17 DOF HUMANOID ROBOT

A Major Project Report Submitted in Partial Fulfilment of the Requirement of the Degree

of

BACHELOR OF TECHNOLOGY

in

ELECTRONICS AND COMMUNICATION ENGINEERING

by

ABHISHEK KUMAR (201500740)

ABHISHEK ROY (201500276)

Under the guidance of

MR. AMIT AGARWAL

Assistant Professor (E&C)

SMIT SIKKIM MANIPAL UNIVERSITY

INSPIRED BY LIFE

SIKKIM MANIPAL INSTITUTE OF TECHNOLOGY

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

SIKKIM MANIPAL INSTITUTE OF TECHNOLOGY

MAJITAR, EAST SIKKIM-737136, June 2019

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एकीकृत परीक्षण परिसर, चान्दीपुर

INTEGRATED TEST RANGE, CHANDIPUR

यह स्थापना आईएसओ 9001-2015 प्रमाणित है This is an ISO 9001-2015 Establishment

VOCATIONAL TRAINING CERTIFICATE

Certified that *Shri Abhishek Kumar* a student of *08th Semester, B.Tech* in *Electronics and Communication Engineering* of *Sikkim Manipal Institutre of Technology, Majitar, East Sikkim* has successfully completed his Vocational/ Summer Training Program with a major project on *17 DOF HUMANOID ROBOT* during *15 Jan – 17 May 2019* in the Directorate of *Electro-Optics Tracking System* of this Establishment under the guidance of Shri Dipak Das, Sc-F.

स्थान Place: चान्दीपुर Chandipur

तिथि Date : 17 May 2019

रक्षा अनुसंधान तथा विकास संगठन DEFENCE R&D ORGANISATION ITR, CHANDIPUR आई.टी.आर, चान्दीपुर

ग्रुप निदेशक (मासंवि)

Group Director(HRD)

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This is to certify that the project report entitled " 17 DOF (degree of freedom) humanoid robot " submitted by Abhishek kumar (201500740) and Abhishek Roy (201500276) to Sikkim Manipal Institute Of Technology, Sikkim in partial fulfilment for the award of degree of Bachelor of Technology in Electronics And Communication Engineering, is a bonafide record of the project work carried out by them under my guidance and supervision during the academic session January-May, 2019.

Name of Supervisor:

Dipak Das

Scientist 'F'

INTEGRATED TEST RANGE

DRDO, BALASORE

ODISHA

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Name of Supervisor:
Prof. Amit Agarwal
(Assistant Professor)
Department of E&C

Prof. (Dr.) Sourav Dhar
Head of Department
Department of E&C
SMIT, Sikkim

ABSTRACT

Humanoid robots are without question a hot topic in research today. A dream of humanoid robot researchers is to develop a complete "human-like" artificial agent both in terms of body and brain. We now have seen an increasing number of humanoid robots (such as Honda's ASIMO, Aldebaran's Nao and many others). These, however, display only a limited number of cognitive skills in terms of perception, learning and decision-making. For decades, popular culture has been enthralled with the possibility of robots that act and look like humans. We are promised by film, fiction and television that humanoids will cook for us, clean for us, become our best friends, teach our children, and even fall in love with us. Recently, the media has covered a surprising number of new humanoid robots emerging on the commercial market. Like many new technologies, these early generations of commercially available humanoids are costly curiosities, useful for entertainment. Yet, in time, they accomplish a wide variety of tasks in homes, battlefields, nuclear plants, government installations, factory floors, and even space stations. Humanoids may prove to be the ideal robot design to interact with people. Humanoid robotics also offers a unique research tool for understanding the human brain and body. Already, humanoids have provided revolutionary new ways for studying cognitive science. Using humanoids, researchers can embody their theories and take them to task at a variety of levels. Aside from their traditional roles, humanoid robots can be used to explore theories of human intelligence. This paper reviews a wide variety of humanoid robots being used throughout the world and explaining its typical applications and future challenges while developing humanoid robots which may come across such endeavours.

The humanoid research is an approach to understand and realize the complex real-world interactions between a robot, an environment, and a human. The humanoid robotics motivates social interactions such as gesture communication or co-operative tasks in the same context as the physical dynamics. This is essential for three-term interaction, which aims at fusing physical and social interaction at fundamental levels. People naturally express themselves through facial gestures, expressions, and the movement of different body parts. Our goal is to build a human like robot having 17 degrees of freedom and can be interfaced in robotics applications. This system does not require any special type of motors. By using multiple servo motors, we can accurately predict and robustly track the movement of robot's body parts. Since we reliably track the movement in real-time, we are also able to make him walk like us i.e. human beings. Our system can recognize a large set of movement of body parts like walking, sitting i.e. up and down motion and basic pt. drills using hand movement.

Human-Robot has recently received considerable attention in the academic community, in labs, in technology companies, and through the media. Because of this attention, it is desirable to present a survey of Humanoid Robot to serve as a tutorial to people outside the field and to promote discussion of a unified vision of Humanoid Robot within the field.

A humanoid robot is a robot with its overall appearance, based on that of the human body, allowing interaction with made-for-human tools or environments. In general, humanoid robots have a torso with a head, two arms and two legs, although some forms of humanoid robots may model only part of the body, for example, from the waist up. Some humanoid robots may also have a 'face', with 'eyes' and 'mouth'. Androids are humanoid robots built to aesthetically resemble a human. A humanoid robot is an autonomous robot because it can adapt to changes in its environment or itself and continue to reach its goal. This is the main difference between humanoid and other kinds of robots.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude and appreciation to the Electronics and Communication Department, SMIT for providing the opportunity of major project and to my HOD, Dr. Sourav Dhar for his support.

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Dept. Of Electronics and Communication, SMIT.

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CHAPTER 1

Overview of Humanoid Robots

1.1: INTRODUCTION

Among the first verifiable automation is a humanoid drawn by Leonardo da Vinci (1452–1519) in around 1495. Leonardo's notebooks, rediscovered in the 1950s, contain detailed drawings of a mechanical knight in armour which was able to sit up, wave its arms and move its head and jaw. Especially, an emergence of humanoid robots is strongly expected because of friendly design. Concepts of artificial servants and companions date at least as far back as the ancient legends of Cadmus, who is said to have sown dragon teeth that turned into soldiers and Pygmalion whose statue of Galatea came to life. Many ancient mythologies included artificial people, such as the talking mechanical handmaidens built by the Greek god Hephaestus (Vulcan to the Romans) out of gold, the clay golems of Jewish legend and clay giants of Norse legend.

In 1954 George Devol invented the first digitally operated and a programmable robot called the Unimate. In 1956, Devol and his partner Joseph Engelberger formed the world's first robot company. In 1961, the first industrial robot, Unimate, went online in a General Motors automobile factory in New Jersey. Mechanical automata were constructed in the 10th century BC in the Western Zhou Dynasty. The artisan Yan Shi made humanoid automata that could sing and dance. The machine is said to have possessed lifelike organs, like bones, muscles and joints.

The history of robotics has its origins in the ancient world. The modern concept began to be developed with the onset of the Industrial Revolution, which allowed the use of complex mechanics, and the subsequent introduction of electricity. This made it possible to power machines with small compact motors. In the early 20th century, the notion of a humanoid machine was developed. Today, one can envisage human-sized robots with the capacity for near-human thoughts and movement. The first uses of modern robots were in factories as industrial robots – simple fixed machines capable of manufacturing tasks which allowed production with less need for human assistance. Digitally controlled industrial robots and robots using artificial intelligence have been built since the 2000s. The ever-increasing need for the technology of humanoid robot in fields is going from a battlefield to as simple as a home has caused a revolutionary increasing in the growth of the technologies of humanoid robots. A computer being among us to help us out in ways better than an expected individual can is more than enough reason for the necessity of humanoid robots. They look like us, they communicate like us, they walk like us; all of these simple actions that humans are born with are nearly perfected to be duplicated by humanoid robots. As simple as the name suggests they are derivatives if human nature. Depicting human nature from a tiny movement to a finger to looking as close to an actual human has been a huge development in the field of robotics. The growth of the development of humanoid robots has to be considered one of the best possible growths in the field of robotics. The journal is divided into 3 stages of humanoid robots as for a human. The past, where how it all started out and the growth of it from literal and fictional state to a physical state. The present; where it showcases the current life of humanoid robots and the future; where it's most likely to be.

Humanoid robot lifespan is ever increasing with the aging of population and declining of birth rates. With the increase need for manpower which is not to be found in terms of humans itself the best possible substitute have become humanoid robots because of which the technology relating humanoid robot has increased along the present years and is estimated to improve in the forthcoming years. The attributes of a humanoid robot should have the least flaw as compared to an actual human. Following the path of a human hand is considered to be one of the vital movements of a humanoid robot. A Human hand has a degree of freedom of 22.

Another key feature that has been perfected over the years is the function of a humanoid robot to walk like a human. Throughout the years stable walking has been perfected for a humanoid robot with the concepts of zero moment point and mass centre. Process of stable walking has been made easier with predictive PID controller that actually imitates the time that is calculated and in doing so it reduces the factor of complexity in the control. Furthermore, into humanoid robot motion would be human activities such as swimming.

The P3 humanoid robot was revealed by Honda in 1998 as a part of the company's continuing humanoid project. In 1999, Sony introduced the AIBO, a robotic dog capable of interacting with humans; the first models released in Japan sold out in 20 minutes. Honda revealed the most advanced result of their humanoid project in 2000, named ASIMO. ASIMO can run, walk, communicate with humans, recognise faces, environment, voices and posture, and interact with its environment. Sony also revealed its Sony Dream Robots, small humanoid robots in development for entertainment. In October 2000, the United Nations estimated that there were 742,500 industrial robots in the world, with more than half of them being used in Japan.

In April 2001, the Canadarm2 was launched into orbit and attached to the International Space Station. The Canadarm2 is a larger, more capable version of the arm used by the Space Shuttle, and is hailed as "smarter". Also, in April, the Unmanned Aerial Vehicle Global Hawk made the first autonomous non-stop flight over the Pacific Ocean from Edwards Air Force Base in California to RAAF Base Edinburgh in Southern Australia. The flight was made in 22 hours.

In 2005, Cornell University revealed a robot capable of self-replication; a set of cubes capable of attaching and detaching, the first robot capable of building copies of itself. Self-driving cars had made their appearance by around 2005, but there was room for improvement. None of the 15 devices competing in the DARPA Grand Challenge (2004) successfully completed the course; in fact no robot successfully navigated more than 5% of the 150-mile (240 km) off-road course, leaving the $1 million prize unclaimed. In 2005, Honda revealed a new version of its ASIMO robot, updated with new behaviours and capabilities.

1.2: Motivation

Because of having very hazardous test environment, places like Test Ranges have very specific requirements for robots. Bipedal robots are able to move in areas that are normally inaccessible to wheeled robots such as stairs or any levelled elevation or depression. Most man-made vehicles today travel on wheels and for good reason: wheels are much easier to construct and control. In today's economy, they also tend to be much cheaper than their legged counterparts. However, legs have distinct advantages over wheels. The biggest advantage is in transvers ability and efficiency. Also, there are of lot of safety cases, to check whether all the systems are working perfectly in an undesired environment. Moreover, a humanoid robot can give the exact pictures of working devices at a test range where human involvement is difficult such as at launching time and on a launching pad.

1.3: Appearance of humanoid robots

A humanoid robot is a robot with its body shape built to resemble the human body. The design may be for functional purposes, such as interacting with human tools and environments, for experimental purposes, such as the study of bipedal locomotion, or for other purposes. In general, humanoid robots have a torso, a head, two arms, and two legs, though some forms of humanoid robots may model only part of the body, for example, from the waist up. Some humanoid robots also have heads designed to replicate human facial features such as eyes and mouths. Androids are humanoid robots built to aesthetically resemble humans.

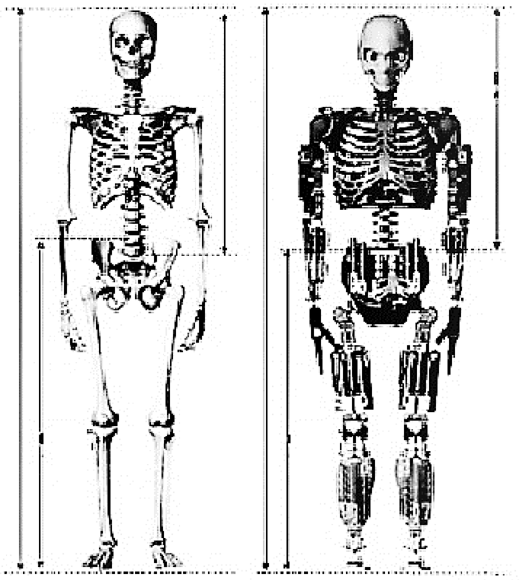
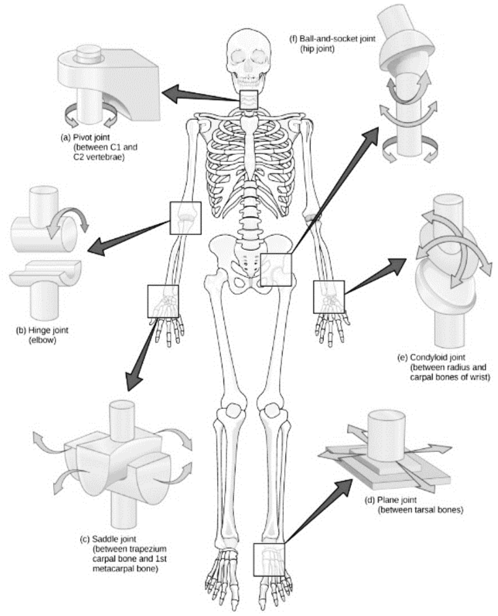


Fig 1: Skeletal appearance of human (left side)

and humanoid robot (right side)

In the previous figure we have seen that the skeleton system of human body and that of robot's body is quite similar, the only difference is about the constituents of bone of the human body and the bone which is made up of either iron or aluminium in the robot's body.

Similarly, the joints of human body and of the robot's body are also similar. In human body, joints are generally formed of round shaped bones but in robot's body the joints are the motors which are required for the movement of entire body parts.



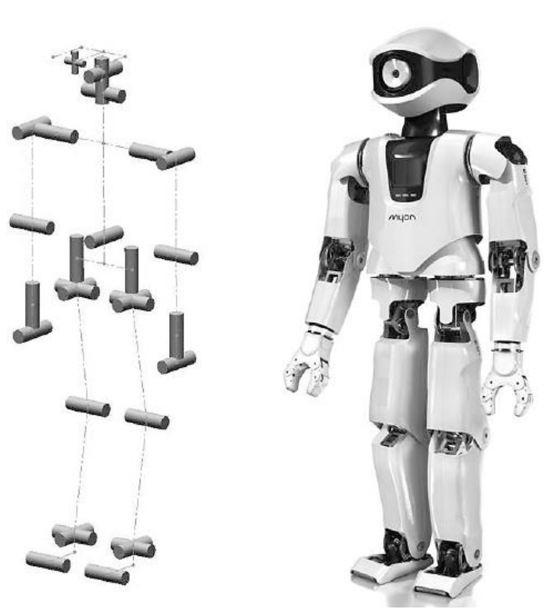


Fig 2: Joints of human body

Fig 3: Joints of Robot's body

Here, the most important thing is the locomotion of the robot i.e. walking of the robot with the close resemblance to the human being. For this, the leg design matters the most where each and every joint of the robot's leg must coincide with the joints of human being's leg.

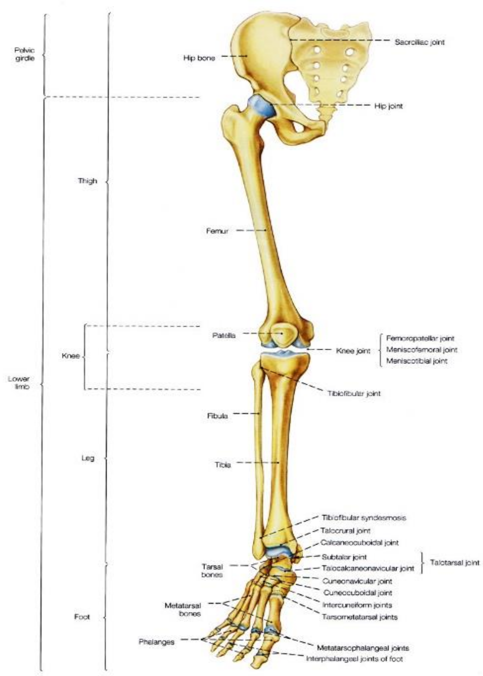
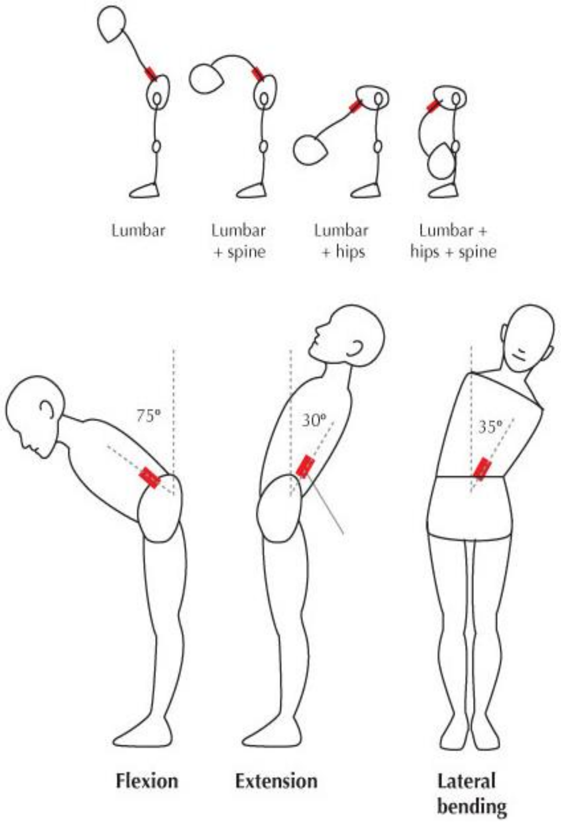


Fig 4: leg structure

Now, about the waist joint that human have: the waist of the human can move in 90 degrees in left roll and 90 degrees in right roll moreover 180 degrees in front side and approx. 35 degrees in back side. But here, there is a limitation for the robot's designing architecture to have same movement as that of human waist can. Then also there are few robots which can approximately replicates the human waist's movement but with few limitations.



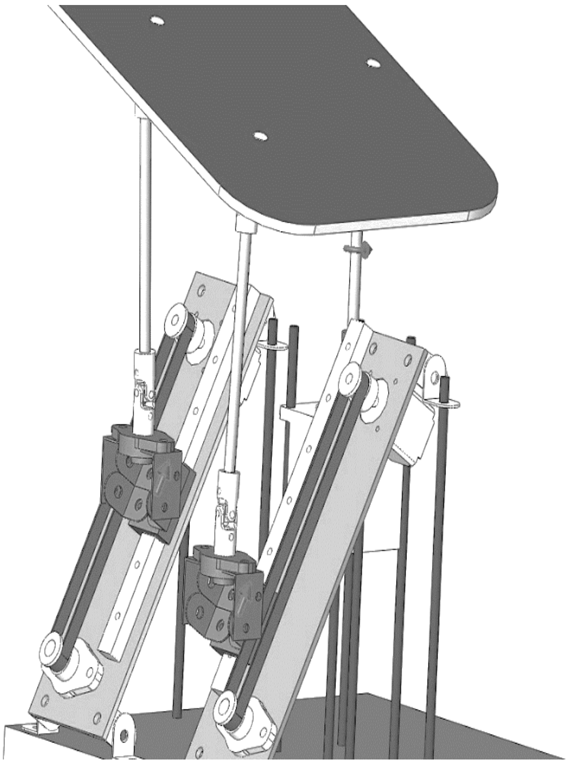


Fig 5: Waist structure of human body

Fig 6: Waist structure of Robot

Here also in the above figure 6 we can see that the waist can move in sideways and up and down but cannot roll on the same axis. This is the limitation of the design structure of the robot's body.

Now, one of the most important part of the human body is the arm i.e. the hand movement. Basically, the human hand and robot's hand are quite similar. One important characterization of the human hand is the number of degrees of freedom (DOF) spanned by its movements. Anatomically, the five digits of the hand comprise a total of 15 joints, which afford approximately 20 DOFs. Humans constantly use their hands to interact with the environment and they engage spontaneously in a wide variety of manual activities during everyday life. In contrast, laboratory-based studies of hand function have used a limited range of predefined tasks. So, unless and until we have an algorithm and is controlled by artificial intelligence the hand movement works only on predefined programming skills.

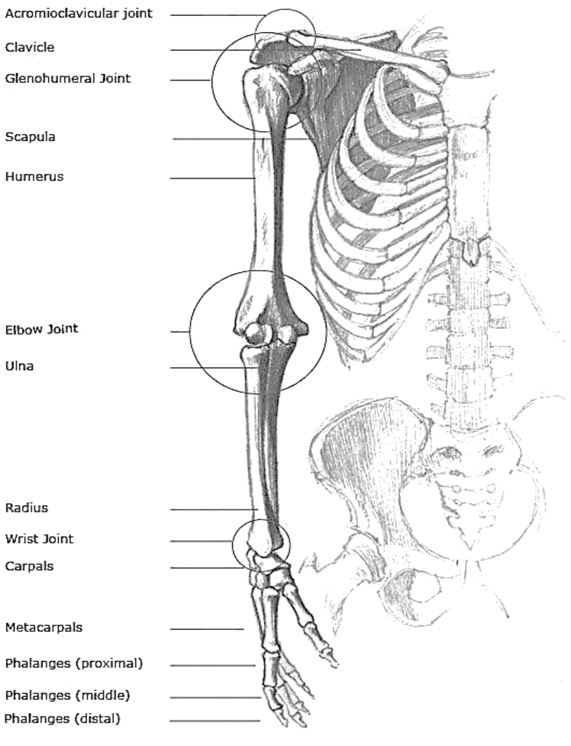


Fig 7: Human hand joints

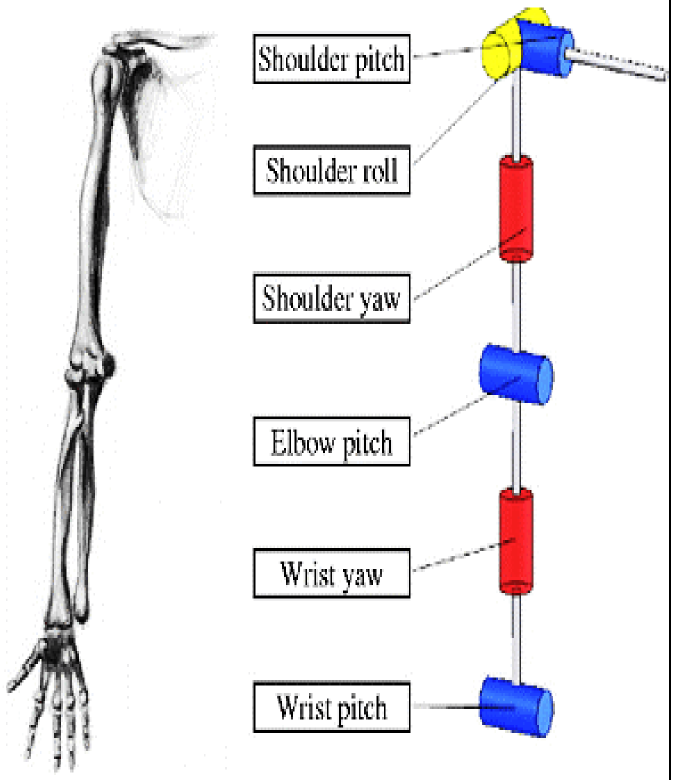


Fig 8: Robot's hand joints

Now, finally we are up to the best, complex and vital part of a human as well as robot's body i.e. the head part which makes the robot's resemblance same as the human body and in human body it consists of brain which controls the whole body and in robot it contains the AI which control the whole motors connected in different parts of the body.

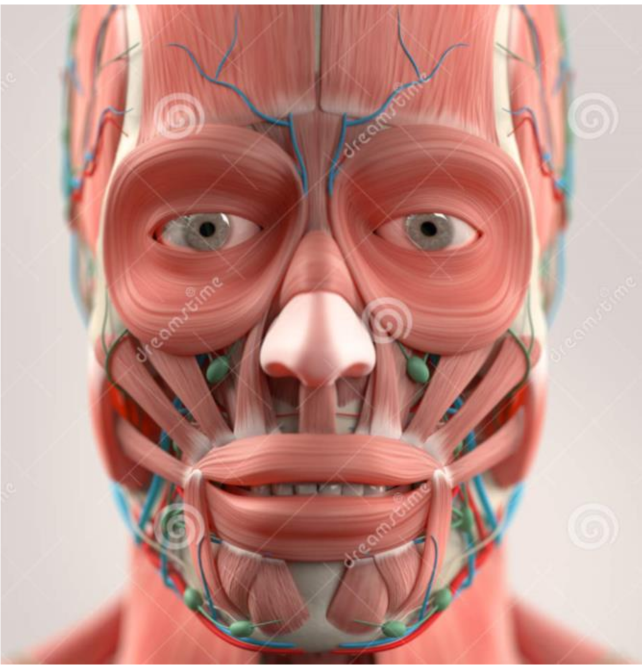


Fig 9: Head and facial muscle of human

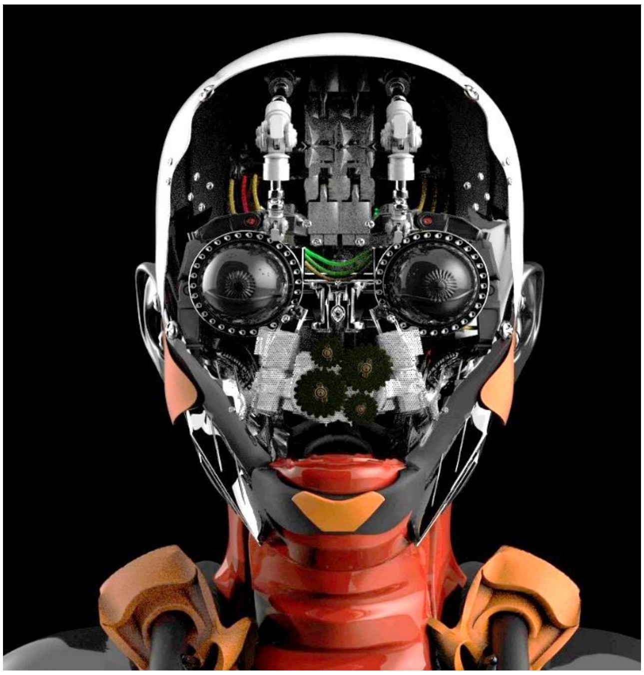


Fig 10: Head and facial motor of Robot

Our human head is controlled by brain but robot's body is controlled by artificial intelligence or a set of predefined programs which acts as a brain in robot.

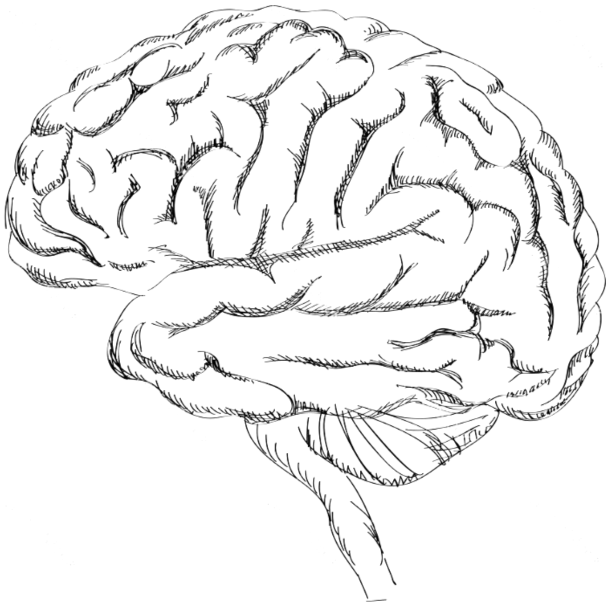


Fig 11: Human brain

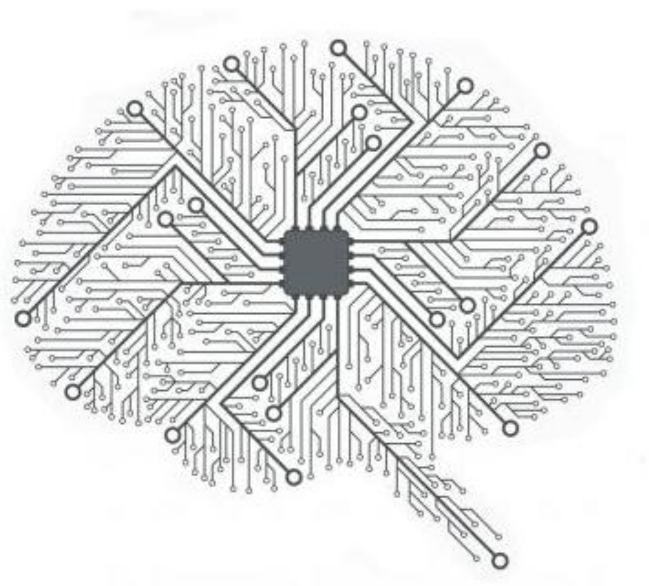


Fig 12: Artificial intelligence

1.4: Application of robots

1. Social humanoid robots are used by individuals or organizations to help and assist people in their daily life activities. These robots are commonly pre-programmed to perform mundane tasks and are also known as assistive robots. There have been many instances where robots have been used to reduce human error.

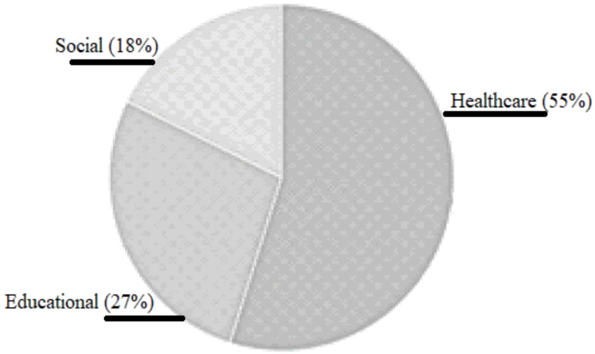


Fig 13: Effective use of robot

2. Outer Space Applications: Robots are playing a very important role for outer space exploration. The robotic unmanned spacecraft is used as the key of exploring the stars, planets...etc.

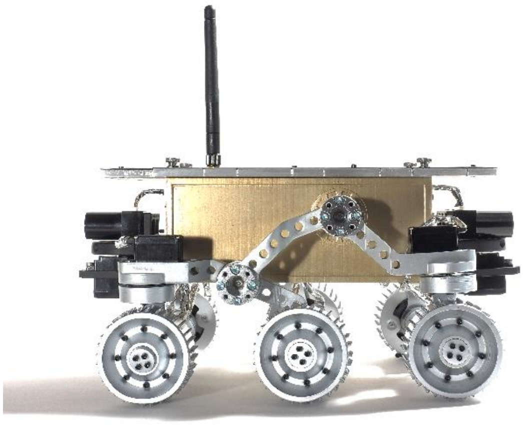


Fig 14: Robotic rover

3. In today's modern army robotics is an important factor which is researched and developed day by day. Already remarkable success has been achieved with unmanned aerial vehicles like the Predator drone, which are capable of taking surveillance photographs, and even accurately launching missiles at ground targets, without a pilot.

Fig 15: Predator drone

4. Health Service: Under development is a robotic suit that will enable nurses to lift patients without damaging their backs. Scientists in Japan have developed a power-assisted suit which will give nurses the extra muscle they need to lift their patients - and avoid back injuries.

Fig 16: Power assisted suit

5. They are also employed for jobs which are too dirty, dangerous or dull to be suitable for humans. Robots are widely used in manufacturing, assembly and packing and mass production of consumer and industrial goods.

Fig 17: Robotic arm

6. The robots can perform the tasks faster than the humans and much more consistently and accurately, they become more common each and every day, the robotic pets can help the patients with depression and they keep them active.

Fig 18: Robotic pet

7. The robots do anything which we need to be precise & accurate, new jobs are created because the people have to fix and design the robots, the robots can work without sleep so, they can work 24/7/365.

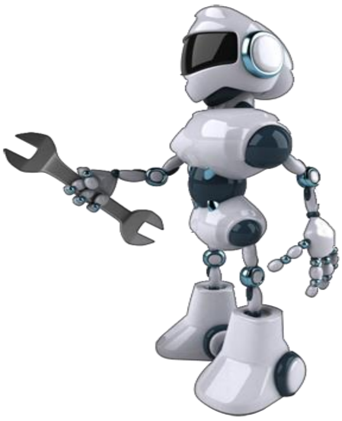


Fig 19: Maintenance robot

8. The robots can do the jobs that the people are unwilling to do, many robotic probes have been sent throughout the solar system to never return back to Earth, they can be stronger than the people, the robots in the warfare eliminate putting more people at risk.

Fig 20: Automatic tank machine guns

9. The robots cannot tremble or shake as the human hands do, they can have much smaller & versatile moving parts than the people, they have performed the medical surgeries because they can be faster and more precise than the people.

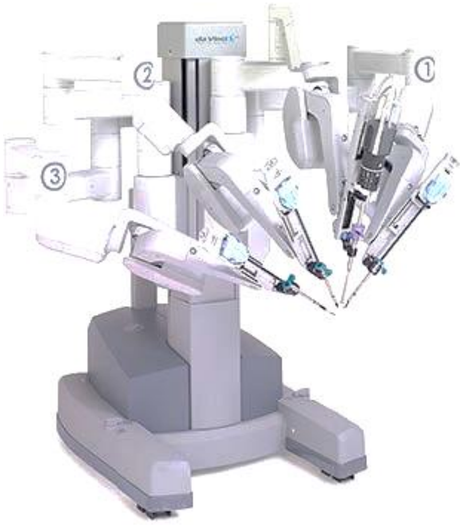


Fig 21: Robotic surgical machine

Chapter 2

Joints and Movement

2.1 Introduction

And although man-made machines still don't move with the fluidity and freedom of living creatures, researchers are steering their robots toward the goal of fast, accurate, autonomous movement on two legs and four legs, as well as by flying, swimming and rolling. ... Ruina says the machine moves "like a robot on crutches."

When it comes to robot motion, computer scientists find inspiration in everything from humans to cockroaches. And although man-made machines still don't move with the fluidity and freedom of living creatures, researchers are steering their robots toward the goal of fast, accurate, autonomous movement on two legs and four legs, as well as by flying, swimming and rolling. According to Marc Raibert, founder and president of Boston Dynamics, the Breakthrough Award–winning creators of Big Dog, the complexity of handling uneven terrain means ground robots are tougher to engineer than bots that move through the water and air. "On the ground, you're very close to terrain variation," Raibert says. "The sky and sea are smooth by comparison."

2.2 Basic joints

1. Shoulder joint:

The human shoulder is made up of three bones: the clavicle (collarbone), the scapula (shoulder blade), and the humerus (upper arm bone) as well as associated muscles, ligaments and tendons. In human beings the deltoid is the major arm abductor, as it originates on the clavicle and scapula and it inserts on the humerus. The pectoralis major originates on the ribs and sternum and it inserts on the humerus, thus causing flexion and adduction of the arm. That's how an arm moves in human body.

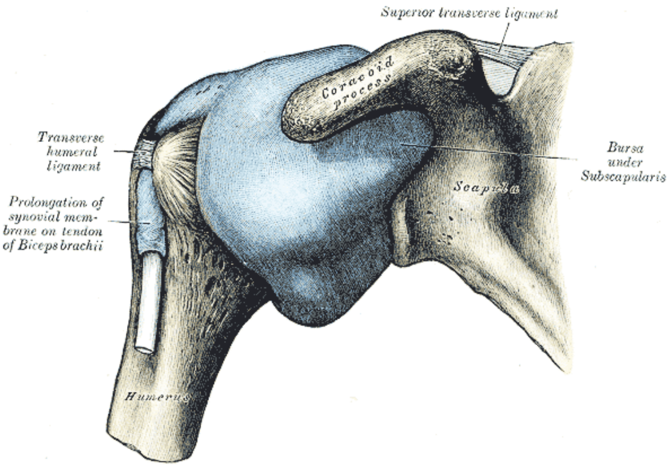


Fig 26: shoulder joint (human)

But in a robot the joints are made up of motors. So, at the time of operation of motor only one thing should be kept in mind that stability should not be compromised while movement. Basically, when a motor moves it creates momentum which destabilizes the complete body structure leads in falling of the robot. A typical robotic arm is made up of seven metal segments, joined by six joints. The computer controls the robot by rotating individual step motors connected to each joint (some larger arms use hydraulics or pneumatics).

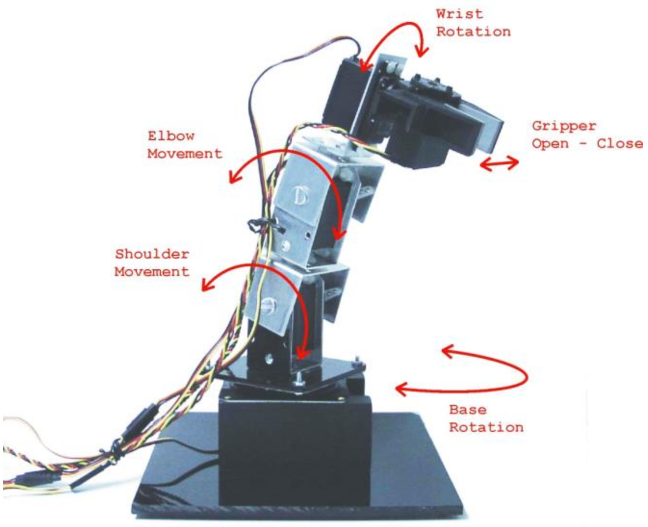


Fig 27: shoulder joint (robot)

2. Elbow joint

The elbow is a hinged joint made up of three bones, the humerus, ulna, and radius. The ends of the bones are covered with cartilage. Cartilage has a rubbery consistency that allows the joints to slide easily against one another and absorb shock. The muscles in your forearm cross the elbow and attach to the humerus. The elbow is the visible joint between the upper and lower parts of the arm. The elbow is one of the largest joints in the body. In conjunction with the shoulder joint and wrist, the elbow gives the arm much of its versatility, as well as structure and durability. The elbow swings 180 degrees in one direction to extend the forearm, and it also helps turn the forearm at the point where the parallel bones in the forearm—the radius and ulna—meet.

Several major muscles and tendons—fibrous bands that join muscles to bone or muscles to other muscles—meet at the elbow. These include the biceps, triceps, brachioradialis, and extensor carpi radialis longus tendons.

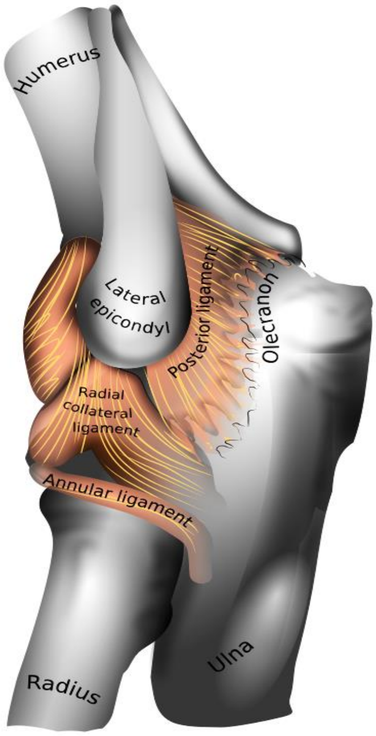
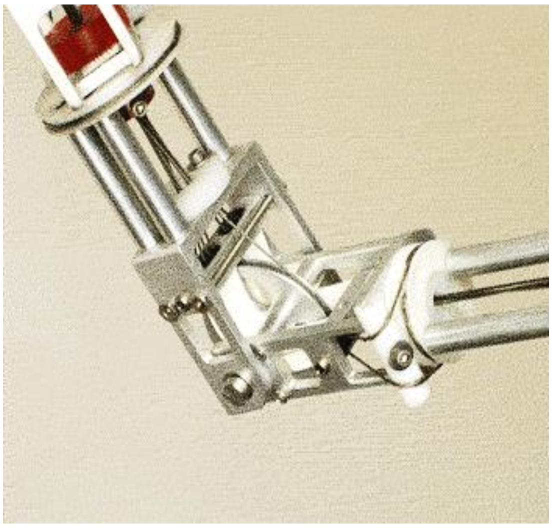


Fig 28: Human elbow

In robots, the elbow joint is a servo or a step motor which is connected to the shoulder motor and the wrist motor. The elbow motor gives the arm much of its versatility, as well as durability. Here also the elbow swings in 180 degrees in one direction to the extended forearm but since some servos can rotate in all direction the robot's elbow can move beyond 180 in both the directions i.e. sometimes in backward direction also. Due to the complexity of the physical structure of the upper limb of the human body, the joints of the robot are difficult to be aligned with the human joints in real time. The elbow joint kit allows multiple servos to be connected to each other, making it easy to create snake-like robots or appendages with multiple degrees of freedom. They needed high levels of flexibility and low weight, with simple upgrade options for additional axes. These requirements have now been elegantly translated into a new concept with a multiple axis joint made from plastic and cable controls. The cables themselves are moved from the arm 's "shoulder joint" using compact, high performance, brushless dc servo motors. This prevents inertia in the arm, allows dynamic movements and means the drive block can be compact in design.



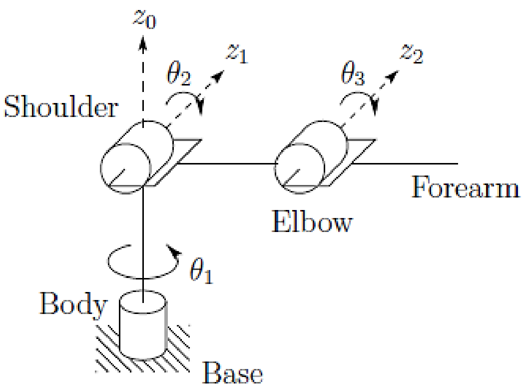


Fig 29: Robot elbow joint and fbd diagram

3. <u>Wrist joint</u>

The wrist joint is the radiocarpal joint which is a complex biaxial synovial joint that bridges the hand to the forearm. It involves the three carpal bones, the proximal carpal bones – scaphoid, lunate and triquetral. • It also involves the distal end of the radius and an articular disc which lies over the ulna. The wrist is an ellipsoidal (condyloid) type synovial joint, allowing for movement along two axes. This means that flexion, extension, adduction and abduction can all occur at the wrist joint. All the movements of the wrist are performed by the muscles of the forearm.

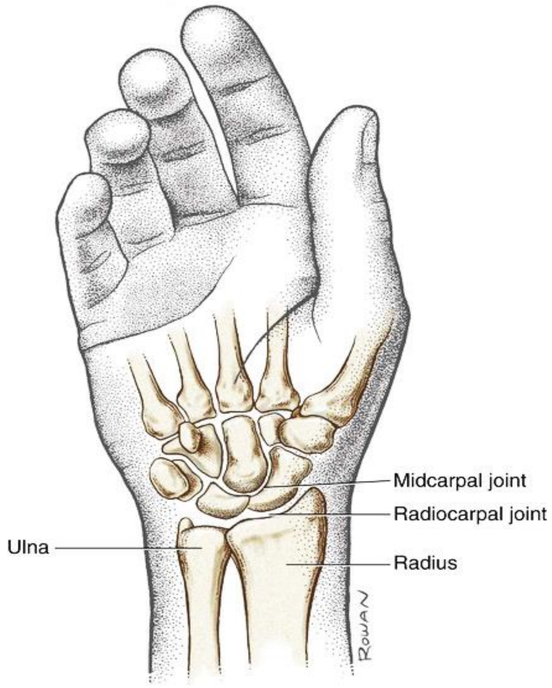


Fig 30: Human wrist joint

The three types of motion for a robot's wrist are

(1) bending or rolling forward and backward,

(2) yawing (spinning) from right to left or left to right

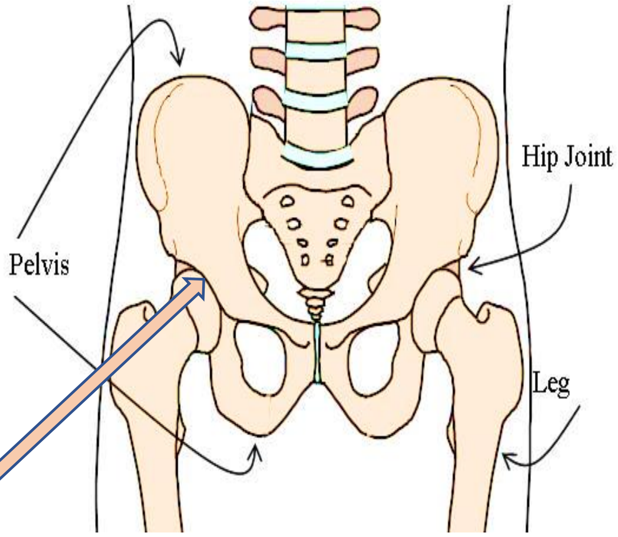
(3) swivelling, which is nothing more than rolling down to the right or left.

The main function is to lift heavy weight by the help of wrist as it is controlled by servo motors so it can lift heavy weights as compared to humans. A robot has six degrees of freedom if it can move its wrist three ways and its arm three ways. This is very limited when you compare it with human shoulder, arm, and wrist motions. Humans have forty-two degrees of freedom. As you can see, the robot arm needs improvement if it is to be as versatile as the human arm. There is some question as to whether the human arm and wrist should be emulated. However, such emulation would call for some rather involved engineering to get the job done right. At present, it is possible for a robotic hand to do what the human hand can do: grip, push, pull, grasp, and release.

Fig 31: Wrist joint and claw of robot

4. <u>Waist joint</u>

The waist is the part of the abdomen between the rib cage and hips. On people with slim bodies, the waist is the narrowest part of the torso. The waistline refers to the horizontal line where the waist is narrowest, or to the general appearance of the waist. The main purpose of waist is to make movement side wise either in left or right direction and up and down in front side up to 180 degrees and back up to 35 degrees. Torso i.e. trunk which is also called waist of the body is the vital part which makes a human stand in its normal position i.e. it keeps the upper portion intact with the lower portion of the body.



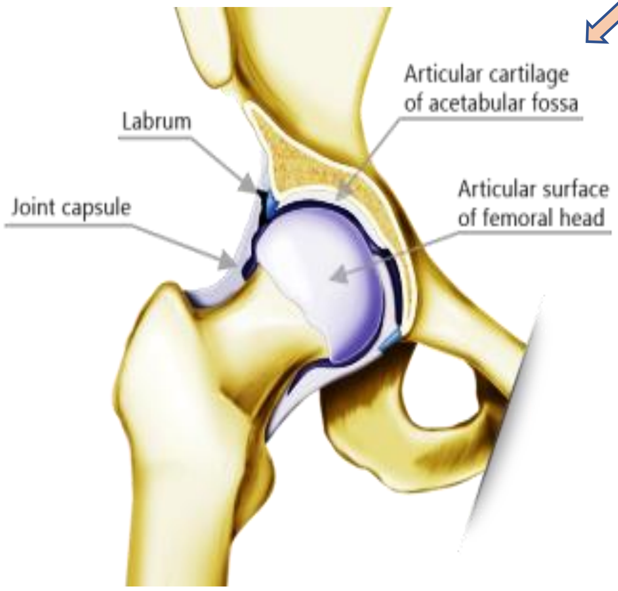


Fig 32: Waist joint and hip joint of human

A waist joint is designed for a humanoid robot, which has the characteristics of a large range of motion and high mechanical strength. Among all the issues that we are facing now, walking pattern planning and balance control is one of the main research areas of humanoid robot, is completely dependent on the waist alignment at the time of walking of the robot. Moreover, the standing position of the robot completely depends on the waist part that is the torso part of the body.

Fig 33: Waist joint and hip joint of robot

5. Leg joint

The bones of the leg and foot form part of the appendicular skeleton that supports the many muscles of the lower limbs. These muscles work together to produce movements such as standing, walking, running, and jumping. At the same time, the bones and joints of the leg and foot must be strong enough to support the body's weight while remaining flexible enough for movement and balance. The femur, or thigh bone, is the largest, heaviest, and strongest bone in the human body it can account for about a quarter of someone's height. The ankle is a joint that connects the lower leg to the foot. Its main function is to allow for plantar flexion and dorsiflexion of the foot. The feet are made up of many bones, muscles, and ligaments. In fact, nearly one-quarter of the bones in the body are found in the feet.

Fig 34: Human leg joints

The robot consists of three segments: a lower leg, an upper leg and a body, connected to each other by actuated rotational joints. Point F is the foot of the robot, point K its knee and point H its hip. The leg is joint is one of the vital parts because of the high complexity of the layout of joint parts; necessity of this joint for robot movement in space; complexity of calculating joint unit due to the assumed highest load of parts relative to all other joints. The robots in market have stability problem in dynamic condition. More number of links made robot complex in analysis of mechanism.

Fig 35: Robot leg joints

2.3Movement of joints of robot's body (Hardware required)

Since, the whole robot's body is made up of aluminium and iron and each joint is connected via servos motors & all servos needs to be controlled very precisely to perform perfect movement of different body parts. So, to control different motors we need a micro controller such as Atmega or Arduino Uno or Arduino mega etc. Here we have used Arduino Uno as our Central processing unit and along with that a motor driver commonly known as PCA 9685 (basically works on adafruit library) to control the whole motor sets. We need external power supply for our motor driver. So, here are the following things we needed to make our robot work:

2.3.1 Arduino Uno

Arduino is a basic single board microcontroller designed to make applications, interactive controls, or environments easily adaptive. The hardware consists of a board designed around an 8-bit microcontroller, or a 32-bit ARM. Current models feature things like a USB interface, analog inputs, and GPIO pins which allows the user to attach additional boards. Introduced in 2005, the Arduino platform was designed to provide a cheaper way for hobbyists, students and professionals to create applications that play in the human interface world using sensors, actuators, motors, and other rudimentary products. Common applications for students or the inexperienced are simple robots or motion detectors. It offers a simple integrated IDE (integrated development environment) that runs on regular personal computers and allows users to write programs for Arduino using C or C++.

The 5 Major Benefits of Using Arduino Uno:

I. **Inexpensive** - Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost less than $50.

II. **Cross-platform** - The Arduino software runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.

III. **Simple, clear programming environment** - The Arduino programming environment is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. For teachers, it's conveniently based on the Processing programming environment, so students learning to program in that environment will be familiar with the look and feel of Arduino.

IV. **Open source and extensible** software - The Arduino software is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it's based. Similarly, you can add AVR-C code directly into your Arduino programs if you want to.

V. **Open source and extensible hardware** - The Arduino is based on Atmel's ATMEGA8 and ATMEGA168 microcontrollers. The plans for the modules are published under a Creative Commons license, so experienced circuit designers can make their own version of the module, extending it and improving it. Even relatively inexperienced users can build the breadboard version of the module in order to understand how it works and save money.

Disadvantages of Arduino Uno:

I. It's mostly still AVR (8-bit) "eco-system" (and +5 V). There are many claims that other (e.g. ARM) architecture are supported but you'll find pretty soon that even 32-bit boards designed by Arduino team (e.g. Due, Zero, MKR) are not supported in a similar way to 8-bit (Uno, Leonardo, Mega2560), therefore there are still second choices.

II. If we need more processing power and working memory then Arduino is not a good choice.

III. One disadvantage of the Arduino Microcontroller is that its resolution is only 10 bits.

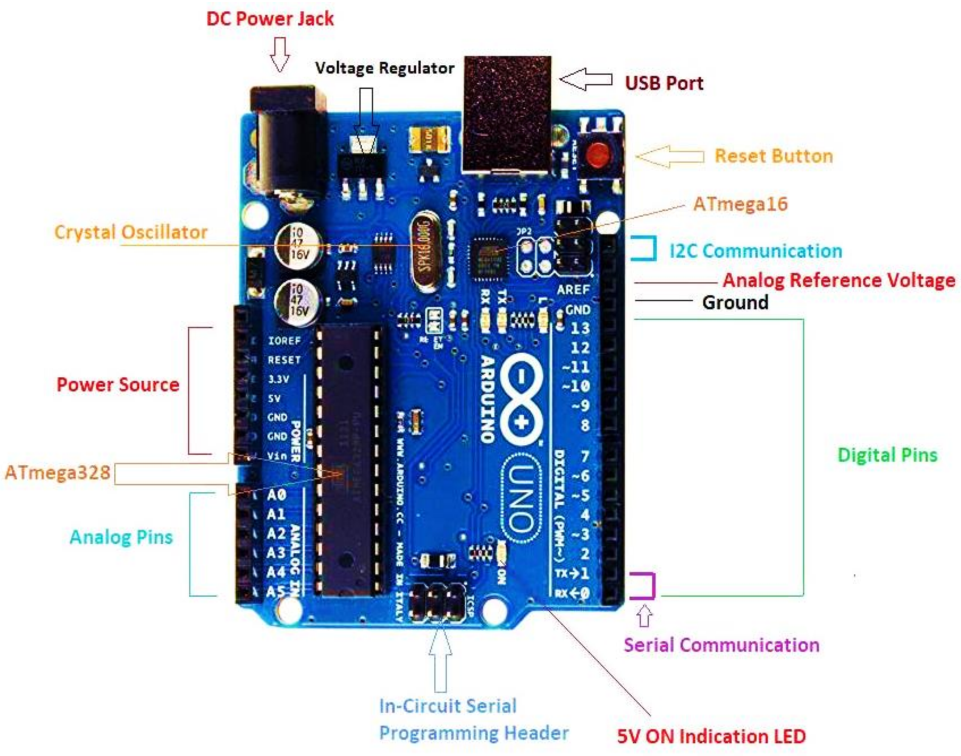


Fig 36: Arduino Uno (connected at back side of the robot)

2.3.2 PCA 9685 Motor driver

a. The PCA9685 is an I²C-bus controlled 16-channel Servo controller.
b. Output voltage: 2.3V to 5.5V(Max)
c. 1 MHz Fast-mode Plus compatible I²C-bus interface with 30 mA high drive capability on SDA output for driving high capacitive buses.
d. 6 hardware address pins allow 62 PCA9685 devices to be connected to the same I²C-bus.

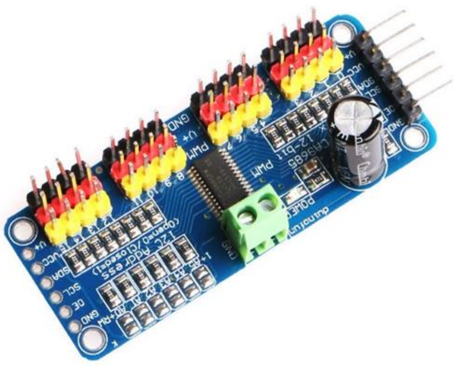


Fig 37: PCA 9685(connected at back side of the robot)

2.3.3 Servo Motor

Fig 38: Servo motor

a. If a heavy load is placed on the motor, the driver will increase the current to the motor coil as it attempts to rotate the motor.

b. There is no out-of-step condition.

c. High-speed operation is possible.

d. They are used in robots because of their smooth switching on and off and accurate positioning.

2.3.4 Ultrasonic sensor

Fig 39: ultrasonic sensor

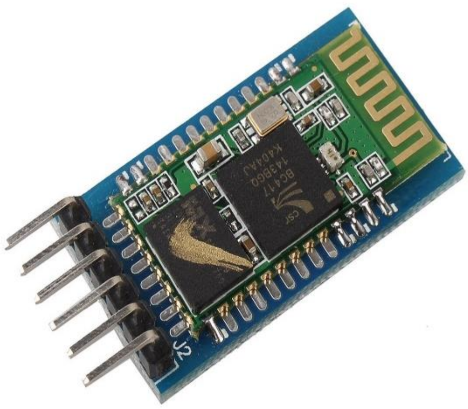
1. The ultrasonic sensor has high frequency, high sensitivity and high penetrating power therefore it can easily detect the external or deep objects.

2. These sensors easily interface with microcontroller or any type of controller.

3. These sensors have greater accuracy then other methods for measuring the thickness and depth of parallel surface.

4. These sensors could easily sense the nature, shape and orientation of that specific objects which is within the area of these sensors.

2.3.5 Bluetooth module



- Slave default Baud rate: 9600, Data bits:8, Stop bit:1, Parity: No parity.
- Auto-connect to the last device on power as default.
- Permit pairing device to connect as default.
- Auto-pairing PINCODE:" 1234" as default. Typical -80dBm sensitivity.
- Up to +4dBm RF transmit power.
- 3.3V to 5 V I/O.

2.4 Robot’s body parts

These are the basic connection of servos at different position of the body like arm, wrist, waist, leg, feet etc. Here we need different sized servo brackets and needs to be tightened by the help of screws and nuts.

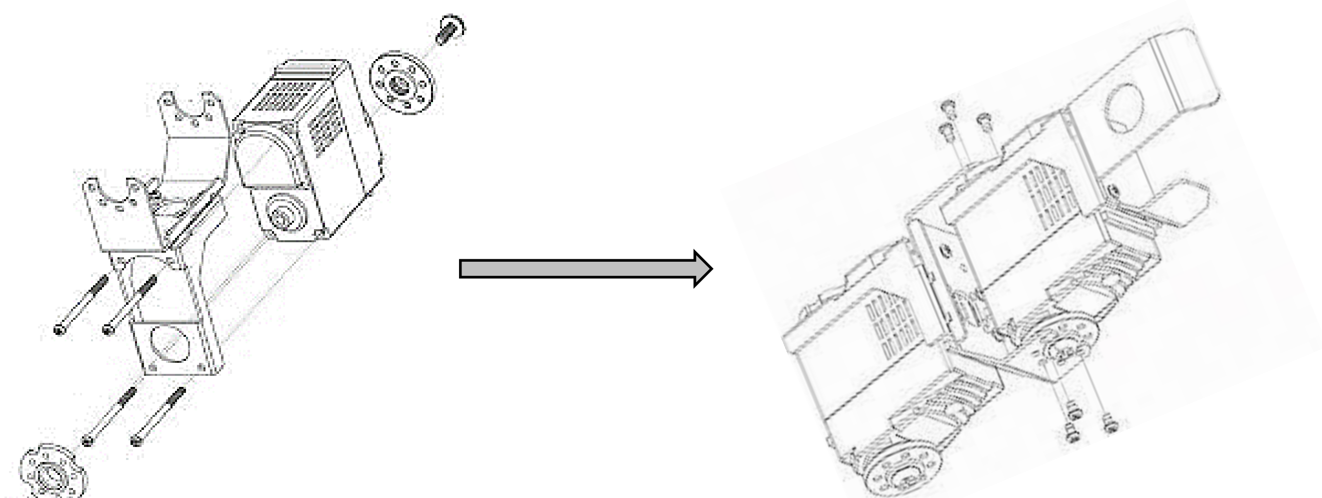
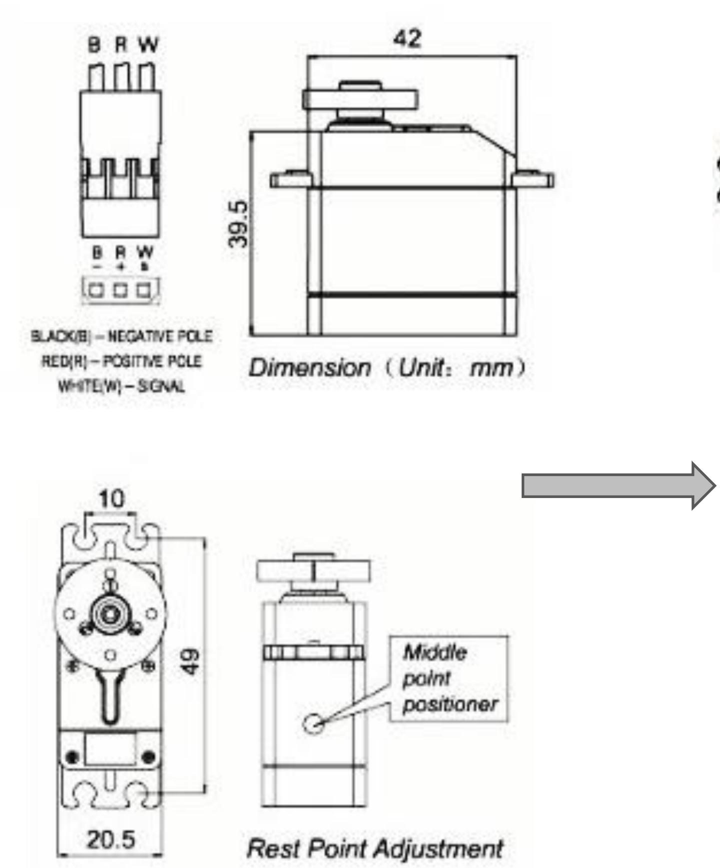


Fig 40: Formation of arm

So, in previous picture we see the formation of the arm similarly, now we can see the formation of robot’s chest and waist by the help of several servos.



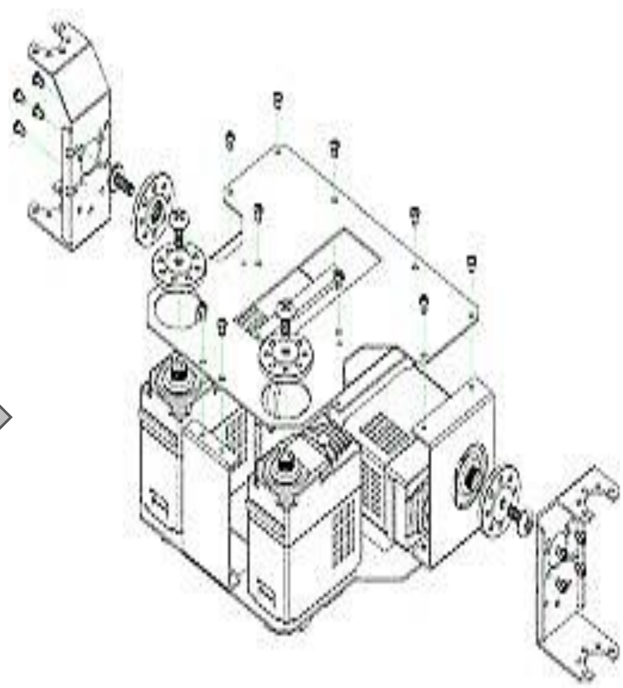


Fig 41: Formation of chest

Here, in above figure we can see that after attaching the chest motors we have attached waist motors also. Moreover, we need to connected the hands via u shaped servo bracket on the both right and left sides. And finally, a chest cover is used to make it appear like human's chest.

Now, it's about connecting the legs which is the most complex work because we always need to test the range of operation of each motor at each time. Here in this condition hit and trial method is used to know which motor needs to be connected at which place in the leg. So, below is the leg architecture of robot using servo motors.

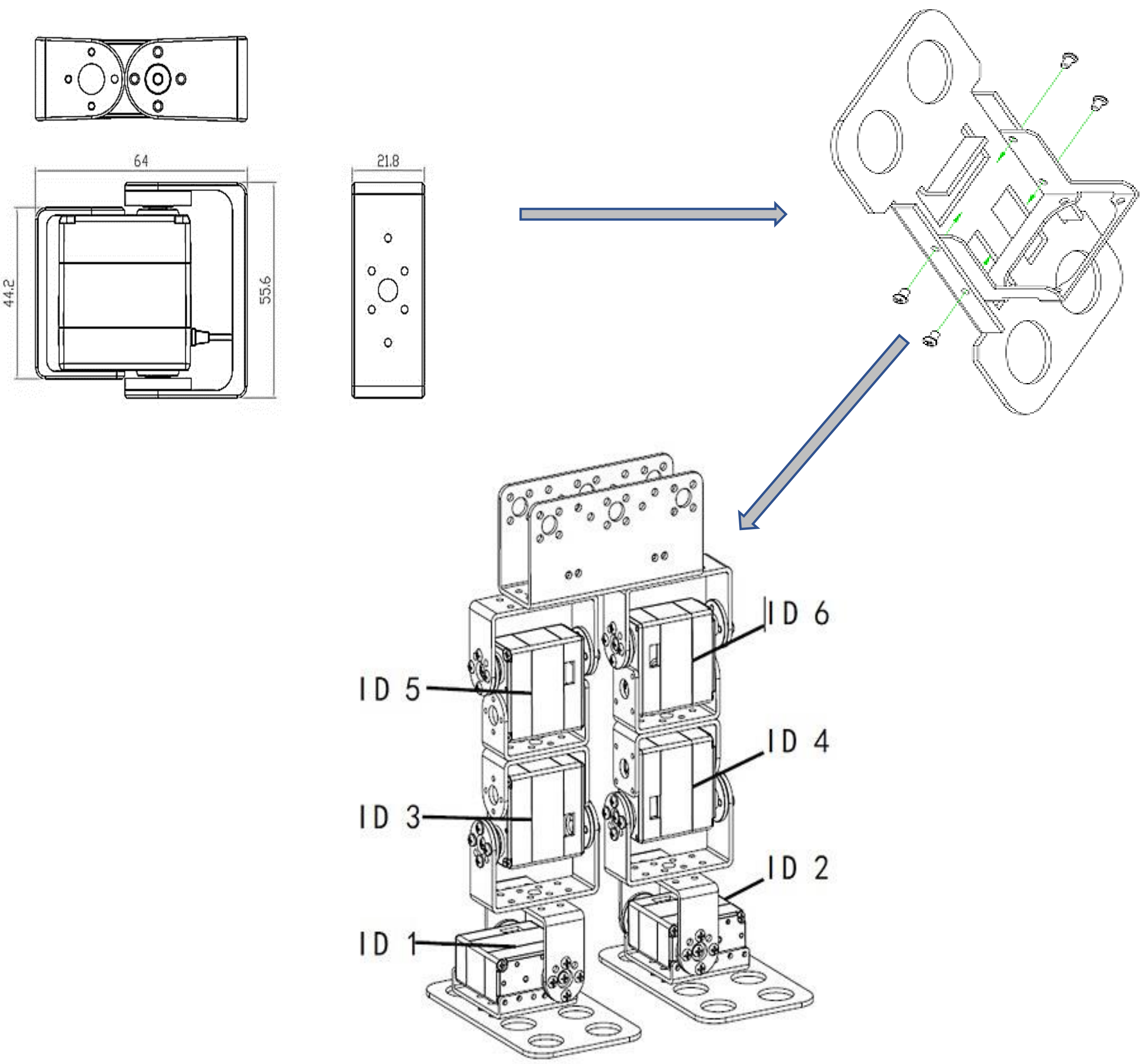


Fig 42: leg joints and structure (robot)

So, we have connected all the servo motors of our robot at desired points to provide human like posture or appearance and to produce same movement as that of human.

Therefore, it's time to put the different covers on the body.

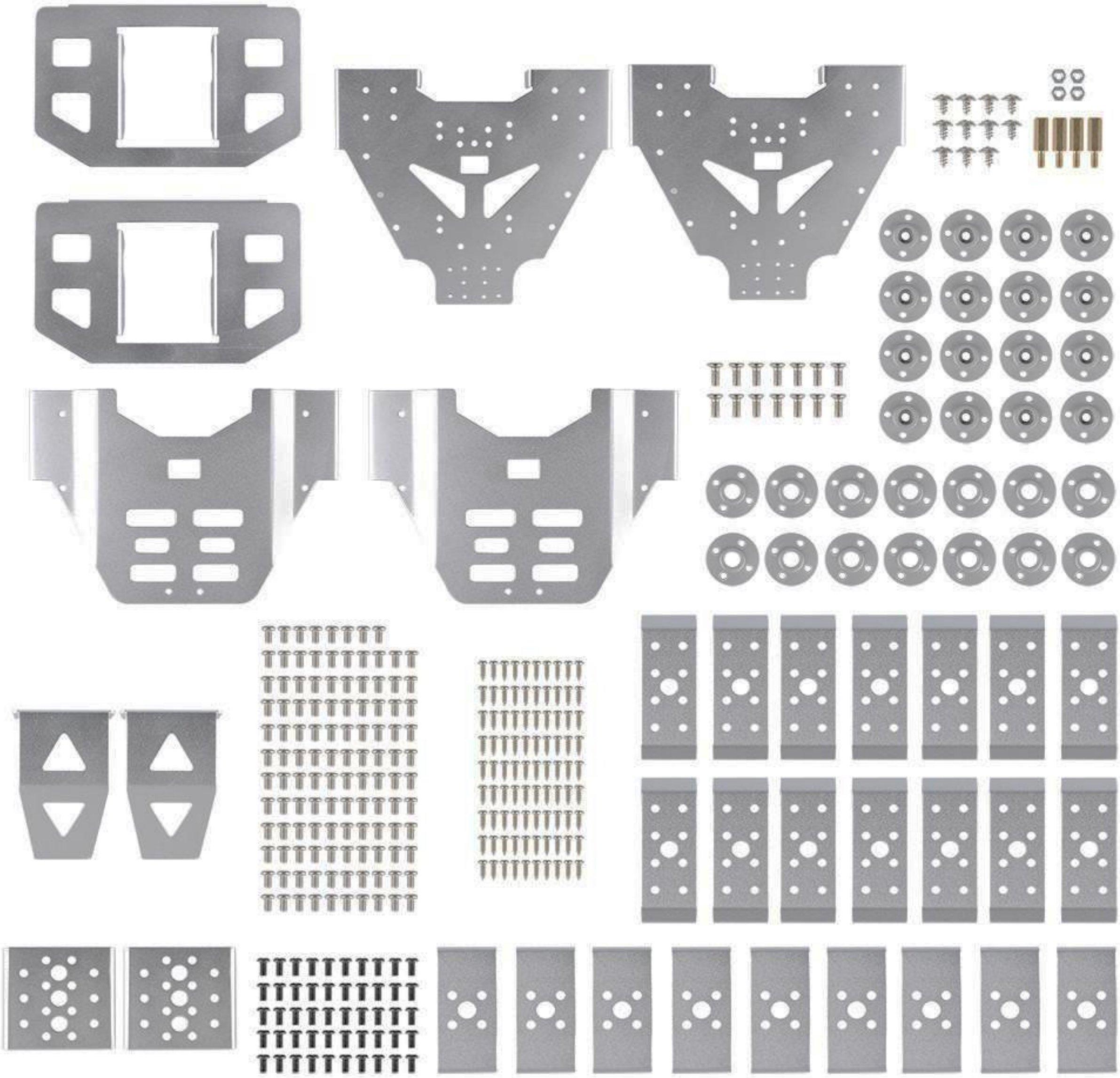


Fig 43: Covers of the robot

Here in above picture, are the cover to be adjusted in chest, leg, hands, feet etc.

So, finally below is the final appearance of our humanoid robot

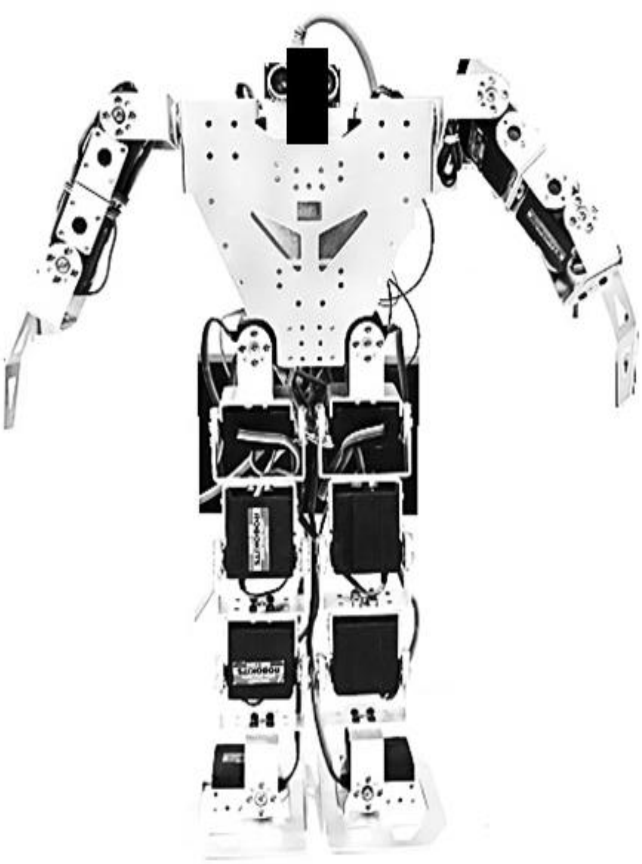


Fig 44: Humanoid robot (front look)

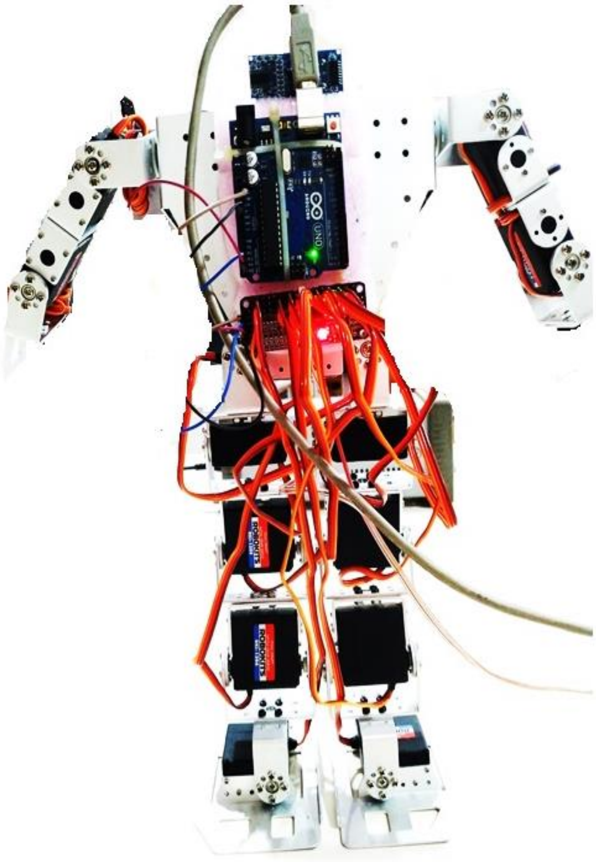
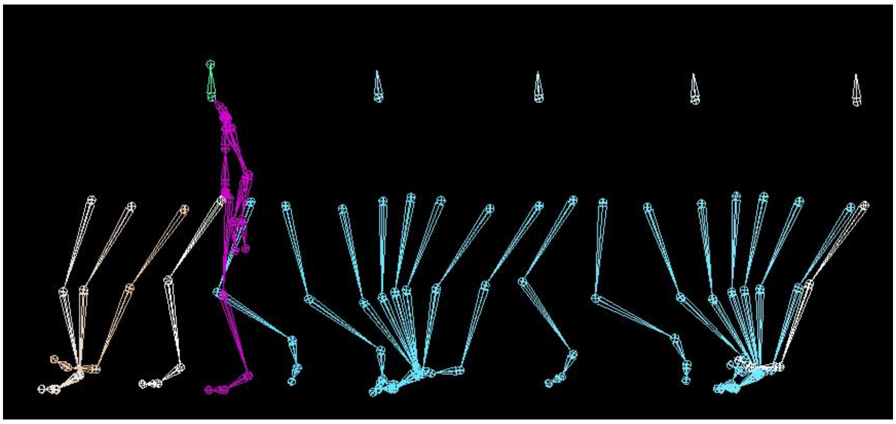


Fig 45: Humanoid robot (back look)

2.5 Walking pattern

The word walk is descended from the Old English weal can "to roll". Walking (also known as ambulation) is one of the main gaits of locomotion among legged animals. Walking is typically slower than running and other gaits. Walking is defined by an 'inverted pendulum' gait in which the body vaults over the stiff limb or limbs with each step. This applies regardless of the unusable number of limbs—even arthropods, with six, eight, or more limbs, walk. In humans and other bipeds, walking is generally distinguished from running in that only one foot at a time leaves contact with the ground and there is a period of double-support. In contrast, running begins when both feet are off the ground with each step. The most important thing is to maintain COG.

Fig 46: human walking
(aligning the centre of gravity)



In human we have a brain which can control the walking purpose efficiently but in robot we have to create an algorithm for walking which generally uses an artificial intelligence or we have to make a pre-programmed instruction set for the walking purpose of the robot. Both the mentioned works above are very complex and difficult to understand. Here, we have chosen the second method other than artificial intelligence as we have programmed the Arduino for direct walking by providing different set of instruction for different servos.

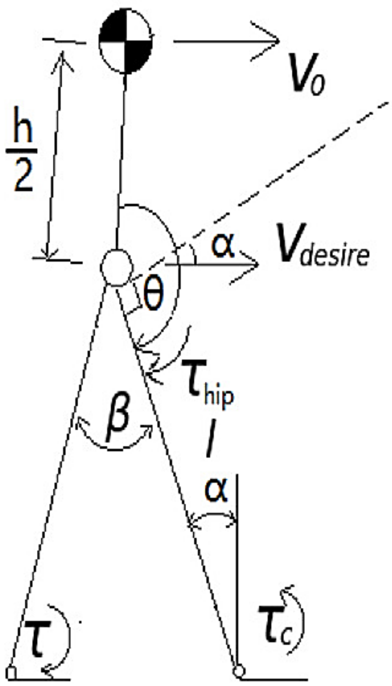


Fig 47: FBD of walking robot

(h= total height of the robot

Θ= angle between torso and leg

α= angle of the desired velocity in forward direction

β= angle between the legs)

2.5.1 Problems while walking of robot

Generally, this happens at the time of second step when hip motors don't go back at its initial position and further moves towards forward direction.

This therefore creates a situation of toppling of the robot and hence provide marginal stability towards first step.

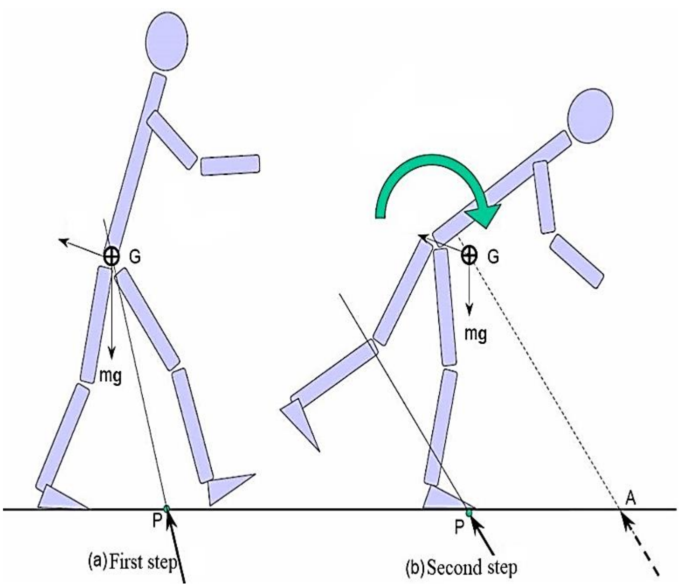


Fig 48: Marginal stability

(G= centre of gravity)

So, to remove the toppling problem, we need to stabilize the robot at its every step of walk by making the hip motors running in to and fro motion. But finally, it creates a problem in which the robot takes only one step and again, gets back to its initial position.

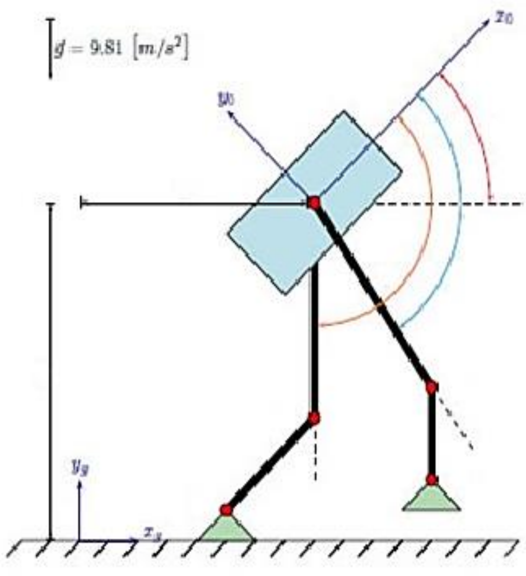


Fig 49: Stable position at the time of walking

2.5.2: Solution of walking of the robot

Finally, to make robot walk we have chosen pendulum model of walking.

Here, in pendulum model robot first lean on its one of the legs and then put the other leg in forward direction and when the forwarded leg gets intact with the ground the leaned leg gets straighten up and same procedure will be followed by the other leg.

In this model one thing must be kept in the mind that at every following step the robot loses its previous stable position so, a new stable position must be there to keep the robot walking continuous. This, helps the centre of gravity remains at the same position at the time of walking. In human this process is done automatically by the help of brain.

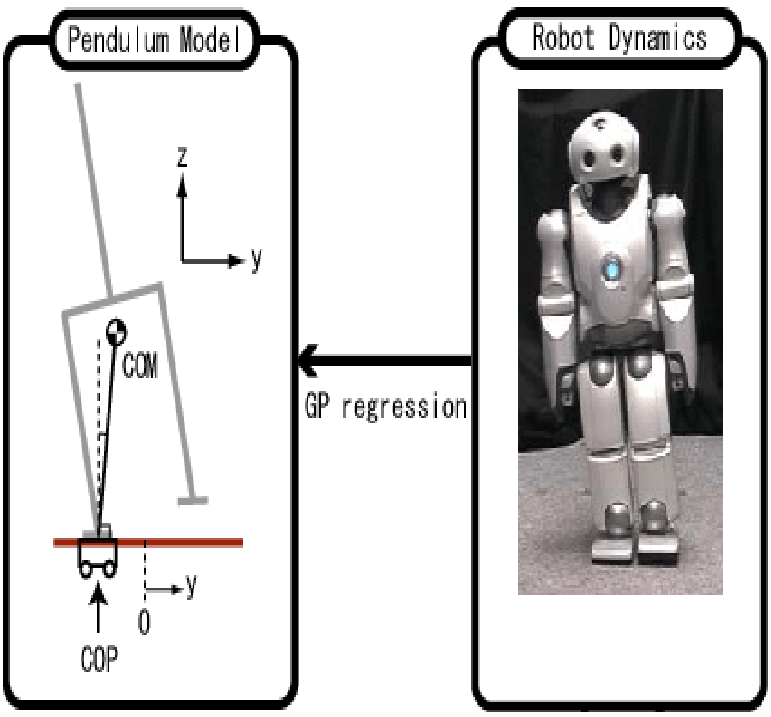


Fig 50: Pendulum model of walking (for the robot)

2.6 Basic Hand Movement

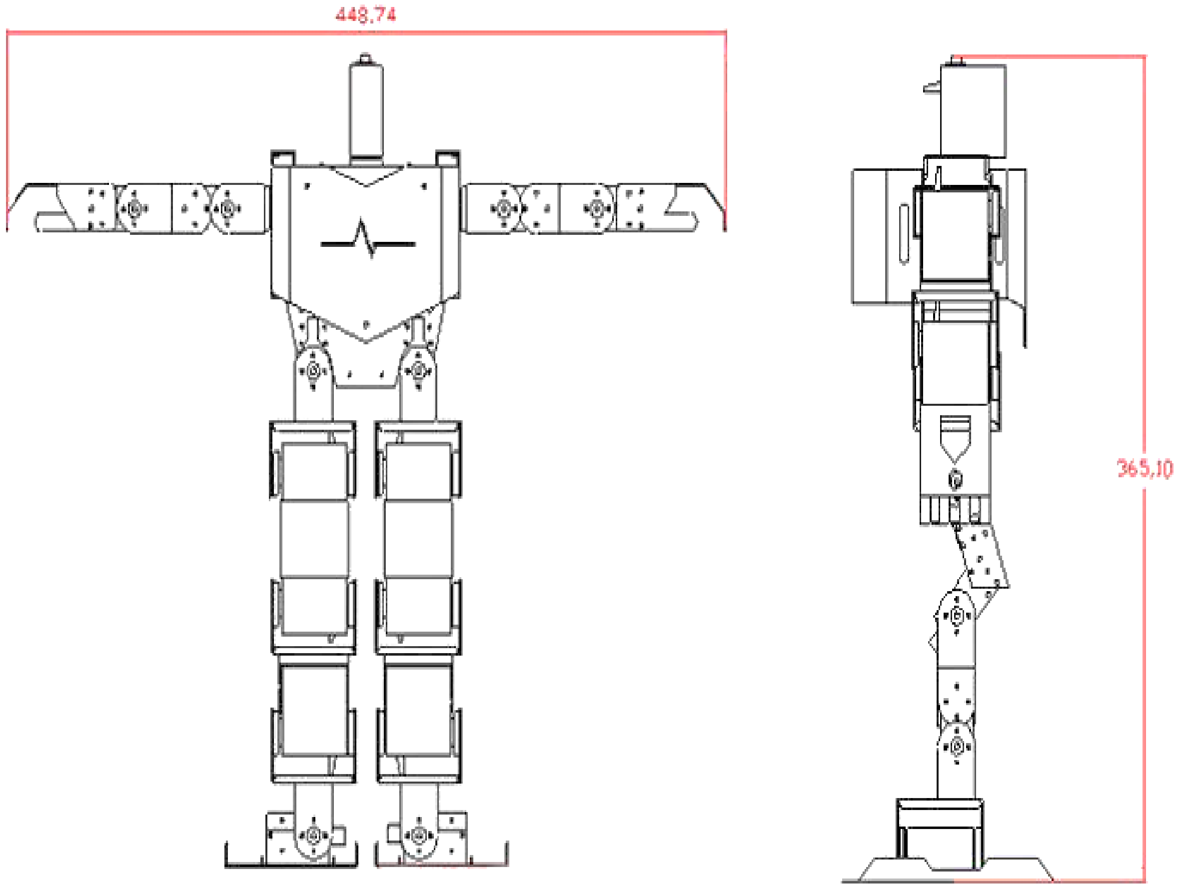


Fig 51: Hand movement (units in mm)

It's the basic physical training drill i.e. pt. drill in which both the hand shows its complete movement in all the direction. Moreover, robot cannot stand like human for the sake of stability so they stand by folding their ankle by a small amount.

Chapter 3

Literature survey

3.1 Introduction

Since the dawn of robotics and intelligent machineries in the world, they are becoming more and more integrated with our lives. Robots were initially designed to co-operate and coexist with humans and aid them. But their economic and social influence is always a topic of predicament. Humanoid robots have been in the headlines since a long time. Many researchers are working on different applications of these robots. Today, a humanoid robot is capable to display only a limited subset of skills. These efforts by the researchers are motivated by the vision to create a general-purpose robot which will work in cooperation with the humans. It is suggested that very advanced robotics will facilitate the augmentation of ordinary human beings. In other words, trans-humanism will prevail. The onset of robotic era has given certain social outcomes that are always a question of debate. Now a days, various articles investigates the social significance of robotics for the years to come in Europe and the US by studying robotics developments in five different areas: the home, health care, traffic, the police force, and the army. Our society accepts the use of robots to perform dull, dangerous, and dirty industrial jobs. But now that robotics is moving out of the factory, the relevant question is how far do we want to go with the automation of care for children and the elderly, of killing terrorists, or of making love? This literature review attempts to provide an engaged but sober (non-speculative) insight into the societal issues raised by the new robotics: which robot technologies are coming; what are they capable of; and which ethical and regulatory questions will they consequently raise?

Until recently, robots were mainly used in factories for automating production processes. In the 1970s, the appearance of factory robots led to much debate on their influence on employment. Mass unemployment was feared. Although this did not come to pass, robots have radically changed the way work is done in countless factories. This article focuses on how the use of robotics outside the factory will change our lives over the coming decades.

New robotics no longer concerns only factory applications, but also the use of robotics in a more complex and unstructured outside world, that is, the automation of numerous human activities, such as caring for the sick, driving a car, making love, and killing people. New robotics, therefore, literally concerns automation from love to war. The military sector and the car industry are particularly strong drivers behind the development of this new information technology. In fact, they have always been so. The car industry took the lead with the introduction of the industrial robot as well as with the robotization of cars. The military, especially in the United States, stood at the forefront of artificial intelligence development, and now artificial intelligence is driven by computers and the Internet. More precisely, robotics makes use of the existing ICT infrastructure and also implies a continued technological evolution of these networks. Through robotics, the Internet has gained, as it were, ‘senses and hands and feet’. The new robot is thus not usually a self-sufficient system. In order to understand the possibilities and impossibilities of the new robotics, it is therefore important to realise that robots are usually supported by a network of information technologies, such as the Internet, and thus are often presented as networked robots.

New robotics is driven by two long-term engineering ambitions. Firstly, there is the engineering dream of building machines that can move and act autonomously in complex and unstructured environments. Secondly, there is the dream of building machines that are capable of social behaviour and have the capacity for moral decision making. The notion that this may be technologically possible within a few decades is referred to as the ‘strong AI’ view (AI: artificial intelligence). It is highly doubtful that this will indeed happen. At the same time, the ‘strong AI’ view prevails in the media and is highly influential in the formulation and public financing of IT research. It is beyond dispute that this technology will strongly influence the various practices researched. This also puts many societally and politically sensitive issues on the political and public agenda. For example, according to Peter Singer, the robotization of the army is ‘the biggest revolution within the armed forces since the atom bomb’. The robotization of cars, too, appears to have begun causing large technological and cultural changes in the field of mobility. Netherlands Organisation for Applied Scientific Research (TNO) describes the introduction of car robots as a “gradual revolutionary development”. Through robots, the police may enjoy an expansion of the current range of applications for surveillance technologies. Home automation and robotics make tele-care possible and will radically change health care practice over the coming years. Finally, we point to the fact that over the past years, ‘simple’ robotics technologies have given the entertainment industry a new face: think of Wii or Kinect. We will continue to be presented with such technological gadgets in the coming period.

New robotics offers numerous possibilities for making human life more pleasant, but it also raises countless difficult societal and ethical issues.

3.2 Objectives

The lifelike appearance of robots may raise various issues. To improve the interaction between humans and robots, robotics explicitly makes use of the ability of man to anthropomorphise technology. This raises questions about the limits within which this psychological phenomenon may be used. Some fear that a widespread future use of socially intelligent nanny robots may negatively influence the emotional and social development of children. Others warn of the possibility that persuasive social robots may influence or fake people, and may even try to deceive them.

NASA’s vision for space exploration stresses the cultivation of human-robotic systems. Similar systems are also envisaged for a variety of hazardous earthbound applications such as urban search and rescue. Recent research has pointed out that to reduce human workload, costs, fatigue driven error and risk, intelligent robotic systems will need to be a significant part of mission design. However, little attention has been paid to joint human-robot teams. Making human-robot collaboration natural and efficient is crucial. In particular, grounding, situational awareness, a common frame of reference and spatial referencing are vital in effective communication and collaboration. Augmented Reality (AR), the overlaying of computer graphics onto the real worldview, can provide the necessary means for a human-robotic system to fulfil these requirements for effective collaboration. This article reviews the field of human-robot interaction and augmented reality, investigates the potential avenues for creating natural human-robot collaboration through spatial dialogue utilizing AR and proposes a holistic architectural design for human-robot collaboration.

The next several sections review current robot research and how the latest generation of robots supports these characteristics. Research into human-robot interaction, the use of robots as tools, robots as guides and assistants, as well as the progress being made in the development of humanoid robots, are all examined. Finally, a variety of efforts to use robots in collaboration are examined and analysed in the context of the human-human model presented.

Augmented Reality (AR) is a technology that facilitates the overlay of computer graphics onto the real world. AR differs from virtual reality (VR) in that in a virtual environment the entire physical world is replaced by computer graphics, AR enhances rather replaces reality. AR is an ideal platform for human-robot collaboration because it provides the following important qualities:

• The ability to enhance reality.

• Seamless interaction between real and virtual environments.

• The ability to share remote views (ego-centric view).

• The ability to visualize the robot relative to the task space (exo-centric view).

• Spatial cues for local and remote collaboration.

• Support for transitional interfaces, moving smoothly from reality into virtuality.

• Support for a tangible interface metaphor.

• Tools for enhanced collaboration, especially for multiple people collaborating with a robot.

Since the invention of robots, this field of science has fascinated many people. Robots were initially designed to do primitive and repetitive jobs on behalf of humans. But with the passage of time, the constantly evolving technology has successively blurred the lines between fantasies and realty. Today, robots coexist with us, programmed with capabilities to exceed human excellence even designed in appearance similar to humans. They can intercept environmental stimuli and generate accurate response with precision. Unlike a fictional book or a movie, the artificial intelligence has not reached to such level that the robots can be general purpose. They have limited skills. This paper reviews the history of humanoid robots, discusses the present developments of advanced and humanoid robotics, and ponders upon future developments in the field.

Social Impact of automation and robotics:

On the positive side, there's an exponential rise in productivity and efficiency. Jobs are being finished on a faster rate with assurance of accuracy at very optimal prices. But this mostly benefits the high-skilled worker at the cost of livelihood of low and middle skilled workers. Robots and automated machines are replacing manual labours each day. Displacement of jobs by robots has increased the rate of unemployment by two folds as they can work relentlessly while maintaining the accuracy with which the job is done. They don't demand wages or leaves. This benefits businesses on financial grounds and overall productivity. Some common robots that humans interact with on daily basis, robots that define the initial stage of fully autonomous robots:

Hotel Room Service: As robotics and advanced machinery continue to evolve, various hotels around the world are employing robots as their staff members to attend to their guests and ensure their comfortable stay. They can satisfactorily do jobs like serving, cleaning and provide room services, largely replacing human staff. Companies like Aloft and Savioke have already designed such roots like 'Relay' and 'Boltr' that are specialized in making room deliveries with the only need to load them with stuff you want to deliver and entering the room number, thus easing human efforts.

Telemedicine Robots: Robots have been prevalent in medical industry for years. But with technology advancing, scientists have taken this a step further. Robots are now equipped with microphones, camera and a display monitor that can act as doctor's assistant round the clock. They can move around the hospital delivering medicines to the patients and ferrying stuff for doctors. They can sit and monitor patients and also provide assistance with movements. Doctors can attend to their patients from anywhere in the hospital or even by not being in the hospital altogether. Robots like 'RP- Vita' can even help doctors with critical surgeries and even do some jobs on behalf of the doctors that need utmost precision. These high-precision robots are largely decreasing the demand of nurses and assistant doctors.

Self-Driving Bots: Lately, driving, the most common occupation in the world in under threat of being replaced by robots and autonomous cars are gaining popularity with each passing day. Deaths by car crash have been a concern of utmost importance in recent decades. Due to increasing density of cars on roads and inevitability of human's erroneous disposition have fueled the need for self-driving bots that are safer, cleaner and affordable. Self- driving bots are a boon to people with physical disabilities or for people who simply don't know who to drive. Powerful cameras, lasers and sensor are the basic technology behind these autonomous driving cars. For e.g. LIDAR- 'Laser Illuminating Detection and Ranging'- technology used in Google's driver less cars that inspects and constructs a 3-D map of the area and effuses laser beams that reflects of the surrounding objects that helps to interpret its size and distance from the car and avoid any potential danger. This technology is further infused with 'Google Maps' for positioning and to assist with directions. These cars are highly echo-friendly with the only fuel being electricity and also zero or negligible emission.

Humanoid robots resemble the appearance of human beings that helps humans to familiarize with robots easily. It is an autonomous robot specially designed to interact with the human environment. This implies that it adapts to the changes in the environment and acquaints with its surroundings to reach its goal. This is the essential difference between a humanoid robots and normal robots. Some of the capabilities of humanoid robots:

• It is capable of self-maintenance.

• It is talented to autonomously learn about things. A humanoid robot does not require any outside assistance for performing tasks. It adjusts to its surroundings.

• It tends to not to indulge in any harmful situation and protects people as well as their property.

The prominent difference in the normal robots and a humanoid robot is in the way of movement. The motion of humanoid robots should be more human-like, using biped legged locomotion. Also, the motion should result in minimum energy consumption. These two conditions differentiate a humanoid robot from a normal robot. Therefore, the study on these kinds of structures is foremost. In other words, a study on the dynamics and control is essentially crucial to develop such structures.

3.3 Formulation of Research problem

1. **New materials, fabrication methods**

Gears, motors, and actuators are fundamental to today's robots. But tremendous work is already being done with artificial muscles, soft robotics, and assembly strategies that will help develop the next generation of autonomous robots that are multifunctional and power-efficient.

2. **Creating bio-inspired robots**

Robots inspired by nature are becoming more common in robotics labs. The main idea is to create robots that perform more like the efficient systems found in nature. But the study says the major challenges involved with this area have remained largely unchanged for 30 years – a battery to match metabolic conversion, muscle-like actuators, self-healing material, autonomy in any environment, human-like perception, and computation and reasoning.

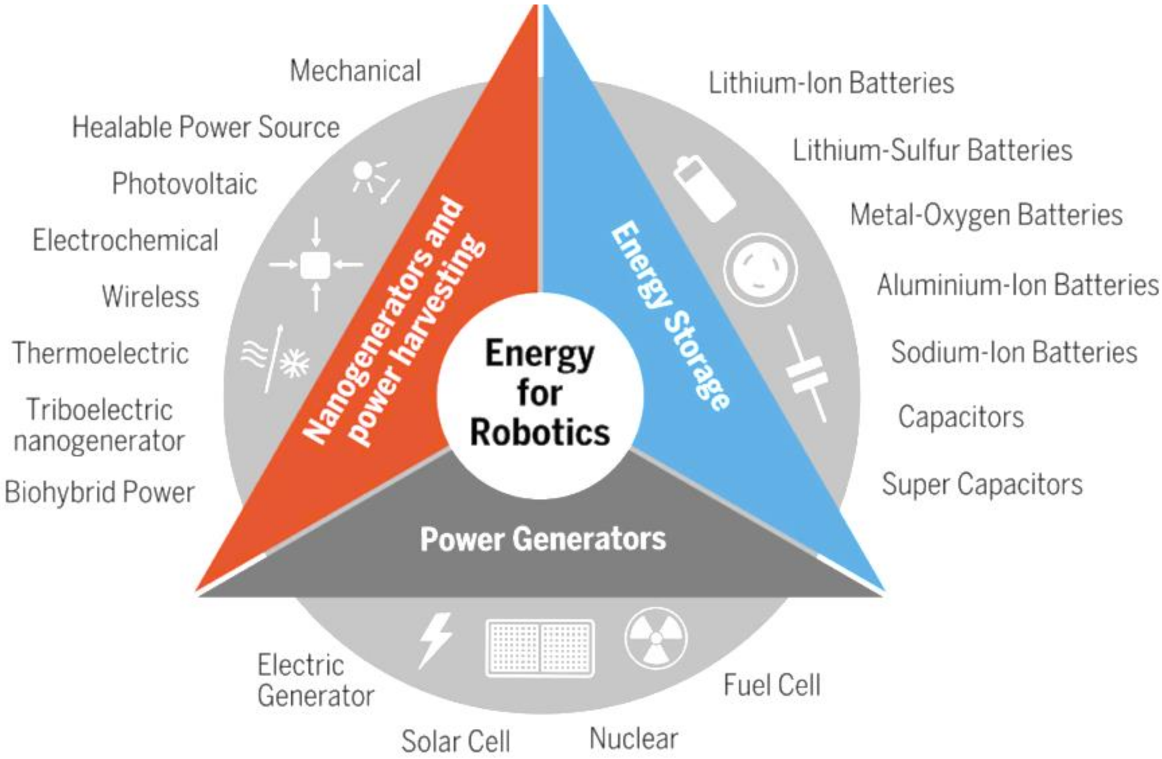
Materials that couple sensing, actuation, computation, and communication must be developed and shared before this segment takes off. These advances could lead to robots with features such as body support, weight reduction, impact protection, morphological computation, and mobility.

3. **Better power sources**

Robots, typically, are energy-inefficient. Improving the battery life is a major issue, especially for drones and mobile robots. Thankfully, increased adoption of these systems is leading to new battery technologies that are affordable, safe and longer-lasting.

Work is certainly being done to make the components of a robot more power efficient. But the study mentions robots that need to operate wirelessly in unstructured environments will eventually extract energy from light, vibrations, and mechanical movement.

Research is also being done to improve battery technology beyond the nickel-metal hydride and lithium ion options currently available.



4. **Communication in robot swarms**

Robot swarms are tricky because they need to sense not only the environment, but also each robot in the swarm. They need to communicate with the other robots, too, while acting independently.

5. **AI that can reason**

The study calls AI the “underpinning technology for robotics,” but acknowledges that “we still have a long way to go to replicate and exceed all the facets of intelligence that we see in humans.” The key is to combine advanced pattern recognition and model-based reasoning to develop AI that can reason and has common sense.

AI that can learn complex tasks on its own with minimal training data is also critical. The study does mention that DeepMind’s AlphaGo Zero system is a good example of this, but it says “we do not yet have systems that can do this easily across heterogeneous tasks and domains.”

6. **Brain-computer interfaces**

Brain-computer interfaces (BCIs) enable some device and machines to be controlled by your mind. BCIs could be quite useful in augmenting human abilities in the future, but developing the technology for wider adoption is the challenge.

The equipment for sensing brain signals is expensive and cumbersome, and the data processing can be tricky. There’s also a long period of training, calibration and learning.

But this is certainly an exciting area to watch. Johnny Matheny, who lost his arm to cancer in 2005, is the first person to live with an advanced mind-controlled robotic arm. In December 2017, researchers from Johns Hopkins Applied Physics Lab delivered the arm to Matheny at his home in Port Richey, Florida. Johns Hopkins has received more than $120 million from the US Defence Department to help pay for the arm's development over the past 10 years.

7. **Social robots for long-term engagement**

Humans are, generally, adept at interpreting social behaviour. Robots are not. The study says the three biggest challenges of building social robots that truly interact with humans are modelling social dynamics, learning social and moral norms, and building a robotic theory of mind

Today's social robots have been designed for short interactions, which isn't how human relationships work. Social robots must expand from moment-to-moment engagements to long-term relationships.

8. **Medical robotics with more autonomy**

From minimally invasive surgery, hospital optimization, to emergency response, prosthetics, and home assistance, medical robotics represents one of the fastest growing sectors. But the challenge is building reliable systems with greater levels of autonomy.

A long-term challenge is to enable one surgeon to supervise a set of robots that can perform routine procedure steps autonomously and only call on surgeons during critical, patient-specific steps. The study says, "Perhaps the most significant challenge of automating any clinical task is to be able to anticipate, detect, and respond to all possible failure modes. Medical device regulation of autonomous robots will likely need to develop in a manner that balances the requirements for provably safe algorithms with compliance costs."

Chapter 4

Design of Eye

4.1 Introduction

The Raspberry Pi is a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote teaching of basic computer science. Raspberry pi is a portable, power -ful and minicomputer. The board length is only 85mm and width is only 56mm.Its size only as big as a credit card but it is a capable little PC. It can be used for many of the things that your desktop PC does, like high-definition video, spreadsheets, word-processing, games and more. Raspberry Pi also has more wide application range, such as music machines, parent detectors to weather stations, tweeting birdhouses with infra-red cameras, lightweight web server, home automation server, etc. It enables people of all ages to explore computing, learn to program and understand how computers work. The Raspberry Pi Model B+ provides more GPIO, more USB than Model B. It also improves power consumption, audio circuit and SD card. It is more useful for embedded projects.

It has the following specifications:

1. Quad core 64-bit processor clocked at 1.4GHz
2. 1GB LPDDR2 SRAM
3. Dual-band 2.4GHz and 5GHz wireless LAN
4. Bluetooth 4.2 / BLE
5. Higher speed ethernet up to 300Mbps
6. Power-over-Ethernet capability

Fig 52: R-pi

Advantage of Raspberry Pi over another processor:

1. Cost effective
2. Easy Availability in India
3. Knowledge base is quite high for R Pi
4. Many addons are already available for R Pi as it has completed almost 5/6 years
5. Size and portability
6. Continuous improvement and ability to load normal Linux OS and there are many Linux Distributions exclusively for R Pi and Windows 10 IoT Core is also possible to load in R Pi.

Disadvantage of Raspberry Pi over another processor:

Even though Raspberry Pi can perform different tasks, there are some limitations due to its hardware. Because of its processor, it cannot run X86 operating systems. Some common ones like Windows and Linux distros are not compatible

1. Low power
2. Less memory
3. Clock speed is less
4. Graphics capabilities lags behind today’s market

4.2 Raspberry Pi Camera (BCM 2835)

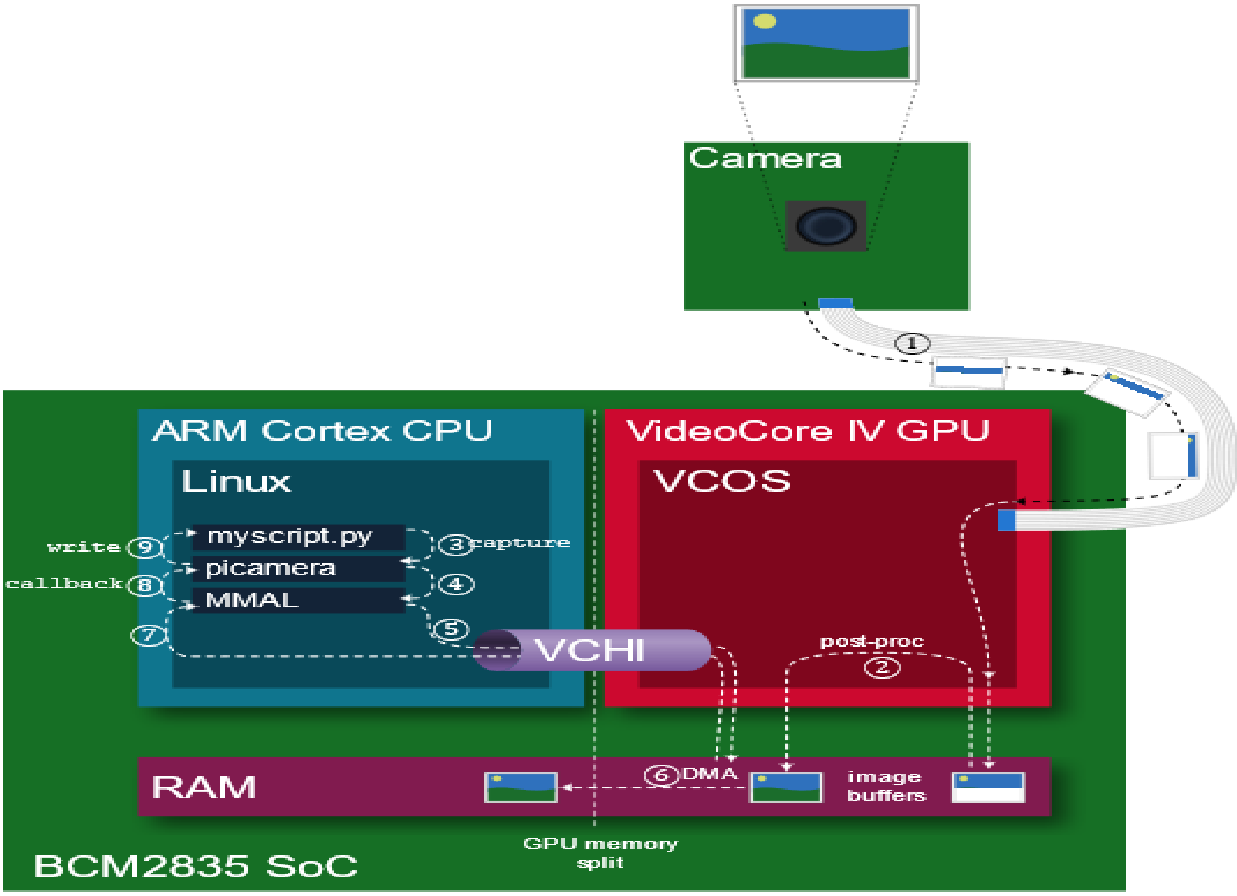


Fig 53: R-pi with pi camera

The following diagram illustrates that the BCM2835 System on Chip (SoC) is comprised of an ARM Cortex CPU running Linux (under which is running a python file which is using pi camera), and a Video Core IV GPU running VCOS. The Video Core Host Interface (VCHI) is a message passing system provided to permit communication between these two components. The available RAM is split between the two components (128Mb is a typical GPU memory split when using the camera). Finally, the camera module is shown above the SOC. It is connected to the SoC via a CSI-2 interface providing 2Gbps of bandwidth.

The following step takes place while streaming Video via R-pi:

- The camera's sensor has been configured and is continually streaming frame lines over the CSI-2 interface to the GPU.
- The GPU is assembling complete frame buffers from these lines and performing post-processing on these buffers.
- Meanwhile, over on the CPU, the python file makes a capture call using pi camera.

- The pi camera library in turn uses the MMAL API to enact this request.
- The MMAL API sends a message over VCHI requesting a frame capture.
- In response, the GPU initiates a DMA transfer of the next complete frame from its portion of RAM to the CPU's portion.
- Finally, the GPU sends a message back over VCHI that the capture is complete.
- This causes an MMAL thread to fire a call back in the pi camera library, which in turn retrieves the frame (in reality, this requires more MMAL and VCHI activity).
- Finally, pi camera calls write on the output object provided by python file.

4.3 Communication over a Network

Networking: Networking is the concept of two programs communicating across a network. It is the practice of transporting and exchanging data between nodes over a shared medium in an information system. Networking comprises not only the design, construction and use of a network, but also the management, maintenance and operation of the network infrastructure, software and policies. Computer networking enables devices and endpoints to be connected to each other on a local area network (LAN) or to a larger network, such as the internet or a private wide area network (WAN). This is an essential function for service providers, businesses and consumers worldwide to share resources, use or offer services, and communicate. Networking facilitates everything from telephone calls to text messaging to streaming video to the internet of things (IoT).

Types of Networking: There are two primary types of computer networking, wired networking and wireless networking.

Wired networking requires the use of a physical medium for transport between nodes. Copper-based Ethernet cabling, popular due to its low cost and durability, is commonly used for digital communications in businesses and homes. Alternatively, optical fibres are used to transport data over greater distances and at faster speeds, but it has several trade-off's, including higher costs and more fragile components. Wired networking offers greater speed, reliability and security compared to wireless networks

Wireless networking uses radio waves to transport data over the air, enabling devices to be connected to a network without any cabling. Wireless LAN's are the most well-known and widely deployed form of wireless networking. Alternatives include microwave, satellite, cellular and Bluetooth, among others. Wireless networking tends to provide more flexibility, mobility and scalability.

Networking can also be classified according to how it's built and designed, encompassing approaches that include software-defined networking (SDN) or overlay networks. Networking can also be categorized by environment and scale, such as LAN, campus, WAN, data centre networks or storage area networks.

Components of Networking: Computer networking requires the use of physical network infrastructure including switches, routers and wireless access points and the underlying firmware that operates such equipment. Other components include the software necessary to monitor, manage and secure the network. Additionally, networks rely on the use of standard protocols to uniformly perform discrete functions or communicate different types of data, regardless of the underlying hardware. For example, voice over IP (VoIP) can transport IP telephony traffic to any endpoint that supports the protocol. HTTP provides a common way for browsers to display webpages. The internet protocol suite, also known as TCP/IP, is a family of protocols responsible for transporting data and services over an IP-based network.

4.4 Client Server Model/Architecture

Client-server is a relationship in which one program (the client) requests a service or resource from another program (the server). Today, computer transactions in which the server fulfils a request made by a client are very common and the client-server model has become one of the central ideas of network computing. In this context, the client establishes a connection to the server over a local area network (LAN) or wide-area network (WAN), such as the Internet. Once the server has fulfilled the client's request, the connection is terminated.

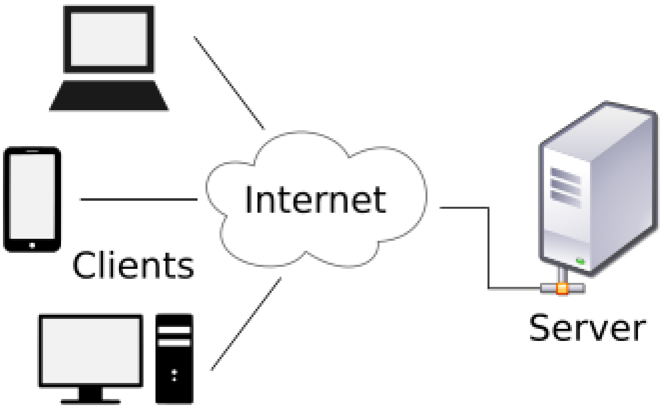


Fig 54: Server client connection

In the early days of the internet, the majority of network traffic was between remote clients requesting web content and the data centre servers that provided the content. This traffic pattern is referred to as north-south traffic. Today, with the maturity of virtualization and cloud computing, network traffic is more likely to be server-to-server, a pattern known as east-west traffic. This, in turn, has changed administrator focus from a centralized security model designed to protect the network perimeter to a decentralized security model that focuses more on controlling individual user access to services and data, and auditing their behaviour to ensure compliance with policies and regulations.

Client-Server Protocols: Clients typically communicate with servers by using the TCP/IP protocol suite. TCP is a connection-oriented protocol, which means a connection is established and maintained until the application programs at each end have finished exchanging messages. It determines how to break application data into packets that networks can deliver, sends packets to and accepts packets from the network layer, manages flow control and handles retransmission of dropped or garbled packets as well as acknowledgement of all packets that arrive. In the Open Systems Interconnection (OSI) communication model, TCP covers parts of Layer 4, the Transport Layer, and parts of Layer 5, the Session Layer.

Advantages of Client-Server model: An important advantage of the client-server model is that its centralized architecture helps make it easier to protect data with access controls that are enforced by security policies. Also, it doesn't matter if the clients and the server are built on the same operating system because data is transferred through client-server protocols that are platform agnostic.

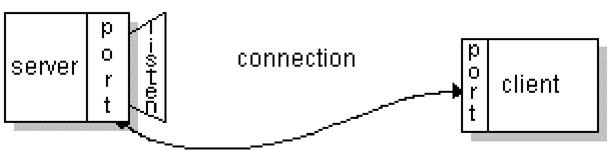
Disadvantages of Client-Server model: An important disadvantage of the client-server model is that if too many clients simultaneously request data from the server, it may get overloaded. In addition to causing network congestion, too many requests may result in a denial of service.

Other Program relationship Models: Other program relationship models included master/slave and peer-to-peer (P2P). In the P2P model, each node in the network can function as both a server and a client. In the master/slave model, one device or process (known as the master) controls one or more other devices or processes (known as slaves). Once the master/slave relationship is established, the direction of control is always one way, from the master to the slave.

4.5 Socket Communication

Sockets are programming concepts for connection and communication in a bidirectional manner from program to program. They handle implementation of Transmission Control Protocol (TCP) and User Datagram Protocol (UDP). Normally, a server runs on a specific computer and has a socket that is bound to a specific port number. The server just waits, listening to the socket for a client to make a connection request. On the client-side, the client knows the hostname of the machine on which the server is running and the port number on which the server is listening. To make a connection request, the client tries to rendezvous with the server on the server's machine and port. The client also needs to identify itself to the server so it binds to a local port number that it will use during this connection. This is usually assigned by the system.

If everything goes well, the server accepts the connection. Upon acceptance, the server gets a new socket bound to the same local port and also has its remote endpoint set to the address and port of the client. It needs a new socket so that it can continue to listen to the original socket for connection requests while tending to the needs of the connected client.



On the client side, if the connection is accepted, a socket is successfully created and the client can use the socket to communicate with the server. The client and server can now communicate by writing to or reading from their sockets.

A socket is one endpoint of a two-way communication link between two programs running on the network. A socket is bound to a port number so that the TCP layer can identify the application that data is destined to be sent to. An endpoint is a combination of an IP address and a port number. Every TCP connection can be uniquely identified by its two endpoints. That way you can have multiple connections between your host and the server. The python.net package in the Python platform provides a class Socket that implements one side of a two-way connection between your python program and another program on the network. The Socket class sits on top of a platform-dependent implementation, hiding the details of any particular system from your python program.

Client: An end device interfacing with humans. Example: Web browsers are client that connect to web servers for downloading and interacting.

Server: A device that provide service to the client. Example: www.google.com is a server-based system that provides service to the clients, i.e. web browsers.

Port Address:

In computer networking, a port is an endpoint of communication. Physical as well as wireless connections are terminated at ports of hardware devices. At the software level, within an operating system, a port is a logical construct that identifies a specific process or a type of network service. Ports are identified for each protocol and address combination by 16-bit unsigned numbers, commonly known as the port number. Inbound packets are received, and the port number in the header is used to decide which application is to be passed the packets. The software port is always associated with an IP address of a host and the protocol type of the communication. It completes the destination or origination network address of a message. Ports provide a multiplexing service for multiple services or multiple communication sessions at one network address. In the client–server model of application architecture, a multiplexing service is established, so that multiple simultaneous communication sessions may be initiated for the same service. The most commonly used protocols that use ports are the Transmission Control Protocol (TCP) and the User Datagram Protocol (UDP). Specific port numbers are commonly reserved to identify specific services. The lowest numbered 1024 port numbers are called the well-known port numbers, and identify the historically most commonly used services. Higher-numbered ports are available for general use by applications and are known as ephemeral ports.

Network Address: A network address is any logical or physical address that uniquely distinguishes a network node or device over a computer or telecommunications network. It is a numeric/symbolic number or address that is assigned to any device that seeks access to or is part of a network.

4.6 Socket Methods

Socket methods at server side

1. Socket (Socket family, Socket type): This constructor creates a new socket where the socket family can be (socket.AF_INET, socket. SOCK_STREAM) for TCP communication and (socket.AF_INET, socket. SOCK_DGRAM) for UDP communication are used.

2. Bind ((hostname, port)): Bind method takes a turple of host address and port, Here the host address refers to the IP address of the device and the port number which is assigned to it.

3. Listen (): Start listening for TCP/UDP connections.

4. Accept (): Accepts a connection when found and return a new socket.

<u>Socket method at client side:</u>

a. Connect ((hostname, port)): Takes a turple of IP address and port number. If connection is successful then message will be sent.

b. Recv (buffer): Tries to grab data from a TCP connection and waits.

c. Send (bytes): Attempts to send the bytes given to it.

d. Close (): Close the socket/connection and frees the port.

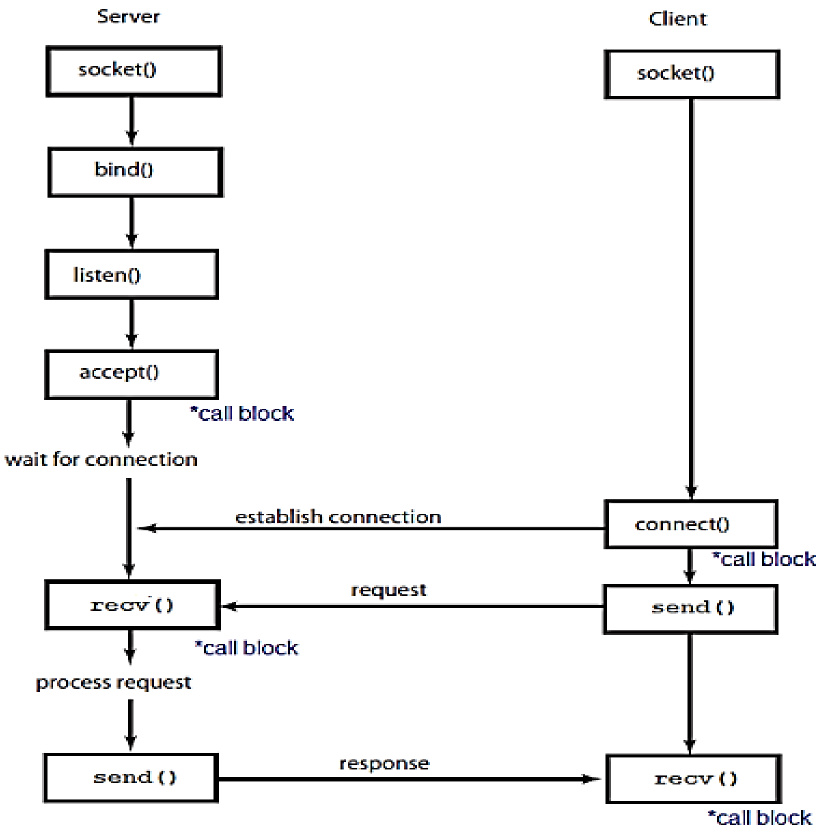


Fig 55: Flowchart of server client communication using TCP

4.7 Advantage of TCP over UDP

TCP (Transmission Control Protocol) is connection oriented, whereas UDP (User Datagram Protocol) is connection-less. This means that TCP tracks all data sent, requiring acknowledgment for each octet (generally). UDP does not use acknowledgments at all, and is usually used for protocols where a few lost datagrams do not matter. Because of acknowledgments, TCP is considered a reliable data transfer protocol. It ensures that no data is sent to the upper layer application that is out of order, duplicated, or has missing pieces. It can even manage transmissions to attempt to reduce congestion. UDP is a very lightweight protocol defined in RFC 768. The primary uses for UDP include service advertisements, such as routing protocol updates and server availability, one-to-many multicast applications, and streaming applications, such as voice and video, where a lost datagram is far less important than an out-of-order datagram.

4.8 Final flowchart of our project

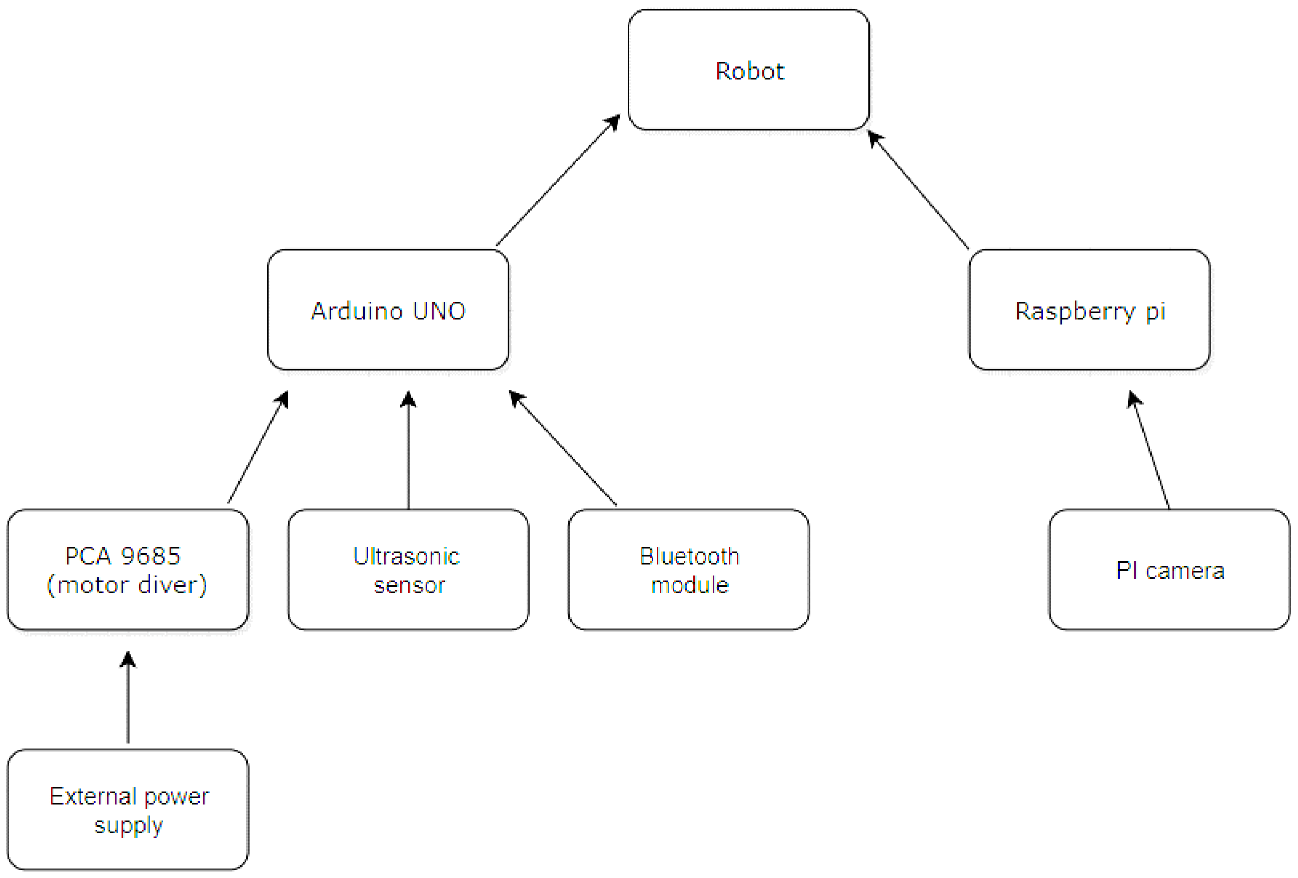


Fig A: Final flowchart of project

Chapter 5

Result and conclusion

Following results are obtained

Finally, we have achieved our goal to make the robot stand and walk (pendulum way of walking), approximately in the same way as human did but with a lesser speed because of the fact that robot always need to find a stable position after completing each step of walking. We have also connected an ultrasonic sensor to the robot so that it can detect nearby obstacles and avoids the colliding.

Moreover, we have connected a raspberry pi with pi camera in the place of head of the robot so that we can get the real time live feeds of the places where the robot goes at remote location.

Also, we have connected a Bluetooth module to the Arduino so that the complete robot can be controlled wirelessly.

So, finally our whole robot can be controlled wirelessly from a remote location and real time videos and images can be taken from the remote location by the help of pi camera.

Future scope of present work

a. Social humanoid robots are used by individuals or organizations to help and assist people in their daily life activities. These robots are commonly pre-programmed to perform mundane tasks and are also known as assistive robots. There have been many instances where robots have been used to reduce human error.

b. There are various human jobs which can be easily automated using RPA tools and technology. The future scope of RPA can be observed in the field of data entry and data rekeying jobs. These tasks could be easily automated with RPA. The various repetitive tasks such as formatting, data assembling or anything which requires a series of steps are easily carried out with the help of RPA.

c. **Efficiency:** The software robots are highly efficient and they can operate 24/7 without taking any break.

d. **Accuracy:** In order to carry out data entry task, the robots can perform it in the same way as the human beings without making any mistakes.

e. **Cost Reduction:** The software robots help to reduce the organizations cost.

f. **Enhanced audit and monitoring compliance:** A detail audit logs are offered by the robots by allowing the advanced business analytics and enhanced compliance.

g. **Military robots** are autonomous robots or remote-controlled mobile robots designed for military applications, from transport to search & rescue and attack. Some such systems are currently in use, and many are under development.

h. **NASA** is about to use its **Valkyrie** robot for future missions to Mars. Valkyrie is a 6-2 humanoid robot weighing 300 lb. The robot’s brain is powered by **two Intel Core i7** computers, and the head houses lidar sensors, cameras, and a Multisense SL camera to continually scan the surrounding objects and environments. The Multisense camera combines laser, 3D stereo, and video to sense the environment. Hazard cameras look ahead and behind from the torso to detect possible dangers.

i. Robots are already taking over some of the most hazardous jobs available, including bomb defusing. They are technically humanoid robot, being used as the physical counterpart for defusing bombs, but requires a complex and highly efficient artificial intelligence to control them. As technology improves, we will likely see more AI integration to help these machines function.

j. At this stage, most robots are still emotionless and it's hard to picture a robot you could relate to. However, a company in Japan has made the first big steps toward a robot companion—one who can understand and feel emotions. Introduced in 2014, "Pepper" the companion robot, the robot was programmed to read human emotions, develop its own emotions, and help its human friends stay happy. Pepper goes on sale in the U.S. in 2016, and more sophisticated friendly robots are sure to follow.

Statistics of selling of multipurpose industrial Robots:

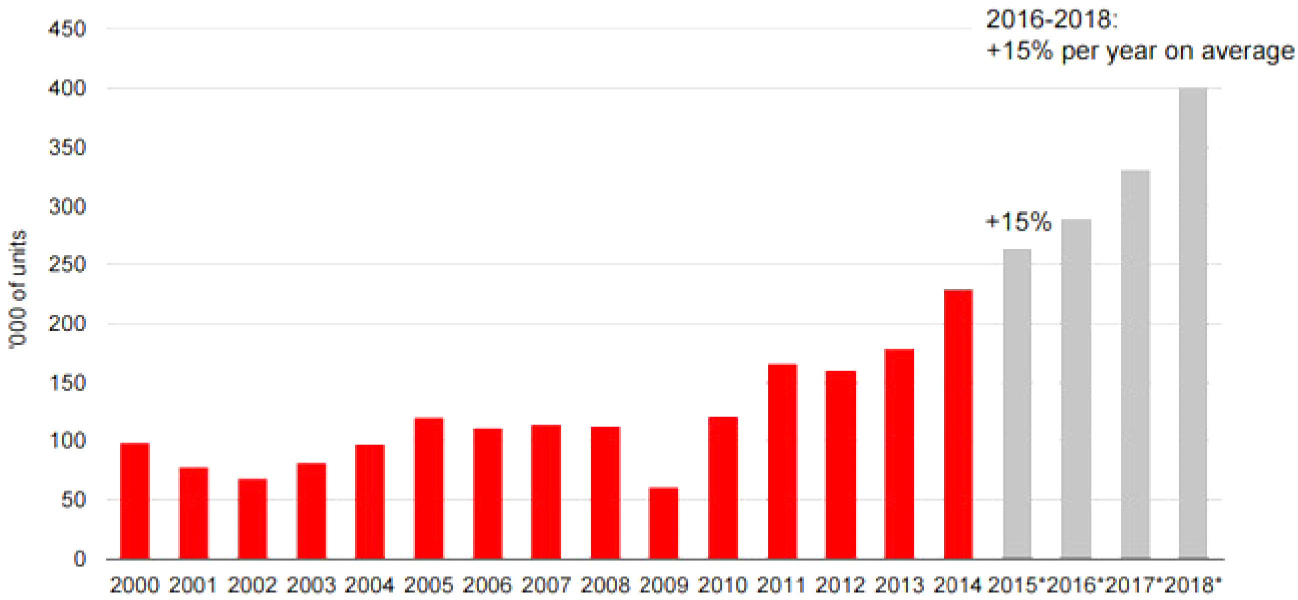
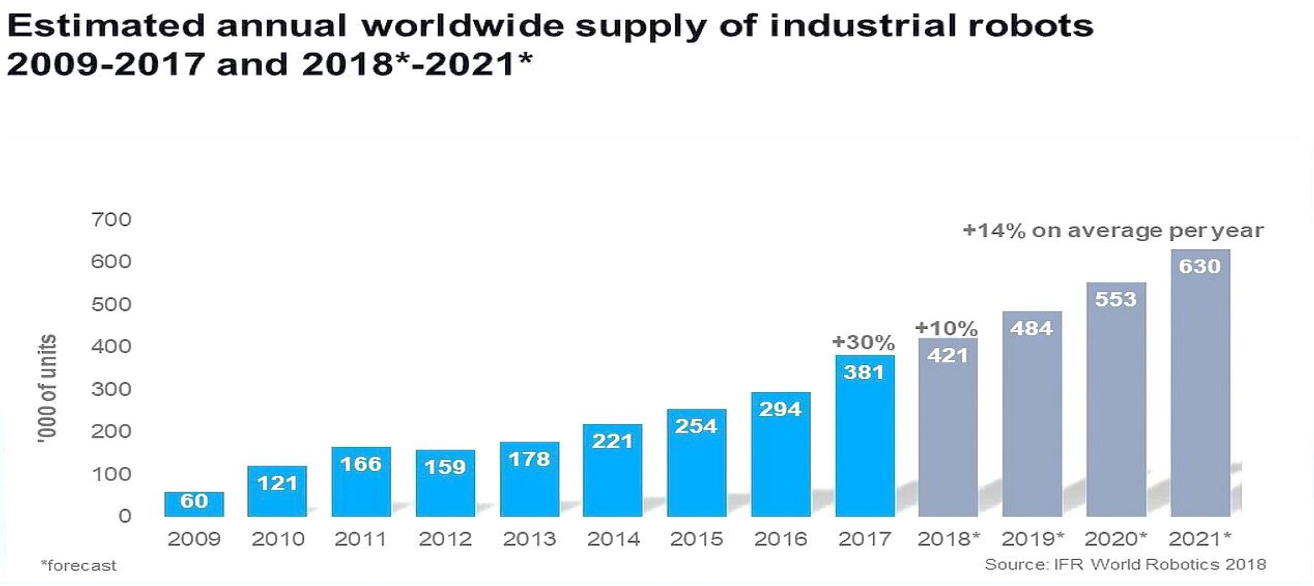


Fig 56: Worldwide annual supply of multipurpose industrial robots



Total World's Robot's Population (till 2008)

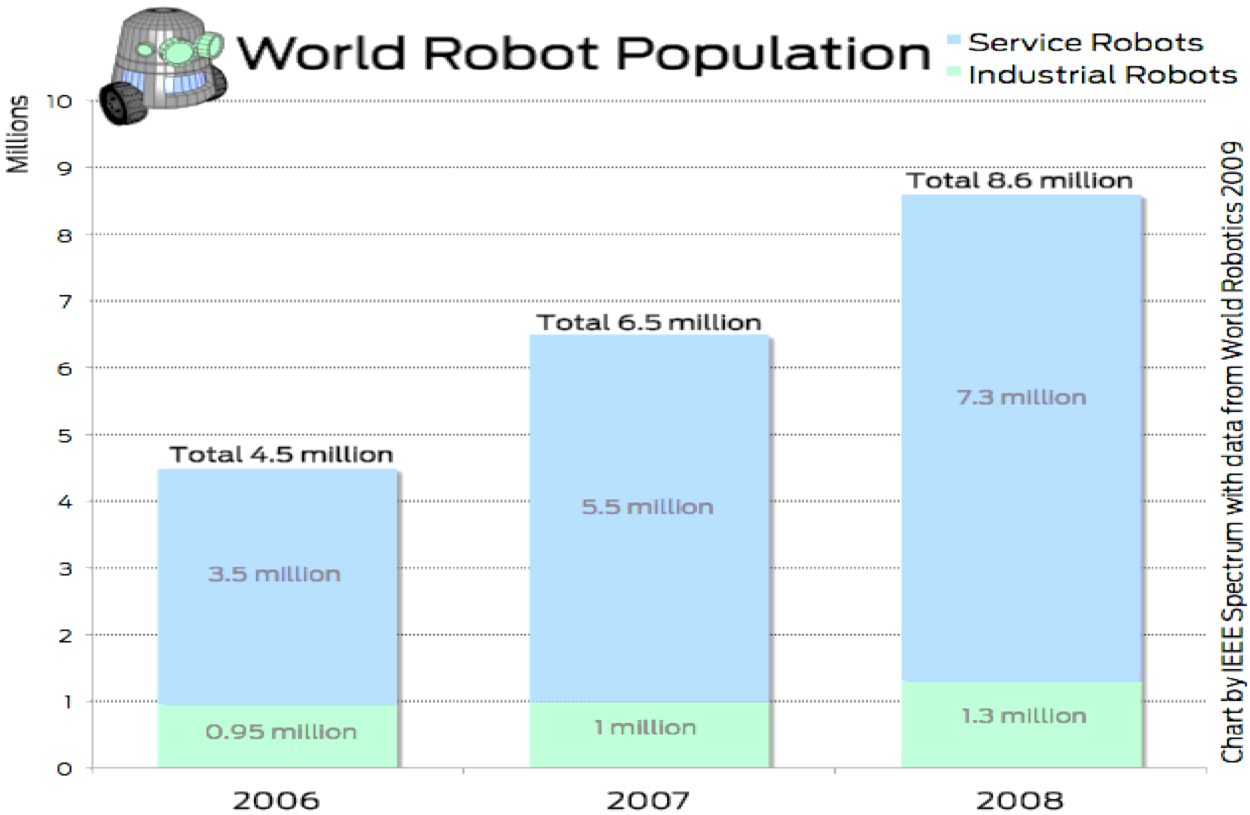
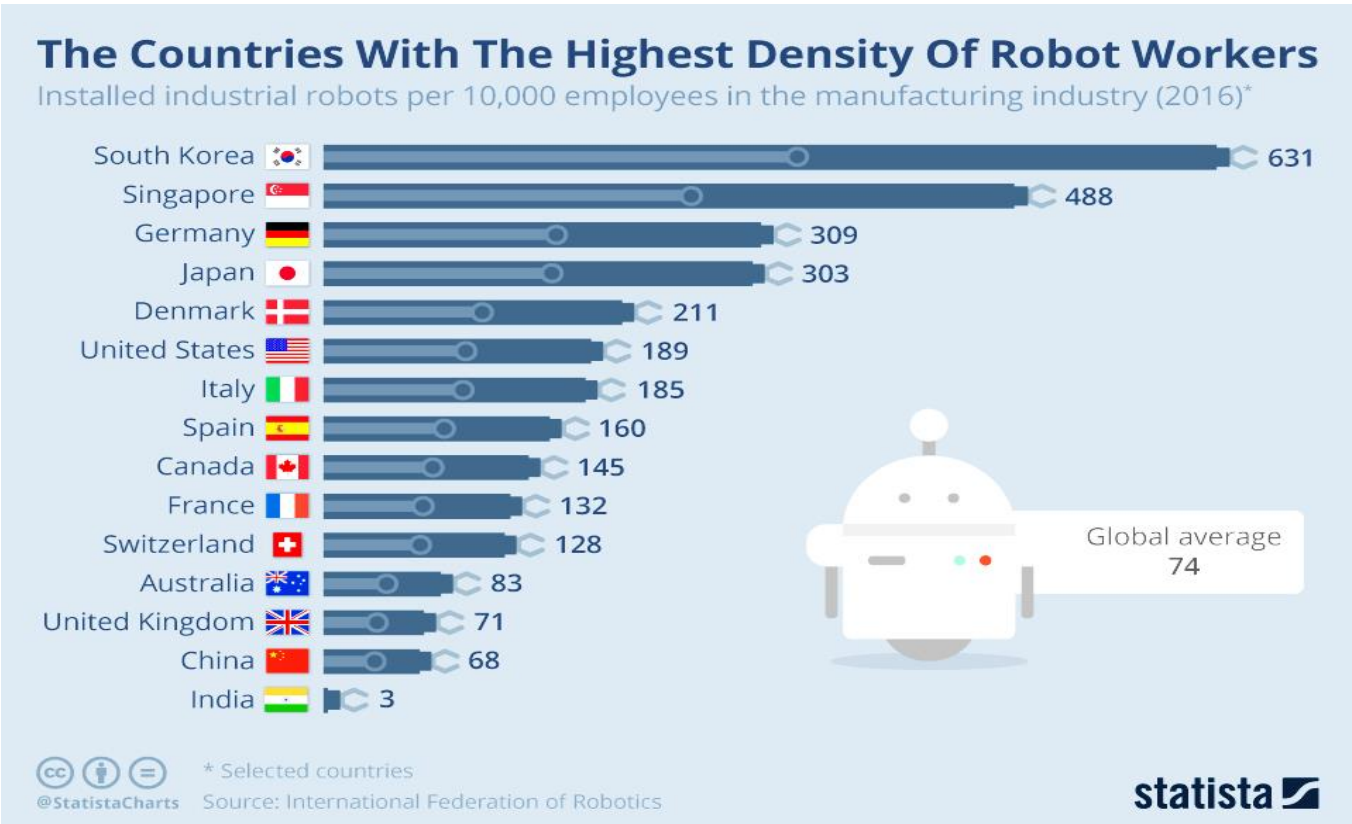


Fig 57: World's Robot's population

Countries with highest density of robot workers (till 2016):



Conclusion:

The 3 aspects of time are shown in this journal. The creation of the idea of humanoid robot from the past to its present state to its future is being understood and showcased in this journal. The different aspects of humanoid robots and its application and its future possibilities are shown in this journal. The journal starts with the current status of the idea of humanoid robots. The existing technological developments in the field are shown. One of the key motions to be mastered in humanoid robots is the duplication of the motion of a human hand; the degree of freedom for a human hand is 27 making it one of the hardest to be mimicked to perfection. Humanoid robots are called as such because of its similarities to that of a human being and the technological advancements being carried out so as to attain the perfection as the name suggests is vast. A minor motion from rolling of an eye to that of taking a swim is a possibility in the existing development. The path that the field of humanoid robots has come gets dated back up to 50 ADS where the ideas where fictional and dreams that were yet to be fulfilled. The development in science that led to the breakthrough of human mimicking and incorporating them into robots have been one of the major advancements in this field. Human body works in manners that are yet to be discovered, the versatility of the human body to move the way it does and to perform the way is beyond technological capabilities for the existing ones, with the development of artificial intelligence which is one of the major field for humanoid robot in the existing years and the coming years; it is believed to overcome hurdles that are yet to overcome. From a meagre dream about robots to a robot that is possible of its own dreams has been the expected life of a robot. Development in the field of A.I as put forward by the film industry show cases it as one that cannot be controlled by human nature; as robots were once a dream so have A.I come out in the form of dreams and pictorial representation. The coming years are the years of development of A.I and as we go along, we are getting closer to it. Artificial intelligence is the next stepping stone for the humanoid robots and someday it will be achieved.

Appendix:

Sample Arduino codes for movement of Robot’s different body parts:

1. To keep the robot in standing position

```
#include <Wire.h>
#include <Adafruit_PWMServoDriver.h>
#define SERVOMIN 90
#define SERVOMAX 610

int angle;
int angletopulse(int);
Adafruit_PWMServoDriver pwm = Adafruit_PWMServoDriver();

void setup()
{
 pinMode(13,OUTPUT);
 Serial.begin(9600);
 pwm.begin();
 pwm.setPWMFreq(60);  // Analog servos run at ~60 Hz updates
 yield();
 pwm.setPWM(2,0,angletopulse(72));//locking angle of right waist is 72 degrees
 delay(100);

 pwm.setPWM(3,0,angletopulse(51));//locking angle of left waist is 51 degrees
 delay(100);

 pwm.setPWM(5,0,angletopulse(85));//locking angle of left leg upper motor(85 degrees)
 delay(100);

 pwm.setPWM(4,0,angletopulse(120));//locking angle of right leg upper motor(120 degrees)
 delay(100);

 pwm.setPWM(6,0,angletopulse(115));//locking angle of right leg middle motor(115 degrees)
 delay(100);

 pwm.setPWM(7,0,angletopulse(66));//locking angle of left leg middle motor(66 degrees)
 delay(100);

 pwm.setPWM(8,0,angletopulse(70));//locking angle of right leg lower motor(70 degrees)
 delay(100);

 pwm.setPWM(9,0,angletopulse(100));//locking angle of left leg lower motor(100 degrees)
 delay(100);

 pwm.setPWM(11,0,angletopulse(95));//locking angle of right leg bottom level motor(95 degrees)
 delay(100);

 pwm.setPWM(14,0,angletopulse(157));//locking angle of left leg bottom level motor(157 degrees)
```

```
  delay(100);
}

  int angletopulse(int ang)
{
  int pulse=map(ang,0,180,SERVOMIN,SERVOMAX);
  Serial.println("value of angle");
  Serial.println(ang);
  Serial.println("value of pulse");
  Serial.println(pulse);
  return pulse;
}
void loop()
{

}
```

2. To make the robot sit

```
#include <Wire.h>
#include <Adafruit_PWMServoDriver.h>
#define SERVOMIN 90
#define SERVOMAX 610

int angle;
int angletopulse(int);
Adafruit_PWMServoDriver pwm = Adafruit_PWMServoDriver();

void setup()
{
  pinMode(13,OUTPUT);
  Serial.begin(9600);
  pwm.begin();
  pwm.setPWMFreq(60);  // Analog servos run at ~60 Hz updates
  yield();
  pwm.setPWM(2,0,angletopulse(72));//locking angle of right waist is 72 degrees
  delay(100);

  pwm.setPWM(3,0,angletopulse(51));//locking angle of left waist is 51 degrees
  delay(100);

  pwm.setPWM(5,0,angletopulse(85));//locking angle of left leg upper motor(85 degrees)
  delay(100);

  pwm.setPWM(4,0,angletopulse(120));//locking angle of right leg upper motor(120 degrees)
  delay(100);
```

```
  pwm.setPWM(6,0,angletopulse(115));//locking angle of right leg middle motor(115 degrees)
  delay(100);

  pwm.setPWM(7,0,angletopulse(66));//locking angle of left leg middle motor(66 degrees)
  delay(100);

  pwm.setPWM(8,0,angletopulse(70));//locking angle of right leg lower motor(70 degrees)
  delay(100);

  pwm.setPWM(9,0,angletopulse(100));//locking angle of left leg lower motor(100 degrees)
  delay(100);

  pwm.setPWM(11,0,angletopulse(95));//locking angle of right leg bottom level motor(95
degrees)
  delay(100);

  pwm.setPWM(14,0,angletopulse(157));//locking angle of left leg bottom level motor(157
degrees)
  delay(100);


  delay(3000);



  pwm.setPWM(6,0,angletopulse(115));
  delay(100);

  pwm.setPWM(7,0,angletopulse(66));
  delay(100);

  pwm.setPWM(8,0,angletopulse(70));
  delay(100);

  pwm.setPWM(9,0,angletopulse(100));
  delay(100);





  pwm.setPWM(6,0,angletopulse(117));
  delay(100);
```

```
pwm.setPWM(7,0,angletopulse(64));
delay(100);

pwm.setPWM(8,0,angletopulse(68));
delay(100);

pwm.setPWM(9,0,angletopulse(102));
delay(100);




pwm.setPWM(6,0,angletopulse(119));
delay(100);

pwm.setPWM(7,0,angletopulse(62));
delay(100);

pwm.setPWM(8,0,angletopulse(66));
delay(100);

pwm.setPWM(9,0,angletopulse(104));
delay(100);




pwm.setPWM(6,0,angletopulse(121));
delay(100);

pwm.setPWM(7,0,angletopulse(60));
delay(100);

pwm.setPWM(8,0,angletopulse(64));
delay(100);

pwm.setPWM(9,0,angletopulse(106));
delay(100);




pwm.setPWM(6,0,angletopulse(123));
```

```
delay(100);

pwm.setPWM(7,0,angletopulse(58));
delay(100);

pwm.setPWM(8,0,angletopulse(62));
delay(100);

pwm.setPWM(9,0,angletopulse(108));
delay(100);




pwm.setPWM(6,0,angletopulse(125));
delay(100);

pwm.setPWM(7,0,angletopulse(56));
delay(100);

pwm.setPWM(8,0,angletopulse(60));
delay(100);

pwm.setPWM(9,0,angletopulse(110));
delay(100);




pwm.setPWM(6,0,angletopulse(127));
delay(100);

pwm.setPWM(7,0,angletopulse(54));
delay(100);

pwm.setPWM(8,0,angletopulse(58));
delay(100);

pwm.setPWM(9,0,angletopulse(112));
delay(100);
```

```
pwm.setPWM(6,0,angletopulse(129));
delay(100);

pwm.setPWM(7,0,angletopulse(52));
delay(100);

pwm.setPWM(8,0,angletopulse(56));
delay(100);

pwm.setPWM(9,0,angletopulse(114));
delay(100);




pwm.setPWM(6,0,angletopulse(131));
delay(100);

pwm.setPWM(7,0,angletopulse(50));
delay(100);

pwm.setPWM(8,0,angletopulse(54));
delay(100);

pwm.setPWM(9,0,angletopulse(116));
delay(100);




pwm.setPWM(6,0,angletopulse(133));
delay(100);

pwm.setPWM(7,0,angletopulse(48));
delay(100);

pwm.setPWM(8,0,angletopulse(52));
delay(100);

pwm.setPWM(9,0,angletopulse(118));
delay(100);
```

```
pwm.setPWM(6,0,angletopulse(135));
delay(100);

pwm.setPWM(7,0,angletopulse(46));
delay(100);

pwm.setPWM(8,0,angletopulse(50));
delay(100);

pwm.setPWM(9,0,angletopulse(120));
delay(100);




pwm.setPWM(6,0,angletopulse(137));
delay(100);

pwm.setPWM(7,0,angletopulse(44));
delay(100);

pwm.setPWM(8,0,angletopulse(48));
delay(100);

pwm.setPWM(9,0,angletopulse(122));
delay(100);




pwm.setPWM(6,0,angletopulse(139));
delay(100);

pwm.setPWM(7,0,angletopulse(42));
delay(100);

pwm.setPWM(8,0,angletopulse(46));
```

```
delay(100);

pwm.setPWM(9,0,angletopulse(124));
delay(100);




pwm.setPWM(6,0,angletopulse(141));
delay(100);

pwm.setPWM(7,0,angletopulse(40));
delay(100);

pwm.setPWM(8,0,angletopulse(44));
delay(100);

pwm.setPWM(9,0,angletopulse(126));
delay(100);




pwm.setPWM(6,0,angletopulse(143));
delay(100);

pwm.setPWM(7,0,angletopulse(38));
delay(100);

pwm.setPWM(8,0,angletopulse(42));
delay(100);

pwm.setPWM(9,0,angletopulse(128));
delay(100);



pwm.setPWM(6,0,angletopulse(145));
delay(100);

pwm.setPWM(7,0,angletopulse(36));
delay(100);
```

```
pwm.setPWM(8,0,angletopulse(40));
delay(100);

pwm.setPWM(9,0,angletopulse(130));
delay(100);




//again further lowering


pwm.setPWM(6,0,angletopulse(147));
delay(100);

pwm.setPWM(7,0,angletopulse(34));
delay(100);

pwm.setPWM(8,0,angletopulse(38));
delay(100);

pwm.setPWM(9,0,angletopulse(132));
delay(100);





pwm.setPWM(6,0,angletopulse(149));
delay(100);

pwm.setPWM(7,0,angletopulse(32));
delay(100);

pwm.setPWM(8,0,angletopulse(36));
delay(100);

pwm.setPWM(9,0,angletopulse(134));
delay(100);
```

```
  pwm.setPWM(6,0,angletopulse(151));
  delay(100);

  pwm.setPWM(7,0,angletopulse(30));
  delay(100);

  pwm.setPWM(8,0,angletopulse(34));
  delay(100);

  pwm.setPWM(9,0,angletopulse(136));
  delay(100);
…………………………….
………………………….....
…………………………….
.
.
.
.
.
.
.
.
.


}

  int angletopulse(int ang)
{
  int pulse=map(ang,0,180,SERVOMIN,SERVOMAX);
  Serial.println("value of angle");
  Serial.println(ang);
  Serial.println("value of pulse");
  Serial.println(pulse);
  return pulse;
}
void loop()
{

}
```

Raspberry (python) program for eye design:

Server side:

```python
import socket
import sys
import cv2
import pickle
import numpy as np
import struct
import zlib
global key

HOST = ''
PORT = 8485

s=socket.socket(socket.AF_INET, socket.SOCK_STREAM)
print('Socket created')

s.bind((HOST, PORT))
print('Socket bind complete')
s.listen(10)
print('Socket now listening')

conn, addr = s.accept()

data = b""          #byte to string
payload_size = struct.calcsize(">L")        #big endian unsigned long integers
#print("payload_size: {}".format(payload_size))
while True:
   while len(data) < payload_size:
      #print("Recv: {}".format(len(data)))
      data += conn.recv(8*4096)

   #print("Done Recv: {}".format(len(data)))
   packed_msg_size = data[:payload_size]
   data = data[payload_size:]
   msg_size = struct.unpack(">L", packed_msg_size)[0]
   #print("msg_size: {}".format(msg_size))
   while len(data) < msg_size:
      data += conn.recv(8*4096)
   frame_data = data[:msg_size]
   data = data[msg_size:]

   frame=pickle.loads(frame_data, fix_imports=True, encoding="bytes")
   frame = cv2.imdecode(frame, cv2.IMREAD_COLOR)
   cv2.imshow('ImageWindow',frame)
   key = cv2.waitKey(1)
   if key == ord('q'):
      break

cv2.destroyAllWindows()
```

Client side

```
import cv2
import io
import socket
import struct
import time
import pickle
import zlib

client_socket = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
client_socket.connect(('192.168.43.254', 8485))
connection = client_socket.makefile('wb')

cam = cv2.VideoCapture(0)

img_counter = 0

encode_param = [int(cv2.IMWRITE_JPEG_QUALITY), 100]

while True:
    ret, frame = cam.read()
    frame = cv2.cvtColor(frame, cv2.COLOR_BGR2BGRA)
    frame = cv2.flip(frame, 180)
    result, frame = cv2.imencode('.jpg', frame, encode_param)
    data = zlib.compress(pickle.dumps(frame, 0))
    data = pickle.dumps(frame, 0)
    size = len(data)


    #print("{}: {}".format(img_counter, size))
    client_socket.sendall(struct.pack(">L", size) + data)
    img_counter += 1
```

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