



PROJECT REPORT

INDEX

1. Abstract.....	2
2. Technologies Used.....	3
3. Libraries Used.....	5
4. Features and Functionalities.....	7
5. Proposed Design.....	8
6. Components Used.....	9
6.1 Mechanical Components	9
6.2 Electronic Components.....	9
7. Assembling	15
8. Motion Analysis.....	16
9. Applications and Advantages.....	17
10. Images	18
11. Conclusion	19

1. ABSTRACT

The world is advancing towards the technological enhancement with an exceptional pace. Machine learning, Artificial Intelligence, Deep Learning, Computer Vision are some of the hot buzz technologies that are expanding their reach and everyone is demanding it, whether it be the AI based companies, private organizations, Researchers, and even in defence systems. AI is providing a plethora of possibilities for people to create and grab more opportunities and along with when AI is embedded with other technologies like Computer Vision, Natural Language Processing, and Embedded Systems, it becomes a lot more brilliant product.

When Artificial Intelligence and Embedded Systems are together constituted we get some very good results. So we at AMURoboclub will be creating an AI based Humanoid Robot which will be fully functional and will be serving for good reasons. Along with AI it will be having Computer Vision and NLP embedded in it for the visual and audio/text processing. Face Recognition and Chatbot will be some of its functionalities. Also for the working of the bot we will be using a microcontroller and it will serve as a bridge between the programming and the hardware part. Several motors, camera, microphone and speakers will be used in the formation of humanoid bot. Humanoid bot is one of the great innovations of the Science and Technology, a complete combination of software and hardware bind together with AI and other tech to work as one of the greatest advancements of technology.

Humanoid robots have several advantages like they can do things that people can do and even things that people are unable to do. They make mistakes and learn by them and then they don't repeat it, can do a task again and again. They can be used to teach children or read to them those are unable to do so. They can also be AI-Assistants. There are a lot more advantages and implementations of Humanoid Robots. We hope to make a well equipped and well working Humanoid robot under the guidance of our teachers and faculty.

2. TECHNOLOGIES USED

Technology is the sum of techniques, skills, methods, and processes used in the production of goods or services or in the accomplishment of objectives, such as scientific investigation.

Technology can be the knowledge of techniques, processes, and the like, or it can be embedded in machines to allow for operation without detailed knowledge of their workings. Systems (e. g. machines) applying technology by taking an input, changing it according to the system's use, and then producing an outcome are referred to technology system or technological systems.

The technologies that will be used in this AI based Humanoid robot:-

2.1 Artificial intelligence

Artificial Intelligence (AI) is the combined attribute of science and computer that makes the system or program or any machines perform the Intelligent and Imaginative functions of a human, independently and solution to problems, be able to make decisions. The main aim of Artificial Intelligence systems is to have the ability to discover, which makes people increase their performance and productivity over time. Artificial Intelligent Technology tools include machine learning and deep learning which gives an analysis report to increase the clarity of planning, reasoning, thinking, problem-solving and also learning.

Emotions intercept the intellectual thinking of human which is interference for artificial thinkers. Apart from emotional handling, a robot is also programmed to think logically and take effective decisions.

Technologies used in Artificial intelligence that will be used in AI based Humanoid robot:-

2.1.1 Machine Learning

The science of getting a computer to act without programming. Deep learning is a subset of machine learning that, in very simple terms, can be thought of as the automation of predictive analytics.

There are three types of machine learning algorithms:

Supervised learning: Data sets are labeled so that patterns can be detected and used to label new data sets.

Unsupervised learning: Data sets aren't labeled and are sorted according to similarities or differences.

Reinforcement learning: Data sets aren't labeled but, after performing an action or several actions, the AI system is given a feedback.

In our Humanoid robot machine learning algorithms will be used in computer vision and face recognition algorithm.

2.1.2 Computer vision

In order to make robot autonomous, it is important to make them able to perceive the world, and build a representation of it. Computer vision is interesting because it is a passive exteroceptive sensor giving a large set of information on the environment. When a representation is available, computer vision make possible to generate plans for the robot to evolve in the environment and search or manipulate objects. The problem of having a robot build a map of an unknown environment and localize itself is called SLAM (Self Localization And Map building). Computer vision will be useful to the Humanoid bot as it will control the actions of the bot like, bot hands action, bot's walking pattern etc, based on facial recognition system that will be coded using Python programming language and its libraries.

2.1.3 Natural Language Processing

A fundamental behavioral and cognitive capability of humanoid robots is speech, as spoken language is the primary means of communication between humans. Natural Language Processing is the ability of the computer program to understand human languages as it is spoken. NLP is a component of AI. Most NLP techniques rely on Machine Learning to derive meaning from human language. NLP will be used by the Humanoid bot as, when the text has been provided by humans, the robot will utilize algorithms to extract meaning associated with every sentence and collect essential data from them. Through NLP we will program the bot in such a way that it will provide certain specific answers to certain questions asked by humans.

Technologies not a part of Artificial Intelligence:-

2.2 Database Management System

Database technologies take information and store, organize, and process it in a way that enables user to easily and intuitively go back and find details they are searching for. Here for the Humanoid robot facial recognition system, a dataset of faces of individual will be created and stored and managed by a proper database management system, here used MySQL.

2.3 Programming Language

We will be using python as the programming language for the Humanoid robot as, Python offers concise and readable codes. While complex algorithm and versatile workflows stand behind machine learning and artificial intelligence, python's simplicity allows developers to write reliable systems. Python is rich in inbuilt libraries that provides solutions for tricky algorithms of AI and ML.

3. LIBRARIES USED

3.1 OpenCV:

OpenCV, which stands for Open Source Computer Vision, is an open source computer vision and machine learning software library. OpenCV was built to provide a common infrastructure for computer vision applications and to accelerate the use of machine perception in the commercial products. The library has more than 2500 optimized algorithms, which can be used to detect and recognize faces, identify objects, classify human actions in videos, track camera movements, track moving objects, stitch images together to produce a high resolution image of an entire scene, find similar images from an image database etc. In Humanoid bot, we will use this library to recognize faces of the people for which the bot is already trained.

3.2 Numpy:

NumPy, which stands for Numerical Python, is a library consisting of multidimensional array objects and a collection of routines for processing those arrays. Using NumPy, mathematical and logical operations on arrays can be performed. It can also be used to perform fourier transforms and routines for shape manipulation. NumPy has in-built functions for linear algebra and random number generation.

3.3 PIL:

PIL, which stands for Python Imaging Library, is a library that adds support for opening, manipulating, and saving many different image file formats. It offers several standard procedures for image manipulation. These include: per-pixel manipulations, masking and transparency handling, image filtering, such as blurring, contouring, smoothing, or edge finding, image enhancing, such as sharpening, adjusting brightness, contrast or color, adding text to images and much more.

3.4 PyAudio:

PyAudio is a cross-platform audio I/O library. With PyAudio, we can easily use Python to play and record audio streams on a variety of platforms(e.g., GNU/Linux, Microsoft Windows, and Mac OS X). In Humanoid bot since we will be using Raspberry pi 4B+ so this library will help us to interface external microphone with raspberry pi.

3.5 speech_recognition:

It is a library for performing speech recognition with the Google Speech Recognition API. It is used to translate speech to text. Since our one of the objectives is to recognize speech in Humanoid bot, so this library will help us to achieve the same.

3.6 Mysql.connector:

MySQL Connector is a driver for connecting to a MySQL database server through the Open Database Connectivity application program interface, which is the standard means of connecting to any database. mysql.connector is a module that is used for this purpose in python language. In Humanoid bot since we have to maintain the dataset of authorized users that will be recognized by the bot, so for that purpose we will create a database of those authorized users that will be linked to our main python application through this module.

3.7 pyttsx3:

pyttsx3 is text-to-speech conversion library in Python. This lets us synthesize text into audio that we can hear. It can be used with a variety of platforms(e.g., GNU/Linux, Microsoft Windows, and Mac OS X).

3.8 os:

The os module in python provides functions for interacting with the operating system. Using this module, we can have many portable ways of using operating system dependent functionality in our bot.

3.9 Adafruit-GPIO:

This library is to provide a cross-platform GPIO(General Purpose Input/Output) interface on the Raspberry Pi. In Humanoid bot, we will use this library to control and interface with servo motors.

3.10 time:

The Python time module provides many ways of representing time in code, such as objects, numbers, and strings. It also provides functionality other than representing time, like waiting during code execution and measuring the efficiency of your code.

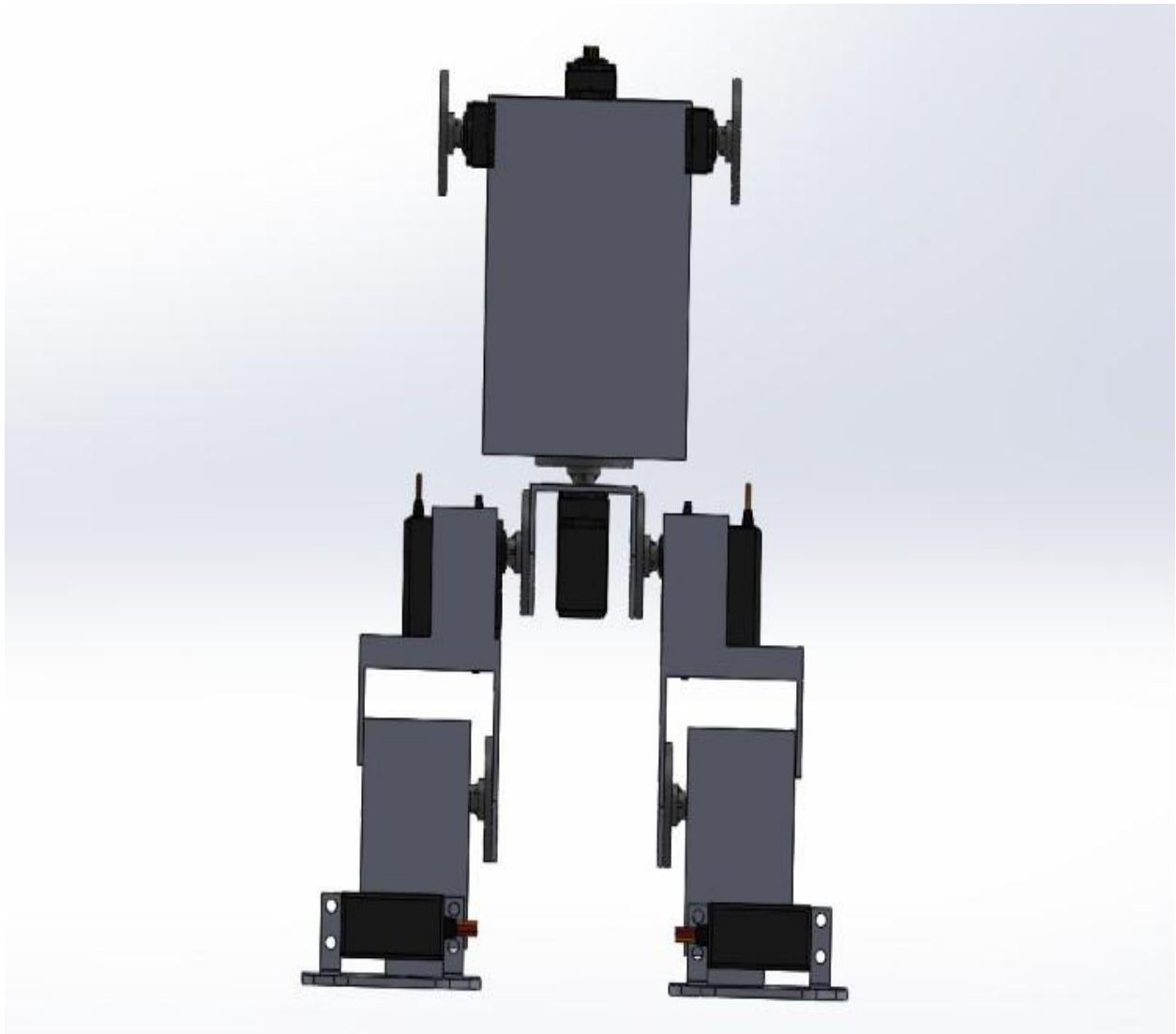
4. FEATURES AND FUNCTIONALITIES

The humanoid bot proposed above will be having following features and functionality advantages:

1. It will be using servo motors wherever possible to have more precise motion. Basic use of servos is to provide the most accurate motion. Servo works on the feedback loop mechanism hence it works quite accurate.
2. It is using NLP for better interaction with the user. After using NLP the robot will be able to give answers for a certain number of questions asked by the client/user.
3. For better recognition of the user Pi camera using face recognition and detection code will be used. Dataset will be created and after that face recognition will be achieved. The robot will start working after it will detect and recognize the face for the user authentication.
4. The size of the robot has been manipulated to have the limited size of the robot keeping in mind the stability. It can be used for the home assistance.
5. The current proposed design is having a wide room for welcoming new aspect to extend its usability in whichever field required. We can add and update more functionalities in the robot as per required.
6. It will be having its own Database and server for uploading new data and fetching the stored data.
7. It will work on voice commands using pyaudio and pyttsx3. Also it will be using Google's Speech Recognition Library for the Audio purposes.

5. PROPOSED DESIGN

This is the proposed design of Humanoid Robot we have prepared in SOLIDWORKS. It comprises a metal frame body completely insulated from the circuitry and metal geared servos. The real robot will be completely different from this design as this is only for reference purpose. It will be having 11-DOF as it will be using 11 servo motors for its motion.



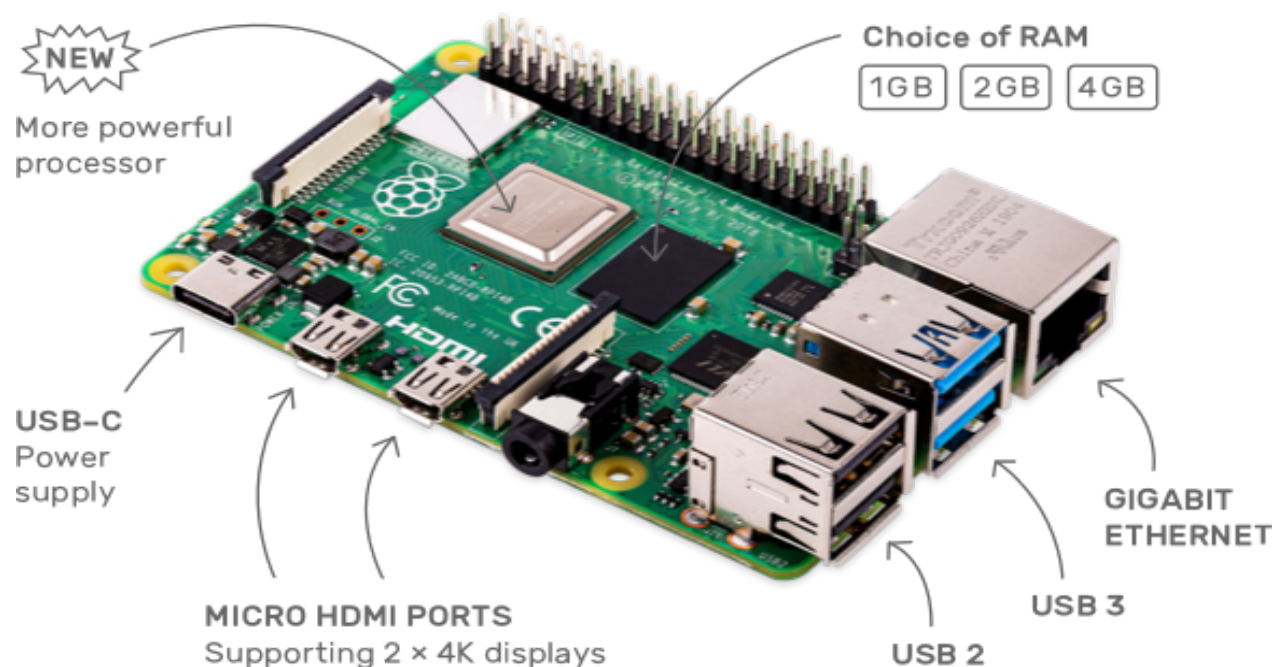
6. COMPONENTS USED

6.1 MECHANICAL COMPONENTS

When it comes to the mechanical parts, the very first thing is the chassis of the robot that will be made by either the insulated metal frame or with the acrylic sheet, whatever fits in the budget. The chassis will be mainframe of the robot on which other parts will be attached and on it we will be having servos and other parts of the bot (limbs and legs). The chassis should be lightweight and strong at the same time as its lightweight will allow the motion of the bot to be smooth and fluent. If we use a metal frame we will have to insulate it from the circuitry to prevent any kind of circuit damage and for the finalized product we can cover the chassis with the acrylic sheet in order to make it look better. Other mechanical components are also used such as Nut-bolts, washers etc. Most important mechanical concept is to make a bipedal robot which can work efficiently, Achieving this is a great task as it requires logic and concept building.

6.2 ELECTRONIC COMPONENTS

6.2.1 Raspberry pi 4B+



The Raspberry pi 4B+ is a low cost, **credit-card sized computer** that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. It's capable of doing everything you'd expect a desktop computer to do, from browsing the internet and playing high-definition video, to making spreadsheets, word-processing, and playing games.

The Raspberry pi 4B+ is a powerful tool when it comes to artificial intelligence (AI) and machine learning (ML). Its processing capabilities, matched with a small form factor and low power requirements, make it a great choice for smart robotics and embedded projects.

OpenCV: The tool of choice for many robot builders, the Open Source Computer Vision Library not only gives your Pi sight, but the ability to 'comprehend' what it sees. A powerful tool for intelligent object recognition.

TensorFlow: If you want to implement machine learning on a Pi, chances are you'll be using TensorFlow to do it. The official site not only features full documentation, but also a range of courses

6.2.2 USB Sound Card



An external sound card is an incredibly useful piece of equipment for computers and offices. Its numerous functions and features allow it to turn any average computer into a full home-theater audio solution. It is a trade-off of 1 USB port for multiple audio ports, which can include:

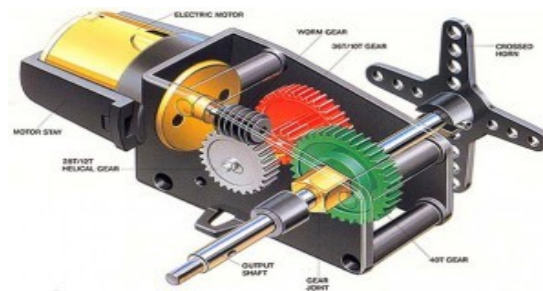
- 3.5mm Output jack
- 3.5mm Input jacks
- Coaxial S/PDIF jack
- Optical S/PDIF jack

A sound card needs to convert the bits from a computer. For going from the computer to speakers, a Digital-to-Analog Converter (DAC) receives the train of bits from the computer and

transform it into a waveform. The DAC will take samples from the bit train and create the shape of a wave from it. This wave becomes the electric current to be sent to speakers.

An external sound card usually has a way to input sound as well. A microphone can capture sound and send it to the sound card. The sound card will then amplify the electric current in order to translate it to 1's & 0's for the computer. This process is done through Analog-to-Digital Converters (ADC). These are also built-in to external sound cards.

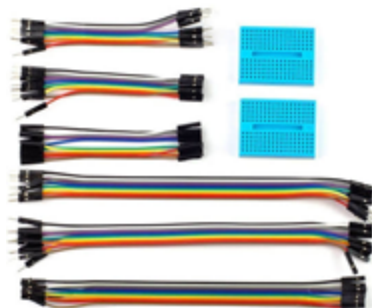
6.2.3 Positional Rotation Servo Motor



The **servo motor** is most commonly used for high technology devices in the industrial applications like automation technology. It is a self contained electrical device, that rotate parts of a machine with high efficiency and great precision. The output shaft of this motor can be moved to a particular angle.

Positional rotation servo motor is the most common type of servo motor. The shaft's o/p rotates in about 180° . It includes physical stops located in the gear mechanism to stop turning outside these limits to guard the rotation sensor. These common servos involves in radio controlled water, radio controlled cars, aircraft, robots, toys and many other applications.

6.2.4 Wires & Circuitry

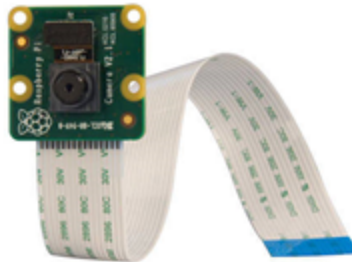


Jumper wires are simply wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering. Jumper wires are typically used with breadboards and other prototyping tools in order to make it easy to change a circuit as needed.



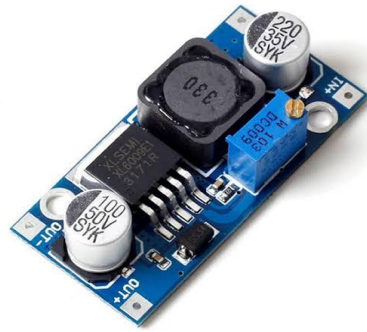
PCB stands for "Printed Circuit Board." A PCB is a thin board made of fiberglass, composite epoxy, or other laminate material. Conductive pathways are etched or "printed" onto board, connecting different components on the PCB, such as transistors, resistors, and integrated circuits.

6.2.5 Pi Camera



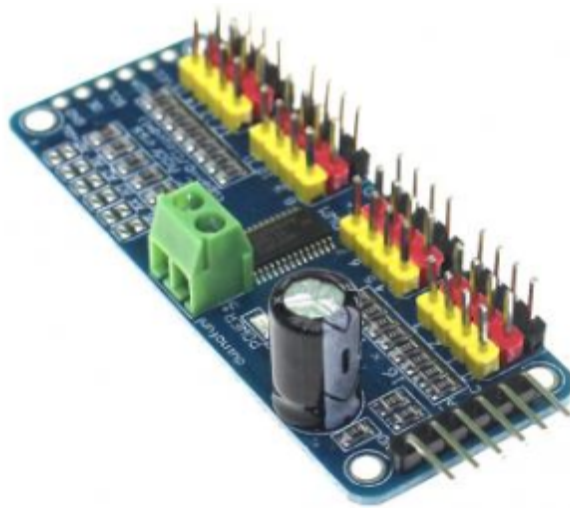
The webcam integrated on Raspberry: The **PiCamera**. It has the ability to take pictures and videos in HD. But also to make image analysis in Python, thanks to the libraries that makes it possible, including **OpenCV**.

6.2.6 Buck Converter



The buck converter is a ubiquitous DC-DC converter that efficiently converts a high voltage to a low voltage efficiently. Efficient power conversion extends battery life, reduces heat, and allows for smaller gadgets to be built. The buck converter can be used in lots of cool applications.

6.2.7 Servo Controller



servo controller is the heart of a servo system. A typical servo system consists of a motor, feedback device, and the controller. The control circuitry typically involves a motion controller, which generates the motion profile for the motor, and a motor drive which supplies power to the motor based on the commands from the motion controller. Servo systems are closed-loop systems which have some benefits over open-loop systems including the fact that they improve transient response times, reduce steady state errors and reduce system sensitivity to load parameters.

6.2.8 Servo Tester



Servo tester used for testing of servo motor has 3 Operation Modes:

- Automatic mode:- Operates servos to their end point and back “window wiper” mode:
Make the servo swing like window wipers in the biggest angle
- Manual mode:- Turn the knob with different speed, check the reaction time
- Neutral / Center mode:- Centers servos to their neutral position Ideal for when setting servos up in a model

7. ASSEMBLING

One of the main causes of worry in any project is putting things together (i.e. assembling) and specifically in Humanoid Robot balancing of the whole body is an important aspect which is highly affected by the assembling of the Robot. The proper coordinated assembly of hardware and software components mentioned above was what required. During initiation phase the challenge was to finalize the size of robot which could not only incorporate all the electronic components rather could also have smooth motion. Therefore, the team decided to have the size of the bot within about 2 feet in height.

The upper body of the Robot contains electronic components like Raspberry Pi, Servo Driver, Buck Converter, Motor Driver and battery. Hands being currently equipped with servo motors were developed by mounting the servos with the basic hardware structure. Head part contained camera and speaker for vision and voice of the bot.

The lower body(legs) is still in developing phase and as per the current structure it is having two 60RPM Johnson motors for motion and a tester wheel for support, but team is having a vision of transforming it to give proper biped motion.

Future challenge before the team is to modify and extend the structure without affecting the stability of the Robot. In that aspect the team is working on the overall stability of the robot with a finalized bi-ped motion as well as fusing the hardware structure with a simplified version of all the electronic components used. *Path chosen is the halfway taken.* Team with enthusiasm to convert the ideas to prototype has a vision to convert the challenge to destination and will assemble it the way it demands.

8. MOTION ANALYSIS

During initial planning of the robot one of the main challenges was to decide the motions of the bot. Continuing with the simplicity of the design and focusing more on the application area, as per starting requirement, the team decided to make a static bot as per the lower body (legs) is concerned.

For upper body hands and head were given motion of minimum requirement using servo motors(MG996R and MG95s). The initial design used two servo motors for each hand i.e. one for elbow giving it motion in x-y plane and other on shoulder giving it motion on y-z plane. Head having camera for vision was required to move about two axis (at minimum) and therefore team used two servos of low power(MG995s) for head.

The initial design worked successfully but curiosity of the human mind is something that never ends and motivates one to keep on trying and improving. The team decided to move a step forward and give legs of the bot there freedom and it was planned to transform the bot from static to dynamic.

The idea now was to develop a bot which could move from one place to another with proper biped motion on command from the user. Tough was the task, but success is where innovation meets implementation. The team continued there work for second phase and has reached a leap of their target.

Currently, the bot has been completed in two pieces, namely lower and upper body. The lower body(legs) now could move on wheels powered by DC motors or could also have baby steps, which the team is working over, to properly finalize as biped motion. The upper body have been transformed to have a servo at abdomen part and hands been equipped and improved with three servos this time giving the whole body an extended freedom of motion.

The current challenge before the team is two finalize the biped motion and assembling the lower and upper body but as *Smooth seas don't make skillful sailors* , the team is working over the challenges .

In coming future team is planning to extend the mechanism of hands giving them power to pick, hold and place the objects so that the application area of this robot could be extended to household assistance.

9. APPLICATIONS AND ADVANTAGES

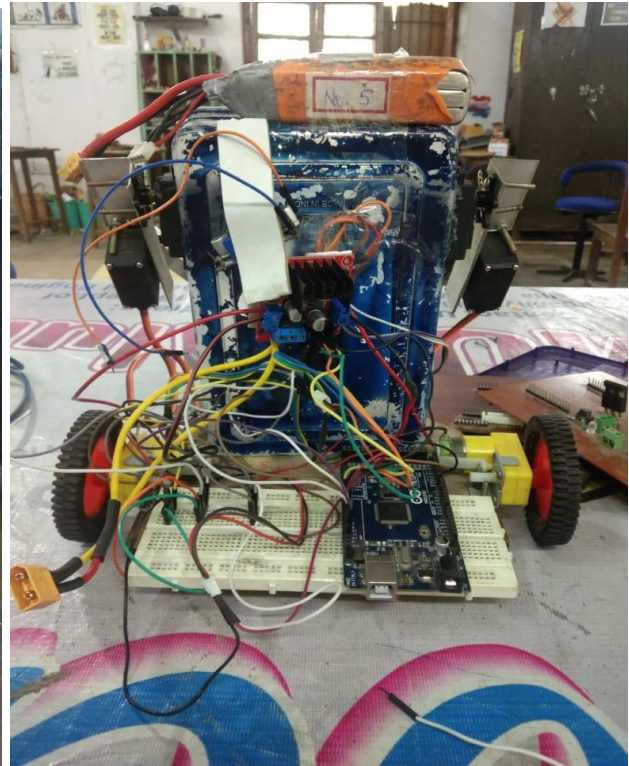
Humanoid Robots can be used in everyday life where they can do the jobs that the people wouldn't want to do. They can do them more efficiently as well, They will get more adept all the time. They will do cheaply & easily many tasks that human workers do now. It is a great challenge in robotics to build robots that do things like humans in a world made for humans. They can move & perform well-designed tasks.

It is a robot with its overall appearance based on that of the human body. It consists of a torso with a head, two arms & two legs, although some forms of humanoid robots may model only part of the body, for example, from the waist up, and below they may have wheels to move unlike humans. They may also have a face, with eyes & a mouth. It may have a head designed to replicate the human facial features like the eyes and mouths. It can be used for the functional purposes, like interacting with the human tools and environments, for experimental purposes, such as the study of locomotion, or for other purposes. Humanoid robots can perform any task a human being can, so long as they have the proper software, Although they look realistic, they have no cognition or physical autonomy, They can be used for future dangerous & distant space exploration missions, They can serve as the companions & assistants for the humans in daily life, they can be used as the ultimate helpers in man-made & natural disasters and as virtual tourist guide also.

Humanoid robots will be useful to many people around the globe, We can use these robots for educational purposes as well, Robotics is being used by the teachers to help instruct students on how to program, Robot teacher is also used to interact with children and teach them to do simple tasks. Many people can benefit from these humanoid robots, They will take care for the sick, collect the rubbish, guard homes and offices, and give the directions on the street, Life with Humanoid Robots in society will be very different but very efficient and the economy will be increased.

The corporations and businesses will also be appreciative of the robots because they could use them to replace the jobs, This means less money that businesses will have to fork out to its employees, They can be used as entertainers & in commercial spaces but they will not undertake major tasks, These robots can do amazing things that even people could not do, They can now sing & dance and look almost like human when doing so.

10. IMAGES



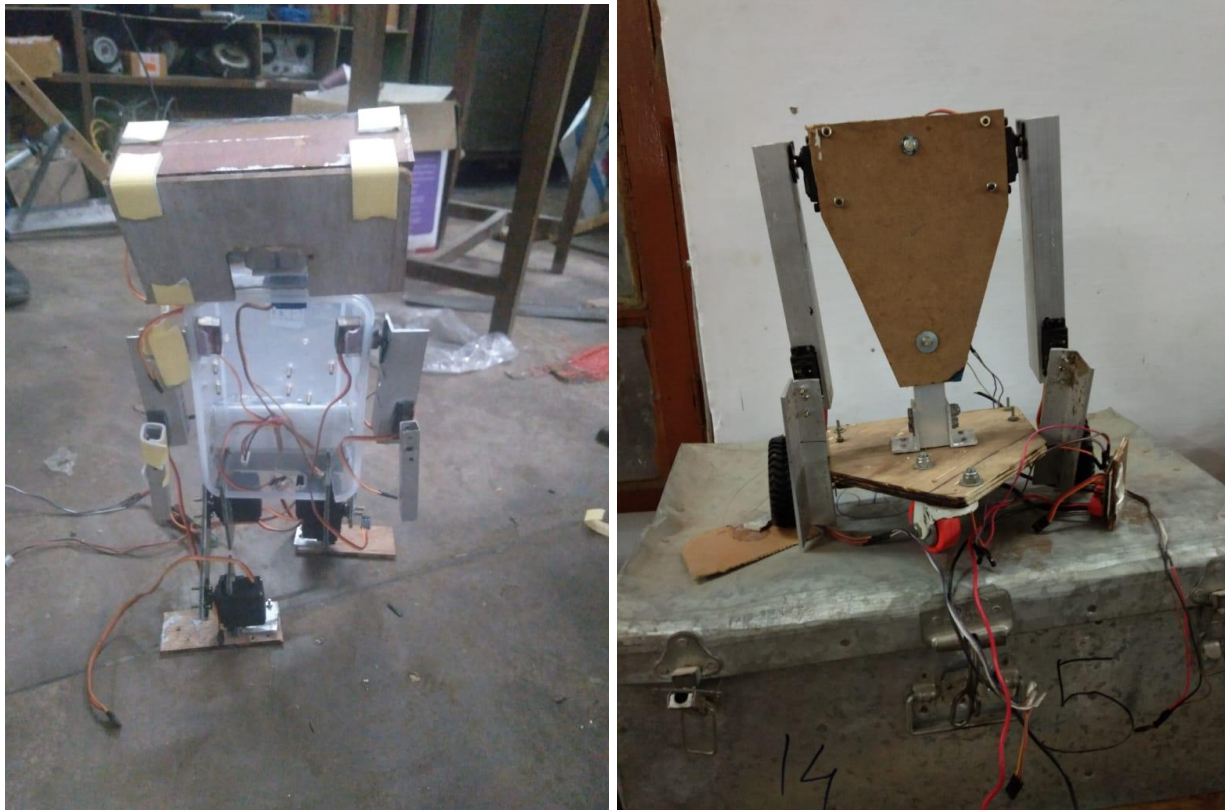


Fig : final images of the bot.

11. CONCLUSION

Our ultimate goal here is to make a Humanoid Robot which is capable of preface recognition and conversing with people using a chatbot system. It would be incorporating artificial intelligence, machine learning, computer vision and natural language processing to carry out basic tasks and understand some basic commands, with its movements being controlled with the help of servo motors for precise movement of the body. We have a proposed design plan according to which we are planning to proceed with the project, with further room for development and enhancements in the bot. these types of humanoid robots find a lot of applications in today's day and age, which can range from household assistants to tourist guide, they can be used in defence services and for various other industrial purposes. They carry a huge potential on how machines can help improve our lives even further and make them more sustainable.