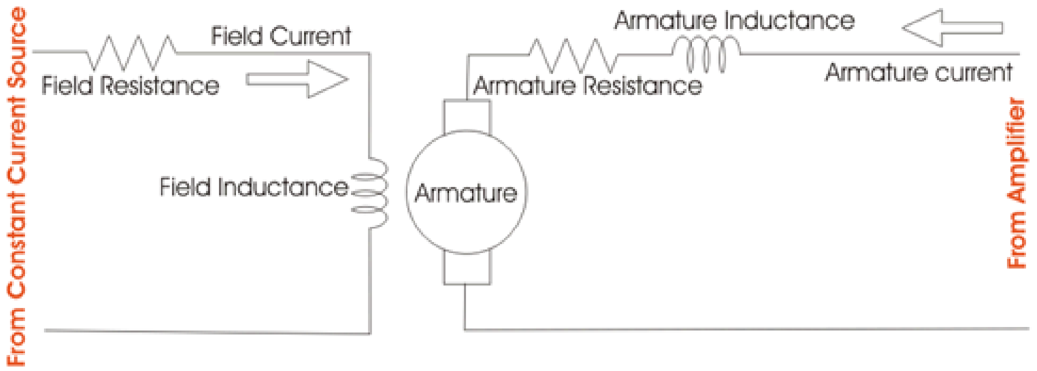
From general torque equation of DC motor it is found that, torque $T \propto \varphi I_a$. Where, φ is field flux and I_a is armature current. But in field controlled DC servo motor, the armature is excited by constant current source , hence I_a is constant here. Hence, $T \propto \varphi$

As field of this DC servo motor is excited by amplified error signal, the torque of the motor i.e. rotation of the motor can be controlled by amplified error signal. If the constant armature current is large enough then, every little change in field current causes corresponding change in torque on the motor shaft. The direction of rotation can be changed by changing polarity of the field. The direction of rotation can also be altered by using split field DC motor, where the field winding is divided into two parts, one half of the winding is wound in clockwise direction and other half in wound in anticlockwise direction. The amplified error signal is fed to the junction point of these two halves of the field as shown below. The magnetic field of both halves of the field winding opposes each other. During operation of the motor, magnetic field strength of one half dominates other depending upon the value of amplified error signal fed between these halves. Due to this, the DC servo motor rotates in a particular direction according to the amplified error signal voltage.

The main disadvantage of field control **DC servo motors**, is that the dynamic response to the error is slower because of longer time constant of inductive field circuit. The field is an electromagnet so it is basically a highly inductive circuit hence due to sudden change in error signal voltage, the current through the field will reach to its steady state value after certain period depending upon the time constant of the field circuit. That is why field control DC servo motor arrangement is mainly used in small servo motor applications. The main advantage of using field control scheme is that, as the motor is controlled by field - the controlling power requirement is much lower than rated power of the motor.

4.3 *ARMATURE CONTROLLED DC SERVO MOTOR THEORY*

The figure below shows the schematic diagram for an armature controlled DC servo motor. Here the armature is energized by amplified error signal and field is excited by a constant current source



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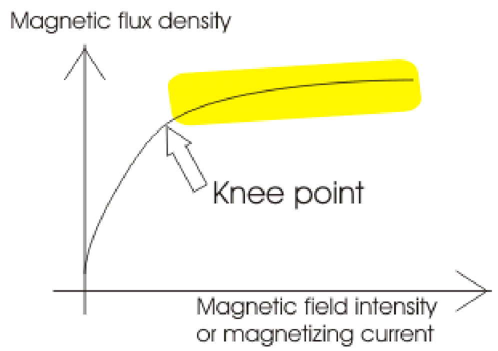
The field is operated at well beyond the knee point of magnetizing saturation curve. In this portion of the curve, for huge change in magnetizing current, there is very small change in mmf in the motor field. This makes the servo motor is less sensitive to change in field current. Actually for armature controlled DC servo motor, we do not want that, the motor should response to any change of field current.



Again, at saturation the field flux is maximum. As we said earlier, the general torque equation of DC motor is, torque $T \propto \varphi I_a$. Now if φ is large enough, for every little change in armature current I_a there will be a prominent changer in motor torque. That means servo motor becomes much sensitive to the armature current.

As the armature of DC motor is less inductive and more resistive, time constant of armature winding is small enough. This causes quick change of armature current due to sudden change in armature voltage. That is why dynamic response of armature controlled DC servo motor is much faster than that of field controlled DC servo motor.

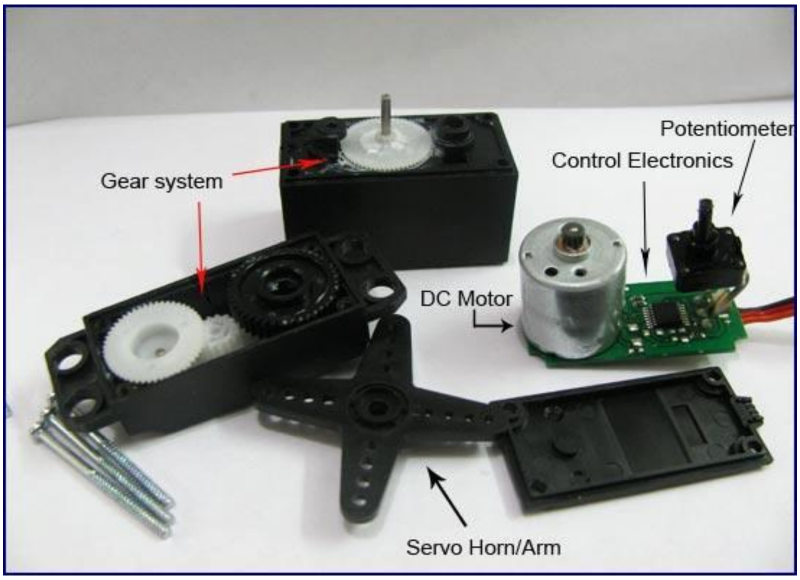
The direction of rotation of the motor can easily be changed by reversing the polarity of the error signal.

4.4 *PERMANENT MAGNET DC SERVO MOTOR*

Field control is not possible in the case of permanent magnet DC motor as the field is a permanent magnet here. DC servo motor working principle in that case is similar to that of armature controlled motor.

4.5 *WORKING PRINCIPLE OF DC SERVO MOTOR*

A DC servo motor is an assembly of four major components, namely a DC motor, a position sensing device, a gear assembly, and a control circuit. The below figure shows the parts that consisting in RC servo motors in which small DC motor is employed for driving the loads at precise speed and position.



A DC reference voltage is set to the value corresponding to the desired output. This voltage can be applied by using another potentiometer, control pulse width to voltage converter, or through timers depending on the control circuitry.

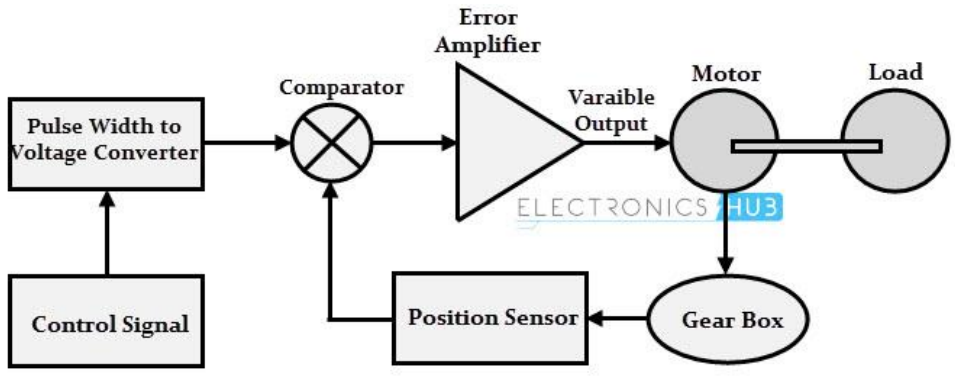
The dial on the potentiometer produces a corresponding voltage which is then applied as one of the inputs to error amplifier.

In some circuits, a control pulse is used to produce DC reference voltage corresponding to desired position or speed of the motor and it is applied to a pulse width to voltage converter.

In this converter, the capacitor starts charging at a constant rate when the pulse high. Then the charge on the capacitor is fed to the buffer amplifier when the pulse is low and this charge is further applied to the error amplifier.

So the length of the pulse decides the voltage applied at the error amplifier as a desired voltage to produce the desired speed or position.

In digital control, microprocessor or microcontroller are used for generating the PWM pluses in terms of duty cycles to produce more accurate control signals



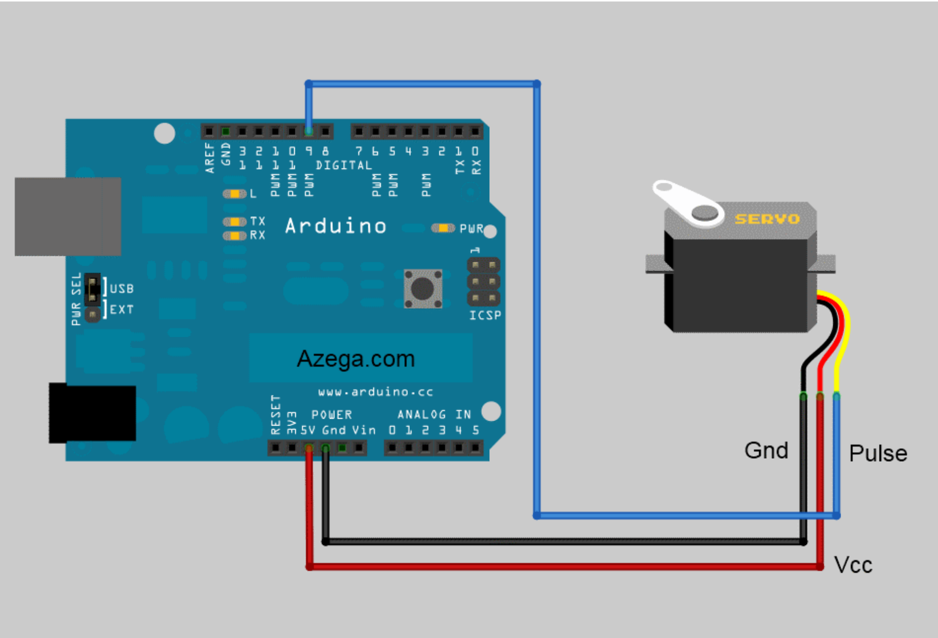
The feedback signal corresponding to the present position of the load is obtained by using a position sensor. This sensor is normally a potentiometer that produces the voltage corresponding to the absolute angle of the motor shaft through gear mechanism. Then the feedback voltage value is applied at the input of error amplifier (comparator).

The error amplifier is a negative feedback amplifier and it reduces the difference between its inputs. It compares the voltage related to current position of the motor (obtained by potentiometer) with desired voltage related to desired position of the motor (obtained by pulse width to voltage converter), and produces the error either a positive or negative voltage.

This error voltage is applied to the armature of the motor. If the error is more, the more output is applied to the motor armature.

As long as error exists, the amplifier amplifies the error voltage and correspondingly powers the armature. The motor rotates till the error becomes zero. If the error is negative, the armature voltage reverses and hence the armature rotates in the opposite direction.

4.6 SERVO CONNECTIONS WITH ARDUINO



5 WHEELS VS CONTINUOUS TRACKS

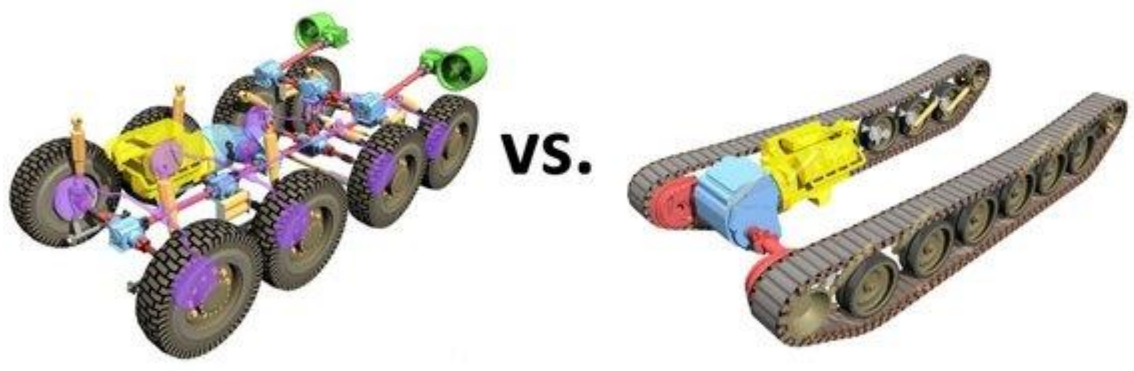
Sometimes is very difficult to choose between wheels and tracks when you build a robot because each system provides certain features and performances. More than that, each system has its strengths and weaknesses.

By finding series of lists with advantages and disadvantages for both wheels and continuous tracks. With all these positions in mind, we have to choose the best system for your robot.

Choosing the best system depends on several factors including here the traction, ground pressure, suspension, and steering. The traction is greater if you use tracks instead wheels, but for the best results this depends on the terrain. If you want a less ground pressure, you have to choose the tracks. The tracks have a lower ground pressure than wheels and are more suited to soft surfaces. For soft surfaces can be used larger tires, but these has limits and cannot work in all conditions – for example on snow.

Building suspension for tracked robot is more complicated than for a wheeled robot. The suspension system has an important role related to traction by keeping the tracks or wheels on the terrain.

The wheels have a significant advantage in steering compared to tracks, and this can be translated into a good maneuverability for the wheels.



Wheeled robots vs. tracked robots is a well-known subject under debate for a long period of time. In the following, you can find the advantages and disadvantages of both vehicle propulsion: wheels and continuous tracks.

5.1 ADVANTAGES AND DISADVANTAGES USING WHEELS

The wheels are everywhere in robotics and is one of the main components that facilitates the movement by reducing the friction. Most robots are designed with 3 wheels, 2 motors and 2-speed controllers. This is the most common structure for a robot designed for a simple structure, to move quickly, easily controlled, spin on the spot, or turn around in small places.

In general, wheels are used for:

- **low production costs** – this is the case if we compare the prices for wheels and tracks;
- **speed** – compared with tracks, the wheels need a lower amount of torque to move on from stationary;
- **maneuverability** – the wheels provide high maneuverability compared with continuous tracks. The tracks are very difficult in maneuverability;
- **lightweight** – continuous tracks are much heavier than wheels, and this is the main reason why wheels are used especially in cases when the mass of the robot is a critical property – for example, space exploration missions;
- **simplicity** – a wheel has less moving parts, which means that there are fewer components that can get damaged;
- **materials** – several materials can be used to build wheels that meet environmental conditions;

5.2 DISADVANTAGES USING WHEELS

Using the wheel, is not always the best case. There are some situations where the wheels are not the best choice.

In general, wheels are not used when:

- **drive over obstacles** – depending on the terrain, a robot needs to pass small or large obstacles. For a wheel to get over a vertical obstacle, it has to be at least twice as tall as the vertical obstacle;

5.3 ADVANTAGES AND DISADVANTAGES USING CONTINUOUS TRACKS

The continuous band of treads driven by a series of wheels is used when the wheels cannot be used. In this area can be added a variety of scenarios, including the move on uneven terrain or when it’s needed high traction.

In general, continuous tracks are used for:

- **power efficiency** – compared with wheels, continuous tracks have high performance and optimized traction system, which is a plus in power delivery efficiency;
- **traction** – the traction is high even on slippery surfaces like snow or wet concrete;
- **moving on rough terrain** – using continuous tracks, a robot can operate on rough terrain while the wheels can get stuck. Also, the continuous band of treads can ascend and descend stairs, surmount obstacles, or cross ditches;
- **aesthetics** – the tracks look more aggressive than wheels;
- **ground impact** – a robot that moves on rubber tracks has a lower PSI on the ground. That means a less impact on the ground, especially when the robot is heavy;
- **weight growth potential** – a robot with continuous tracks has a weight spread over the entire surface of the track. This is one of the reasons that a robot with rubber tracks support a heavy load;

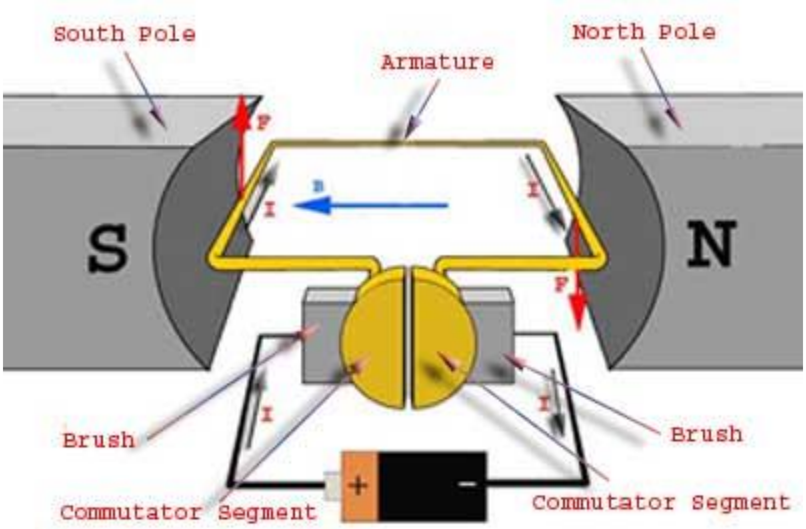
5.4 DISADVANTAGES USING CONTINUOUS TRACKS

In general, continuous tracks are not used in cases of:

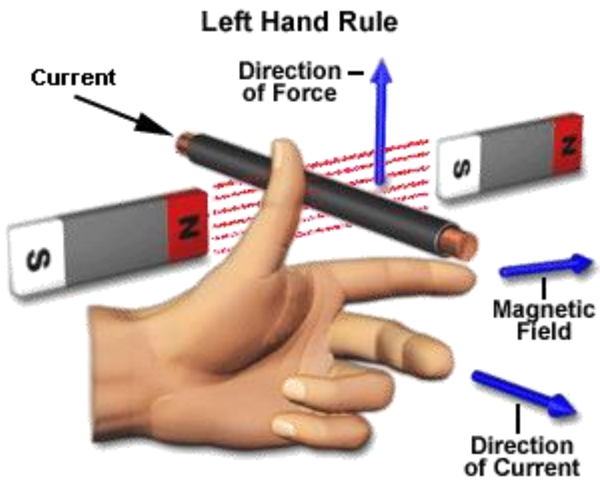
- **lower speed** – due to more friction and a complex mechanical system, the robots with continuous tracks has lower speed compared with robots on wheels;
- **less maneuverability** – robots on tracks are less precise in maneuverability and require more power when turning;
- **easily break** – the continuous tracks can be easily broken or dislodged than wheels;
- **short life** – rubber tracks have a running time much smaller than the wheels;
- **difficult to repair** – the continuous tracks are difficult to repair or replace than wheels;

6 DC MOTOR

A DC motor in simple words is a device that converts direct current(electrical energy) into mechanical energy. The very basic construction of a DC motor contains a current carrying armature which is connected to the supply end through commutator segments and brushes it is placed within the north south poles of a permanent or an electro-magnet

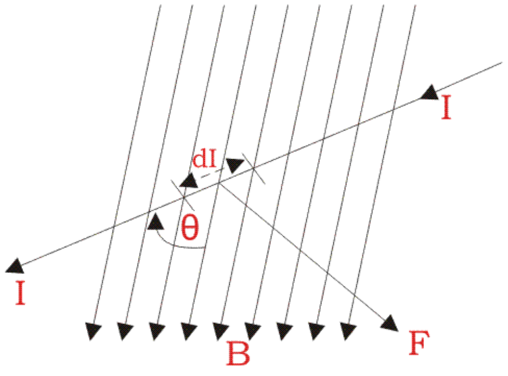


Now to go into the details of the **operating principle of DC motor** its important that we have a clear understanding of Fleming's left hand rule to determine the direction of force acting on the armature conductors of DC motor.



Fleming's left hand rule says that if we extend the index finger, middle finger and thumb of our left hand in such a way that the current carrying conductor is placed in a magnetic field (represented by the index finger) is perpendicular to the direction of current (represented by the middle finger), then the conductor experiences a force in the direction (represented by the thumb) mutually perpendicular to both the direction of field and the current in the conductor.

For clear understanding the **principle of DC motor** we have to determine the magnitude of the force, by considering the diagram below. We know that when an infinitely small charge dq is made to flow at a velocity ‘v’ under the influence of an electric field E, and a magnetic field B, then the Lorentz Force dF experienced by the charge is given by:-



$$dF = dq(E + vB)$$

For the **operation of DC motor**, considering E = 0

$$dF = dq \times v \times B$$

i.e. it’s the cross product of dq v and magnetic field B.

$$dF = dq\frac{dL}{dt} \times B \qquad \left[V = \frac{dL}{dt}\right]$$

Where dL is the length of the conductor carrying charge q.

$$dF = dq\frac{dL}{dt} \times B$$

$$or,\ dF = IdL \times B \qquad \left[Since,\ current\ I = \frac{dq}{dt}\right]$$

$$or,\ F = IL \times B = ILB\sin\theta$$

$$or,\ F = BIL\sin\theta$$

From the 1st diagram we can see that the construction of a DC motor is such that the direction of current through the armature conductor at all instance is perpendicular to the field. Hence the force acts on the armature conductor in the direction perpendicular to the both uniform field and current is constant.

$$i.e.\ \theta = 90^\circ$$

So if we take the current in the left hand side of the armature conductor to be I, and current at right hand side of the armature conductor to be − I, because they are flowing in the opposite direction with respect to each other. Then the force on the left hand side armature conductor,

$$F_i = BIL\sin 90^\circ = BIL$$

Similarly force on the right hand side conductor

$F_r = B(-I)L \sin 90° = -BIL$

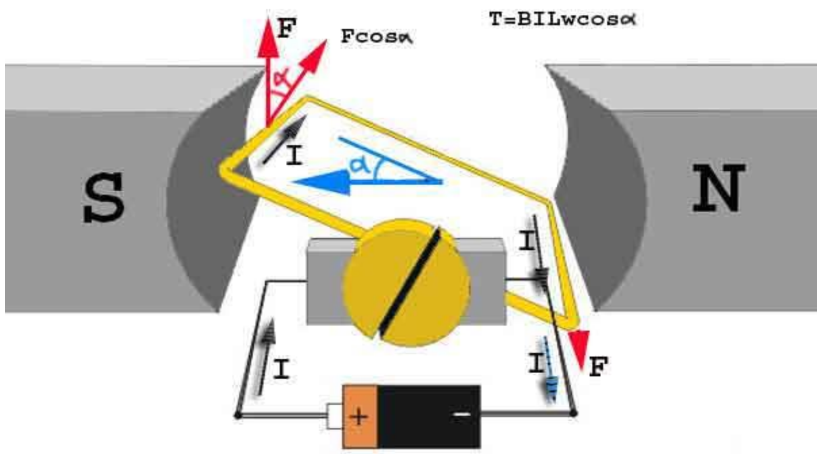
∴ we can see that at that position the force on either side is equal in magnitude but opposite in direction. And since the two conductors are separated by some distance w = width of the armature turn, the two opposite forces produces a rotational force or a torque that results in the rotation of the armature conductor. Now let's examine the expression of torque when the armature turn crate an angle of α with its initial position. The torque produced is given by,

$Torque = (force,\ tangential\ to\ the\ direction\ of\ armature\ rotation) \times (distance)$

$or,\ \tau = F \cos\alpha \times w$

$or,\ \tau = BILw \cos\alpha$

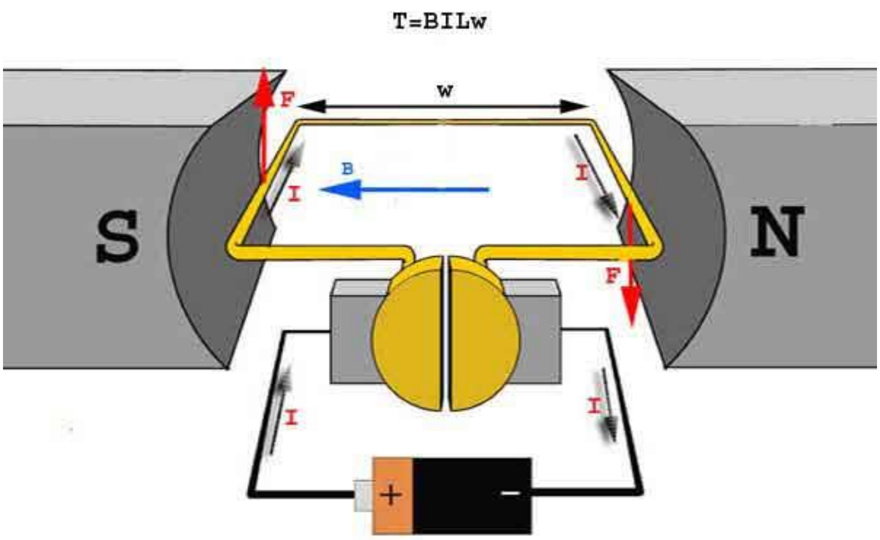
Where, α is the angle between the plane of the armature turn and the plane of reference or the initial position of the armature which is here along the direction of magnetic field. The presence of the term cosα in the torque equation very well signifies that unlike force the torque at all position is not the same. It in fact varies with the variation of the angle α. To explain the variation of torque and the principle behind rotation of the motor let us do a step wise analysis.



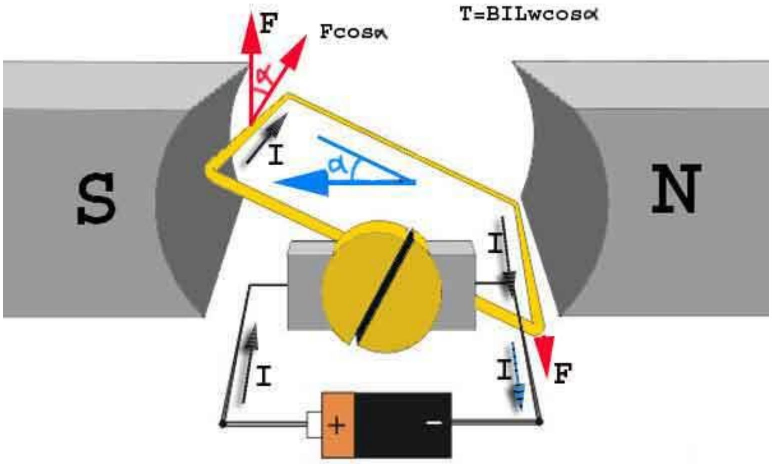
Step 1: Initially considering the armature is in its starting point or reference position where the angle α = 0.

$\therefore\ \tau = BILw \times \cos 0° = BILw$

Since, α = 0, the term cos α = 1, or the maximum value, hence torque at this position is maximum given by τ = BILw. This high starting torque helps in overcoming the initial inertia of rest of the armature and sets it into rotation.

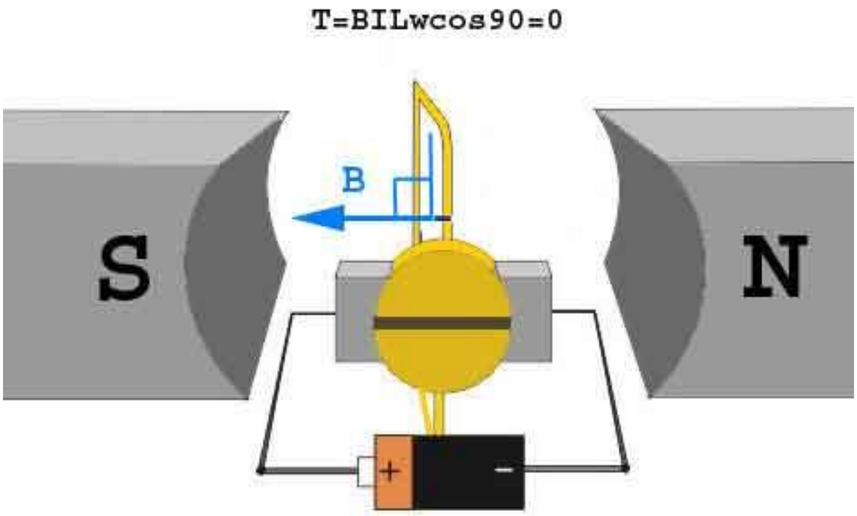


Step 2: Once the armature is set in motion, the angle α between the actual position of the armature and its reference initial position goes on increasing in the path of its rotation until it becomes 90° from its initial position. Consequently the term cosα decreases and also the value of torque. The torque in this case is given by τ = BILwcosα which is less than BIL w when α is greater than 0°.



Step 3: In the path of the rotation of the armature a point is reached where the actual position of the rotor is exactly perpendicular to its initial position, i.e. α = 90°, and as a result the term cosα = 0. The torque acting on the conductor at this position is given by,

$$\therefore \tau = BIL\omega \times \cos 90^o = 0$$



i.e. virtually no rotating torque acts on the armature at this instance. But still the armature does not come to a standstill, this is because of the fact that the operation of DC motor has been engineered in such a way that the inertia of motion at this point is just enough to overcome this point of null torque. Once the rotor crosses over this position the angle between the actual position of the armature and the initial plane again decreases and torque starts acting on it again.

6.1 DC MOTOR SPECIFICATIONS:

High performance DC geared motors with robust metal gear box for heavy duty applications, available in wide RPM range and ideally suited for robotics and industrial applications.

6.2 ***Specification***:

1. 60 RPM 12V DC MOTORS WITH METAL GEARBOX.
2. 18000 RPM BASE MOTOR.
3. SHAFT DIAMETER: 6MM.
4. GEARBOX DIAMETER 37 MM.
5. MOTOR DIAMETER 28.5 MM
6. LENGTH 63 MM WITHOUT SHAFT
7. SHAFT LENGTH 15MM
8. WEIGHT: 300 GM.
9. 10KGCM TORQUE.
10. NO LOAD CURRENT: 800MA (MAX).

7 IMPLEMENTATION OF FIRE FIGHTING ROBOT

Fire-fighting is an important but dangerous occupation. A fire-fighter must be able to get to a fire quickly and safely extinguish the fire, preventing further damage and reduce fatalities. Technology has finally bridged the gap between fire fighting and machines allowing for a more efficient and effective method of fire fighting. Robots designed to find a fire, before it rages out of control, could one day work with fire fighters greatly reducing the risk of injury to victims. Our world is currently facing the global warming whereby the average temperature of our earth atmosphere and oceans is increasing year by year. Studies shows that our earth mean surface temperature has increased about 0.8C which about two-third of increase occurring since 1980. The global warming of the earth may lead to more forest fire and fire disaster occur as everything gets more flammable due to the high temperature of our earth atmosphere. Therefore, fire extinguishing robot is needed to reduce all the damage cause by natural or human made fire disaster.

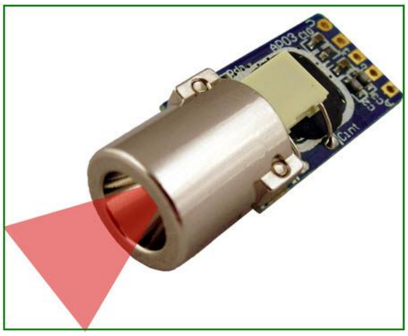
The robot has been designed for the purpose of aiding rescue people. Common situations that employ the robot are urban disasters, hostage situations, and explosions. This phase focuses on the robot that will reach the un-accessible areas like stairs, uneven path and would douse fire.

The proposed vehicle has a water jet spray which is capable of sprinkling water. The sprinkler can be moved towards the required direction. The advent of new high-speed technology provided realistic opportunity for new robot controls and realization of new methods of control theory. This technical improvement together with the need for high performance robots created faster, more accurate and more intelligent robots using new robots control devices, new drivers and advanced control algorithms. The robot would describe a new economical solution of robot control systems. The presented robot control system can be used for different sophisticated robotic applications. Whether due to technological curiosity to build machines that mimic human's or desire to automate work with machine, research in speech recognition as a first step towards human-machine communication. The controlling devices of the whole system are Arduino as Microcontrollers, water pump-spray, DC motors interfaced to Microcontroller.

7.1 COMPONENTS USED

7.1.1 IR Sensors

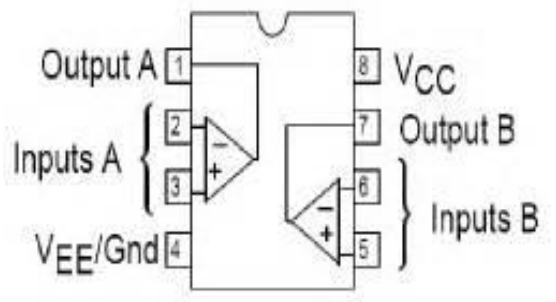
An infrared sensor is an electronic device, that emits in order to sense some aspects of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. These types of sensors measures only infrared radiation, rather than emitting it that is called as a passive IR sensor. Usually in the infrared spectrum, all the objects radiate some form of thermal radiations. These types of radiations are invisible to our eyes, that can be detected by an infrared sensor. The emitter is simply an IR LED (Light Emitting Diode) and the detector is simply an IR photodiode which is sensitive to IR light of the same wavelength as that emitted by the IR LED. When IR light falls on the photodiode, the resistances and these output voltages, change in proportion to the magnitude of the IR light received.



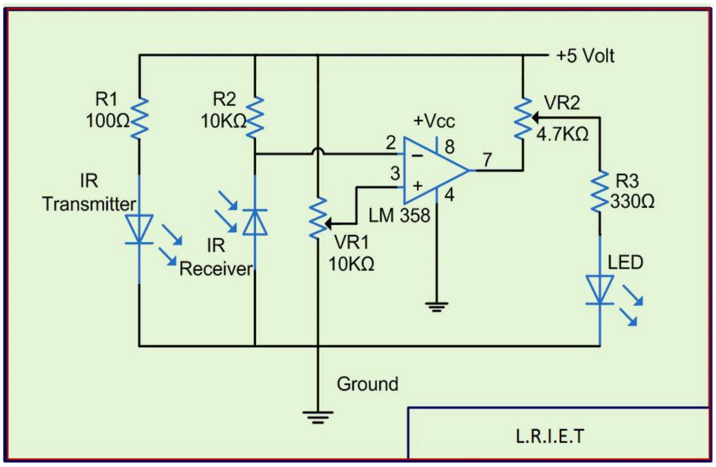
7.1.1.1 IR Sensor Circuit Diagram and Working Principle

An infrared sensor circuit is one of the basic and popular sensor module in an electronic device. This sensor is analogous to human's visionary senses, which can be used to detect obstacles and it is one of the common applications in real time. This circuit comprises of the following components

- LM358 IC 2 IR transmitter and receiver pair
- Resistors of the range of kilo ohms.
- Variable resistors.
- LED (Light Emitting Diode).

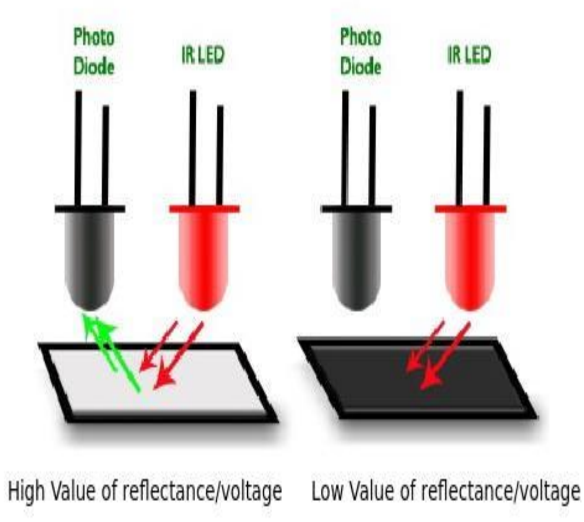


LM358



The transmitter section includes an IR sensor, which transmits continuous IR rays to be received by an IR receiver module. An IR output terminal of the receiver varies depending upon its receiving of IR rays. Since this variation cannot be analyzed as such, therefore this output can be fed to a comparator circuit. Here an operational amplifier (op-amp) of LM 339 is used as comparator circuit.

When the IR receiver does not receive a signal, the potential at the inverting input goes higher than that non-inverting input of the comparator IC (LM339). Thus the output of the comparator goes low, but the LED does not glow. When the IR receiver module receives signal to the potential at the inverting input goes low. Thus the output of the comparator (LM 339) goes high and the LED starts glowing. Resistor R1 (100), R2 (10k) and R3 (330) are used to ensure that minimum 10 mA current passes through the IR LED Devices like Photodiode and normal LEDs respectively. Resistor VR2 (preset=5k) is used to adjust the output terminals. Resistor VR1 (preset=10k) is used to set the sensitivity of the circuit Diagram.



Light comparison[9]

Name	Wavelength	Frequency (Hz)
Gamma ray	less than 0.01 nm	more than 30 EHz
X-ray	0.01 nm – 10 nm	30 EHz – 30 PHz
Ultraviolet	10 nm – 400 nm	30 PHz – 790 THz
Visible	400 nm– 700 nm	790 THz – 430 THz
Infrared	700 nm – 1 mm	430 THz – 300 GHz
Microwave	1 mm – 1 meter	300 GHz – 300 MHz
Radio	1 meter – 100,000 km	300 MHz – 3 Hz

7.1.1.2 Different Types of IR Sensors and Their Applications

IR sensors are classified into different types depending on the applications. Some of the typical applications of different types of sensors are

The speed sensor is used for synchronizing the speed of multiple motors. The temperature sensor is used for industrial temperature control. PIR sensor is used for automatic door opening system and Ultrasonic sensor are used for distance measurement.

IR Sensor Applications

IR sensors are used in various Sensor based projects and also in various electronic devices which measures the temperature that are discussed in the below.

Radiation Thermometers

IR sensors are used in radiation thermometers to measure the temperature depend upon the temperature and the material of the object and these thermometers have some of the following features

- Measurement without direct contact with the object
- Faster response
- Easy pattern measurements

Flame monitors

These types of devices are used for detecting the light emitted from the flames and to monitor how the flames are burning. The Light emitted from flames extend from UV to IR region types. PbS, PbSe, Two-color detector, pyro electric detector are some of the commonly employed detector used in flame monitors.

Moisture Analyzers

Moisture analyzers use wavelengths which are absorbed by the moisture in the IR region. Objects are irradiated with light having these wavelengths (1.1 µm, 1.4 µm, 1.9 µm, and 2.7µm) and also with reference wavelengths. The Lights reflected from the objects depend upon the moisture content and is detected by analyzer to measure moisture (ratio of reflected light at these wavelengths to the reflected light at reference wavelength). In GaAs PIN photodiodes, Pbs photoconductive detectors are employed in moisture analyzer circuits.

Gas Analyzers

IR sensors are used in gas analyzers which use absorption characteristics of gases in the IR region. Two types of methods are used to measure the density of gas such as dispersive and non dispersive.

Dispersive: An Emitted light is spectroscopically divided and their absorption characteristics are used to analyze the gas ingredients and the sample quantity.

Non dispersive: It is most commonly used method and it uses absorption characteristics without dividing the emitted light. Non dispersive types use discrete optical band pass filters, similar to sunglasses that are used for eye protection to filter out unwanted UV radiation.

This type of configuration is commonly referred to as non dispersive infrared (NDIR) technology. This type of analyzer is used for carbonated drinks, whereas non dispersive analyzer is used in most of the commercial IR instruments, for an automobile exhaust gas fuel leakages.

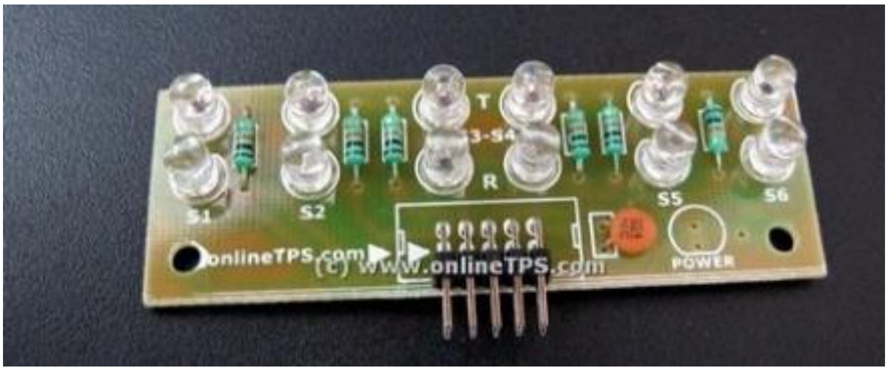
IR Imaging Devices

IR image device is one of the major applications of IR waves, primarily by virtue of its property that is not visible. It is used for thermal imagers, night vision devices, etc.

For examples Water, rocks, soil, vegetation, an atmosphere, and human tissue all features emit IR radiation. The Thermal infrared detectors measure these radiations in IR range and map the spatial temperature distributions of the object/area on an image. Thermal imagers usually composed of a Sb (indium antimonite), Gd Hg (mercury-doped germanium), Hg Cd Te (mercury-cadmium-telluride) sensors.An electronic detector is cooled to low temperatures using liquid helium or liquid nitrogen's. Then the Cooling the detectors ensures that the radiant energy (photons) recorded by the detectors comes from the terrain and not from the ambient temperature of objects within the scanner itself an IR imaging electronic devices.

7.1.2 Sensor Array

A sensor array is a group of sensors, usually deployed in a certain geometry pattern, used for collecting and processing electromagnetic or acoustic signals. The advantage of using a sensor array over using a single sensor lies in the fact that an array adds new dimensions to the observation, helping to estimate more parameters and improve the estimation performance. For example an array of radio antenna elements used for beamforming can increase antenna gain in the direction of the signal while decreasing the gain in other directions, i.e., increasing signal-to-noise ratio (SNR) by amplifying the signal coherently. Another example of sensor array application is to estimate the direction of arrival of impinging electromagnetic waves. The related processing method is called array signal processing. Application examples of array signal processing include radar/sonar, wireless communications, seismology, machine condition monitoring, astronomical observations fault diagnosis, etc.



Algorithm for Black Line Following (Using 3 IR Sensors) And Node Detection

Let the three IR be spaced enough that when on node all the IR sensors are turned off and while on line only the sensor in the centre is turned off.

1. If the sensor on left is turned off, the right motor is run at higher speed as compared to left motor till the time only centre IR sensor is turned off.
2. If the sensor on right is turned off, the left motor is run at higher speed as compared to right motor till the time only centre IR sensor is turned off.
3. If all the three IR sensors are turned off, it signifies the node has arrived and robot is functioned to stop and carry out the fire fighting mechanism.

7.1.3 Flame sensor

A flame detector is a sensor designed to detect and respond to the presence of a flame or fire. Responses to a detected flame depend on the installation, but can include sounding an alarm, deactivating a fuel line (such as a propane or a natural gas line), and activating a fire suppression system. When used in applications such as industrial furnaces, their role is to provide confirmation that the furnace is properly lit; in these cases they take no direct action beyond notifying the operator or control system. A flame detector can often respond faster and more accurately than a smoke or heat detector due to the mechanisms it uses to detect the flame.

7.1.3.1 Basic principle

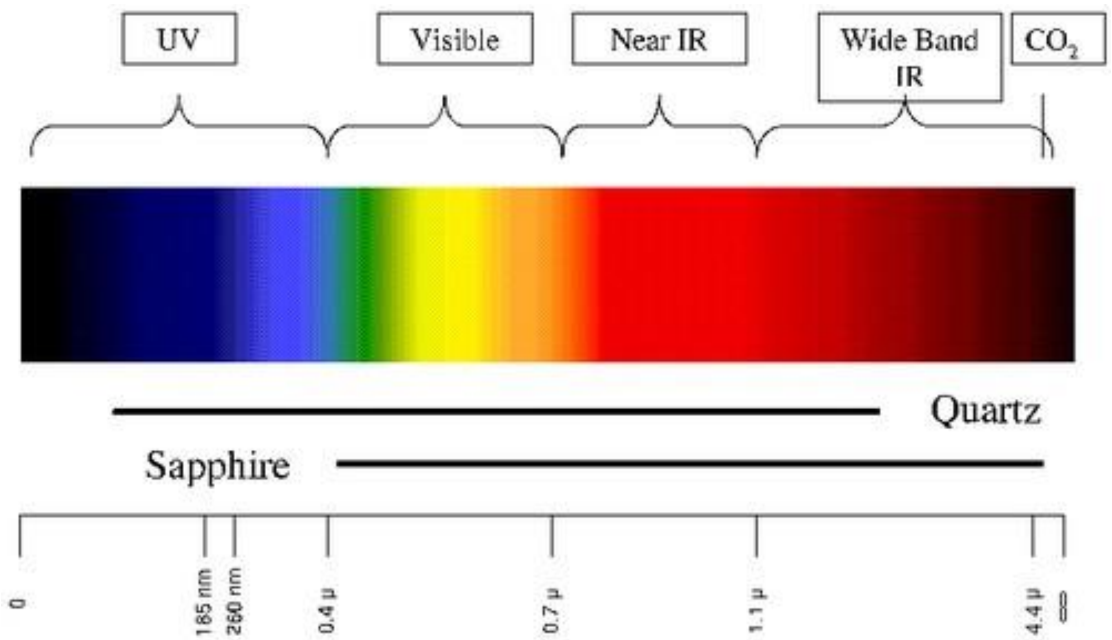
Flame detectors respond to the production of one or a combination of ultra-violet or infrared spectrums of electromagnetic radiation. These detectors are often used in situations where there is a potential for the rapid development of fire such as flammable liquids. These detectors comprise an electronic circuit with an electromagnetic radiation receiver. Flame detectors are

actuated when they receive electromagnetic radiation from one or more defined wave lengths are received according to their design in the ultra-violet or infrared spectrum.
One of the methods to improve the performance of flame detectors and reduce the effect of deceptive phenomena and false alarms has been to combine both ultra-violet and infra-red technologies into the one system or two or three separate wavelengths in the infrared spectrum.

7.1.3.2 Multi-sensor fire detectors

Over the last 20 years there has been a dramatic improvement in the ability of manufacturers to incorporate two or more of the technologies discussed this article, This combination of technologies has occurred to; (1) improve the performance of an existing method of fire detection; and (2) in some cases to reduce or eliminate the effect of deceptive phenomena causing false alarms. Multi-sensor detectors are not a panacea and must operate according to their approval. The combination of multiple sensors using clever algorithms that may suppress short term deceptive phenomena.

7.1.3.3 Types of flame sensor



7.1.3.4 Features that flame sensor must possess

- High Photo Sensitivity
- Fast Response Time
- Easy to use
- Sensitivity must be adjustable

The flame sensor used in the project is-

7.1.3.5 Usage:

These types of sensors are used for short range fire detection and can be used to monitor projects or as a safety precaution to cut devices off / on.

7.1.3.6 Range:

We have found this unit is mostly accurate up to about 3 feet.

7.1.3.7 How it works:

The flame sensor is very sensitive to IR wavelength at 760 nm ~ 1100 nm light.

Digital output (D0): When the temperature reaches a certain threshold, the output high and low signal threshold adjustable via potentiometer.

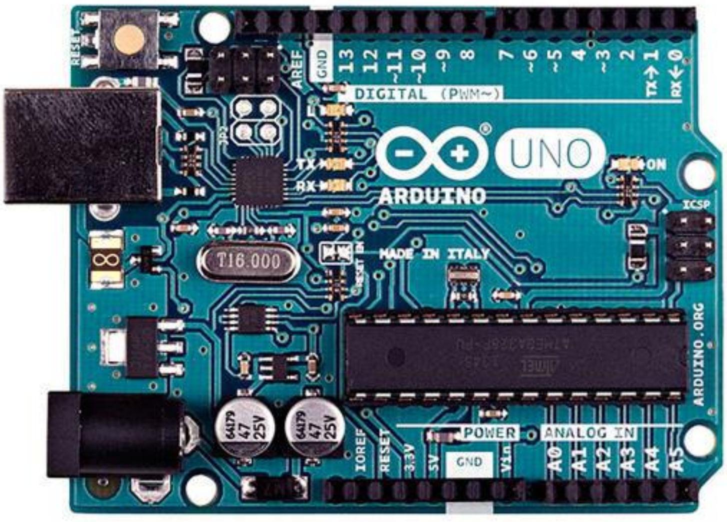
7.1.3.8 Pins:

VCC...... Positive voltage input: 3.3V

D0......... Digital output

GND..... Ground

7.1.3.9 Flame sensor connections with Arduino-



1. Connect D0 to any of the input pin of Arduino.
2. Connect GND to ground of Arduino board and VCC to 5V.
3. A flame, if detected, would show an output of "High Flame" and if not would show an output of "Low Flame"

7.1.4 Water pump

It will be connected to the Arduino.

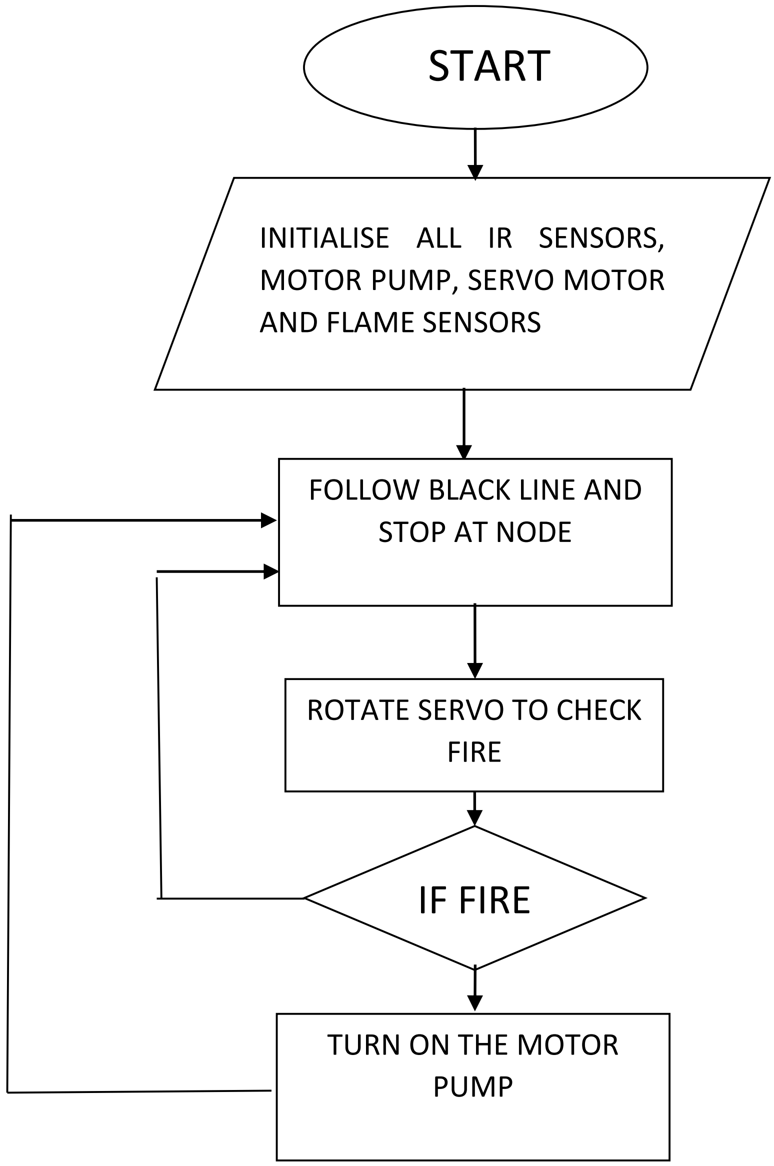
It is used to dispense water and control the fire.

The water pump is actually a sucker that has a water tank from which it sucks water and then throw it through the sprinkler. The pump is programmed so, that when the flame is detected i.e when the flame sensors are turned on, the water pumps starts working and the water is sprinkled aiming at the fire.

7.2 FINAL ALGORITHM FOR FIRE FIGHTING ROBOT

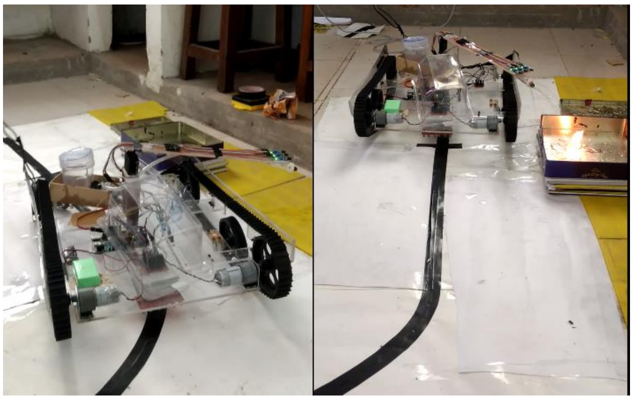
1. Robot starts from a point and begins following a line.
2. Just at the node, the robot stops and the arm, that is connected to servo and has flame sensors on its front, starts moving from its initial point.
3. As the arm moves the flame sensors detect the fire at each position.
4. As the flame sensors turn on, the water pump starts sprinkling water till the fire is doused.
5. After dousing the fire, the robot starts following the line and the procedure repeats when the node arrives.

7.3 *FLOW CHART FOR STAIR CLIMBING AND FIRE FIGHTING ROBOT*

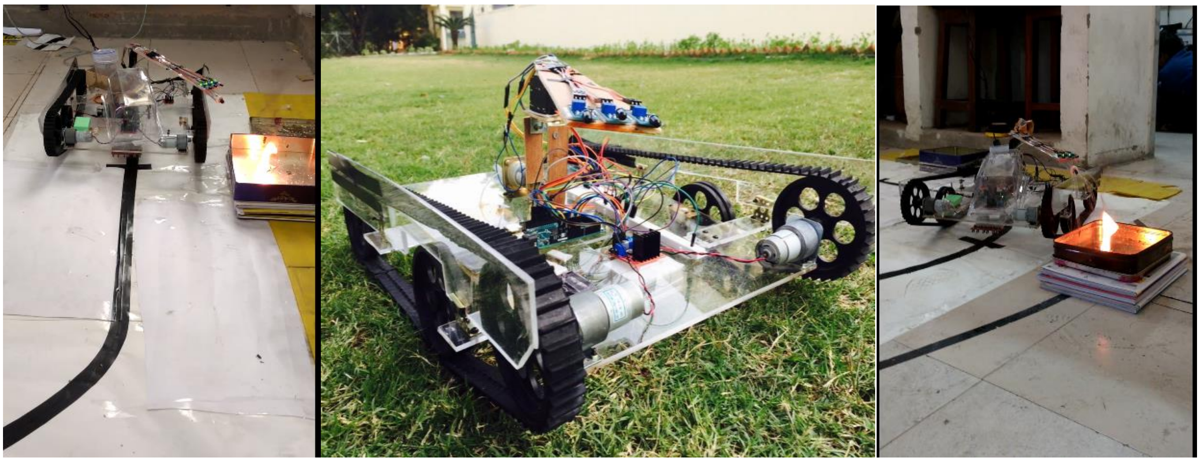


STAIR CLIMBING ACTION

LINE FOLLOW AND NODE DETECTION



FIRE FIGHTING ACTION



8 IMPLEMENTATION OF FIRE FIGHTING ROBOT USING IMAGE PROCESSING

Fire causes a huge loss to human life and property; hence early detection of fire is very important. Fire detectors, smoke detectors and temperature detectors have been widely used to protect property and give warning of fires.

Traditional methods like sensor based methods have many disadvantages: they have transmission delay; they are applicable mainly for indoor regions and cannot be used for outdoor regions to monitor a large area. While vision-based fire detection has many advantages: a large area can be monitored, the exact location of the fire can be located and can be fabricated along with the surveillance camera. With vision based fire detection, we can detect fire from afar.

To curb the disadvantages of using the IR Fire sensors in our robot we use Image Processing. The two-layer fire detection makes the fire detection system in our robot more robust and reduces the error.

8.1 WORKING OF THE ROBOT

Step 1

Through the camera attached to the front of the robot, the robot captures live video of the surroundings.

Step 2

Through programming, image is retrieved frame wise from the video. In each frame, the continuous process of fire detection takes place.

Step 3

If the fire is detected, the robot starts moving toward the fire.

Step 4

When the distance between the fire and the robot becomes less than 1 metre, the flame sensors attached to the robot switch on.

Step 5

When the flame sensors switched on, the robot is commanded to stop moving.

Step 6

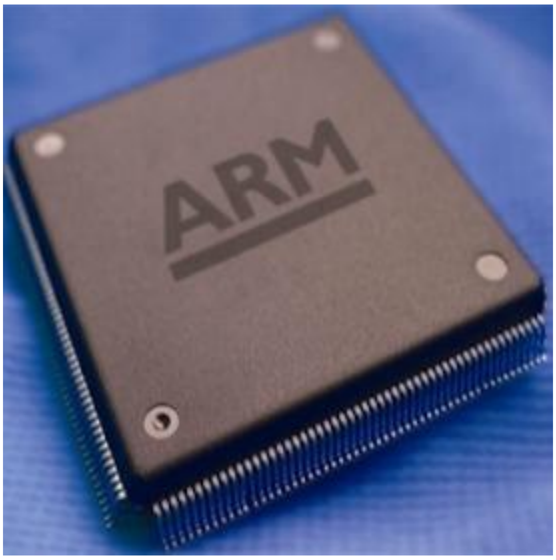
As soon as the robot stops, the pump action is initiated to douse the fire.

8.2 *COMPONENTS USED*

8.2.1 Raspberry Pi-2 MODULE

8.2.2 Processor

It has a 900MHz quad-core ARM Cortex-A7 CPU (Central Processing Unit). As it has an ARMv7 processor, which is a 32-bit microprocessor core, it can run the full range of ARM GNU/Linux distributions, including Snappy Ubuntu Core, as well as Microsoft Windows 10.



8.2.3 RAM

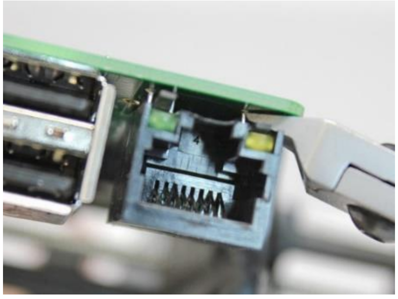
Raspberry Pi 2 has 1 GB RAM (Random Access Memory). It is a form of computer data storage which stores frequently used program instructions to increase the general speed of a system. A random-access memory device allows data items to be read or written in almost the same amount of time irrespective of the physical location of data inside the memory.

8.2.4 USB Ports

The Raspberry Pi 2 has four USB ports, where one can connect it to keyboards, mouse, WiFi dongles, and USB sticks containing all the files. Since the ports don't provide much power, if one wants to add a USB hub to the Pi one needs to find one that comes with an external power supply.

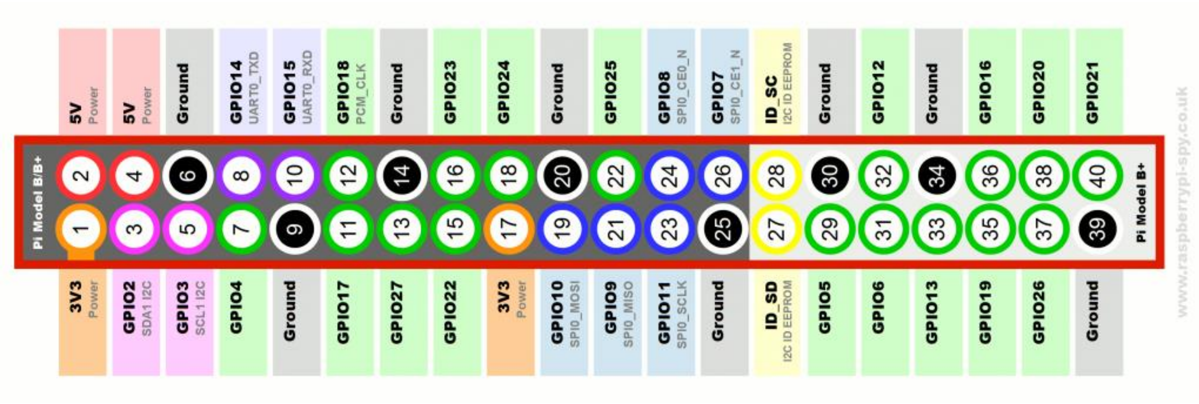
8.2.5 Ethernet Port

The traditional way to connect to the internet is via a wire called an Ethernet cable. One can find a few similar ports like this at the rear of the routers that will let one connect the Raspberry Pi directly into it. This method is easier to set up than WiFi and may provide faster internet, but one is then limited by the length of the cable.



8.2.6 GPIO Header

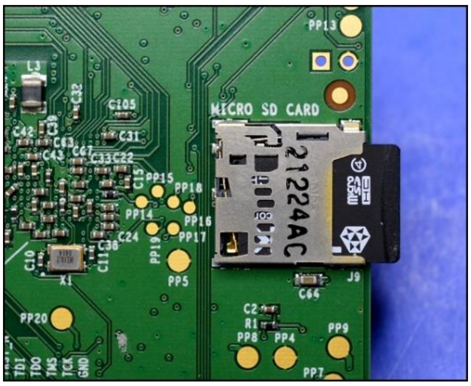
This comprises general-purpose input/output (GPIO) pins. They're a set of connections that have various functions, but their main one is to allow connection of Raspberry Pi with an electronic circuit. The Pi can also be programmed to control the circuit and do some amazing things with it.



The Raspberry Pi has digital inputs/outputs on its 40-pin connector that comply with 3.3V logic levels. 3.3V logic levels means that the Raspberry Pi will interpret anything very close to zero volts as a logic ‘0’ and anything higher than around 2V as a logic ‘1’. Inputs beyond 3.3V will damage the board. Similarly, when GPIO pins are configured to become outputs, the Raspberry Pi will set the pin to either a voltage close to 0V or a voltage close to 3.3V.

8.2.7 Micro SD Card Slot

A little SD card is used as the Raspberry Pi’s hard drive. This is where the operating system will live once it is loaded on there. Most computers won’t be able to directly connect to a micro SD card, so an adaptor that plugs into normal SD card slots is used. We use a Class 10, 16 GB Micro SD Card.

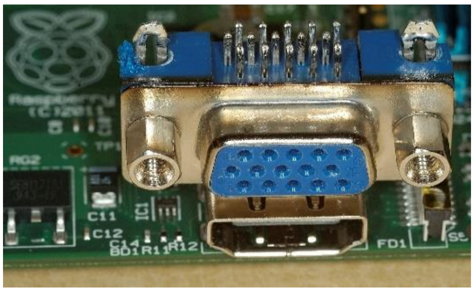


8.2.8 Power

This is the kind of small charging port one might find in their smartphone. With this micro-USB port one can power the Pi with the right kind of mobile phone charger or directly from the PC – however, it's best to use the official Raspberry Pi power supply to make sure the Pi is getting enough power.

8.2.9 HDMI Port

This is an HDMI (High-definition Multimedia Interface) port, it's also found on the back of most modern TVs and computer monitors. One can use a standard HDMI cable to connect the Raspberry Pi to a chosen screen, to see (and hear) whatever it's doing. One needs to plug it in to set up the Pi.



8.2.10 Audio Port

This looks like a headphone socket because that's exactly what it is. A 3.5mm jack to be precise, this allows to connect the Pi to computer speakers, or one could even plug in their favourite headphones.

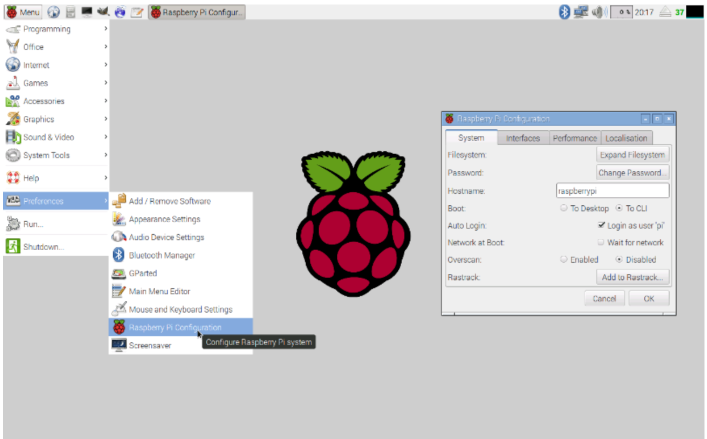
8.2.11 Operating System- Raspbian

A free Debian-based OS optimized for Raspberry Pi's hardware, Raspbian comes with all the **basic programs and utilities** you expect from a general-purpose operating system. Supported officially by the Raspberry foundation, this OS is popular for its fast performance and its more than 35,000 packages.

This operating system is loaded onto the MicroSD Card through the computer and the MicroSD Card is then inserted into the MicroSD Card slot in the Raspberry Pi module.

Interface

Raspbian with PIXEL (which stands for 'Pi Improved Xwindow Environment, Lightweight') is a huge software update to the desktop environment. It introduces a crisp new interface, and is brimming with new programs and features.



8.2.12 WiFi MODULE

WiFi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. The WiFi module we are using has a USB, because of which the connection between WiFi Module and Raspberry Pi Module can be made much more easily.

8.2.13 Logitech Camera

Logitech camera is used to capture live video stream of the surroundings. The captured video is divided into images(frames) which are processed individually to detect the fire.

8.3 PROGRAMMING SOFTWARE USED

The programming language Python has been used to write the program for Image processing. Python is a widely used high-level programming language for general-purpose programming, created by Guido van Rossum and first released in 1991. An interpreted language, Python has a design philosophy which emphasizes code readability (notably using whitespace indentation to delimit code blocks rather than curly braces or keywords), and a syntax which allows programmers to express concepts in fewer lines of code than possible in languages such as C++ or Java. The language provides constructs intended to enable writing clear programs on both a small and large scale.

The main reason for using Python for programming the Image Processing part of our robot was that it is highly compatible with Raspberry Pi.

8.3.1 Functions involved in the Program Code

- **Modules** (Python Source files) are imported to expose certain classes, function and global variables.

import cv2

This module contains functions related to video and image manipulation.

import math

By importing this module, one can use any mathematical function without prefixing math.

import numpy

NumPy is an extension to the Python programming language, adding support for large, multi-dimensional arrays and matrices, along with a large library of high-level mathematical functions to operate on these arrays.

import time

This module provides various time-related functions. For example, sleep().

import RPi.GPIO as GPIO

That statement “includes” the RPi.GPIO module, and goes a step further by providing a local name – GPIO – which we’ll call to reference the module from here on.

- **Setting up the GPIO mode**

  This function is used to determine which of the two **pin-numbering schemes** you want to use

GPIO.setmode(GPIO.BCM)

Broadcom chip-specific pin numbers. These pin numbers follow the lower-level numbering system defined by the Raspberry Pi’s Broadcom-chip brain.

GPIO.setmode(GPIO.BOARD)

Board numbering scheme. The pin numbers follow the pin numbers on header P1.

- **Setting a Pin Mode**

GPIO.setup(23, GPIO.OUT)

We have to declare a “pin mode” before we can use it, as either an input or output.

- **Digital Output**

GPIO.output(23, GPIO.HIGH)

We use this function to write the pin HIGH or LOW.

- ***cv2.VideoCapture(1)***

This function opens the Logitech Camera attached to Raspberry Pi.

- ***lower = np.array([15, 40, 255],np.uint8)***

  upper = np.array([255, 255, 255],np.uint8)

We create arrays containing BGR values of Flame Pixels. Here, the upper value for detection of flame pixel is taken as (255,255,255) while the lower values are (15,40,255).

The pixels having the values between the given upper and lower values will be the ones that would be detected through the further program.

- ***cv2.GaussianBlur(orig_img, (5,5), 0)***

  In image processing, a Gaussian blur (also known as Gaussian smoothing) is the result of blurring an image by a Gaussian function. It is a widely-used effect in graphics software, typically to reduce image noise and reduce detail.

- ***cv2.cvtColor(orig_img, cv2.COLOR_BGR2HSV)***

Using this function, we change color-space. I.e. we convert BGR values to HSV (Hue Saturation Values). R, G, and B components of an object's color in a digital image are all correlated with the amount of light hitting the object, and therefore with each other, image descriptions in terms of those components make object discrimination difficult. Descriptions in terms of hue/lightness/chroma or hue/lightness/saturation are often more relevant.

- ***cv2.resize()***

Scaling is just resizing of the image. The abovementioned function is available on OpenCV for this purpose. The size of the image can be specified manually, or we can specify the scaling factor.

- ***cv2.dilate()***

The above function is used to dilate an image. Dilation is a morphological image processing operations. Morphological image processing basically deals with modifying geometric structures in the image. Dilation adds an extra layer of pixels on a structure.

- ***cv2.inrange()***

In this function, we specify the arrays containing the upper and lower limits of BGR values of the flame. By using this function we specify the range of pixel values that need to be detected.

- ***cv2.findContours()***

Contours can be explained simply as a curve joining all the continuous points (along the boundary), having same color or intensity. The contours are a useful tool for shape analysis and object detection and recognition. Here, we use the function to find the boundary of the flame.

- ***cv2.drawContours()***

The above function is used to a draw contour around the detected flame.

9 CONCLUSION

In this project the robot is designed to climb stairs and extinguish fire. Thus this project would be an advancement over the prior Fire Fighting Robots upon the implementation of Image processing. This project is presenting a unique vision of the concepts which are used in this particular field. It aims to promote technology innovation to achieve a reliable and efficient outcome from the various instruments. The analysis result shows that higher efficiency is indeed achieved using the embedded system. With a common digitalized platform, these latest instruments will enable increased flexibility in control, operation, and expansion; allow for embedded intelligence, essentially foster the resilience of the instruments; and eventually benefit the customers with improved services, reliability and increased convenience. This project presents the major features and functions of the various concepts that could be used in this field in detail through various categories.

10 PROSPECTIVE APPLICATION

- It can be used for defense purposes.
- It will help in fighting forest fires.
- This robot will be able to go to places were human life can be at risk and can help in surveillance, as a camera will be placed at the front side of the robot which will send live video to the device linked with it.
- This can be used near electric circuits in schools, colleges and hospitals.
- The potential application of the multifunctional firefighting system has been defined as a group that includes the chemical and oil industry, nuclear plants, military storage facilities, as well as mine fields and dangerous substance transport.

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