DESIGN AND FABRICATION OF HUMANOID ROBOT

A Project report submitted

in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

In

MECHANICAL ENGINEERING

By

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CERTIFICATE

This is to certify that the Project Report entitled "**DESIGN AND FABRICATION OF HUMANOID ROBOT**" being submitted by K. NARENDRA KUMAR (318126520025), K. KAVYA (319126520L11), CH. TARUNKUMAR REDDY (318126520011), A. SASHANK (318126520002), K. SIRI (318126520020) in partial fulfilments for the award of degree of BACHELOR OF TECHNOLOGY in MECHANICAL ENGINEERING. It is the work of bonafide, carried out under the guidance and supervision of, DR. RAJESH GHOSH B.E, M.TECH, Ph.D., Associate Professor, DEPARTMENT OF MECHANICAL ENGINEERING during the academic year of 2018-2022.

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ABSTRACT

It is estimated that by the year 2030, 800 million workers all over the world be replaced by robots. This is evident that Robotic revolution is happening in a large scale. Robots eliminate dangerous jobs for humans because they are capable of working in hazardous environments. They can handle lifting heavy loads, toxic substances and doing repetitive tasks. They have helped to prevent many accidents, also saving time and money.

Legs are not new to humans or animals but building legs for a robot is a complex process. Adding legs to robots is a complex task, but there are many advantages of legs over wheels. Legged robots can navigate on any kind of surfaces which is inaccessible for robots with wheels. Wheels require a continuous path to travel whereas legs can step over isolated paths and move on. Legged robots require the system to generate an appropriate Gait to move, whereas wheels just need to roll. Gait is pattern of movement of limbs in animals and humans used for locomotion over a variety of surfaces. The same concept is used to design the pattern of movement of robots on different surfaces.

This project aims to design a humanoid robot with additive manufacturing process. Various parts of the robot are designed in the Solidworks Software and then the parts are printed with the help of a 3-D printer(material-PLA), and then they are assembled with addition to various components like servo motors etc. Overall, the project aim is to make a robot to walk with the set of commands given to it.

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CHAPTER 1

INTRODUCTION

1 INTRODUCTION

The study of robotics originates back to ancient Egypt where priests created masks that moved as a way to intimidate their worshippers. Robotics, as we know it today, originated half a century ago with the creation of a robot named “Unimate”. This Robot was created by George Devol and Joseph Engelberger. Unimate was created with the intention of being used in industry at a General Motors plant, working with heated Die-casting machines. In recent years the development of humanoid robots has become a larger area of focus for the engineering community. Humanoid robots are precisely what their name would lead you to expect, robots designed to look and act like humans. While their Current use is primarily within the entertainment industry, there are hopes that one day they will be able to be used in a broader domain.

Modern investigations into humanoid robot development have led to the desire to create a robot that can not only walk from one destination to another, but also discern Objects in front of it and be able to compensate for that by moving around them. This was where the current project came into play. The purpose of this project was to design and build a humanoid robot that was capable of walking smoothly. Due to constant advances in technology, humanoid robots of the future will be capable of helping mankind by accomplishing tasks that may too dangerous, dirty, dull or even physically impossible, such as exploring other planets. Though there is still room for improvement for the locomotion of these robots to become more and more similar to that of a human, the future looks bright for the development of the next generation of Humanoid robots.

1.1 DEFINITION OF HUMANOID ROBOT

A humanoid robot is a robot resembling the human body in shape. The design may be for functional purposes, such as interacting with human tools and environment, for experimental purposes, such as the study of bipedal locomotion, or for other purposes. They are professional service robots built to mimic human motion and interaction. Like all service robots, they provide value by automating tasks in a way that leads to cost-savings and productivity. Humanoid robots are a relatively new form of professional service robot. When asked to envision a “robot” most people will tell you they imagine a piece of machinery that resembles a human form. A humanoid robot can be defined as “a robot with its overall appearance based on that of the human body. 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).

A humanoid robot is an autonomous robot because it can adapt to changes in its environment or itself and continue to reach its goal". The torso of a humanoid robot serves two major functions. The first is that is typically houses the central computer for the robot as well as the power, in most cases batteries. Secondly, the torso is where the centre of mass is located. This will prove to be crucial when we are determining the placement of the power and computer in the robot. Attached to the torso are a head, arms, and legs. Robots can have arms for many purposes.

When designing a robot whose Primary objective is walking, arms are likely not going to be needed to perform assigned Tasks. The arms instead have the potential to be used to balance the robot. If a robot is turning, its centre of gravity can be thrown off centre and cause it to start to lean. The arms can be used in order to help it regain balance. The cameras and/or sensors used to discern objects in front of the robot are located in the robot's head. As with humans, robots have the capability of having their heads be able to turn around a certain pivot point, i.e., a spine. Having the ability to discern objects around it and not just in front of the robot will allow it to better adapt to its surroundings. Some robots are also given the capability of showing emotions when given extra sensors and programs to help it recognize the emotions of people it is interacting with.

The last, and possibly most important, characteristic that helps define a humanoid Robot is legs. There are several different ways in which a robot can walk on two legs. One method was demonstrated by a team at the Massachusetts Institute of Technology (MIT) with their robot named Toddler. The robot wobbled side-to-side with two straight legs, thus giving it the name Toddler. More recently, robots have started to be created with a greater human likeness. Legs are being created with hips, knees, and ankle joints. With every robot, there are different methods of creating these legs based off of the task it is designed to do. Another important aspect to consider is the shape of the foot, particularly with regards to its interaction with the ankle joint. Some robots are created to push off with the foot in an effort to move it forward, while others depend on the motors in the robot's upper leg to move it.

The mechanical aspects of the robot are a major part in defining it as a humanoid robot. However, the software is also unique. Humanoid robots are also known for being able to interact with humans and adapt to their surroundings. They are also known for being able to learn new material and then use it at a later date, whether it is face recognition or potentially remembering a path previously taken.

1.2 HISTORY OF ROBOTS

Greek Times

Some historians affirm that Talos, a giant creature written about in ancient greek literature, was a creature (either a man or a bull) made of bronze, given by Zeus to Europa.

Figure 1.1. Talos

According to one version of the myths he was created in Sardinia by Hephaestus on Zeus command, who gave him to the Cretan king Minos. In another version Talos came to Crete with Zeus to watch over his love Europa, and Minos received him as a gift from her. There are suppositions that his name Talos in the old Cretan language meant the "Sun" and that Zeus was known in Crete by the similar name of Zeus Tallaios. Since Talos was a bronze man, his blood was lead, which they believed was a divine fluid (ichor), identical to that what runs in the veins of the gods. Talos single vein was leading from his neck through his body to one of his heels, which was closed by a bronze nail or a bronze peg or a pin.

77-100 BC

In 1901, between the islands of Crete and Kythera, a diver found the remnants of what might only be considered a mechanical computer. The device is a complex mix of gears which most likely calculated the position of the sun, moon or other celestial bodies. The device dates back 2000 years and is considered to be of Greek origin and was given the name “The Antikythera Device”.

10-70AD

The Hero of Alexandria, a Mathematician, Physicist and Engineer (10-70AD) wrote a book titled Automata (Arabic translation, or in Greek “moving itself”) which is a collection of different devices which could have been used in temples. The Hero of Alexandria designed an odometer to be mounted on a cart and measure distances travelled. Among his other inventions are a wind powered organ, animated statues and the Aeolipile. Although conceived simply as a trinket, the Aeolipile can be considered the forefather of modern steam engines.

Medieval times

Automatons, human-like figures run by hidden mechanisms, were used to impress peasant worshippers in church into believing in a higher power. [These mechanisms] created the illusion of self-motion (moving without assistance). The clock jack was a mechanical figure that could strike time on a bell with its axe. This technology was virtually unheard of in the 13th century.

1495

Leonardo da Vinci designed what may be the first humanoid robot though it cannot be confirmed if the design was actually ever produced. The robot was designed to sit up, wave its arms, and move its head via a flexible neck while opening and closing its jaw.

1801

Joseph-Marie Jacquard invented a machine (essentially a loom) that could be programmed to create designs that could be printed onto cloth or tissue.

1921

The term "robot" was first used in a play called "R.U.R." or "Rossum's Universal Robots" by the Czech writer Karel Capek. The plot was simple: man creates a robot to replace him and then robot kills man.

Figure 1.2. Rossum's Universal Robots

1937-1938

Westinghouse creates ELEKTRO a human-like robot that could walk, talk, and smoke. ELEKTRO was first unveiled at the 1939 world’s fair.

1941

Science fiction writer Isaac Asimov first used the word "robotics" to describe the technology of robots and predicted the rise of a powerful robot industry. The term robotics refers to the study and use of robots; it came about in 1941 and was first adopted by Isaac Asimov, a scientist and writer. It was Asimov who also proposed the following “Laws of Robotics” in his short story Run-around in 1942.

1948

W. Grey Walter created his first robots; Elmer and Elsie, also known as the turtle robots. The robots were capable of finding their charging station when their battery power ran low.

1954

George Devol designed the first truly programmable robot and called it UNIMATE for "Universal Automation." (US patent 2 998 237) Later, in 1956, George Devol and Joseph Engelberger formed the world's first robot company “Unimation” which stands for “universal automation”.

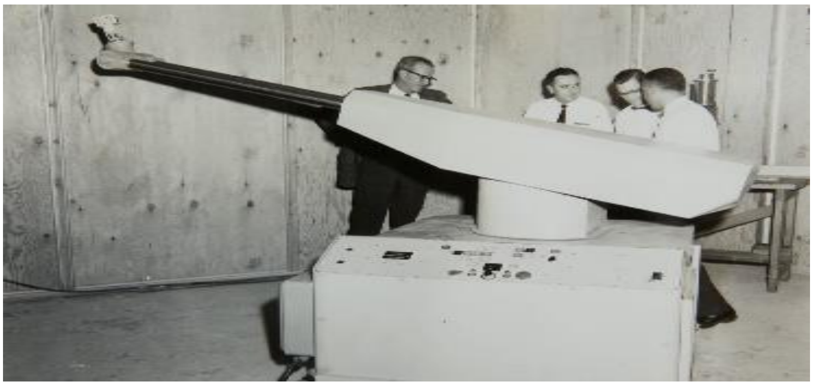

Figure 1.3. UNIMATE

As a result, Engelberger has been called the 'father of robotics’. Unimation is still in production today, with robots for sale.

1960’s

One of the first operational, industrial robots in North America appeared in the early 1960’s in a candy factory in Kitchener, Ontario.

1968

The first computer-controlled walking machine was created by Mcgee and Frank at the University of South Carolina.

1968

The first manually controlled walking truck was made by R. Mosher. It could walk up to four miles an hour.

1969

Victor Scheinman created the Stanford Arm, which was the first successful electrically-powered, computer-controlled robot arm.

1969

WAP-1 became the first biped robot and was designed by Ichiro Kato. Air bags connected to the frame were used to stimulate artificial muscles WAP-3 was designed later and could walk on flat surfaces as well as climb up and down stairs or slopes. It could also turn while walking.

1978

Shigeo Hirose created ACMVI (Oblix) robot. It had snake-like abilities. The Oblix eventually became the MOGURA robot arm used in industry.

1979

The Stanford Cart crossed a chair-filled room without human assistance. The cart had a TV camera mounted on a rail which took pictures from multiple angles and relayed them to a computer. The computer analyzed the distance between the cart and the obstacles.

1996

Honda created the P2, which was the first major step in creating their ASIMO. The P2 was the first self-regulating, bipedal humanoid robot.

1997

NASA's Pathfinder landed on Mars. The wheeled robotic rover sent images and data about Mars back to Earth.

1997

Honda created the P3, the second major step in creating their ASIMO. The P3 was Honda’s first completely autonomous humanoid robot.

1999

Sony released the first Aibo robotic dog. It makes vaguely dog-like sounds, walks around, plays with toys, responds to commands, occasionally misbehaves and uses cameras and facial recognition technology to interact differently with each person it encounters.

Figure 1.4. AIBO

2002

Honda created the Advanced Step in Innovative Mobility (ASIMO). It is intended to be a personal assistant. It recognizes its owner's face, voice, and name. Can read email and is capable of streaming video from its camera to a PC.

Figure 1.5. ASIMO

2005

The Korean Institute of Science and Technology (KIST), created HUBO, and claims it is the smartest mobile robot in the world. This robot is linked to a computer via a high-speed wireless connection; the computer does all of the thinking for the robot.

1.3 ADVANTAGES OF ROBOTS

SAFETY

Safety is the most obvious advantage of utilizing robotics. Heavy machinery, machinery that runs at hot temperature and sharp objects can easily injure a human being. By delegating dangerous tasks to a robot, you’re more likely to look at a repair bill than a serious medical bill or a lawsuit. Employees who work dangerous jobs will be thankful that robots can remove some of the risks.

Figure 1.6. Robot performing welding operation

SPEED

Robots don’t get distracted or need to take breaks. They don’t request vacation time or ask to leave an hour early. A robot will never feel stressed out and start running slower. They also don’t need to be invited to employee meetings or training session. Robots can work all the time, and this, speeds up production. They keep your employees from having to overwork themselves to meet high pressure deadlines or seemingly impossible standards.

JOB CREATION

Robots don’t take jobs away. They merely change the jobs that exist. Robots need people for monitoring and supervision. The more robots we need, the more people we’ll need to build those robots.

Figure 1.7. Man monitoring a robot

By training your employees to work with robots, you’re giving them a reason to stay motivated in their position with your company. They’ll be there for the advancements and they’ll have the unique opportunity to develop a new set of tech or engineering related skills.

CONSISTENCY

Robots never need to divide their attention between a multitude of things. Their work is never contingent on the work of other people. They won’t have unexpected emergencies, and they won’t need to be relocated to complete a different time sensitive task. They’re always there, and they’re doing what they’re supposed to do. Automation is typically far more reliable than human labour.

PERFECTION

Robots will always deliver quality work. Since they're programmed for precise, repetitive motion, they're less likely to make mistakes. In some ways, robots are simultaneously an employee and a quality control system. A lack of quirks and preferences, combined with the eliminated possibility of human error, will create a predictably perfect product every time.

1.4 DISADVANTAGES OF ROBOTS:

THEY LEAD HUMANS TO LOSE THEIR JOBS

Robots have a nasty habit of taking peoples' jobs, In a capitalist system business owners have to do what it takes to maximize profits. And the brutal efficiency of robots makes them perfect for the task.

Figure 1.8. Humans losing job

Humans just can't compete with a robot that can work 24/7 without making any mistakes. That fact can force people out of jobs they've done their entire lives.

THEY NEED CONSTANT POWER

Robots need oodles of electricity to run. That makes them expensive to run (more on this later) and potentially damaging to the environment. Unless we shift over to greener sources of energy, the growing demand for robots in society could lead to additional issues with global warming and greenhouse gas emissions.

THEY PERFORM RELATIVELY FEW TASKS

In a similar way, robots are only suited, as of now, for specific roles and responsibilities. They come into their own in industry, research, medical practices, and the military. Outside of those domains, though, they have minimal practical usage. Our day to day lives are slowly becoming more robot-centric. For now, though, there's a way to go before we start putting robots to work around the house at scale.

THEY IMPACT HUMAN INTERACTION

Human interaction will suffer as robots become an increasing part of life. Already, the rise of mobile phones has started this slippery slope. Just look around you in any public space and you see a mass of people staring at their screens. We're more connected via the internet than ever before, but more isolated, lonely, and depressed too. We risk forgetting what it means to have an actual, real-life, human interaction. There's every reason to believe that this is going to worsen as robots get an ever-greater role to play in daily life.

THEY CAUSE CYBER SECURITY ISSUES

Robots open the door to a range of cyber security problems too. Even today, the rise of computers leaves many organisations and individuals open to attack. Hacks, ransom ware, and identity theft are all potential hazards. Now, fast forward a few decades to a time when robots are an everyday part of life. They might be helping out around the house, caring for peoples' wellbeing, and running any number of key tasks. Imagine if somebody hacked their system and programmed them to 'misbehave'.

1.5 APPLICATIONS OF ROBOTS

AGRICULTURE

Agriculture is the sector that is the basis of human civilization. However, agriculture is also a seasonal sector that is dependent on ideal weather conditions optimal soil, etc. Moreover, there are many repetitive tasks in agriculture that are just a waste of farmer's time and can be performed more suitable by robots. These include seeding, weed control, harvesting, etc. Robots are usually used for harvesting the crops which allow farmers to be more efficient.

Figure 1.9. Solar powered robot from Ecorobotix

An example of a robot that is used to remove weeds in farms is the Ecorobotix. It is powered by solar energy and can be used to target and spray weeds using a complex camera system.

HEALTH CARE

Robots have changed healthcare a lot. And all for the better! They can help doctors in performing operations more precisely, be used as prosthetic limbs, provide therapy to patients, etc. The possibilities are limitless. One example of this is the Da Vinci Robot that can help surgeons in performing complex surgeries relating to the heart, head, neck, and other sensitive areas.

Figure 1.10. Da Vinci Robot

There are other robotic devices that are created like exoskeletons that can be used to provide additional support for people undergoing rehabilitation after spinal injuries, strokes, etc.

MANUFACTURING

There are many repetitive and common tasks in the manufacturing industry that don’t require any usage of the mind like welding, assembly, packing, etc. These tasks can be easily done by robots while leaving the mentally challenging and creative tasks to humans.

Figure 1.11. Robots in Industries

These robots can be trained to perform these repetitive and monotonous tasks with precision under the guidance and supervision of a human. This option is also best for the manufacturing processes that are dangerous and may be harmful to humans.

MILITARY

Robots also have many applications in the military. They can be used as drones to keep surveillance on the enemy, they can also be used as armed systems to attack the opposing forces or as Medicare agents to help friendly forces. Some of the popular robots used in the Military sector include MAARS (Modular Advanced Armed Robotic System) which looks like a tank and contains tear gas and lasers to confuse enemies and even grenade launcher for desperate situations. DOGO is also a tactical combat robot that has a camera for spying on the activities of the enemy and a 9-millimeter pistol for emergency situations.

Figure 1.12. DOGO Robot

SECURITY

Imagine if all the security guards are robots? Even thieves would be scared! That's why robots are being proposed as security agents as they can protect humans, and they wouldn't be in danger like human security guards would be. Currently, robotics companies are working on pairing robot guards with human security consultants.

Figure 1.13. Security Robot by Knight Scope

A very famous company in this field is Knight Scope in the United States that has autonomous security robots capable of assisting human security guards with real-time, actionable intelligence. These robots can help with crimes such as armed robberies, burglaries, domestic violence, fraud, hit, and runs, etc.

SPACE EXPLORATION

There are many things in space that are very dangerous for astronauts to do. Humans can’t roam on Mars all day to collect soil samples or work on repairing a spaceship from the outside while it’s in deep space! In these situations, robots are a great choice because there are no chances for the loss of human life then. So, space institutions like NASA frequently use robots and autonomous vehicles to do things that humans can’t. For example, Mars Rover is an autonomous robot that travels on Mars and takes pictures of Martian rock formations that are interesting or important and then sends them back on Earth for the NASA scientists to study.

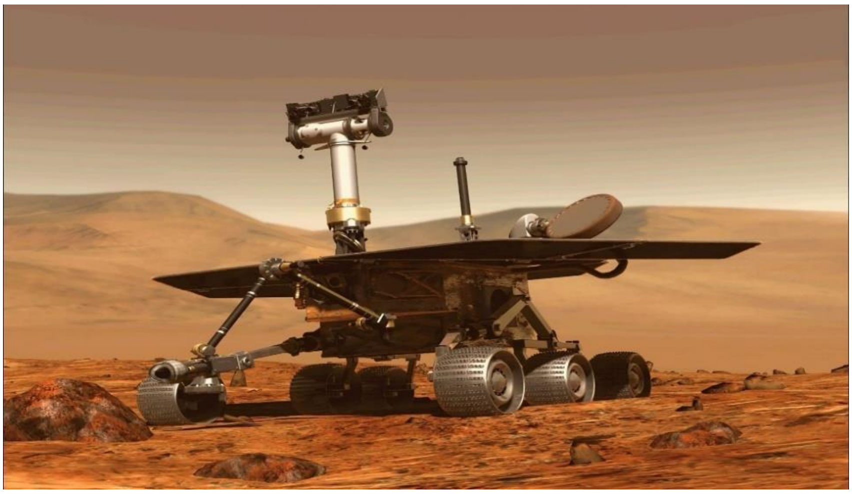

Figure 1.14. Mars Rover

ENTERTAINMENT

Robots are also a big draw in the entertainment industry. While they cannot exactly become actors and actresses, they can be used behind the sets in movies and serials to manage the camera, provide special effects, etc. They can be used for boring repetitive tasks that are not suitable for a human as cinema is, after all, a creative industry. Robots can also be used to do stunt work that is very dangerous for humans but looks pretty cool in an action movie. Theme parks like Disney World are also using autonomous robots to enhance the magical experience of their customers.

UNDERWATER EXPLORATION

Robots are a great option for exploring places that humans cannot reach easily, like the depths of the ocean! There is a lot of water pressure deep in the ocean which means humans cannot go that down and machines such as submarines can only go to a certain depth as well. A deep underwater is a mysterious place that can finally be explored using specially designed robots. These robots are remote-controlled, and they can go into depths of the ocean to collect data and images about the aquatic plant and animal life.

CUSTOMER SERVICE

There are robots that are developed to look exactly like humans for cosmetic purposes. These robots are primarily used in the field of customer service in high visibility areas to promote robotics. One such example is Nadine, a humanoid robot in Singapore that can recognize people from previous visits, make eye contact, shake hands, continue chatting based on previous meetings, etc.

Figure 1.15. Junko Chihira Robot

Another such customer service robot is Junko Chihira in Japan, a humanoid robot working at the tourist information centre in Aqua City Odaiba, a shopping centre on Tokyo’s waterfront.

1.6 REAL LIFE ROBOTS:

SOPHIA

Nations Sophia is a social humanoid Robot developed by the Hong Kong based company Hanson Robotics. Sophia was activated on February 14, 2016 and made her first public appearance in mid-March 2016 at South-by-South West (SXSW) in Austin, Texas, United States.

Figure 1.16. SOPHIA Robot

Sophia has been covered by media around the globe, and has participated in many high-profile interviews. In October 2017, Sophia was given Saudi Arabian Citizenship, and became the first robot to receive citizenship of any country. In November 2017, Sophia was named the United Nations development program's first Innovation Champion, and is the first non-human to be given a united title.

ASIMO

ASIMO (Advanced Step in Innovative Mobility) is a humanoid robot created by Honda in 2000. It is currently displayed in the Miraikan museum in Tokyo, Japan. On 8 July 2018, Honda posted the last update of ASIMO through their official page stating that it would be ceasing all development and production of ASIMO robots in order to focus on more practical applications using the technology developed through ASIMO’s lifespan. The name was chosen in honour of Isaac Asimov.

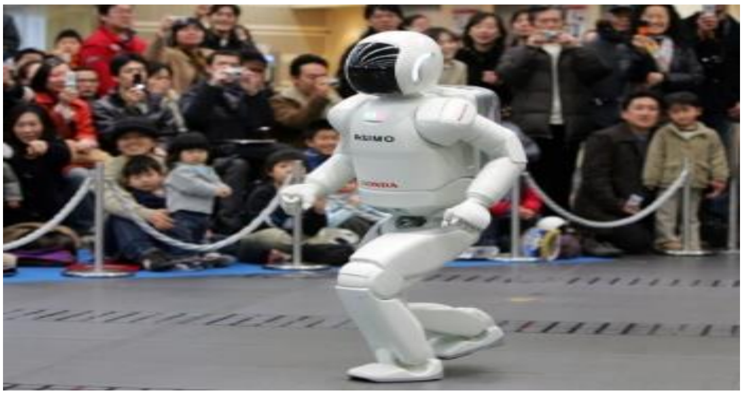

Figure 1.17. ASIMO Robot

ATLAS

Atlas is a bipedal humanoid robot primarily developed by the American robotics company Boston Dynamics with funding and oversight from the U.S Defence Advanced Research Projects Agency (DARPA). The robot was initially designed for a variety of search and rescue tasks, and was unveiled to the public on July 11, 2013.

Figure 1.18. ATLAS Robot

NAO

NAO (pronounced now) is an autonomous, programmable humanoid robot developed by Aldebaran Robotics, a French robotics company headquartered in Paris, which was acquired by Softbank group in 2015 and rebranded as Softbank Robotics. The robot's development began with the launch of Project Nao in 2004. On 15 August 2007, Nao replaced Sony's robot dog Aibo as the robot used in the Robocup Standard Platform League (SPL), an international robot soccer competition.

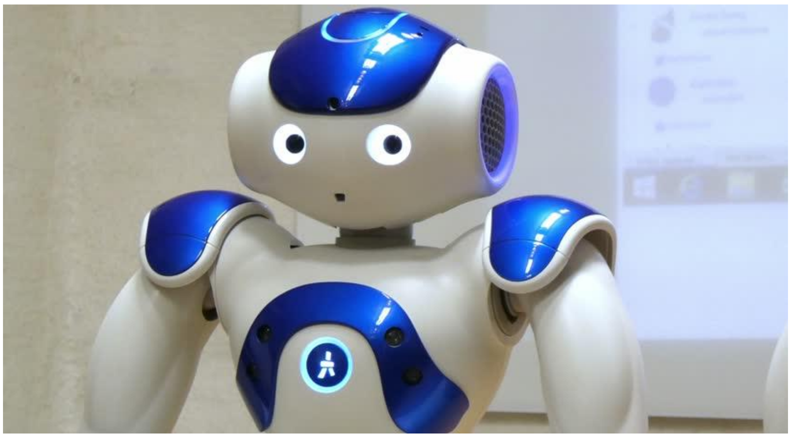

Figure 1.19. NAO Robot

The Nao was used in RoboCup 2008 and 2009, and the NaoV3R was chosen as the platform for the SPL at RoboCup 2010. Several versions of the robot have been released since 2008. The Nao Academics Edition was developed for universities and laboratories for research and education purposes. It was released to institutions in 2008, and was made publicly available by 2011. Various upgrades to the Nao platform have since been released, including the 2011 Nao Next Gen and the 2014 Nao Evolution. Nao robots have been used for research and education purposes in numerous academic institutions worldwide. As of 2015, over 5,000 Nao units are in use in more than 50 countries.

CHAPTER 2

LITERATURE REVIEW

2 LITERATURE REVIEW:

2.1 T. Furuta, T. Tawara:

The Authors worked on the design and construction of compact body humanoid robots and various biped locomotion control strategies implemented onto them in the ESYS humanoid project at the Engineering Systems Laboratory are presented. Design concepts and hardware specifications of the constructed compact size humanoid robots from Mk.1 to Mk.5 are discussed. As for the biped walk control, four biped locomotion control strategies all of which have various advantages such as versatility, high-energy efficiency, smooth loading on hardware, and real-time gait generation, are proposed. 3D biped dynamic walking of the constructed humanoids is realized by implementing the proposed biped control strategies onto them. Results of evaluation experiments on the proposed control strategies are reported.

2.2 Qinghua Li:

The authors propose learning control methods for compensative trunk motion for a biped walking robot that has a trunk, based on the ZMP (zero moment point) stability criterion, for the cases of the ZMP being inside the stable region and outside the stable region, respectively. They have developed a biped walking robot with a ZMP measurement system and a support device. The results of computer simulation and learning control experiments confirm the convergence of the learning methods and the change of the convergence rate with the change of the weight coefficient. The learning control experiments for the case of the ZMP being outside the stable region show that even though the walking state of the robot itself changes, with the support of a human and by its learning with the ZMP and the support force, stable walking even without the support of a human ultimately is realized.

2.3 Funinori Yamasaki:

In this paper, a method for co-evolving morphology and controller of bi-ped humanoid robots is proposed. Currently, structure and walking pattern of humanoid robots are designed manually on trial-and-error basis. Although certain control theory exists, for example zero moment point (ZMP) compensation, these theories do not constrain structure of humanoid robot or detailed control. Thus, engineers have to design control program for a priori designed morphology, neither of them shown to be optimal within a large design space. Therefore, evolutionary approaches that enables co-evolution of morphology and control can be useful for designing the humanoid robot. Co-evolution was achieved in a precision dynamics simulator, and discovered unexpected optimal solutions. This indicates that a complex design task of bi-ped humanoid can be performed automatically using evolution-based approach, thus varieties of humanoid robots can be design in speedy manner. This is a major importance to the emerging robotics industries.

2.4 Ashwin Sushil Kumar:

In this paper, a simple design of a fully autonomous bipedal walking robot that uses simple control and has a human-like morphology and gait is presented. Design aspects covered here include a new balancing control approach for regulating the Centre of gravity using the Internal Centre of Gravity Shifter (ICGS). The hip, knee and the foot are designed with a human-oriented approach. The biped gait is achieved with 12 degrees of freedom in the robot, three at each hip, one at each knee, and two at each ankle. It is designed with minimal number of actuators and it is controlled by an ATmega8 microcontroller through a servo controller board.

2.5 Yifeng Cui:

Programming a biped robot to walk is a challenging issue in robotics. For a stable gait, prior knowledge of the robot's physical parameters and sophisticated control algorithms are required. Robot walking by imitating a human gait becomes new challenging issues. Using a human motion data to the robot's walk is convenient even though direct usage of the data usually results in dynamically unstable motion. The purpose of this paper is to develop a new type of encoder and foot sensor for biped imitation control system, which is direct and real-time sensor system. Characteristics of the sensor system are discussed. Finally, the operator's joint motion can be imitated to the robot by using the new type of wearable encoder sensor. CoP through the developed foot sensor can be obtained and utilized to walk.

2.6 Shuuji Kajita:

The authors discuss a ZMP-based running pattern generation for a biped robot equipped with toe springs. Our biped robot HRP-2LT has twelve active DoFs for its legs and two passive DoFs for its toes. The trajectory of the centre of mass is designed to realize the specified running motion and the foot trajectories are determined to get proper spring action at lift off phases. They are interpreted into joint angles by using the resolved momentum control. By the simulation and the preliminary experiment, it is shown that the toe springs are effectively used for running and hopping.

2.7 Sebastian Lohmeier :

This paper presents the leg design of the 22-DoF humanoid walking robot Lola. The goal of the project is to realize a fast, human-like walking motion. The robot is characterized by its lightweight construction, a modular, multi-sensory joint design with brushless motors and an electronics architecture using decentralized joint controllers and sensor data processing. Linear actuators are used for the knee and ankle joints to achieve a better mass distribution in the legs and to improve performance of the stabilizing control. Some critical structural parts have been designed by means of topology optimization in order to balance the demands for high stiffness and strength with low weight.

2.8 J. Yamaguchi :

Authors have focused on the bipedal humanoid robot expected to play an active role in human living space, through studies on an anthropomorphic biped walking robot. As the first stage of developing a bipedal humanoid robot, the authors developed the human-size 35 active DOF bipedal humanoid robot "WABIAN" and the human-size 41 active DOF bipedal humanoid robot "WABIAN-R". The authors also proposed a basic control method of whole body cooperative dynamic biped walking that uses trunk or trunk-waist cooperative motion to compensate for three-axis (pitch, roll and yaw-axis) moment generated not only by the motion of the lower-limbs planned arbitrarily but by the time trajectory of the hands planned arbitrarily. Using these systems and the control method, normal biped walking (forward and backward), dynamic dance, waving arms and hip, dynamic carrying of a load using its arms, and trunk-waist cooperative dynamic walking are achieved.

2.9 S. Takao :

The Authors focused on the degrees-of-freedom for robot foot mechanism. To realize the functions of human locomotion on biped robots, we should know the fundamental aspects of human foot mechanisms through intensive observations of human locomotion. We proposed a novel mechanical shoe with 2-DOF toe parts, which move independently and are able to constrain human foot in various ways. Wearing the mechanical shoes, three subjects were measured on their walking speed, toe joint angles, and center of pressure. They were walking in straight, zigzag and slalom courses. Through these observations, we show that a biped robot with the proposed toe mechanism could potentially walk faster than conventional ones.

2.10 Sebastian Lohmeier :

This paper presents the 25-DOF full-size humanoid robot LOLA. Our goal is to realize fast and human-like walking. Furthermore, we want to increase the robot's autonomous, vision-guided walking capabilities. LOLA is characterized by a redundant kinematic configuration, an extremely lightweight design, joint actuators with brushless motors and an electronics architecture using decentralized joint control. Special emphasis was put on an improved mass distribution to achieve good dynamic performance. Center of mass trajectories are calculated in real-time from footstep locations using a spline collocation method. Reference trajectories are modified by a stabilizing control system based on hybrid force/position control with an inner joint position control loop.

2.11 Y. Ogura :

Authors found that, almost all conventional biped humanoid robots have difficulties in realizing various walking motions such as knee stretch walking like a human because of an insufficiency of DOF. Therefore, we have developed a 16-DOF biped humanoid robot without a trunk: 3-DOF in each ankle, 1-DOF in each knee, 3-DOF in each hip and 2-DOF in the waist. Using the biped robot, basic experiments are conducted and the effectiveness of the leg mechanism is confirmed.

2.12 O. Eiberger :

The authors present a humanoid two-arm system developed as a research platform for studying dexterous two-handed manipulation. The system is based on the modular DLR-Lightweight-Robot-III and the DLR-Hand-II. Two arms and hands are combined with a three degrees-of-freedom movable torso and a visual system to form a complete humanoid upper body. In this paper we present the design considerations and give an overview of the different sub-systems. Then, we describe the requirements on the software architecture. Moreover, the applied control methods for two-armed manipulation and the vision algorithms used for scene analysis are discussed.

2.13 Koichi Nishiwaki :

In this paper authors found that biped walking causes translational acceleration and vibration on the torso where an attitude sensor system is usually implemented. The accuracy of measurement tends to be low because of those bad influences. We propose a method of attitude estimation that takes translational acceleration into account. Planned translational acceleration is derived from generated walking pattern, and subtracted from the output of the accelerometers, so that the effect of acceleration caused by robot motion is cancelled when the direction of gravity acceleration is estimated. An attitude measuring system which consists of 3 fibre optic gyroscopic sensors and 3 servo accelerometers was developed. The system was attached on a full size humanoid HRP-2, and the proposed method was implemented. The performance of the proposed method was evaluated during normal walking of HRP-2.

2.14 Jungwon Yoon :

Authors proposed a new four degrees-of-freedom (dof) humanoid foot device that can allow humanoid robot to walk naturally like normal human. The device can generate rotations at two toe joints and two rotations at ankle. The new mechanism consists of front-left, front-right, and rear platforms, and four limbs. Base of three platforms is located at a humanoid shin. One limb with 6-dof serial joints (S-P-U) is attached to front-left and front-right platforms, respectively, while rear limb (Pe-Re-R) and four-bar limb (S-S) are attached to rear platform. The rear limb is driven by the 2-dof driving mechanism (Pe-Re) with two base-fixed prismatic actuators. The four-bar limb will allow the rear platform to generate pitch motions. A new 4-dof mechanism with three platforms can generate pitch and roll motions at each platform. Kinematic analyses of the suggested mechanism were performed, including inverse and forward kinematics, and velocity analysis. Based on this mechanism, the foot device was developed for natural walking of humanoid robot.

2.15 Kazushi Shimomura :

The authors focussed on the humanoid robot, WABIAN-2R, capable of human-like walk with stretched knees and heel-contact and toe-off motions is proposed in this paper. WABIAN-2R has two 1-DOF passive joints in its feet to enable it to bend its toes in steady walking. Further, it has two 6-DOF legs, a 2-DOF pelvis, a 2-DOF trunk, two 7-DOF arms with 3-DOF hands, and a 3-DOF neck. In addition, a new algorithm for generating walking patterns with stretched knees and heel-contact and toe-off motions based on the ZMP criterion is described. In this pattern generation, some parameters of the foot trajectories of a biped robot are optimized by using a genetic algorithm in order to generate a continuous and smooth leg motion. Software simulations and walking experiments are conducted, and the effectiveness of the pattern generation and mechanism of WABIAN-2R, which have the ability to realize more human-like walking styles in a humanoid robot, are confirmed.

CHAPTER 3

DESIGN AND FABRICATION

3 DESIGN AND FABRICATION

3.1 DESIGN OF HUMANOID ROBOT

SOLIDWORKS

Solidworks is computer-aided design (CAD) software owned by Dassault Systemes. It uses the principle of parametric design and generates three kinds of interconnected files: the part, the assembly, and the drawing. Therefore, any modification to one of these three files will be reflected in the other two. Solidworks helps you perform 2D and 3D modelling, and this CAD software is known for its ease-of-use and intuitiveness. The figure 3.1 shows the interface of the Solidworks software.

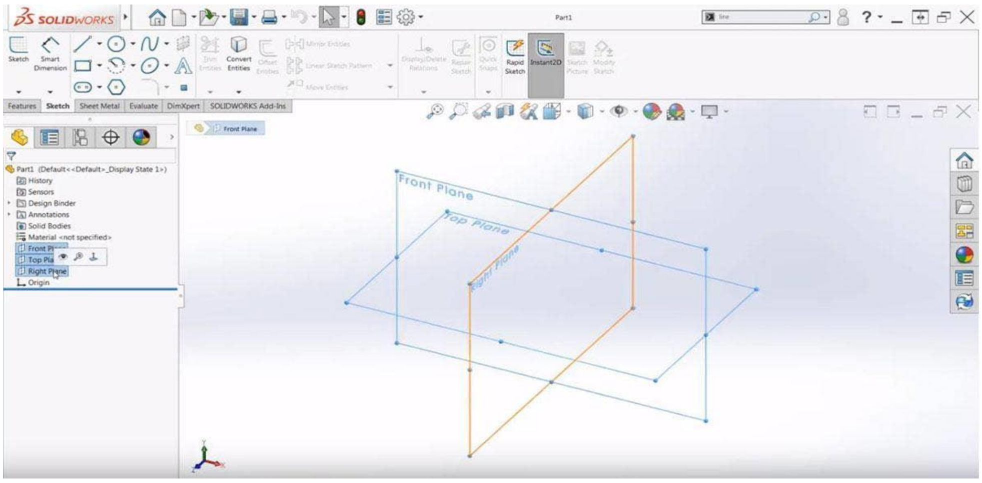

Figure 3.1. Solidworks Interface

FEATURES:

1. Part and assembly modelling
2. 2D drawings
3. Design re-use and automation
4. Animation and visualization
5. Interference check
6. Collaborate and share CAD data (3D interconnect & eDrawings)
7. Advanced CAD file import
8. Basic analysis tools (SimulationXpress & FloXpress)
9. Productivity tools
10. Solid Works CAM Standard

11. Design for manufacturing.

APPLICATIONS:

1. Designing: Surface modelling or parametric/direct solid modelling.
2. Manufacturing: Turning designs into products, including machine modules.
3. Engineering Analysis: Electromagnetic analysis, thermal analysis, fluid analysis and more.

DESIGN OF HUMANOID ROBOT IN SOLIDWORKS:

Various parts of the Humanoid Robot are designed using the Solidworks software. Different parts are first designed with the standard dimensions in the "part modelling section". After completing design of all the parts and the required sub-assemblies, the final assembly is done in the "Assembly section" of the Solidworks software. During the Assembly, proper mating is given. Various parts like robot foot, thighs, servo holder etc. are designed in the part modelling section and all these parts are assembled in the Assembly section and obtained the Final Assembly.

STEP 1:

Various parts of the humanoid robot, like Robot foot, supporting links, Robot thigh, Robot torso, Robot body, Robot arms, head etc. are designed in the Part modelling section of the Solidworks software. Various commands like line, rectangle, arc etc. are used to draw the 2D shapes with the required dimensions, and by using the Extrude Command they are extruded accordingly to the required size.

The figures 3.2, 3.3 and 3.4, are the designs of the Robot foot, supporting link and Robot leg in Solidworks software. In the similar all the Robot parts are designed in the Solidworks software.

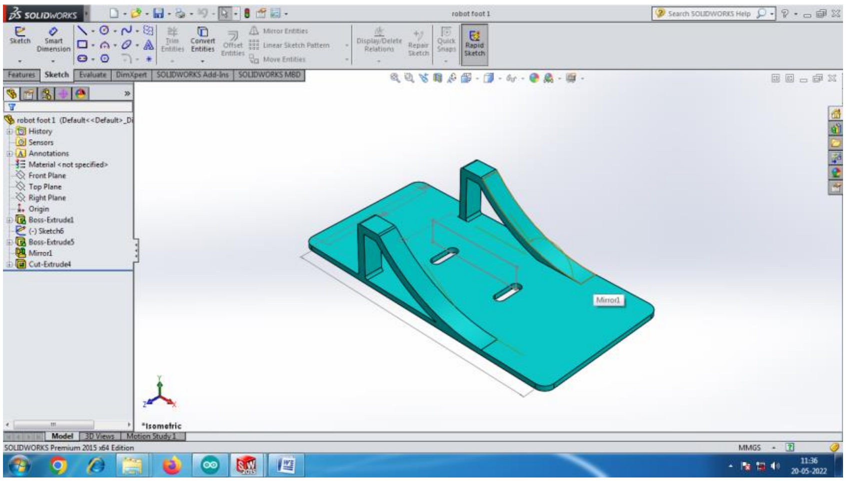

Figure 3.2. Robot Foot

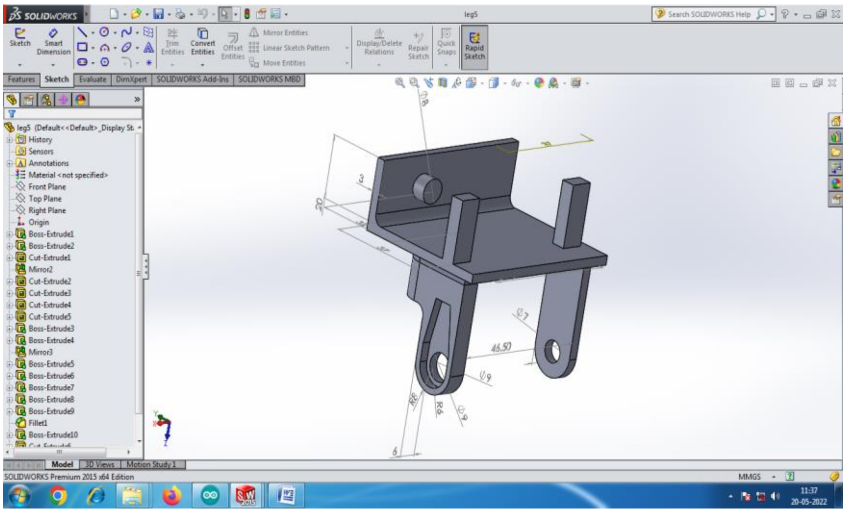

Figure 3.3. Supporting Link

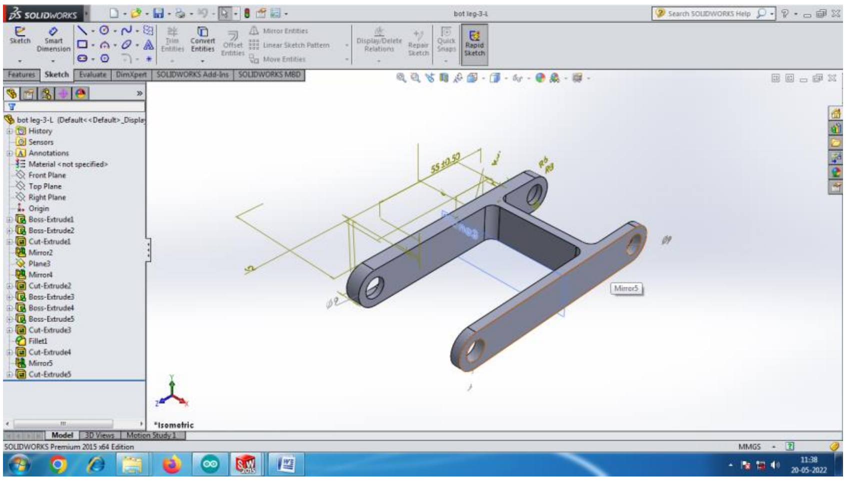

Figure 3.4. Robot Leg

STEP 2:

Once the individual parts are designed in the part modelling section, then some required sub-assemblies are made in the Assembly section of the Solidworks software. These sub-assemblies make the final Assembly design much easier. Mating of components is made by using the “Mate” command. Proper mating is given while designing the sub-assemblies.

STEP 3:

Finally, all the required individual parts and the sub-assemblies are inserted in the Assembly section by using the “Insert Components” command, and some commands like “Coincident”, “Concentric”, etc. are used properly for proper design of the final assembly. The figure 3.5 shows the Final assembly of the Humanoid Robot.

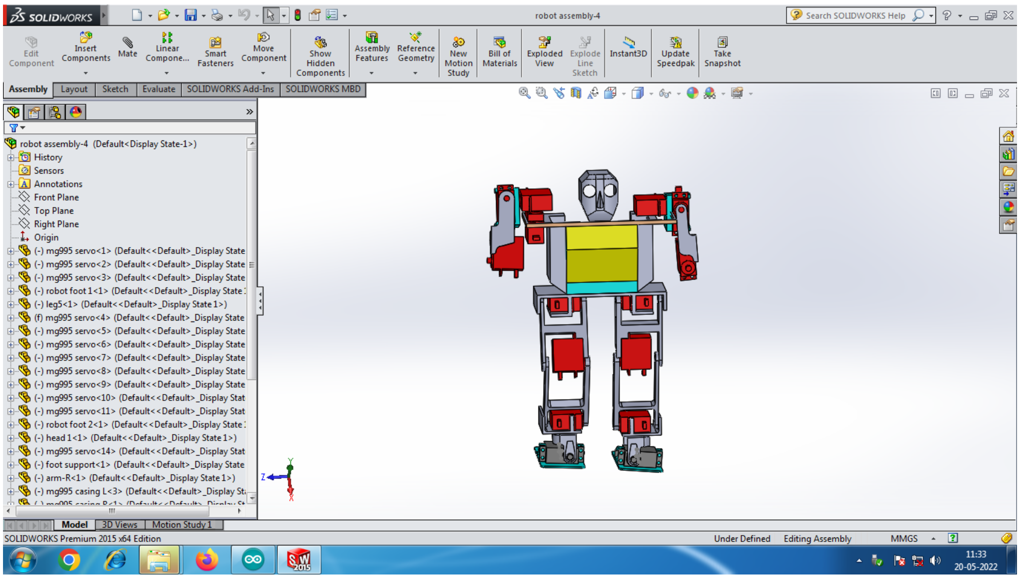

Figure 3.5. Final Assembly of humanoid robot

STEP 4:

After the complete design, the Constraints are defined to specify the conditions that the design must satisfy.

3.2 PARTS OF HUMANOID ROBOT

FLASHFORGE DREAMER 3D PRINTER

1. Dreamer is a reliable 3D printer that can consistently produce high-quality prints at resolutions as fine as 100 microns. It features a versatile printing chamber for different filament printing the build plate is made of 6.5mm thickness alloy of Aluminum-the same grade used in the aerospace industry, excellent heat distribution and never deformed. Top-quality components and advanced assembly lines make Dreamer a more reliable 3D printer

2. Temperature is crucial to ABS filament printing Dreamer features a door that can be closed and a removable top lid to keep out dust and foreign particles meanwhile eliminates exterior temperature interference The build-in heat-controlling sensor activates fans automatically to stabilize the printing temperature for high-quality ABS Prints.

Figure 3.6. Flashforge Dreamer 3-D Printer

3. The Dreamer build plate is made of the same grade of aluminum used in aerospace industry with 6.5mm thickness. It is the best and most level alloy which ever used, and also with excellent heat distribution There are some important factors that proved to deliver reliable and precise prints

4. With a patent nozzle structure, filament loading is smooth and steady, and it suitable for most mainstream printing filaments in the market. The side is equipped with turbofan to

provide air which can effectively improve the modelling effect Being expert in dual colour printing and dual filament printing.

PLA FILAMENT

PLA plastic or polylactic acid is a vegetable-based plastic material, which commonly uses corn-starch as a raw material. The monomer is usually made from fermented plant starch. This material is thermoplastic aliphatic polyester and it is the primary natural raw material used in 3D printing. PLA is a fully biodegradable thermoplastic polymer consisting of renewable raw materials. Among all 3D printing materials, PLA is part of the most popular materials used for additive manufacturing for filament fabrication.

Figure 3.7. PLA Filament

PLA is a user-friendly thermoplastic with a higher strength and stiffness than both ABS and nylon. With a low melting temperature and minimal warping, PLA is one of the easiest materials to 3D print successfully.

PRINTING OF PARTS

1. In the first step, the files in the Solidworks software are saved in the STL format which is the required format for the flashprint.

2. In the next step, the file is opened in the flashprint and is transferred to the dreamer 3D printer.

Figure 3.8. File transfer from Flashprint software to Printer

3. Now the 3D printer automatically prints the required parts with the required dimensions.

4. The printer is given with some input instructions like Fill Density, Fill Pattern, Print Speed, Travel Speed, Left Extruder Temperature, Platform Temperature etc.

5. Finally, all the parts are printed in the dreamer 3D printer using the PLA filament.

PRINTED PARTS:

Before starting the printing operation, we need to place the PLA filament in the Extruder as shown in the figure 3.9.

Figure 3.9. PLA filament placed in the left Extruder

Once the setup is done, we need to start the printer and start the printing operation.

DURING PROCESS:

The figures 3.10 and 3.11 show the 3D printing process of the Robot foot and some other parts. All the parts are similarly printed using the Flashforge Dreamer 3D printer. The Nozzle gets heated upto 200 ºC and it melts the filament and then it makes layers on the printer platform as shown in the figure 3.10. Once the printing is completed, we need to let the platform cool for some time and then collect the part from the printer.

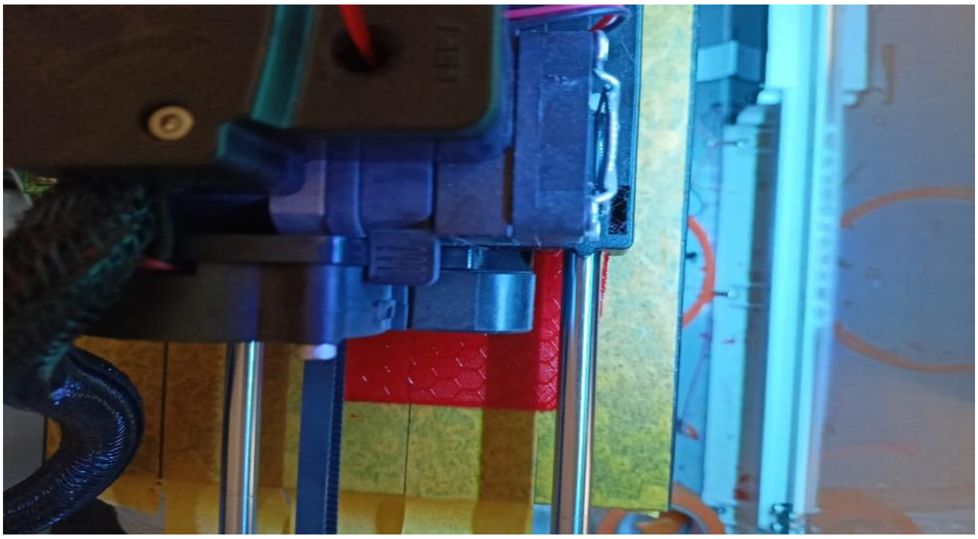

Figure 3.10. Layer by Layer printing on printer platform

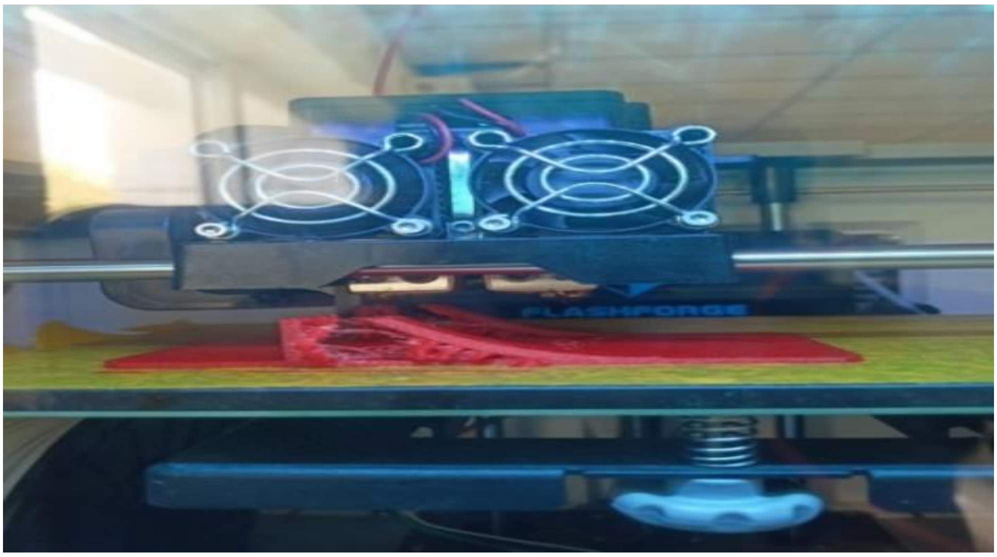

Figure 3.11. Robot foot printing

POST PROCESS:

After the complete process, let the platform in the 3D printer cool down. Then after getting cooled down the parts are taken from the Printer. The figures 3.12, 3.13, 3.14 are some of the parts that are printed from the 3D printer.

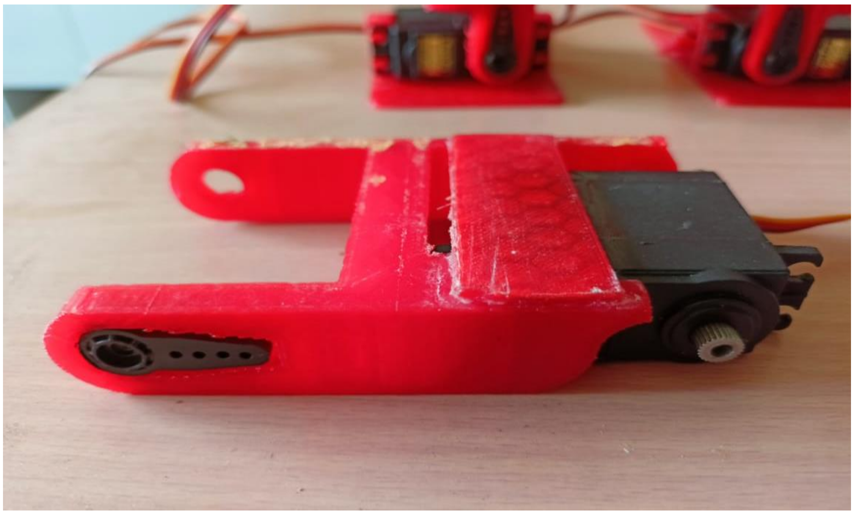

Figure 3.12. Robot thigh

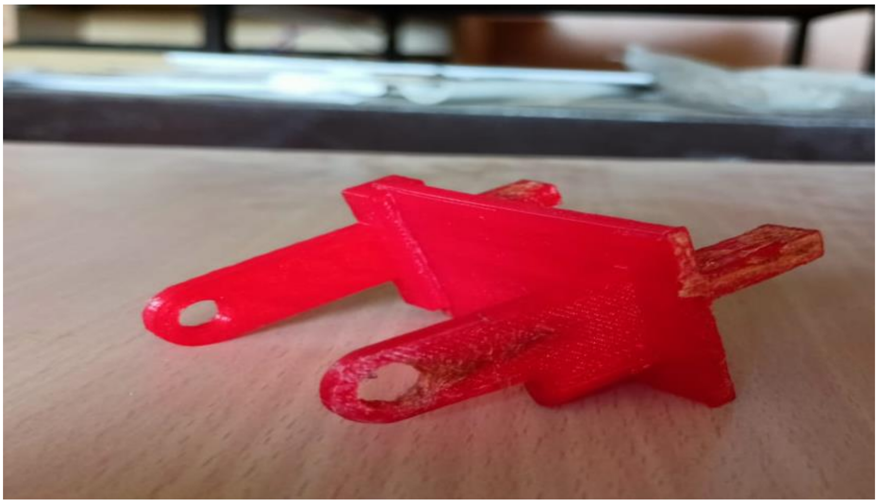

Figure 3.13. Supporting link

Figure 3.14. Foot link

Similarly, all the parts are printed in the 3D printer and all the parts are collected together, and sharp edges and uneven surfaces are filed with the help of knife-edge file and sand paper.

3.3 COMPONENTS USED

MG995 SERVO MOTOR:

MG995 Metal Gear Servo Motor is a high-speed standard servo can rotate approximately 180 degrees (60 in each direction) used for airplane, helicopter, RC-cars and many RC model. Provides 10kg/cm at 4.8V, and 12kgcm at 6V. It is a Digital Servo Motor which receives and processes PWM signal faster and better.

Figure 3.15. MG995 Servo Motor

It equips sophisticated internal circuitry that provides good torque, holding power, and faster updates in response to external forces. They are packed within a tight sturdy plastic case which makes them water and dust resistant which is a very useful feature in RC planes, Boats, and RC Monster Trucks etc. It equips 3-wire JR servo plug which is compatible with Futaba connectors too.

WIRE DESCRIPTION:

1. RED – Positive
2. Brown – Negative
3. Orange – Signal

SPECIFICATIONS:

1. Weight: 55g
2. Dimension: 40.7 × 19.7 × 42.9 mm
3. Operating Speed (4.8V no load): 20sec / 60 deg
4. Operating Speed (6.0V no load): 16sec / 60 deg (no load)
5. Stall Torque (4.8V): 10kg/cm
6. Stall Torque (6.0V): 12kg/cm
7. Operation Voltage: 4.8 - 7.2Volts
8. Gear Type: All Metal Gears
9. Stable and shock proof double ball bearing design
10. Dead band width: 5 µs
11. Temperature range: 0 ºC – 55 ºC.
12. Control System: Analog
13. Operating Angle: 120degree
14. Required Pulse: 900us-2100us

FEATURES:

1. The connection cable is thicker.
2. Equips high-quality motor.
3. High resolution
4. Accurate positioning
5. Fast control response
6. Constant torque throughout the servo travel range
7. Excellent holding power.

ARDUINO UNO

1. Arduino UNO is a low-cost, flexible, and easy-to-use programmable open-source microcontroller board that can be integrated into a variety of electronic projects. This board can be interfaced with other Arduino boards, Arduino shields, Raspberry Pi boards and can control relays, LEDs, servos, and motors as an output.

2. Arduino UNO features AVR microcontroller Atmega328, 6 analogue input pins, and 14 digital I/O pins out of which 6 are used as PWM output.

3. This board contains a USB interface i.e. USB cable is used to connect the board with the computer and Arduino IDE (Integrated Development Environment) software is used to program the board.

4. The unit comes with 32KB flash memory that is used to store the number of instructions while the SRAM is 2KB and EEPROM is 1KB.

5. The operating voltage of the unit is 5V which projects the microcontroller on the board and its associated circuitry operates at 5V while the input voltage ranges between 6V to 20V and the recommended input voltage ranges from 7V to 12V.

ARDUINO UNO COMPONENTS:

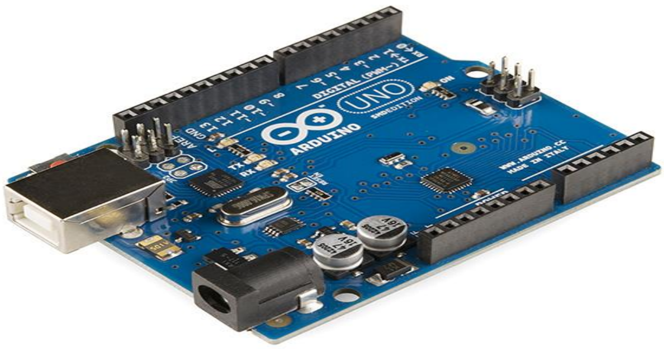

Figure 3.16. Arduino UNO board

The Arduino UNO board contains the following components and specifications

1. ATmega328: This is the brain of the board in which the program is stored.

2. Ground Pin: there are several ground pins incorporated on the board.

3. PWM: the board contains 6 PWM pins. PWM stands for Pulse Width Modulation, using this process we can control the speed of the servo motor, DC motor, and brightness of the LED.

4. Digital I/O Pins: there are 14 digital (0-13) I/O pins available on the board that can be connected with external electronic components.

5. Analogue Pins: there are 6 analogue pins integrated on the board. These pins can read the analogue sensor and can convert it into a digital signal.

6. AREF: It is an Analog Reference Pin used to set an external reference voltage.

7. Reset Button: This button will reset the code loaded into the board. This button is useful when the board hangs up, pressing this button will take the entire board into an initial state.

8. USB Interface: This interface is used to connect the board with the computer and to upload the Arduino sketches (Arduino Program is called a Sketch)

9. DC Power Jack: This is used to power up the board with a power supply.

10. Power LED: This is a power LED that lights up when the board is connected with the power source.

11. Micro SD Card: The UNO board supports a micro-SD card that allows the board to store more information.

12. 3.3V: This pin is used to supply 3.3V power to your projects.

13. 5V: This pin is used to supply 5V power to your projects.

14. VIN: It is the input voltage applied to the UNO board.

15. Voltage Regulator: The voltage regulator controls the voltage that goes into the board

16. SPI: The SPI stands for Serial Peripheral Interface. Four Pins 10(SS), 11(MOSI), 12(MISO), 13(SCK) are used for this communication.

17. TX/RX: Pins TX and RX are used for serial communication. The TX is a transmit pin used to transmit the serial data while RX is a receive pin used to receive serial data.

BREAD BOARD:

1. A breadboard is a construction base for prototyping of electronics. Originally the word referred to a literal bread board, a polished piece of wood used when slicing bread.

2. A breadboard is used to make up temporary circuits for testing or to try out an idea. No soldering is required so it is easy to change connections and replace components. Parts are not damaged and can be re-used afterwards.

3. Almost all the Electronics Club website projects started life on a breadboard to check that the circuit worked as intended.

4. A breadboard allows for easy and quick creation of temporary electronic circuits or to carry out experiments with circuit design.

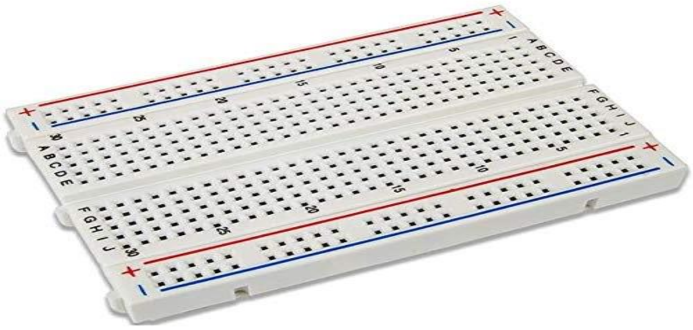

Figure 3.17. Bread Board

5. Breadboards enable developers to easily connect components or wires thanks to the rows and columns of internally connected spring clips underneath the perforated plastic enclosure.

JUMPER WIRES

Jumper wires are simply wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering. Jumper wires are typically used with breadboards and other prototyping tools in order to make it easy to change a circuit as needed.

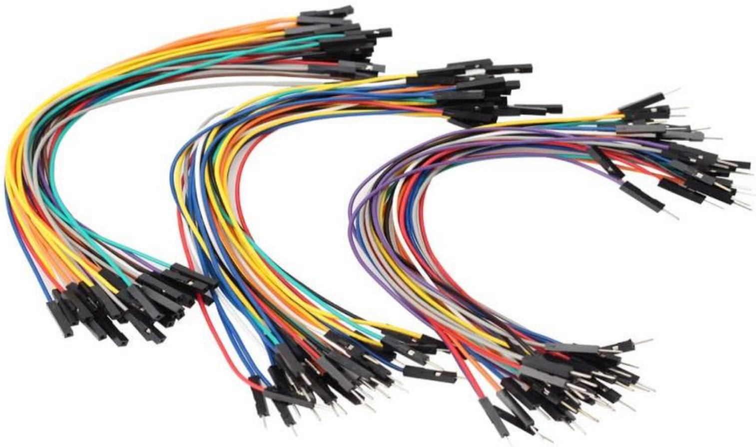

Figure 3.18. Jumper Wires

3.4 ASSEMBLY OF PARTS

1. Filing is done on the parts to avoid the sharp edges as well as the to remove the unwanted material on the parts which are printed.

2. The Sub-Assemblies are first made by applying the mixture of the Araldite gum on the required surfaces and the motors. Once the Sub-Assemblies are made, we need to proceed to the final assembly. The below are some of the sub-assemblies.

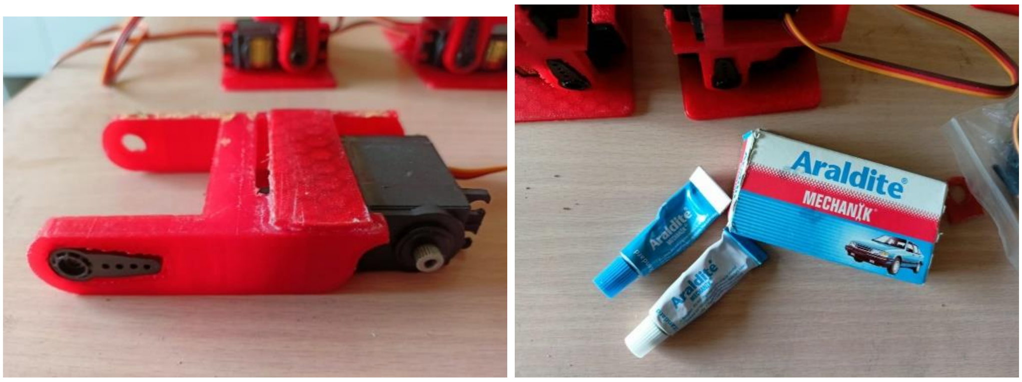

Figure 3.19. Sub-Assemblies of Robot

3. All the individual parts and the sub-assemblies are assembled together according to the design to get the Final Assembly.

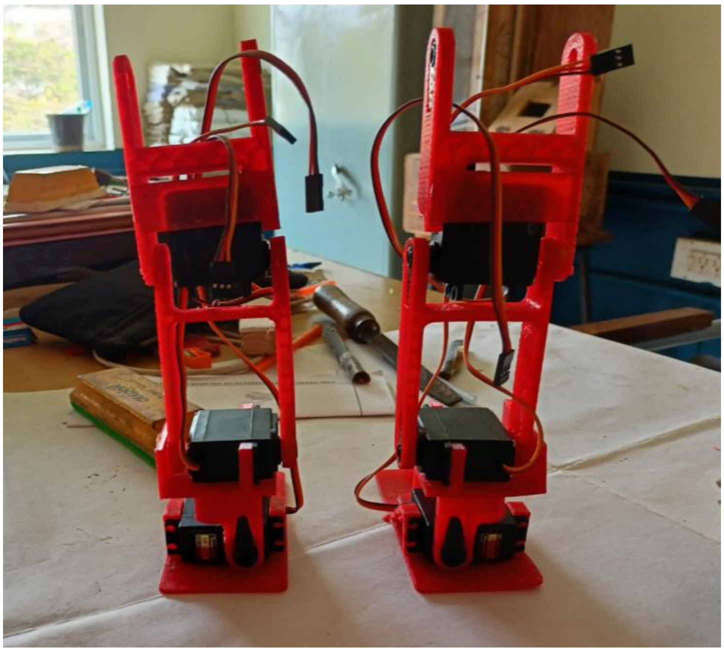

Figure 3.20. Assembling the Robot

4. The figure 3.21 shows the complete assembly of the ‘Humanoid Robot’.

Figure 3.21. Final Assembly of Robot

CHAPTER 4

WIRING AND PROGRAMMING

4 WIRING AND PROGRAMMING

4.1 WIRING

All the wiring is done between the Arduino Uno, Power Source and Motors, and Initially all the Servo motors are fixed at 90 degrees for obtaining the flexible movement of motors.

Figure 4.1. Connecting Motor with Arduino

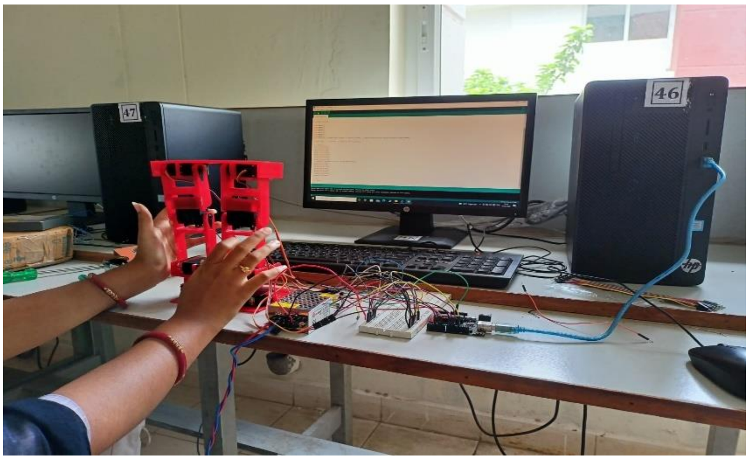

Figure 4.2. Wiring between Power source, Arduino and Servos

4.2 PROGRAMMING

The Arduino platform can control the hardware only if it is programmed well. It is like a brain for the human body. As without proper brain, muscles and skeleton are mal-functional similarly without proper computer programming, actuators and mechanical framework will mal-function. The program is written in an Arduino IDE and then it is fed into the Arduino board through a USB connector from the computer. To make the servo position to 90 degrees, the below code is written.

CODE

```
#include <Servo.h>
Servo myservo;
int pos = 0;
void setup() {
  myservo.attach(9);
}
void loop() {
  for (pos = 0; pos <= 90; pos += 1) {
    myservo.write(pos);
    delay(15);
  }
break;
}
```

With the help of the code all the servos are adjusted to 90 degrees and fixed with the robot parts as shown in figure 4.3.

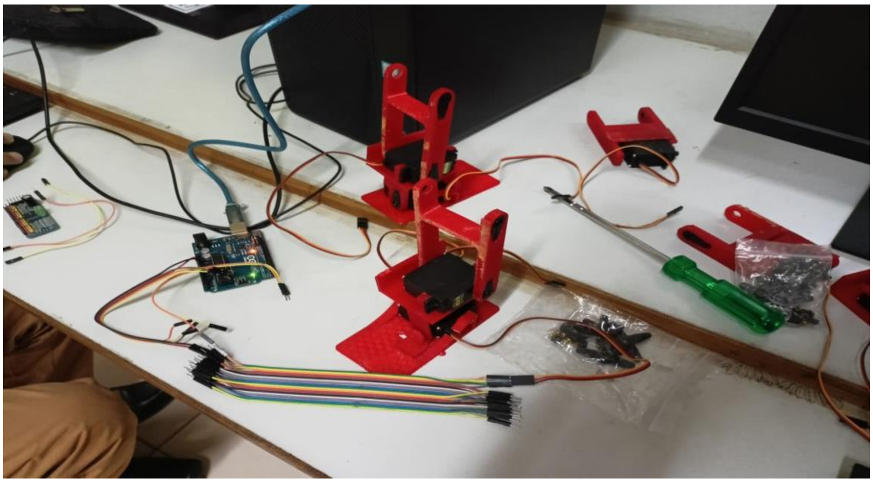

Figure 4.3. Fixing Servos at 90 degrees

4.3 TESTING OF HUMANOID ROBOT

1. All the servos are connected to the Arduino Uno and to the power source with the help of jumper wires.

2. The power supply is given to the bread board and the ground pins and power pins of the servos are arranged accordingly on the bread board.

3. The signal pins of the servos are connected to Arduino board to which the input instructions are given.

4. Now with the help of Servo libraries in Arduino IDE, programming is done accordingly to operate the servos and is sent to Arduino board as input instructions.

5. The balancing and walking program is written by checking the servos at different angles.

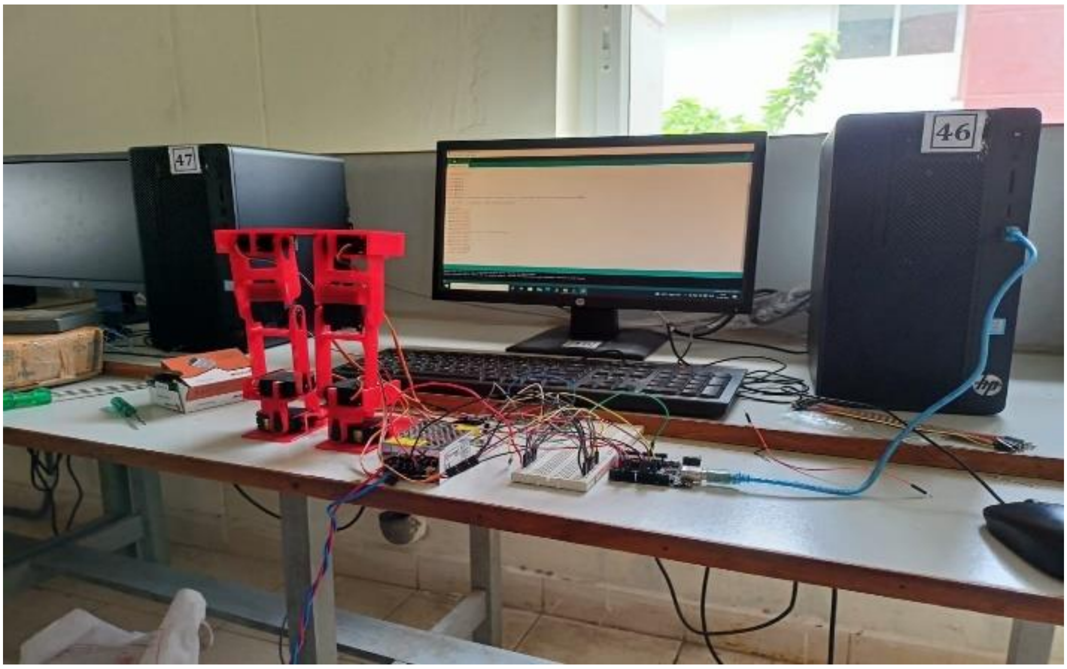

Figure 4.4. Testing the humanoid robot

CHAPTER 5

RESULTS AND DISCUSSIONS

5 RESULTS AND DISCUSSIONS

The robot is given a set of code and it is made to walk. The program is written in such a way that the robot balances while walking. To make it balance, we need to find the centre of gravity of the legs and then we need to write the code accordingly.

Trying with different angles of the servos, finally we have found the correct angles to the servos to make the robot leg balance. The code is written with the help of Servo libraries in Arduino IDE.

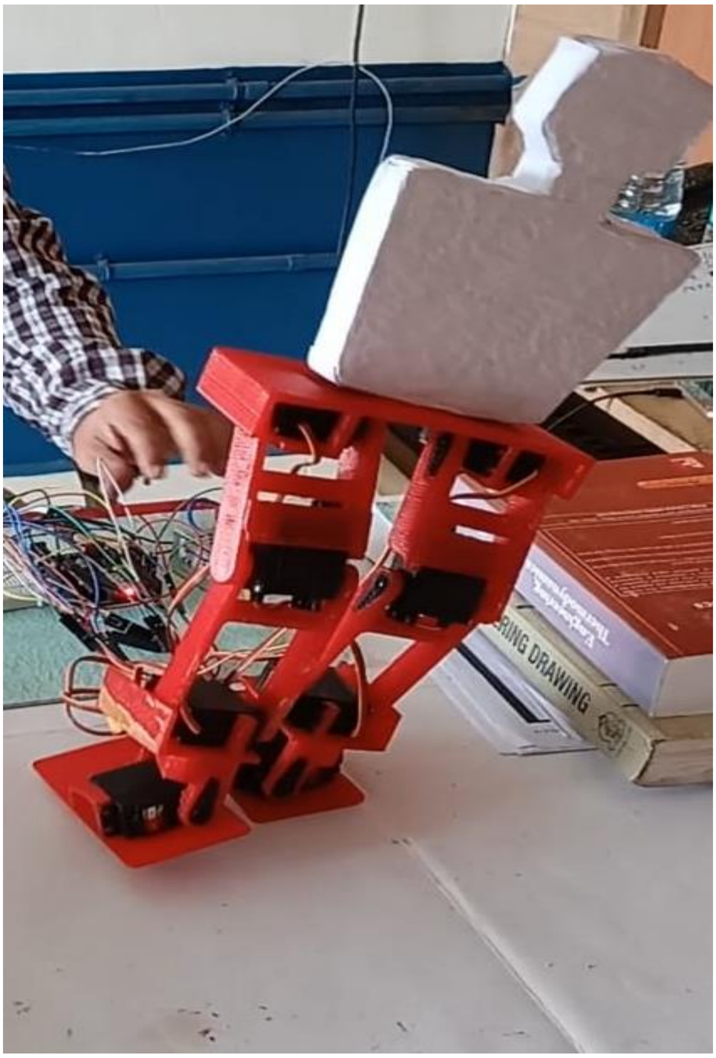

Figure 5.1. Robot standing on left leg

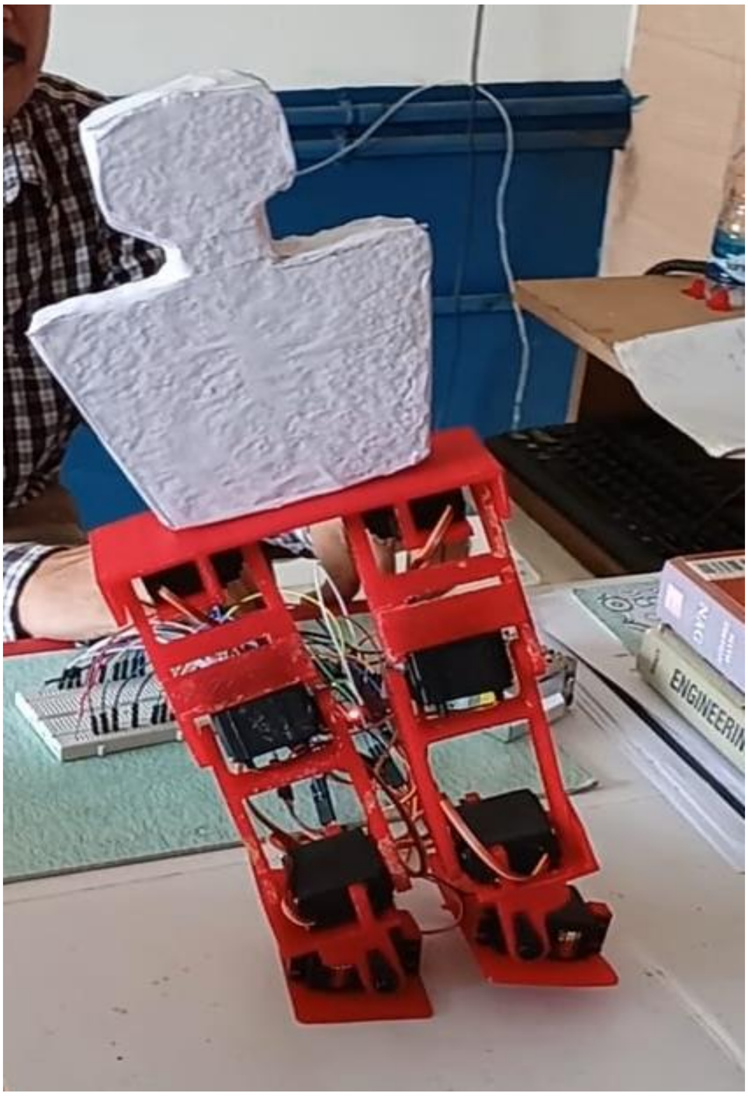

Figure 5.2. Robot standing on right leg

The figures 5.1 and 5.2 shows the Robot standing on the individual legs, and then the forward motion is given to the legs accordingly.

Finally, the Humanoid Robot could achieve the balancing and walking motion which is the desired output.

CHAPTER 6

CONCLUSIONS

6 CONCLUSION

Wheeled robots cannot navigate well over obstacles, and this is the main drawback of this type, depending on the terrain, such as rocky terrain, sharp declines or areas with low friction, there are some situations where the wheels are not the best choice. So, Legs are the best ways to overcome these drawbacks.

So, to overcome these drawbacks legged robots are necessary. In this project we have fabricated the Humanoid Robot which is a legged robot, and we could achieve the walking motion with the help of servo motors. So, we conclude that the walking motion to the robot can be obtained with the help of motors and thereby overcome the disadvantages of wheeled robots.

CHAPTER 7

REFERENCES

7 REFERENCES

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