BIPEDAL ROBOT

Submitted in partial fulfillment of the requirements of the degree of

BACHELOR OF MECHATRONICS ENGINEERING by

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(2022-2023)

NEW HORIZON INSTITUTE OF TECHNOLOGY
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CERTIFICATE

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Declaration

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Project Report Approval for B.E.

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ABSTRACT

A bipedal robot is a type of robot that has two legs and is designed to walk upright like a human. The development of bipedal robots is an important area of research in robotics, as they have the potential to perform tasks in environments that are designed for humans, such as homes, offices, and public spaces. In this abstract, we will discuss the design, control, and applications of bipedal robots.

Design:

The design of bipedal robots involves a range of mechanical, electrical, and software components. The most critical component is the legs, which are typically designed with joints that allow for movement in multiple directions. These joints are actuated by motors that are controlled by a central processing unit (CPU). The robot's body is designed to be lightweight and sturdy, and is often made of materials such as aluminum or carbon fiber.

One of the main challenges in designing bipedal robots is maintaining balance. This is achieved through a combination of sensors, such as accelerometers and gyroscopes, and software algorithms that analyze the sensor data and adjust the robot's movements in real-time. Additionally, many bipedal robots are equipped with cameras or other sensors that allow them to perceive their environment and navigate through it.

Control:

The control of bipedal robots is a complex task that requires advanced software algorithms. The robot's CPU must be able to process large amounts of data in real-time, and make decisions about how to adjust the robot's movements to maintain balance and navigate through the environment.

One approach to controlling bipedal robots is through the use of artificial intelligence (AI). AI algorithms can learn from data and experience, and can adapt to changing environments and situations. For example, a bipedal robot that is designed to navigate through a cluttered room can use AI to learn how to avoid obstacles and navigate around them.

Applications:

Bipedal robots have a range of potential applications in areas such as healthcare, manufacturing, and public service. In healthcare, bipedal robots could be used to assist patients with mobility impairments, or to perform tasks such as delivering medications or supplies.

In manufacturing, bipedal robots could be used to perform tasks that require dexterity and flexibility, such as assembly or quality control. Bipedal robots could also be used in public service, such as in search and rescue operations, or in hazardous environments where it is not safe for humans to enter.

Conclusion:

Bipedal robots are an important area of research in robotics, with potential applications in a range of industries and fields. The design, control, and applications of bipedal robots are complex and challenging tasks that require advanced technologies and expertise. With continued research and development, bipedal robots have the potential to revolutionize the way we live and work, and to improve the quality of life for people around the world.

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CHAPTER 1

INTRODUCTION

1. Introduction:

Nowadays, there are a growing number of ways that machines and robots may help people execute their jobs. Robotic systems are now used in industrial settings to a degree that their speed and precision are superior to those of humans. The progress, on the other hand, is still far from flawless in the area of household or service robots. The primary distinction between industrial and service robots is the working environment. A service robot must be able to adapt to and deal with the typical human living environment in order to effectively do its tasks. Bipedal robots are the most feasible robot structure from a practical standpoint because they resemble humans physically, especially in terms of mobility. However, due to the unstable nature of bipedal walking, the realization of a bipedal robot is more difficult than that of other types of mobile robots. As a result, numerous studies have been conducted, particularly with regard to the stability sensing and control techniques used by bipedal robots.

Although numerous traditional model-based control strategies, including trajectory tracking control, robust control, and model predictive control, have been suggested for the control of bipedal robots, these control laws are often pre-computed and rigid. In terms of stability, adaptability, and robustness, the resulting bipedal robots are typically unsatisfactory. Bipedal robots have five special qualities that make creating control systems difficult and constrained.

CHAPTER 2

LITERATURE SURVEY

2. Litreature Survey:

2.1 The Kinematics of Manipulators under Computer Control:

Remote manipulation involves having a machine perform tasks requiring human dexterity. Originally, the purpose of a manipulator was to protect man from the hazards of performing the work himself. With the advance of technology, the variety of tasks performed in hostile environments has increased. In addition, the scope of the tasks performed by machines has broadened, so that it is desirable for machines to extend the capabilities of men and to replace men at tedious as well as dangerous Jobs. Although today, many processes and machines are automatically controlled, the problems of remote manipulation have yet to be fully solved. One approach to this problem is to use a digital computer to control a manipulator. Then with information obtained from visual as well as other sensory feedback, the computer would hopefully be able to direct the manipulator to perform tasks requiring some intelligence as well as dexterity.

2.2 Machine Learning Algorithms in Bipedal Robot Control:

Over the past decades, machine learning techniques, such as supervised learning, reinforcement learning, and unsupervised learning, have been increasingly used in the control engineering community. Various learning algorithms have been developed to achieve autonomous operation and intelligent decision making for many complex and challenging control problems. One of such problems is bipedal walking robot control. Although still in their early stages, learning techniques have demonstrated promising potential to build adaptive control systems for bipedal robots. This paper gives a review of recent advances on the state-of-the-art learning algorithms and their applications to bipedal robot control. The effects and limitations of different learning techniques are discussed through a representative selection of examples from the literature. Guidelines for future research on learning control of bipedal robots are provided in the end.

2.3 Simulation and Control of Biped Walking Robots:

During the past three decades research and development in robotics has expanded from traditional industrial robot manipulators to include autonomous and animal-like or humanoid robots. Over the past two decades, the field of humanoid robotics has witnessed significant advances. This development has been driven by improvements in actuator, computer and other enabling technologies and guided by the vision of building machines with (some) human-like capabilities.

CHAPTER 3

PROBLEM STATEMENT, OBJECTIVE, SCOPE

3. Problem statement, objective scope:

3.1 Problem Statements:

To develop a model and simulation for a biped walking robot with real- time control. The main challenge is balancing gravity and limb forces with contact forces on the supporting foot, limited by unilateral foot- ground contact. Inequality constraints are necessary for walking pattern generation and stabilizing control, with violation leading to physical impossibility. The robot's compliant foot-ground contact makes it underactuated, requiring a control system to maintain balance and stability during biped walking.

3.2 OBJECTIVE:

To develop bipedal walking robots despite the technical difficulties in implementing reliable locomotion algorithms, for the following reasons:

(1) Accessing areas inaccessible to wheeled robots such as stairs and obstacle- littered areas

(2) Causing less damage on the ground compared to wheeled robots

(3) Providing a humanoid shape for easier interaction with people and better function in areas designed for humans such as houses and factories.

3.3 SCOPE:

The scope of a humanoid robot can vary depending on the specific goals and objectives of the project. However, in general, the scope of a humanoid robot includes the following aspects:

- Design and Construction: The humanoid robot will be designed and constructed to have a human-like appearance with a flexible and dexterous body, and the ability to move like humans.
- Locomotion and Navigation: The humanoid robot will have the capability to move autonomously or under human control, with various modes of locomotion such as walking, running, crawling, or climbing stairs. It will be equipped with sensors and algorithms for perception and navigation

to avoid obstacles and navigate in complex environments.

- Human Interaction: The humanoid robot will be designed to interact with humans in a natural and intuitive way. This may include speech recognition, facial recognition, and emotion detection to understand and respond to human commands, gestures, and expressions.
- Manipulation: The humanoid robot will have the capability to manipulate objects with its hands and fingers, and perform tasks that require dexterity and precision, such as grasping, picking, placing, and manipulating tools. It will also be equipped with sensors and algorithms for object recognition and hand-eye coordination.
- Applications: The humanoid robot may have a wide range of applications, including but not limited to household chores, healthcare settings, personal assistance, industrial tasks, and research and development in robotics, AI, and human-robot interaction.
- Project Timeline and Deliverables: The development of a humanoid robot project will typically be carried out in multiple phases, with specific milestones and deliverables defined in a project timeline. This may include prototype development, testing, and refinement stages.
- Resources and Constraints: The scope of a humanoid robot project should take into account the available resources, including budget, expertise, and technology constraints, to ensure a realistic and achievable scope.

In conclusion, the scope of a humanoid robot project encompasses various aspects such as design, construction, locomotion, human interaction, manipulation, autonomy, safety, applications, timeline, and resources. The specific scope will depend on the goals and objectives of the project, and should be clearly defined and communicated to ensure successful project execution.

CHAPTER 4

MATERIAL & METHODOLOGY

4. Material & Methodology:

Materials and methodology are critical aspects of designing and building a bipedal robot. Here is a general outline of the material and methodology for creating a bipedal robot:

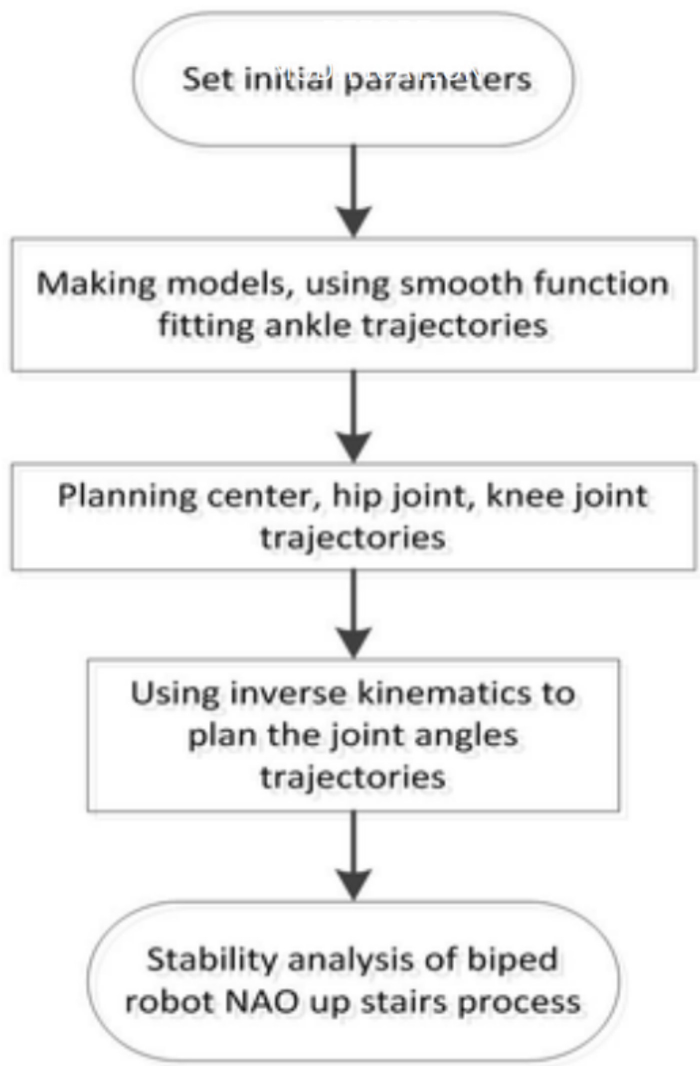

Fig. 4.1 Block diagram of Bipedal Robot

4.1 Material Selection:

Choosing suitable materials for the robot's body, limbs, and other components is crucial for its stability, durability, and functionality. Materials such as lightweight metals (e.g., aluminum, titanium), composites (e.g., carbon fiber, fiberglass), and plastics (e.g., ABS, polycarbonate) are commonly used for building robot structures. The selection of materials may depend on factors such as weight requirements, strength, and cost.

4.2 Mechanical Design:

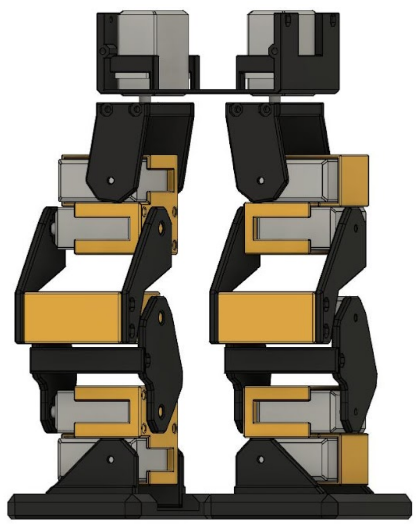

Fig. 4.2 CAD Design

The mechanical design of the bipedal robot involves creating the structural framework, joints, and linkages that allow the robot to walk and perform other desired movements. CAD (Computer-Aided Design) software is typically used to create 3D models of the robot's components, which can then be manufactured using CNC machining, 3D printing, or other fabrication methods.

4.3 Actuators:

Bipedal robots require actuators (motors) to provide motion to the limbs and joints, on specific position, orientation, and other environmental variables. The selection and integration of appropriate actuators a depends on the desired functionalities and performance requirements of the robot.

Fig. 4.3 MG995 Servo Motors

MG995 is a type of servo motor commonly used in hobbyist and robotics applications. It is a high-torque servo motor, which means it can exert a large amount of force relative to its size. The MG995 servo motor is rated for a maximum torque of 10 kg-cm, which makes it suitable for applications that require precise control of motion, such as robotic arms, vehicles, and drones. The servo motor is also known for its reliability, accuracy, and affordability, which makes it a popular choice among hobbyists and professionals alike.

4.4 Control System and the Controller:

Developing a control system is a crucial part of creating a bipedal robot. It involves designing algorithms, software, and hardware to process, generate control signals for the actuators, and manage the robot's movements. This may include implementing control strategies such as PID (Proportional-Integral-Derivative) control, inverse kinematics, and gait generation algorithms.

Fig. 4.4 Arduino Uno

Arduino Uno is a popular microcontroller board designed for hobbyists, artists, and professionals to create interactive and electronic projects. It is based on the Atmel AVR microcontroller and comes with various digital and analog input/output pins that can be used to connect to sensors, actuators, displays, and other electronic components.

Arduino Uno board features a USB interface, a power jack, a reset button, and a 16 MHz quartz crystal oscillator, which provide the board with the ability to communicate with the computer, run programs, and control external devices. It can be programmed using the Arduino Integrated Development Environment (IDE), which is an easy-to-use software platform that allows users to write, upload, and debug their code.

The Uno board is open-source, which means that the hardware and software designs are freely available, and users can modify and improve them to suit their needs. It is widely used in various fields, including robotics, home automation, wearable technology, and Internet of Things (IoT) applications.

4.5 Assembly and Integration:

Once all the individual components are fabricated, the robot must be assembled and integrated into a functional system. This involves connecting the actuatorsand control system, and calibrating them to work together seamlessly. The joint of should be attached appropriately as per the initial position angles

4.6 Motor Shield and Drivers:

The Arduino Uno Motor Shield is an expansion board designed for use with the Arduino Uno board. It allows you to easily control up to two DC motors, or a single stepper motor, with the Arduino Uno.

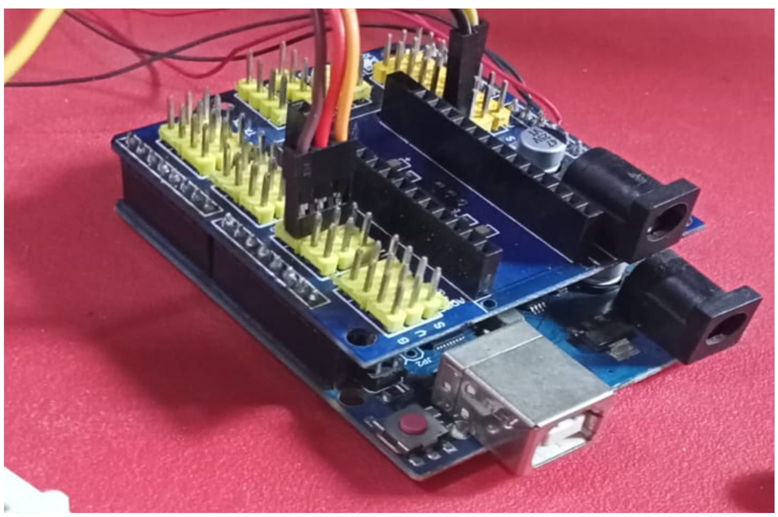

Fig. 4.5 Arduino Uno Servo motor shield

In addition to the DC motor control, the shield also has a connection for a stepper motor, which can be controlled with the Arduino's built-in stepper library. The shield also has various other features, including a 5V regulator to power the Arduino Uno board, and several additional inputs and outputs.

Overall, the Arduino Uno Motor Shield is a great way to add motor control to your Arduino projects and is a popular choice for robotics and automation applications.

Fig. 4.6 3D Printed Parts

The following given image is the legs of our bipedal robot this is how our little assembled robot looks like the yellow and the black parts are the 3D printed parts which are further used to add the motors and connect them so that the power and torque of the motors would be used to make the robot walk.

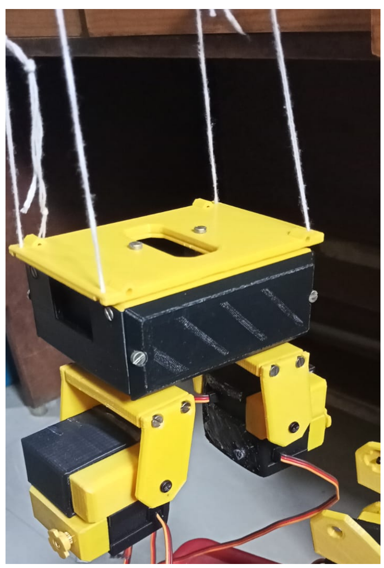

Fig. 4.7 Overhanging Setup

In conclusion, creating a bipedal robot requires careful consideration of materials, mechanical design, actuators and sensors, control systems, assembly, testing, and safety measures. An interdisciplinary approach involving expertise in mechanical engineering, robotics, control systems, and materials science is often necessary to successfully build a functional and safe bipedal robot.

CHAPTER 5

EXPERIMENTATION

5. Experimentation:

Experimentation is a crucial part of developing a bipedal robot, as it helps to evaluate its performance, optimize its functionality, and refine its design. Here are some key areas of experimentation that may be conducted in the development of a bipedal robot:

5.1 Gait and Locomotion:

Bipedal robots require a coordinated and stable gait to walk and move efficiently. Experimentation may involve testing different gait patterns, step lengths, step heights, and walking speeds to optimize the robot's locomotion performance. This may include studying the robot's stability, energy efficiency, and walking speed under various conditions such as different terrains, slopes, and obstacles.

5.2 Balance and Stability:

Maintaining balance and stability is critical for a bipedal robot to prevent falls and ensure safe operation. Experimentation may involve testing the robot's ability to maintain balance during dynamic movements, recover from disturbances, and perform tasks that require shifting its center of mass. This may include studying the robot's stability margins, joint torques, and feedback control algorithms for balance.

5.3 Actuation and Control:

The actuators and control system of a bipedal robot play a critical role in its performance. Experimentation may involve testing the performance of the actuators, such as motors or servos, in terms of their torque, speed, and power consumption. It may also involve experimenting with different control strategies, such as PID control, feedback control, or reinforcement learning algorithms, to optimize the robot's movements and responses.

Concepts like inverse-kinematics are used to set the positions and velocities of the robot legs.

5.4 Durability and Reliability:

Experimentation may also involve long-term testing to evaluate the durability and reliability of the robot's components, including its mechanical structure, actuators and control system. This may include conducting stress tests, fatigue tests, and reliability analyses to identify potential weaknesses and improve the robot's overall performance and lifespan.

Motor testing is an essential step to ensure the reliability of the bipedal robot.

5.5 Safety and Risk Assessment: Experimentation may involve conducting risk assessments and safety tests to identify and mitigate potential hazards associated with the operation of a bipedal robot. This may include testing emergency stop mechanisms, evaluating collision and avoidance strategies, and assessing the robot's compliance with safety standards and regulations.

CHAPTER 6

EXPERIMENTAL SETUP

The experimental setup for a bipedal robot will depend on the specific research or development goals of the project. However, here are some common components that may be included in an experimental setup for a bipedal robot:

Bipedal Robot Platform: The bipedal robot itself will be the primary component of the experimental setup. It may consist of a mechanical structure, actuators (such as motors or servos), sensors (such as accelerometers, gyroscopes, force sensors, or vision systems), and a control system. The robot platform should be designed and built to meet the specific requirements of the experimentation, such as the desired gait patterns, stability requirements, sensing capabilities, and control strategies.

Motion Capture System: A motion capture system may be used to accurately track the movements of the bipedal robot during experimentation. This system typically involves placing markers on the robot's body and using cameras to capture the positions and orientations of these markers in real time. The motion capture data can be used for analyzing the robot's kinematics, dynamics, and gait patterns.

Environmental Setup: Depending on the experimental goals, the bipedal robot may need to operate in a specific environment or terrain. This may require setting up a controlled environment, such as an indoor laboratory with a flat surface or an outdoor environment with different terrains, slopes, or obstacles. The environmental setup should be carefully designed to replicate the real-world conditions relevant to the experiment.

Data Acquisition System: A data acquisition system may be used to collect and record data from the robot's sensors, actuators, and other relevant parameters during experimentation. This may include data such as joint angles, joint torques, sensor readings, and control commands. The data acquisition system should be synchronized with the experimental setup to ensure accurate data collection and analysis.

Computational Resources: Required to understand the workspace of the robotic limbs and calculate the required joint angles for different positions and velocities

Safety Measures: Safety measures should be implemented in the experimental setup to ensure the well-being of researchers, operators, and the robot itself. This may include emergency stop buttons to power off the robot. Handling the robot since the robot is quite fragile..

Experimental Protocol: An experimental protocol should be designed and followed to ensure consistency and reproducibility of the experiments. This may include defining the experimental conditions, specifying the tasks or tests to be performed by the bipedal robot, and detailing the data collection procedures. A well-designed experimental protocol is crucial for obtaining reliable and meaningful results.

In summary the robotic structure would require, a large amount of power source considering the torque requirement of the joint to keep the robot erect. Power switch to control the surge of power which can damage the circuitry.

CHAPTER 7

RESULTS AND FINDINGS

Bipedal robots are robots that are designed to walk on two legs, much like humans do. These robots are of interest because they have the potential to perform tasks in environments that are difficult or dangerous for humans, such as exploring other planets or performing search and rescue operations in disaster zones.
However, designing and building bipedal robots is a difficult and complex task, as it requires the integration of multiple disciplines, including mechanical engineering, control engineering, and computer science. Some of the challenges involved in designing bipedal robots include:

- Stability: Bipedal robots must maintain their balance while walking, which requires sophisticated control systems , its quite difficult to keep track of the robot pose to ensure its stability.
- Energy efficiency: Walking on two legs requires more energy than walking on four legs, so bipedal robots must be designed to minimize energy consumption or a good power supply.
- Flexibility: Bipedal robots must be able to adapt to different environments and terrain types, which requires a high degree of flexibility and adaptability in their design. This may require good actuators and sensor and good control mechanisms.
- Control: Bipedal robots must be able to coordinate the movement of multiple joints and limbs simultaneously, which requires advanced control algorithms and programming, which is possible with a high end computing hardware with multithreading capabilities.

The development of bipedal robots is an ongoing and challenging area of research that has the potential to revolutionize a wide range of industries and applications.There is a wide range of applications for the bipedal robot to use in many kinds of things. It can be used for patrolling, or to monitor in harmful or dangerous environments without risking human lives. It is a robot which will be able to adapt according to the terrain when it is required.

CHAPTER 8

DISCUSSION AND FUTURE SCOPE

Bipedal robots, which mimic human walking patterns, have been a topic of interest in the field of robotics for several decades. In recent years, there has been significant progress in the development of bipedal robots, with several companies and research institutions working on improving their functionality and expanding their applications.

One of the primary applications of bipedal robots is in the field of search and rescue. These robots can navigate rough terrain and narrow spaces that are difficult for humans to access, making them ideal for use in disaster zones. Bipedal robots can also be used for tasks that are too dangerous for humans, such as exploring hazardous environments like nuclear power plants or deep-sea oil rigs.

Another potential application of bipedal robots is in the field of healthcare. They can be used to assist elderly or disabled people with mobility issues, helping them to perform daily tasks such as getting in and out of bed, walking, and climbing stairs. Bipedal robots can also be used in rehabilitation settings to assist patients in recovering from injuries or surgeries, they could be used to perform tasks in factories or warehouses, such as moving heavy objects or transporting materials.

Despite the progress that has been made in the development of bipedal robots, there are still significant challenges to be addressed. One of the biggest challenges is developing algorithms and control systems that allow robots to walk and balance in a stable and efficient manner. Additionally, there is a need for more robust and durable materials to be developed to withstand the stresses of bipedal locomotion.

In conclusion, the development of bipedal robots has the potential to revolutionize a wide range of industries and applications, from search and rescue to healthcare and entertainment. While there are still challenges to be addressed, it is clear that bipedal robots will play an increasingly important role in our lives in the years to come.

CHAPTER 9

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INVERSE KINEMATICS 3DOF ROBOTIC ARM

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*Abstract:-***This paper explores the application of inverse kinematics to control a 3-degree-of-freedom (DOF) robotic hand using an open-source robotic hand model. This study's analytical approach entails calculating the joint angles necessary to get the desired end-effector position. The workspace of the robot hand and its control settings are described. It should be emphasized that only three parameters, namely the positions of the end-effectors, may be controlled due to the robot hand's limited DOF (x, y, z). The benefit of rotatory actuators over linear actuators for robotic hands is also addressed in the piece. Lastly, the method's limitations are examined, including the fact that it only applies to this specific robot system. The concept presented in this paper, which may be used to control a 3DOF robotic hand using inverse kinematics, has potential applications in a number of areas, including industrial automation, prosthetics, and robotics research.**

INTRODUCTION

Robotic systems that behave dynamically like human hands are known as robotic arms. This feature of robotic arms has made them helpful in a variety of applications, such as industrial manufacturing, assembly, surgery, or anything that a human hand can accomplish, but with more precision and a wider range of force and strength.

The popularity of robotic dogs, humanoids, and other "such bio-robots" (robots inspired by biology) is also rising.

These robots will become increasingly significant as the robotics sector develops in various fields and applications. It's important to note that rotary actuators, rather than linear actuators, are typically used in the mechanics of robotic systems.

In comparison to rotary actuators, linear actuators move slowly and provide less power. A robotic system that uses linear actuators for movement may be limited in terms of speed and overall effectiveness as a result. Due to their increased size and weight as well as the additional components needed to transform their linear motion into rotating movement, linear actuators can prove particularly challenging to integrate into a robotic system. As a result, they might be less useful in some situations where weight and space restrictions are an issue.

Rotatory actuators, on the other hand, allow movement and functionality in robotic systems to be more adaptable by having the ability to rotate and pivot in multiple directions. Moreover, rotatory actuators are more compact and lighter than linear actuators, making them simpler to integrate into robotic systems and lowering the system's overall weight.

Therefore, it becomes challenging to analyze the kinematics of a robotic system containing rotatory actuators. An extremely counterintuitive shift in the system's position and speed can result from changing the angles between any two links.

We also go through the 3DOF robotic hand's management of this intricacy.

Figure 1 Robotic Arm

ROBOTIC ARM CONSTRUCTION

A 6DOF open-source robotic hand was utilized, but the gripper was taken out, leaving the remaining system with only 3DOF. Three revolving joints make up the robotic hand. A position-controlled MG995 servo motor is used to actuate the three revolute joints (180 degrees). The robot's foundation and all of its linkages are 3D printed. An Arduino Uno is used to control the robotic hand.

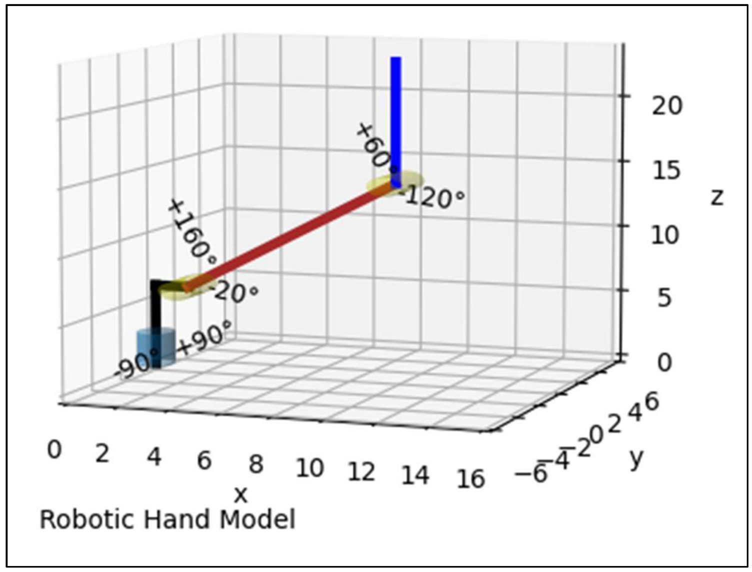

Figure 2 shows graphical model or the Robotic Arm

An end effector is frequently moved in robotics to accomplish a particular position (x, y, z) and orientation (a, b, g) in 3D space. But nonetheless, a robotic hand normally needs at least 6 degrees of freedom to provide this level of control. In the case of a 3DOF robotic hand, control is restricted to just three end effector parameters, namely the locations of (x, y, z).

DH PARAMETER

Link_1_length = 113.2, Joint 2 offset = 13.6, Link_2_length = 120, Link_3_length = 89.5

Joint	a(mm)	α(degree)	d(mm)	θ(degree)	Range(degree)ϕ
1	13.6	90	0	0	-90 to 90
2	120	0	0	0	-20 to 160
3	89.5	-90	0	0	-120 to 60

Table 1 DH parameter of the Robotic Arm

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a -- Distance between z axis of joint$_i$ and joint$_{i+1}$.

α -- Angle between z_i and z_{i+1} about x_i.

d -- Distance between x axis of joint$_i$ and joint$_{i+1}$.

θ -- Angle between x_i and x_{i+1} about z_i.

Range – Min-Max angle to its previous joint.

WORKSPACE OF ROBOTIC ARM

The workspace of a robotic hand cannot be determined in a general way. The workspace will vary depending on the range/type of joints and the length of each link.

For the given robotic arm keeping the joint 1 at 0 degree and iterating joint 2 and joint 3 for different angles of theta, we can obtain a 2D work space of that plane. Figure 3 represents that plane.

We may acquire a 3D workspace of the robotic arm if we rotate this section along the joint 1's range angle, which is between -90 and 90 degrees. Figures 4 and 5 represent the 3D workspace. The robotic arm's workplace is located between the red curved wall and the green wire frame.

The technique discussed in this study is exclusive to the selected robot system, it should be emphasized. A specific posture can be achieved by the robot hand in a maximum of two states thanks to its three joints, each of which can rotate up to 180 degrees. The 2D vertical segment of the robot's workspace in Figure 3 shows that the dot density is greater on the area close to the outer edge. This is due to the fact that the robotic hand can reach those positions in two different states. This indicates that there are two distinct sets of joint angles that can be used to achieve those positions in dense area. The regions where two states are obtained are determined by the range of the revolute joint. At bigger ranges, the region where two states can be obtained expands, whereas for smaller ranges, it contracts. Since there is only one revolute joint along the z-axis, this behavior will remain same for every section for any angle of z axis.

The robotic hand's workplace is located between the red surface and the green wireframe in the 3D plot.

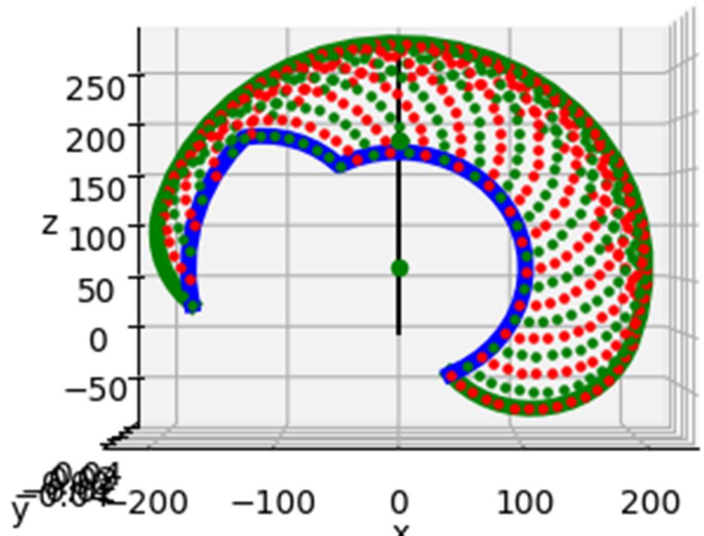

Figure 3 – 2D section

2D section of workspace

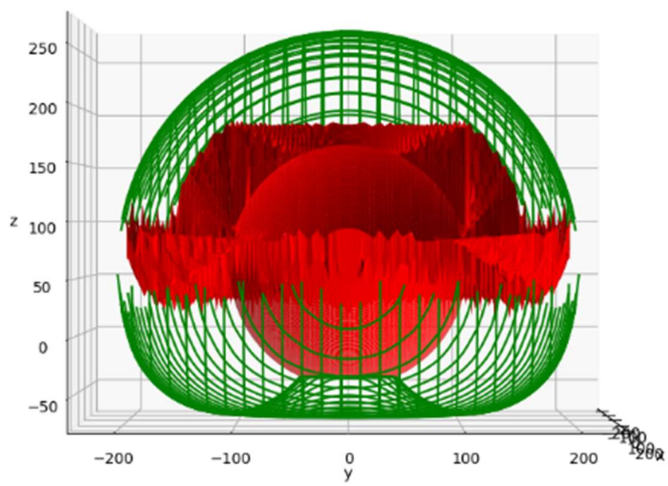

Figure 4 – 3D front view

3D section of workspace(Front_view)

The graph just serves to provide an understanding of the 3D workspace; it does not accurately depict the workspace. Also, the surface's gap can be reached and is necessary for correct interpolation when graphing the surface. Figure 5 with a different view and Figure 6 with a different plot style are provided below for a better understanding of the workspace.

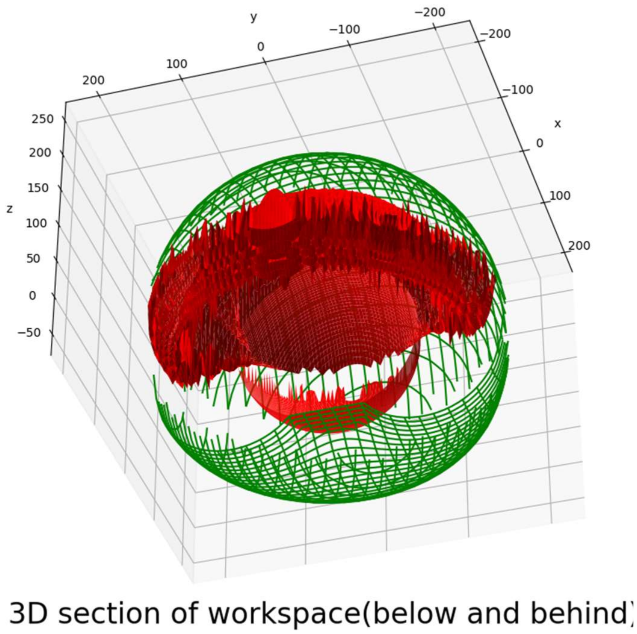

Figure 5 – Orientation changed

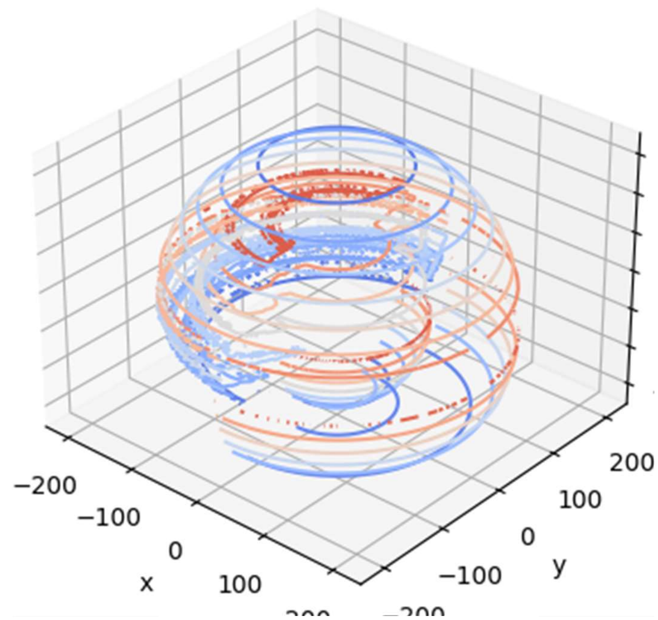

Figure 6 – Plot Method Changed

INVERSE KINEMATICS

The most crucial component of any robotic system is this. Here, the system is provided the specific position where the end effector must be put, and the robotic hand uses inverse kinematics to calculate the revolute joint angles of the robot.

With the analytical approach to inverse kinematics, the joint angles necessary to reach a specified end-effector position are explicitly calculated using mathematical formulas. This approach is relatively quick and easy to use, and it doesn't involve any mathematical optimization methods.

The Newton approach for inverse kinematics, on the other hand, requires iteratively resolving an equation system using numerical optimization techniques.

Although this approach is more difficult and computationally demanding, it can be used to systems with complex or non-linear kinematics.

Generally, the Newton technique is more appropriate for complicated systems with non-linear or complex kinematics whereas the analytical method is simpler and simpler to execute for simple robotic systems.

It should be mentioned that based on the particular application and system requirements, each solution has benefits and drawbacks.

We employ an analytical method to do inverse kinematics for the robotic hand because the model being used is straightforward. Geometry is used to calculate the robot equation. The formulas read as follows.

$$\emptyset 1 = \tan^{-1}\frac{y}{x} \text{------(i)}$$

$$\emptyset 3 = \cos^{-1}\left[\frac{\left[\left(\frac{x-(a1\times\cos\emptyset 1)}{\cos\emptyset 1}\right)^2 + (z-L1)^2 - (a2^2 + a3^2)\right]}{2\times a2\times a3}\right]\text{------(ii)}$$

$$\emptyset 2 = \tan^{-1}\left[\frac{(z-L1)\times\cos\emptyset 1}{x-(a1\times\cos\emptyset 1)}\right] - \tan^{-1}\left[\frac{a3\times\sin\emptyset 3}{a2+(a3\times\cos\emptyset 3)}\right]\text{-----(iii)}$$

Because each equation depends on the results of the one before it, the aforementioned equations must be solved in the sequence specified.
The robotic model cannot be commanded using the generated angles directly. It is important to consider the servo motor's range limitations. An issue for the robot can arise if a specific coordinate point generates a series of angles, any one of which is beyond the permitted range for that specific joint.
Determine the angle (theta) the point makes with the XY plane as well as its separation from the origin. To determine whether a point is below the workspace's outer boundary, add the height components of link 1 and the offset of link 2 together, subtract them from the point's distance, and then compare the result to the sum of lengths of links 2 and 3.

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BIPEDAL ROBOT

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PROJECT GUIDE: DR. VILAS MAPARE

ABSTRACT:

A biped is a multi-jointed machine that can move like a person. Because of the intricacy of the mathematical description, it appears more challenging to analyze the behavioral characteristics of a walking robot. The goal of this project is to create a method for calculating a biped robot's inverse kinematic joint solution. This project attempted to construct a biped robot's lower half, the movement section. It combines design considerations with design simplicity to produce an inverse kinematics study of a biped robot with 12 degrees of freedom (DOF). Five links make up the model, which is joined together by revolute joints. The hip, knee, and ankle joints are present in both legs identically. To solve a univariate polynomial, a symbolic formulation for problem reduction is discussed in this study.

To solve an analytical inverse kinematics problem for a specific end-effector position, a successful methodology is created. This approach offers a quick and easy process for determining the joint solution for bipeds.

INTRODUCTION:

Nowadays, there are a growing number of ways that machines and robots may help people execute their jobs. Robotics systems are now used in industrial settings to a degree that their speed and precision are superior to those of humans. The progress, on the other hand, is still far from flawless in the area of household or service robots. The primary distinction between industrial and service robots is the working environment. A service robot must be able to adapt to and deal with the typical human living environment in order to effectively do its tasks. Bipedal robots are the most feasible robot structure from a practical standpoint because they resemble humans physically, especially in terms of mobility. However, due to the unstable nature of bipedal walking, the realization of a bipedal robot is more difficult than that of other types of mobile robots. As a result, numerous studies have been conducted, particularly with regards to the stability sensing and control techniques used by bipedal robots.

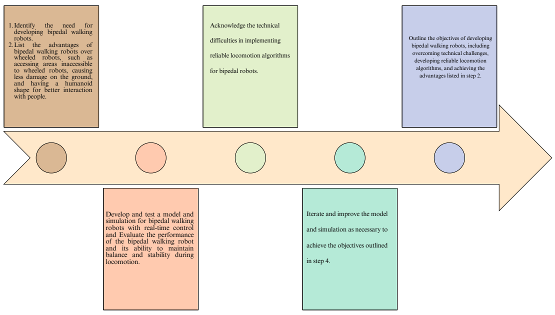
PROBLEM STATEMENT:

To develop a model and simulation for a biped walking robot with real-time control. The main challenge is balancing gravity and limb forces with contact forces on the supporting foot, limited by unilateral foot-ground contact. Inequality constraints are necessary for walking pattern generation and stabilizing control, with violation leading to physical impossibility. The robot's compliant foot-ground contact makes it underactuated, requiring a control system to maintain balance and stability during biped walking.

OBJECTIVES:

To develop bipedal walking robots despite the technical difficulties in implementing reliable locomotion algorithms, for the following reasons:
(1) Accessing areas inaccessible to wheeled robots such as stairs and obstacle-littered areas
(2) Causing less damage on the ground compared to wheeled robots
(3) Providing a humanoid shape for easier interaction with people and better function in areas designed for humans such as houses and factories.

PROCESS:



APPLICATIONS

Search and Rescue: The bipedal robot's capability to navigate through uneven surfaces and climb stairs makes it valuable in search and rescue operations during emergencies.

Industrial Automation: The humanoid shape of the bipedal robot is beneficial for working alongside humans in manufacturing facilities, carrying out tasks that require dexterity and precision.

Healthcare: The bipedal robot can assist individuals with disabilities in mobility and providing physical therapy to those in need.

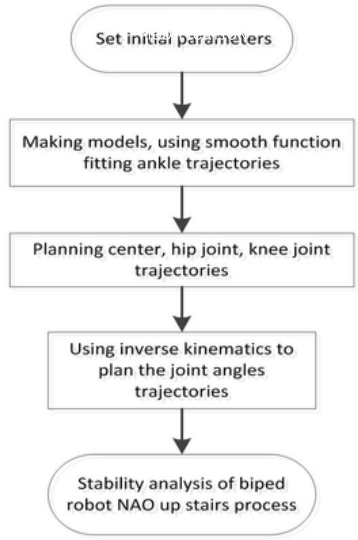
Entertainment: Bipedal robots with a humanoid appearance have potential applications in amusement parks and other entertainment settings, providing interactive experiences for visitors.

Education: Bipedal robots can be used in educational environments to teach robotics and engineering concepts to students while offering hands-on learning opportunities

SCOPE

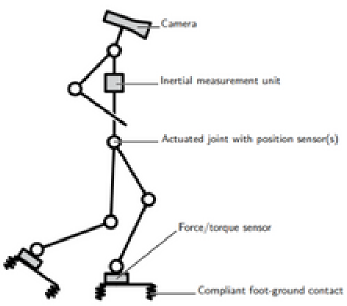
The potential applications of bipedal robots are vast and constantly evolving with the advancements in technology. These robots have the ability to transform numerous industries, including healthcare, entertainment, construction, and manufacturing. Bipedal robots can perform tasks that are dangerous, difficult, or impossible for humans, such as navigating hazardous environments, performing surgeries, and assisting in disaster response efforts. With ongoing research and development, the scope of bipedal robots is expected to expand further, creating new opportunities and applications in various fields.

METHODOLOGY

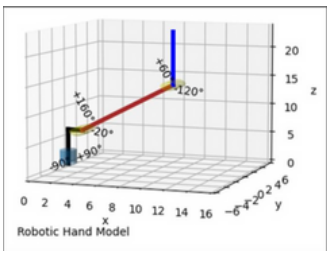


Description:
The article outlines five distinct methodologies for the creation and design of a bipedal robot. The initial methodology involves the selection of suitable materials based on design specifications, material qualities, cost, and availability. The second approach emphasizes the use of CAD software to design the robot's mechanical structure, optimizing for stability, control, and efficiency. The third methodology involves designing the robot's control system, including selecting sensors and actuators, testing and validating the system, and ensuring safety. The fourth approach involves testing and validation, including setting up test scenarios, collecting and analyzing data, and verifying safety measures. Finally, the fifth methodology, iterative refinement, focuses on continuously refining and improving the robot's design and performance based on feedback obtained during testing and validation.

BASIC STRUCTURE OF BIPEDALL ROBOT



STRUCTURE OF ROBOTIC ARM



CONCLUSION

In summary, the article highlights five methodologies for designing and building a bipedal robot. These methodologies, which include material selection, mechanical design, control system design, testing and validation, and iterative refinement, provide a systematic framework for developing a stable, efficient, and safe bipedal robot. By adhering to these methodologies, engineers can ensure that each aspect of the robot's design is thoroughly considered and optimized for performance. Moreover, the iterative refinement process through testing and validation helps in identifying areas for improvement, resulting in a better final product.