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Fabrication of stair climbing robot

[1]M P Durga Prasad, [2]N Pavan Kumar, [3]T Tejesh, [4]M V Sai Ram
[5]V Jay Govind, [6]Mr.J. Rajasekhar

[6]Assistant Professor, Department of Information Technology,Aditya Engineering College (A), Surampalem, Andhra Pradesh, India.
@aec.edu.in
[1,2, 3, 4, 5]Student, Department of Information Technology, Aditya Engineering College (A), Surampalem, Andhra Pradesh, India.
18A91A03E6@aec.edu.in, 18A91A03F0@aec.edu.in, 18A91A03G8@aec.edu.in, 18A91A03D9@aec.edu.in, 18A91A03H1@aec.edu.in, rajasekharj@aec.edu.in

Abstract
Stairs are common obstacles in indoor environments and are difficult to overcome for robots. The speed of robot stair-climbing should be similar to that of humans for commercial products, but their speed remains limited. Additionally, the variety of dimensions of stairs is also a significant problem for robust stair-climbing by robots. In this paper, a curved spoke based tri-wheel mechanism is proposed for fast and robust stair-climbing. The goal speed of stair-climbing is similar to the human speed for variously sized stairs. The proposed wheel system is composed of a tri-wheel mechanism with a curved spoke, wherein the dimensions of the mechanism are determined based on a kinematic analysis. Between the tri-wheels, a stopper mechanism acts to make the initial condition of the sequential stair-climbing the same as the initial starting condition. Static analysis to analyse the minimum friction coefficient is performed to verify the performance of the robot. Experiments based on the prototype are performed to verify the stair-climbing speed for variously sized stairs; the results indicate that fast and robust stair climbing performance is achieved. These findings can be used to design an indoor service robot for various applications.

Introduction

1.1 STAIR CLIMBING ROBOT INTRODUCTION

Stairways are omnipresent in man-made environments. These were designed to easily bridge large vertical distances for humans. However, stairs represent a serious challenge to vehicles and robots during the time of disaster such as fire, earthquakes. There is a strong demand for mobile robots that can climb the stairs, for example, to aid people who have difficulty in walking, in urban search and rescue or urban reconnaissance. However, there are few robots that are suitable for use in rough terrains.

Each classification of mobile robot possesses their unique advantages and suffers from certain disadvantages. For the legged robots, they have the capability to adapt to many kinds of unstructured environment and in doing so they can stabilize themselves as different legs can orient themselves with independent configuration. Nonetheless, these robots are instinctively complex and are comparatively slow. The wheeled robot can relate for the slow locomotive speeds of legged robots as they can move faster because of their rolling motion. However in unstructured conditions, their mobility is often very inadequate and highly depends on the type of surroundings and the typical size of encounter obstacle.

Caterpillars reveal splendid rough terrain capacity due to their steadiness and good friction coefficient whilst moving. The points of interest are simplicity and robustness, however the friction losses between the surface and the robot when the robot's turning are high.

To have a platform with legs that are able to strategically choose contact points on the ground is a vast advantage over wheels in many ways. Not only because of the previously mentioned reason that it can step over obstacles, but also for the fact that it can move smoothly over terrain. Consider a statically stable robot that moves one leg at the time and gently places it at a new stable position, the main body of such a robot would move forward smoothly like a boat, even on really rough terrain like in a forest.

The tracked mobile robots have high off-road capability yet ordinarily have overwhelming weight. However, the tracked mobile robots have low energy efficiency in turning motions. On the other hand, the legged mobile robots have great adaptability in rough terrain but usually involve a complex locomotive mechanism which needs complicated control algorithms.

The wheel has always been the easiest way to implement mobility in a vehicle, and also the fastest method of travel. Relative to speed it is also the most energy efficient way to travel. The implementation is often very simple, and does not require any advanced techniques such as vector controllers or additional joints to get the robot moving.

The locomotion of all wheeled robots can be primarily categorized as active and passive locomotion. Passive locomotion is a concept based on passive suspensions which involves no sensors or any additional actuators and at the same time guarantees stable movement. Whereas, an active robot generally has an entrenched closed loop control this maintain the solidity of the system during motion. Under this definition, Sojourner, and Micro5 are passive robots; walking machines, Nano rover and Space Cat are active robots; Marsokhod and Hybtor are hybrid robots based on their locomotion mode.

It is clear that active locomotion extends the mobility of a robot but simultaneously increases the complexity. It also needs extended control and power resources. However, in many fields of application, power consumption, complexity and reliability are predominant criteria. This is especially the case for planetary rovers. Therefore this work is devoted towards the development of a passive locomotive concept. The robot will combine the advantages of wheeled and leg robots, i.e., it will have the capability of moving fast on smooth surface as well as adapting itself to unstructured terrains owing to its flexible frame design, which allows independent roll of the front and rear wheels.

1.2 GALVANIZED IRON AND HISTORY

From nails and bolts to bridges and framing components, countless items are made of galvanized iron. Galvanized iron has actually been around for centuries, with some of the earliest recorded uses dating back to the 17th century. In recent years, however, it's become an increasingly popular alternative to traditional iron as well as other metals and alloys. Unless you're familiar with it, though, you might be wondering what is galvanized iron and how it differs from standard iron. Below, you'll learn more about galvanized iron.

Galvanized iron is essentially iron that's been coated with a protective zinc layer on the outside. Iron itself is susceptible to weather-related degradation. When exposed to moisture and oxygen, for example, iron will rust and corrode. Over time, the presence of

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the rust and corrosion can eat through the iron, essentially jeopardizing its structural integrity. Thankfully, galvanization offers a simple and effective way to protect iron from weather-related degradation such as this.

1.3 MILD STEEL AND HISTORY

Mild steel is a ferrous metal made from iron and carbon. It is a low-priced material with properties that are suitable for most general engineering applications. Low carbon mild steel has good magnetic properties due to its high iron content; it is therefore defined as being 'ferromagnetic'.

Mild steel has a carbon content of between 0.16% and 0.29 % maximum with a relatively high melting point of between 1450°C to 1520°C. Steels with higher carbon content than mild steel, have a lower melting temperature. This high melting temperature means that mild steel is more ductile when heated, making it particularly suitable for forging, cutting, drilling, welding and is easy to fabricate.

Mild steel is not suitable for through hardening. It can be case hardened by being heated and a chemically reactive source of carbon added, the subsequent quench cycle will harden the surface layer. This outer layer, 'the case' will become hardened.

Mild steel does not have a high resistance to corrosion in its untreated form, however, the corrosion resistance can be greatly improved by applying an appropriate surface protection product to the exposed parts of any project. There is a wide range of red oxide primers, metal paint, metal spray paint and zinc treatments available to enhance the appearance of mild steel and to protect it from rust and corrosion.

Mild steel can be cleaned by 'pickling'. This is a chemical surface treatment that removes stains, contaminants, rust and scale. Surface rust can also be removed by mechanical grinding and then treating with a surface protector such as red oxide primer, zinc primer and metal paints and sprays.

1.4 DC MOTORS AND HISTORY

A DC motor is any of a class of rotary electrical motors that converts direct current (DC) electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current in part of the motor.

DC motors were the first form of motor widely used, as they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight brushed motor used for portable power tools and appliances. Larger DC motors are currently used in propulsion of electric vehicles, elevator and hoists, and in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

1.5 INTRODUCTION TO EMBEDDED SYSTEMS

An embedded system can be defined as a computing device that does a specific focused job. Appliances such as the air-conditioner, VCD player, DVD player, printer, fax machine, mobile phone etc. are examples of embedded systems. Each of these appliances will have a processor and special hardware to meet the specific requirement of the application along with the embedded software that is executed by the processor for meeting that specific requirement. The embedded software is also called "firm ware". The desktop/laptop computer is a general purpose computer. You can use it for a variety of applications such as playing games, word processing, accounting, software development and so on. In contrast, the software in the embedded systems is always fixed listed below:

Embedded systems do a very specific

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task, they cannot be programmed to do different things. . Embedded systems have very limited resources, particularly the memory. Generally, they do not have secondary storage devices such as the CDROM or the floppy disk. Embedded systems have to work against some deadlines. A specific job has to be completed within a specific time. In some embedded systems, called real-time systems, the deadlines are stringent. Missing a deadline may cause a catastrophe-loss of life or damage to property. Embedded systems are constrained for power. As many embedded systems operate through a battery, the power consumption has to be very low.

1.6 OVERVIEW OF EMBEDDED SYSTEM ARCHITECTURE

Every embedded system consists of custom-built hardware built around a Central Processing Unit (CPU). This hardware also contains memory chips onto which the software is loaded. The software residing on the memory chip is also called the 'firmware'. The embedded system architecture can be represented as a layered architecture as shown in Fig(1.6).

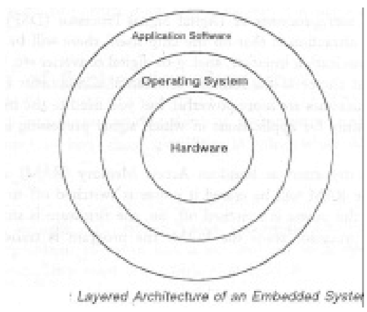

Fig:1.6 Layered Architecture of Embedded Systems

The operating system runs above the hardware, and the application software runs above the operating system. The same architecture is applicable to any computer including a desktop computer. However, there are significant differences. It is not compulsory to have an operating system in every embedded system. For small appliances such as remote control units, air conditioners, toys etc., there is no need for an operating system and you can write only the software specific to that application. For applications involving complex processing, it is advisable to have an operating system. In such a case, you need to integrate the application software with the operating system and then transfer the entire software on to the memory chip. Once the software is transferred to the memory chip, the software will continue to run for a long time you don't need to reload new software.

Now, let us see the details of the various building blocks of the hardware of an embedded system. As shown in Fig. the building blocks are;

- Central Processing Unit (CPU)
- Memory (Read-only Memory and Random Access Memory)
- Input Devices
- Output devices
- Communication interfaces
- Application-specific circuitry

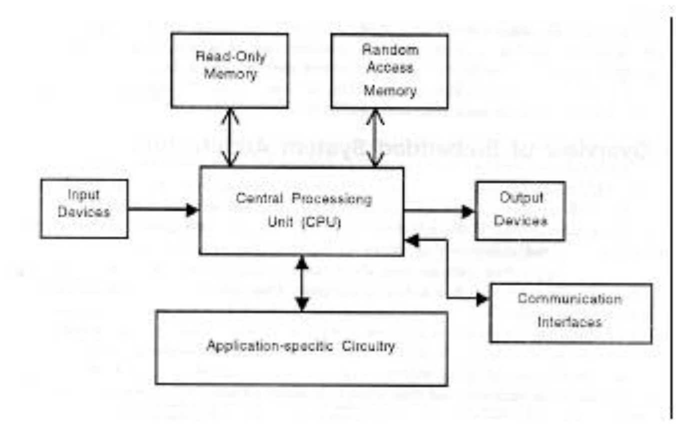

Fig:1.6.1 Building blocks of the hardware of an embedded system

1.6.1 CENTRAL PROCESSING UNIT (CPU)

The Central Processing Unit (processor, in short) can be any of the following: microcontroller, microprocessor or Digital Signal Processor (DSP). A micro-controller is a low-cost processor. Its main attraction is that on the chip itself, there will be many other components such as memory, serial communication interface, analog-to digital converter etc. So, for small applications, a micro-controller is the best choice as the number of external components required will be very less. On the other hand, microprocessors are more powerful, but you need to use many external components with them. D5P is used mainly for applications in which signal processing is involved such as audio and video processing.

1.6.2 MEMORY

The memory is categorized as Random Access 11emory (RAM) and Read Only Memory (ROM). The contents of the RAM will be erased if power is switched off to the chip, whereas ROM retains the contents even if the power is switched off. So, the firmware is stored in the ROM. When power is switched on, the processor reads the ROM; the program is program is executed.

1.6.3 INPUT DEVICES

Unlike the desktops, the input devices to an embedded system have very limited capability. There will be no keyboard or a mouse, and hence interacting with the embedded system is no easy task. Many embedded systems will have a small keypad-you press one key to give a specific command.

1.6.4 OUTPUT DEVICES

The output devices of the embedded systems also have very limited capability. Some embedded systems will have a few Light Emitting Diodes (LEDs) to indicate the health status of the system modules, or for visual indication of alarms. A small Liquid Crystal Display (LCD) may also be used to display some important parameters.

1.6.5 COMMUNICATION INTERFACES

The embedded systems may need to, interact with other embedded systems at they may have to transmit data to a desktop. To facilitate this, the embedded systems are provided with one or a few communication interfaces such as RS232, RS422, RS485, Universal Serial Bus (USB), IEEE 1394, Ethernet etc.

1.6.6APPLICATION-SPECIFIC CIRCUITRY:

Sensors, transducers, special processing and control circuitry may be required fat an embedded system, depending on its application. This circuitry interacts with the processor to carry out the necessary work. The entire hardware has to be given power supply either through the 230 volts main supply or through a battery. The hardware has to design in such a way that the power consumption is minimized.

ENGINEERING MATERIALS

2.1 DC MOTORS

A DC motor is an electric motor that runs on direct current (DC) electricity. DC motors were used to run machinery, often eliminating the need for a local steam engine or internal combustion engine. DC motors can operate directly from rechargeable batteries, providing the motive power for the first electric vehicles. Today DC motors are still found in applications as small as toys and disk drives, or in large sizes to operate steel rolling mills and paper machines. Modern DC motors are nearly always operated in conjunction with power electronic devices.

2.2 TYPES OF MOTORS

2.2.1 PERMANENT-MAGNET ELECTRIC MOTORS

A permanent-magnet motor does not have a field winding on the stator frame, instead relying on permanent magnets to provide the magnetic field against which the rotor field interacts to produce torque. Compensating windings in series with the armature may be used on large motors to improve commutation under load. Because this field is fixed, it cannot be adjusted for speed control. Permanent-magnet fields (stators) are convenient in miniature motors to eliminate the power consumption of the field winding. Most larger DC motors are of the "dynamo" type, which have stator windings.

2.2.2 BRUSHED DC ELECTRIC MOTOR

Workings of a brushed electric motor with a two-pole rotor and permanent-magnet stator. ("N" and "S" designate polarities on the inside faces of the magnets; the outside faces have opposite polarities.)

DC motors have AC in a wound rotor also called an armature, with a split ring commutator, and either a wound or permanent magnet stator. The commutator and brushes are a long-life rotary switch. The rotor consists of one or more coils of wire wound around a laminated "soft" ferromagnetic core on a shaft; an electrical power source feeds the rotor windings through the commutator and its brushes, temporarily magnetizing the rotor core in a specific direction. The commutator switches power to the coils as the rotor turns, keeping the magnetic poles of the rotor from ever fully aligning with the magnetic poles of the stator field, so that the rotor never stops (like a compass needle does), but rather keeps rotating as long as power is applied.

While most commutators are cylindrical, some are flat discs consisting of several segments (typically, at least three) mounted on an insulator.

2.2.3 BRUSHLESS DC ELECTRIC MOTOR

Some of the problems of the brushed DC motor are eliminated in the brushless design. In this motor, the mechanical "rotating switch" or commutator/brush gear assembly is replaced by an external electronic switch synchronized to the rotor's position. Brushless motors are typically 85–90% efficient or more, efficiency for a brushless electric motor, of up to 96.5% was reported whereas DC motors with brush gear are typically 75–80% efficient.

Brushless DC motors are commonly used where precise speed control is necessary, as in computer disk drives or in video cassette recorders, the spindles within CD, CD-ROM (etc.) drives, and mechanisms within office products such as fans, laser printers and photocopiers. They have several advantages over conventional motors:

2.2.4 SWITCHED RELUCTANCE MOTOR

The switched reluctance motor (SRM) has no brushes or permanent magnets, and the rotor has no electric currents. Instead, torque comes from a slight mis-alignment of poles on the rotor with poles on the stator. The rotor aligns itself with the magnetic field of the stator, while the stator field stator windings are sequentially energized to rotate the stator field.

The magnetic flux created by the field windings follows the path of least magnetic reluctance, meaning the flux will flow through poles of the rotor that are closest to the energized poles of the stator, thereby magnetizing those poles of the rotor and creating torque. As the rotor turns, different windings will be energized, keeping the rotor turning.

3.2.5 CORELESS OR IRONLESS DC MOTORS

Nothing in the principle of any of the motors described above requires that the iron (steel) portions of the rotor actually rotate. If the soft magnetic material of the rotor is made in the form of a cylinder, then (except for the effect of hysteresis) torque is exerted only on the windings of the electromagnets. Taking advantage of this fact is the coreless or ironless DC motor, a specialized form of a brush or brushless DC motor. Optimized for rapid acceleration, these motors have a rotor that is constructed without any iron core. The rotor can take the form of a winding-filled cylinder, or a self-supporting structure comprising only the magnet wire and the bonding material. The rotor can fit inside the stator magnets; a magnetically soft stationary cylinder inside the rotor provides a return path for the stator magnetic flux. A second arrangement has the rotor winding basket surrounding the stator magnets. In that design, the rotor fits inside a magnetically soft cylinder that can serve as the housing for the motor, and likewise provides a return path for the flux.

2.2.6 PRINTED ARMATURE OR PANCAKE DC MOTORS

A rather unusual motor design, the printed armature or pancake motor has the windings shaped as a disc running between arrays of high-flux magnets. The magnets are arranged in a circle facing the rotor with space in between to form an axial air gap. This design is commonly known as the pancake motor because of its extremely flat profile, although the technology has had many brand names since its inception, such as Servo Disc.

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2.2.7 UNIVERSAL MOTORS

Modern low-cost universal motor, from a vacuum cleaner. Field windings are dark copper colored, toward the back, on both sides. The rotor's laminated core is gray metallic, with dark slots for winding the coils. The commutator (partly hidden) has become dark from use; it's toward the front. The large brown molded-plastic piece in the foreground supports the brush guides and brushes (both sides), as well as the front motor bearing.

2.3 SELECTION OF MOTOR

Among these above motors dc brushed motors are more preferable for the demo project due to its low cost and high reliability.

Brushed DC motors are one of the oldest motor topologies in existence today. They use stationary brushes mounted to the stator frame which rub against commutator segments on the rotor, which in turn are connected to the rotating coil segments. As the rotor spins, different rotor coils are connected and disconnected in such a way that the net magnetic field produced by the rotor is stationary with respect to the stator frame, and properly oriented with the stator magnetic field so as to produce torque. As the commutator segments rotate past the brushes, the electrical contacts to those particular rotor coil segments will be broken. Since the rotor coils are inductive, and inductors oppose changes in their current by generating a high fly back voltage, sparks are produced between the brushes and the disconnected commutator segments. These sparks result in many negative consequences, such as electrical noise, reduced efficiency, and in some cases, hazardous operation. Furthermore, the brushes must be spring loaded against the commutator segments in order to insure good electrical contact. This further reduces efficiency, and requires periodic maintenance to replace the brushes.

2.4 CRYSTAL OSCILLATOR

The 8051 uses the crystal for precisely that: to synchronize it's operation. Effectively, the 8051 operates using what are called "machine cycles." A single machine cycle is the minimum amount of time in which a single 8051 instruction can be executed. Although many instructions take multiple cycles. 8051 has an on-chip oscillator. It needs an external crystal that decides the operating frequency of the 8051. The crystal is connected to pins 18 and 19 with stabilizing capacitors. 12 MHz (11.059MHz) crystal is often used and the capacitance ranges from 20pF to 40pF.

A cycle is, in reality, 12 pulses of the crystal. That is to say, if an instruction takes one machine cycle to execute, it will take 12 pulses of the crystal to execute. Since we know the we can calculate how many instruction cycles the 8051 can execute per second:

11,059,000 / 12 = 921,583

11.0592 MHz crystals are often used because it can be divided to give you exact clock rates for most of the common baud rates for the UART, especially for the higher speeds (9600, 19200).

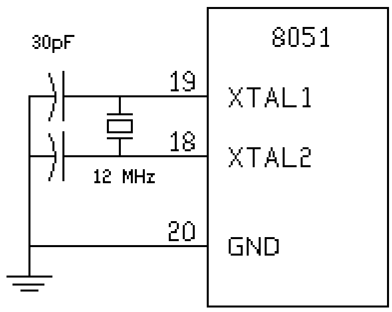

Fig 3.4: Crystal Oscillator

2.4.1 RESET

RESET is an active High input When RESET is set to High, 8051 goes back to the power on state. The 8051 is reset by holding the RST high for at least two machine cycles and then returning it low. Initially charging of capacitor makes RST High, when capacitor charges fully it blocks DC.

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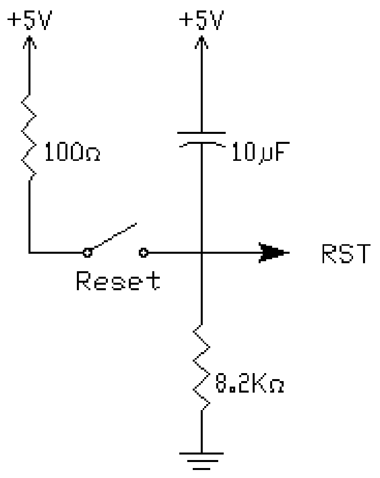

Fig 2.4.1: RESET

2.4.2 SIP RESISTOR

Sip Resistor is a single in pack Resistor (i.e.,) 8 resistors connected in series. Basically SIP resistor is a 9 pin connector first pin is for power supply to the entire 8 resistors in SIP. Generally SIP Resistor is used to close the open drain connections of Port 0.

2.5 LIQUID CRYSTAL DISPLAY

2.5.1 INTRODUCTION:

LCD stands for **L**iquid **C**rystal **D**isplay. LCD is finding wide spread use replacing LEDs (seven segment LEDs or other multi segment LEDs) because of the following reasons:

1. The declining prices of LCDs.
2. The ability to display numbers, characters and graphics. This is in contrast to LEDs, which are limited to numbers and a few characters.
3. Incorporation of a refreshing controller into the LCD, thereby relieving the CPU of the task of refreshing the LCD. In contrast, the LED must be refreshed by the CPU to keep displaying the data.

4. Ease of programming for characters and graphics.

These components are "specialized" for being used with the microcontrollers, which means that they cannot be activated by standard IC circuits. They are used for writing different messages on a miniature LCD.

A model described here is for its low price and great possibilities most frequently used in practice. It is based on the HD44780 microcontroller (*Hitachi*) and can display messages in two lines with 16 characters each.

It displays all the alphabets, Greek letters, punctuation marks, mathematical symbols etc. In addition, it is possible to display symbols that user makes up on its own. Automatic shifting message on display (shift left and right), appearance of the pointer, backlight etc. are considered as useful characteristics.

2.5.2 **PIN DESCRIPTION OF LCD**

2.5.3 PIN FUNCTIONS

There are pins along one side of the small printed board used for connection to the microcontroller. There are total of 14 pins marked with numbers (16 in case the background light is built

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in). Their function is described in the above table.

Function	Pin Number	Name	Logic State	Description
Ground	1	Vss	-	0V
Power supply	2	Vdd	-	+5V
Contrast	3	Vee	-	0 - Vdd
Control of operating	4	RS	0 1	D0 – D7 are interpreted commands D0 – D7 are interpreted a
	5	R/W	0 1	Write data (from controll LCD) Read data (from LCD controller)
	6	E	0 1	Access to LCD disabl Normal operating
Data / commands			From 1 to 0	Data/commands are transferred to LCD
	7	D0	0/1	Bit 0 LSB
	8	D1	0/1	Bit 1
	9	D2	0/1	Bit 2
	10	D3	0/1	Bit 3
	11	D4	0/1	Bit 4
	12	D5	0/1	Bit 5

2.5.4 LCD SCREEN:

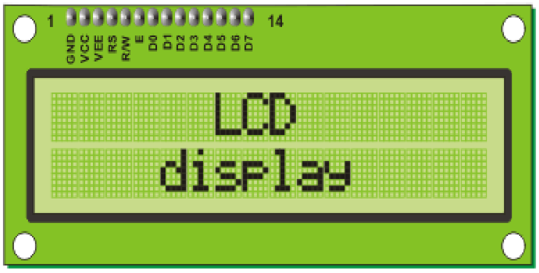

Fig 3.5.4: LCD Screen

LCD screen consists of two lines with 16 characters each. Each character consists of 5x7 dot matrix. Contrast on display depends on the power supply voltage and whether messages are displayed in one or two lines. For that reason, variable voltage 0-Vdd is applied on pin marked as Vee. Trimmer potentiometer is usually used for that purpose. Some versions of displays have built in backlight (blue or green diodes). When used during operating, a resistor for current limitation should be used (like with any LE diode).

2.5.5 LCD BASIC COMMANDS:

All data transferred to LCD through outputs D0-D7 will be interpreted as commands or as data, which depends on logic state on pin RS:

RS = 1 - Bits D0 - D7 are addresses of characters that should be displayed. Built in processor addresses built in "map of characters" and displays corresponding symbols. Displaying position is determined by DDRAM address. This address is either previously defined or the address of previously transferred character is automatically incremented.

RS = 0 - Bits D0 - D7 are commands which determine display mode. List of commands which LCD recognizes are given in the table below:

3.5.5 LCD COMMANDS

Command	RS	RW	D7	D6	D5	D4	D3	D2	D1	D0	Execution Time
Clear display	0	0	0	0	0	0	0	0	0	1	1.64mS
Cursor home	0	0	0	0	0	0	0	0	1	x	1.64mS
Entry mode set	0	0	0	0	0	0	0	1	I/D	S	40uS
Display on/off control	0	0	0	0	0	0	1	D	U	B	40uS

Cursor/Display Shift	0	0	0	0	0	1	D/C	R/L	x	x	40uS
Function set	0	0	0	0	1	DL	N	F	X	x	40uS
Set CGRAM address	0	0	0	1	CGRAM address						40uS
Set DDRAM address	0	0	1	DDRAM address							40uS
Read "BUSY" flag (BF)	0	1	BF	DDRAM address							-
Write to CGRAM or DDRAM	1	0	D7	D6	D5	D4	D3	D2	D1	D0	40uS
Read from CGRAM or DDRAM	1	1	D7	D6	D5	D4	D3	D2	D1	D0	40uS

2.5.6 LCD INITIALIZATION:

Once the power supply is turned on, LCD is automatically cleared. This process lasts for approximately 15mS. After that, display is ready to operate. The mode of operating is set by default. This means that:

1. Display is cleared
2. Mode

DL = 1 Communication through 8-bit interface

N = 0 Messages are displayed in one line

F = 0 Character font 5 x 8 dots

3. Display/Cursor on/off

D = 0 Display off

U = 0 Cursor off

B = 0 Cursor blink off

4. Character entry

ID = 1 Addresses on display are automatically incremented by 1

S = 0 Display shift off

Automatic reset is mainly performed without any problems. Mainly but not always! If for any reason power supply voltage does not reach full value in the course of 10mS, display will start perform completely unpredictably. If voltage supply unit cannot meet this condition or if it is needed to provide completely safe operating, the process of initialization by which a new reset enabling display to operate normally must be applied.

2.5.7 LCD INTERFACING

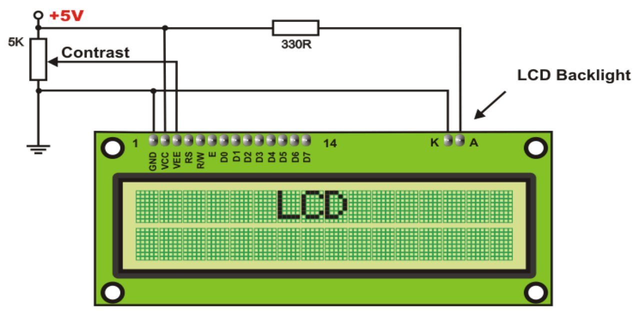

Fig 3.5.7 LCD Interfacing

Here the LCD interfacing is simple to design and to it is easy to communicate from the micro controller. All the data lines should be connected to any of the port of the controller and the command pins should be connected to any another port. That pins are RS, R/W, and ENABLE pin. For the power supply purpose we need to connect to any +5v

DC supply for the VCC and GND pins and the anode and cathode pins are connected to a same supply through a 5K resistance preset (or 5K variable resistor). When the commands are send to the command lines and data is send then LCD module will display the data accordingly.

2.6 LIGHT-EMITTING DIODE (LED)

Light-emitting diodes are elements for light signalization in electronics. They are manufactured in different shapes, colors and sizes. For their low price, low consumption and simple use, they have almost completely pushed aside other light sources- bulbs at first place. They perform similar to common diodes with the difference that they emit light when current flows through them.

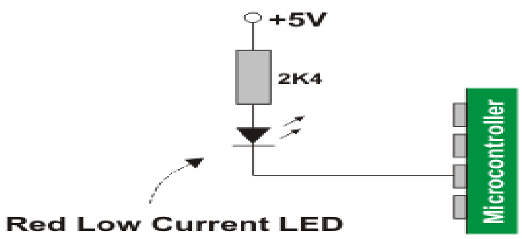

Fig 2.6 LED Interfacing with 89C51 Microcontroller

It is important to know that each diode will be immediately destroyed unless its current is limited. This means that a conductor must be connected in parallel to a diode. In order to correctly determine value of this conductor, it is necessary to know diode's voltage drop in forward direction, which depends on what material a diode is made of and what color it is. There are three main types of LEDs. Standard ones get full brightness at current of 20mA. Low Current diodes get full brightness at ten time's lower current while Super Bright diodes produce more intensive light than Standard ones.

2.7 INTRODUCTION TO MICROCONTROLLER

Based on the Processor side Embedded Systems is mainly divided into 3 types

1. Micro Processor: - are for general purpose e.g. our personal computer

2. Micro Controller: - are for specific applications, because of cheaper cost we will go for these

3. DSP (Digital Signal Processor):- are for high and sensitive application purpose

2.7.1 MICROCONTROLLER VERSUS MICROPROCESSOR

A system designer using a general-purpose microprocessor such as the Pentium or the 68040 must add RAM, ROM, I/O ports, and timers externally to make them functional. Although the addition of external RAM, ROM, and I/O ports makes these systems bulkier and much more expensive, they have the advantage of versatility such that the designer can decide on the amount of

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RAM, ROM and I/O ports needed to fit the task at hand.

A Microcontroller has a CPU (a microprocessor) in addition to a fixed amount of RAM, ROM, I/O ports, and a timer all on a single chip. In other words, the processor, the RAM, ROM, I/O ports and the timer are all embedded together on one chip; therefore, the designer cannot add any external memory, I/O ports, or timer to it. The fixed amount of on-chip ROM, RAM, and number of I/O ports in Microcontrollers makes them ideal for many applications in which cost and space are critical.

2.8 WHAT IS ARDUINO?

Arduino is an open source programmable circuit board that can be integrated into a wide variety of maker space projects both simple and complex. This board contains a microcontroller which is able to be programmed to sense and control objects in the physical world. By responding to sensors and inputs, the Arduino is able to interact with a large array of outputs such as LEDs, motors and displays. Because of it's flexibility and low cost, Arduino has become a very popular choice for makers and maker spaces looking to create interactive hardware projects.

2.8.1 ARDUINO UNO

One of the most popular Arduino boards out there is the Arduino Uno. While it was not actually the first board to be released, it remains to be the most actively used and most widely documented on the market. Because of its extreme popularity, the Arduino Uno has a ton of project tutorials and forums around the web that can help you get started or out of a jam. We're big fans of the Uno because of its great features and ease of use.

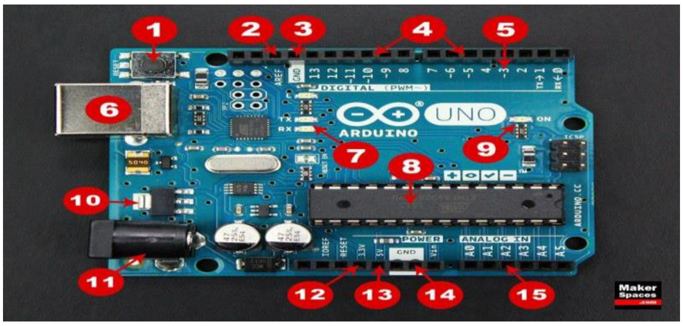

Fig 2.8.1: Arduino UNO

BOARD BREAKDOWN

Here are the components that make up an Arduino board and what each of their functions are.

1. **Reset Button** – This will restart any code that is loaded to the Arduino board
2. **AREF** – Stands for "Analog Reference" and is used to set an external reference voltage
3. **Ground Pin** – There are a few ground pins on the Arduino and they all work the same
4. **Digital Input/Output** – Pins 0-13 can be used for digital input or output
5. **PWM** – The pins marked with the (~) symbol can simulate analog output

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6. **USB Connection** – Used for powering up your Arduino and uploading sketches

7. **TX/RX** – Transmit and receive data indication LEDs

8. **ATmega Microcontroller** – This is the brains and is where the programs are stored

9. **Power LED Indicator** – This LED lights up anytime the board is plugged in a power source

10. **Voltage Regulator** – This controls the amount of voltage going into the Arduino board

11. **DC Power Barrel Jack** – This is used for powering your Arduino with a power supply

12. **3.3V Pin** – This pin supplies 3.3 volts of power to your projects

13. **5V Pin** – This pin supplies 5 volts of power to your projects

14. **Ground Pins** – There are a few ground pins on the Arduino and they all work the same

15. **Analog Pins** – These pins can read the signal from an analog sensor and convert it to digital

2.8.2 ARDUINO POWER SUPPLY

The Arduino Uno needs a power source in order for it to operate and can be powered in a variety of ways. You can do what most people do and connect the board directly to your computer via a USB cable. If you want your project to be mobile, consider using a 9V battery pack to give it juice. The last method would be to use a 9V AC power supply.

Fig 2.8.2: Arduino Power Supply

2.9 POWER SUPPLY:

The input to the circuit is applied from the regulated power supply. The ac. input i.e., 230V from the mains supply is step down by the transformer to 12V and is fed to a rectifier. The output obtained from the rectifier is a pulsating dc voltage. So in order to get a pure dc voltage, the output voltage from the rectifier is fed to a filter to remove any ac components present even after rectification. Now, this voltage is given to a voltage regulator to obtain a pure constant dc voltage.

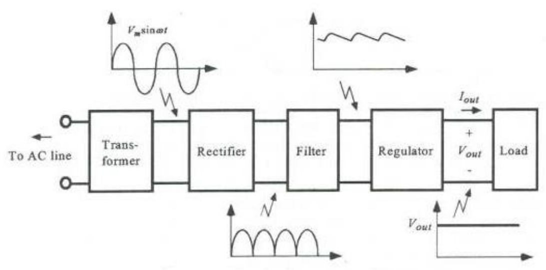

Fig 2.9: Components of a regulated power supply

2.10 TRANSFORMER:

Usually, DC voltages are required to operate various electronic equipment and these voltages are 5V, 9V or 12V. But these voltages cannot be obtained directly. Thus the AC input available at the mains supply i.e., 230V is to be brought down to the required voltage level. This is done by a transformer. Thus, a step down transformer is employed to decrease the voltage to a required level.

2.11 RECTIFIER:

The output from the transformer is fed to the rectifier. It converts A.C. into pulsating D.C. The rectifier may be a half wave or a full wave rectifier. In this project, a bridge rectifier is used because of its merits like good stability and full wave rectification.

2.12 FILTER:

Capacitive filter is used in this project. It removes the ripples from the output of rectifier and smoothens the D.C. Output received from this filter is constant until the mains voltage and load is maintained constant. However, if either of the two is varied, D.C. voltage received at this point changes. Therefore a regulator is applied at the output stage.

2.13 VOLTAGE REGULATOR:

As the name itself implies, it regulates the input applied to it. A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level. In this project, power supply of 5V and 12V are required. In order to obtain these voltage levels, 7805 and 7812 voltage regulators are to be used. The first number 78 represents positive supply and the numbers 05, 12 represent the required output voltage levels.

MATERIALS USED FOR THE ROBOT

4.1 3/4TH GI SQUARE PIPE

It is the one by which the entire frame of the robot is manufactured. It is selected because of its high strength and less weight compared to other metals.

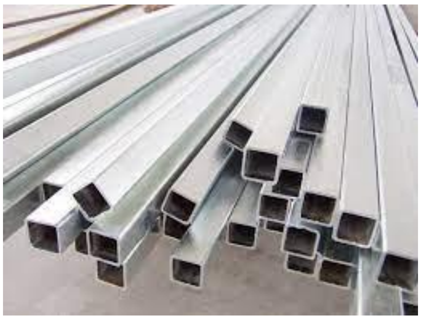

Fig 4.1: GI Square Pipe

4.2 MOTOR

A DC motor is used which helps us to convert electrical energy to mechanical energy. We use Johnson motor to pull up the entire load. Totally, there are 4 motors are used for the movement of robot. The minimum supply needed for the motors is 12V. So that the maximum rpm is gained [8].

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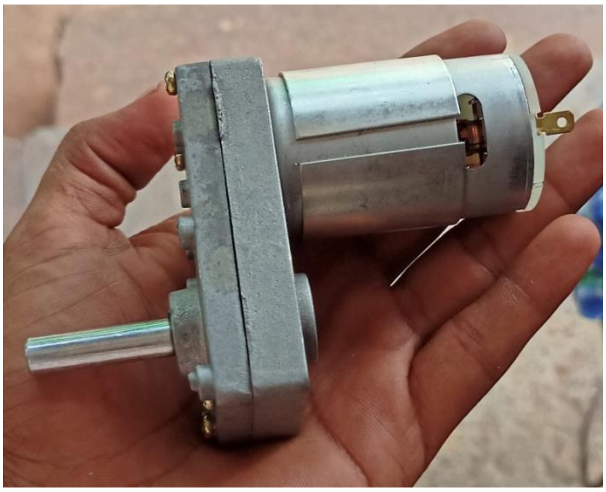

Fig 4.2: 60 rpm 15 torque 12 volts DC Gear motors

4.3 WHEEL BUSHES

Wheel bushes are made up of GI round pipe material. It is converted into required shape by making operations on lathe machine. A bore of 8mm diameter is drilled inside the bush for placing the shaft of the motor.

Fig 4.3: Wheel Bushes

4.4 POWERSUPPLY

A power supply minimum of 12V is required for the robot to run effectively. The input power source provided by a battery, powerbank, micro USB. We use Amptek Battery (12V 1.3AH/20HR) rechargeable battery. Its composition is lead acid. Standby voltage use is about 13.5-13.8V. !4.4-15V is the voltage range of cyclic use. Initial current of this battery is less than 0.39A

Fig 4.4: Battery

4.5 DISPLAY

A 16x2 LCD display is used here. This shows the current motion of the robot either in forward motion or backward motion

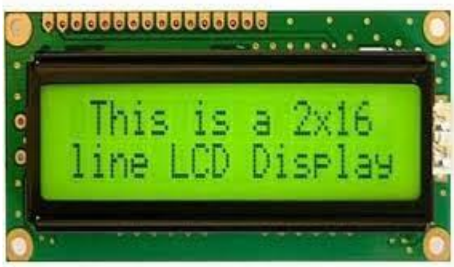

Fig 4.5: 16*2 LCD Display

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4.6 RELAY MODULE

The relay switch module ensures electrical isolation which enable to turn on or off a circuit. This switch isolates voltage and/or current much higher than a microcontroller could handle. The low voltage circuit operated by the microcontroller and the high power circuit are electrically isolated using this switch. The circuits are protected from each other. Blue cubes are 2 channels in the relay module. This module should be powered with 5V or 3.3V sometimes. There are three modes named NC(normally close), COM(common), and NO(normally open) in each channel in the module. From the input signal trigger mode, the jumper cap is been placed at high level effective mode which 'closes' the normally open (NO) switch at high level input and at low level effective mode operates the same with low level input.

Fig 4.6: Relay Module

4.7 SOFTWARE

ARDUINO IDE (Integrated Development Environment) is used here which helps to write computer code and dump the code into the physical board. It is a open source software. It mainly consists of two parts: Editor and Compiler. Editor is used for code writing, where compiling and uploading is done using compiler. • An open source web application called MIT APP INVENTOR originally provided by google allows to create software application for the android operating system. To run an application on android devices, it allows users to drag and drop visual objects. It allows you to select the components for your application and allows to specify how visually the components should behave.

MECHANICAL DESIGN PARADIGM

The design of the robot includes this salient points as discussed in the following.

1) A leg-wheel robot is utilized as an essential robot to examine a suitable mechanism for harsh landscapes on the grounds that both wheel and leg are crucial for rough terrain mobile robots. This kind of robot, which has been examined by Hirose, and different scientists, has both rapid and high versatility for unstructured territories.

2) Each wheel is joined to the tip of a leg on the grounds that by and large, adequate space is not accessible to set the leg and wheel independently on the body

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of the robot. Just like animals and insects living in different conditions have different shapes, there must be specific locomotion mechanisms that are suitable for movement on each rough terrain. Therefore, the proposed mechanism is not the best for all terrains. This robot is specifically designed for climbing the stairs of varying height and in uneven terrains.

5.1 DESIGN OF TRIPLE BENDED CROSS WHEELS

The most crucial part of this project is the development of a triple bended cross wheels.

TRIPLE WHEEL MECHANISM:-

FIGURE:

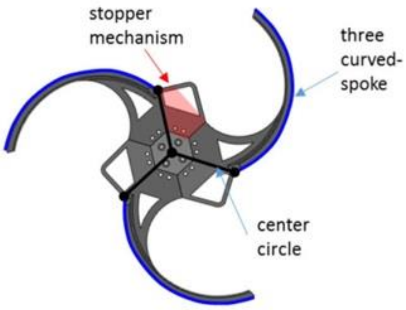

Fig 5.1: Triple bended cross wheels

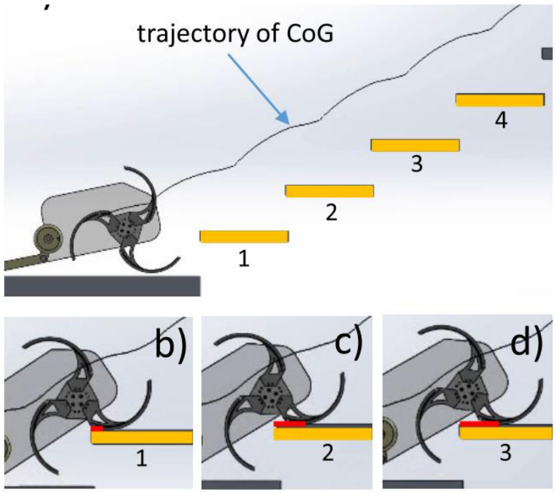

Fig 5.2: Trajectory of CoG

Three-curved-spoke-based stair-climbing and problem of slipping for sequential stair-climbing. (a) Sequential stair-climbing and the trajectory of the center of gravity (CoG), and (b-d) problem of slipping during stepping on the 1st to 3rd stairs. The red line shows that the slip length is increased as the robot travels up the stairs.

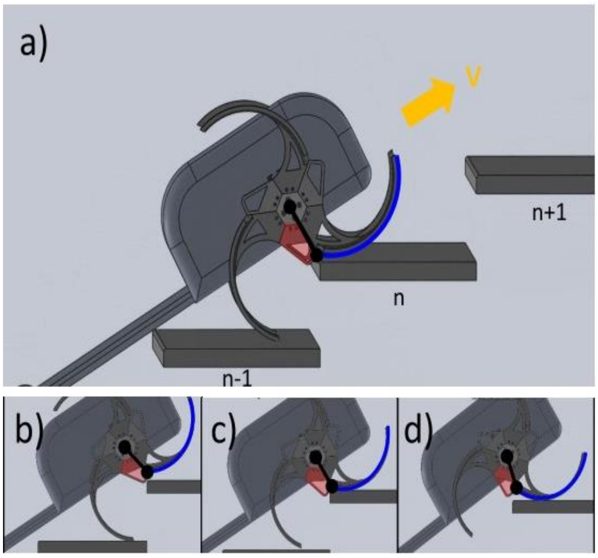

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Fig 5.3: Function of the stopper mechanism. (a) n-th stair during climbing. Note there is no slip after the n-th sequential stair. (b-d) the operation of the stopper mechanism at the corner. (b) The edge of the stopper mechanism touches the riser, (c) the corner of the stopper mechanism rolls following the corner of the stair, and (d) the curved-spoke performs stair-climbing with the same initial condition.

FABRICATION AND ASSEMBLY

6.1 FABRICATION OF WHEELS

At first, we cut the flat mild steel of 15cms length and 2.5cms width. Prepare 12 pieces with the same dimensions. Then, we bend mild sheet flat to 180 degrees like a semicircle by using hydraulic punch. After successful bending of first mild steel piece to the desired shape, then make all the remaining 11 mild steel as same as the first mild steel.

Fig 6.1: Wheel Spokes

After cutting all the pieces, then make a bush of 8mm bore by using galvanized iron and lathe machine.

Fig 6.1.1: Wheel Bushes

Now, join the bush and three cross bended mild steel spokes by placing the bush in the middle and placing the three spokes at correct positions so that there will be equal distance and angle present in between the three spokes by using gas welding. After completion of gas welding, make the arc welding to make the joints strong.

Fig 6.1.2: Wheel assembly

GAS WELDING:

Gas welding is a metal joining process in which fuel gases (gasoline) and oxygen are used to weld and cut metals. It is also a metal joining process in which edge pieces of a metal that required joining are heated at their interface by producing coalescence with one or more gas flames such as oxygen and acetylene. the welding process can weld with or without the application of filler material to the joint.

These types of welding are also known as oxy-fuel welding, oxyacetylene welding, oxy welding. It was developed in 1903 by some French engineers Edmond Fouche and Charles Picard. They use pure oxygen to increase flame temperature instead of air. This flame helps in melting metals and alloys e.g. steel.

In the working of gas welding, oxygen and acetylene burn at about 3,773k (3,500 degrees Celsius). The basic two operations of oxyacetylene welding include welding and cutting; welding operation is carryout when two-parent metals are heated to a temperature that produces a shared pool of molten metal. It cools and produces a joint.

Filler materials are sometimes added to the joint. It improves the strength of the joint and produces a stronger joint even stronger than the parent metal. Whilst in oxyacetylene cutting, there is a special cutting flame (obtain by releasing oxygen gas than acetylene in a torch valve). The torch is used to heat metal to its kindling temperature. it reaches stages where metal burns into a molten oxide as it flows out of the kerf as slag. It contains a mixing chamber, which helps in mixing oxygen and acetylene before it releases as flame.

Fig 6.1.3: Gas Welding

ARC WELDING

Arc welding is a fusion welding process used to join metals. An electric arc from an AC or DC power supply creates an

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intense heat of around 6500°F which melts the metal at the join between two work pieces.

The arc can be either manually or mechanically guided along the line of the join, while the electrode either simply carries the current or conducts the current and melts into the weld pool at the same time to supply filler metal to the join.

Fig 6.1.5: Arc welding and wheels

6.2 FABRICATION OF FRAME

Take 3/4th of GI square pipe and cut into the required dimensions. For the length of the robot, the required dimensions is 2.5 feet and for the breadth of the robot, the required dimensions is 1 feet. Cut two pieces of length 2.5 feet for vertical\longitudinal body and two pieces of length 1 feet for forming width of the robot. Now, join the pieces with the help of arc welding so that a frame in the form of rectangle is formed.

Fig 6.2: Frame Assembly

Then provide two supports to the frame near the center of frame. For mounting the motors, provide four U-shaped joints to the frame at front and back end of the frame according to the dimensions of the motor

6.3 ASSEMBLY

1. First, insert the four motors in the correct positions into the four U shaped cavities that are welded to the frame.
2. Now see that the motors are perfectly fitted to the cavities by tightening the screws and by providing welding to the flats attached to the motors
3. Then, weld the shaft couplings with the wheels by balancing the wheels in the correct positions so that all the base of the wheels are touching the ground.

Fig 6.3: Assembly without Electric Circuit

4. After welding the wheels to the motor, provide grip to the wheels so that they will not slip during the climbing of stairs.
5. Now, cut the cardboard according to the dimensions of the frame and attach to the frame by riveting so that the lower portion is not visible and easy to mount the electronic circuit above it.
6. Mount the electronic circuit on the cardboard and attach to it with the help of nut and bolts.
7. Provide connections as per the instructions.
8. There are two batteries assembled on the robot for proper working. One battery (12V, 1.2ah) is for operating the circuit and other

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battery (12v,7.2amps) is for controlling the motors. Both the batteries are provided with individual switches.

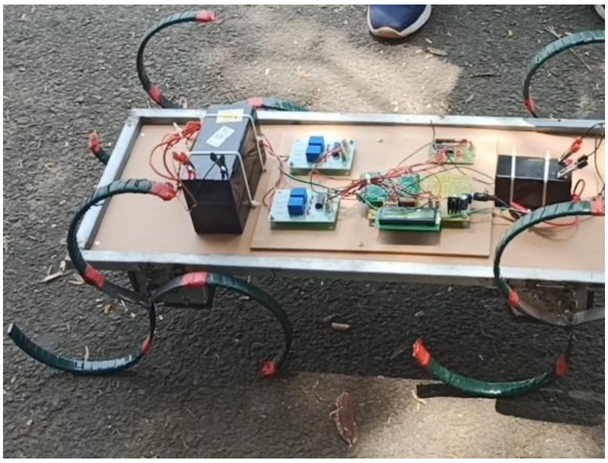

Fig 6.3.1: Assembly with Electric Circuit

6.4 WORKING

1. Connect the circuits as per the instructions.

2. Then connect the positive and negative terminals to the batteries, one from the circuit and other from the motor.

3. After connecting the terminals, switch on the switches of both the batteries so that circuit gets on and motor gets power supply.

4. We can control the robot by using wireless remote controller which works on RF encoder and RF decoder and by using 9v battery.

5. After we operate by using remote controller, the robot will work according to the code that is written on Arduino.

6.4.1 SOFTWARE IMPLEMENTATION

CODE FOR CROSS WHEELS

```
#include <LiquidCrystal.h>
#include <stdio.h>
LiquidCrystal lcd(6, 7, 5, 4, 3, 2);
int m1a = 8;
int m1b = 9;
int m2a = A0;
int m2b = A1;


int rf1 = 10;
int rf2 = 11;
int rf3 = 12;
int rf4 = 13;void setup()
{
  pinMode(m1a, OUTPUT); pinMode(m1b, OUTPUT);
  pinMode(m2a, OUTPUT); pinMode(m2b, OUTPUT);


  pinMode(rf1, INPUT);pinMode(rf2, INPUT);pinMode(rf3, INPUT);pinMode(rf4, INPUT);
    digitalWrite(m1a, LOW);digitalWrite(m1b, LOW);
 digitalWrite(m2a, LOW);digitalWrite(m2b, LOW);
   lcd.begin(16, 2);
  lcd.print("   Welcome  ");
```

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```
  delay(2000);

   lcd.clear();

}

void loop()

{

 if(digitalRead(rf1) == LOW && digitalRead(rf2) == HIGH && digitalRead(rf3) == HIGH && digitalRead(rf4) == HIGH)

   {

      digitalWrite(m1a, HIGH);digitalWrite(m1b, LOW);

      digitalWrite(m2a, HIGH);digitalWrite(m2b, LOW);

      lcd.setCursor(0,0);lcd.print("Front  ");

   }

 if(digitalRead(rf1) == HIGH && digitalRead(rf2) == LOW && digitalRead(rf3) == HIGH && digitalRead(rf4) == HIGH)

   {

      digitalWrite(m1a, LOW);digitalWrite(m1b, HIGH);

      digitalWrite(m2a, LOW);digitalWrite(m2b, HIGH);

      lcd.setCursor(0,0);lcd.print("Back  ");

   }


 if(digitalRead(rf1) == HIGH && digitalRead(rf2) == HIGH && digitalRead(rf3) == LOW && digitalRead(rf4) == HIGH)

   {

      digitalWrite(m1a, HIGH);digitalWrite(m1b, LOW);

      digitalWrite(m2a, LOW);digitalWrite(m2b, HIGH);

      lcd.setCursor(0,0);lcd.print("Left  ");

   }


 if(digitalRead(rf1) == HIGH && digitalRead(rf2) == HIGH && digitalRead(rf3) == HIGH && digitalRead(rf4) == LOW)

   {

      digitalWrite(m1a, LOW);digitalWrite(m1b, HIGH);

      digitalWrite(m2a, HIGH);digitalWrite(m2b, LOW);

      lcd.setCursor(0,0);lcd.print("Right  ");

   }


 if(digitalRead(rf1) == HIGH && digitalRead(rf2) == HIGH && digitalRead(rf3) == HIGH && digitalRead(rf4) == HIGH)

   {

      digitalWrite(m1a, LOW);digitalWrite(m1b, LOW);

      digitalWrite(m2a, LOW);digitalWrite(m2b, LOW);

      lcd.setCursor(0,0);lcd.print("Stop   ");

   }

}
```

CONCLUSION

This project aimed to develop a mechanism for climbing stair using star wheel system which its main idea was making the wheels rolling within motion in flat surfaces while in climbing motion

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the whole system will roll together. Gear system was chosen as transmission system. The design and modeling of a mobile robot with Wheel-Based motion, is inspired from legs of human beings while climbing and descending stairs. Due to its star wheel motion, it has the advantage of ascending, descending and traversing with flexibility toward uphill, downhill and slope surfaces. Furthermore, on flat surfaces it has smooth and fast motion which is due to its wheels motion. It shows that the robot can be used for any terrain a human can go. It can also be used for space researchers as a Spacecraft or war regions identification or unknown terrains.

7.1 FUTURE ADVANCEMENTS

Researches on climbing and descending on a different range of stairs, obstacles, models, inclinations and surface conditions are ongoing. This is the basic needed advancement. There is no left-right motion and also gyrometer should be installed in this robot remains same while moving uphill, downhill.

The following directions could be pursued for the future enhancement of the present project in terms of fully or partial (function specific) autonomous operation:

- Develop control algorithms and sensing techniques that allow the hybrid mobile robot system to operate autonomously in unstructured environments.
- Redesign the system for overall weight reduction without trading off with it payload capacity.
- In the future work, sensors, cameras, manipulators can be added to the robot frame. The robot can then serve complex tasks in dangerous areas remotely.

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