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Ramanagara District, Karnataka, India

2022-2023

A Project Report on

"VIRTUAL ROBOT SIMULATOR"

Submitted in partial fulfilment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

ROBOTICS AND AUTOMATION ENGINEERING

Submitted by

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CERTIFICATE

This is to certify that the project work titled **"VIRTUAL ROBOT SIMULATOR"** is carried out by **Ashish Kumar (19BTRRA004), Manish Kumar Gupta (19BTRRA026), Ashim Dongol (19BTRRA023), Rohit V Patil (19BTLRA007),** are bonafide students of Bachelor of Technology at the Faculty of Engineering & Technology, JAIN DEEMED-TO-BE UNIVERSITY, Bengaluru in partial fulfillment for the award of degree in Bachelor of Technology in Robotics and Automation Engineering, during the academic year **2022-2023**.

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DECLARATION

We, **Ashish Kumar (19BTRRA004), Manish Kumar Gupta (19BTRRA026), Ashim Dongol (19BTRRA023), Rohit V Patil (19BTLRA007),** are students of eighth semester B.Tech in **Robotics and Automation Engineering**, at Faculty of Engineering & Technology, **JAIN DEEMED-TO-BE UNIVERSITY**, hereby declare that the project titled **"Virtual Robot Simulator"** has been carried out by us and submitted in partial fulfilment for the award of degree in **Bachelor of Technology in Robotics and Automation Engineering** during the academic year **2022-2023**. Further, the matter presented in the project has not been submitted previously by anybody for the award of any degree or any diploma to any other University, to the best of our knowledge and faith.

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ACKNOWLEDGEMENT

It is a great pleasure for us to acknowledge the assistance and support of a large number of individuals who have been responsible for the successful completion of this project work.

First, we take this opportunity to express our sincere gratitude to **Faculty of Engineering & Technology, JAIN DEEMED-TO-BE UNIVERSITY** *for providing us with a great opportunity to pursue our Bachelor's* Degree *in this institution.*

In particular we would like to thank ***Dr. Hariprasad S.A****,* ***Director****,* **Faculty of Engineering & Technology**, **JAIN DEEMED-TO-BE UNIVERSITY** *for his constant encouragement and expert advice.*

It is a matter of immense pleasure to express our sincere thanks to ***Dr. R. Sukumar****,* **Head of the department**, **Robotics and Automation Engineering**, **JAIN DEEMED-TO-BE UNIVERSITY,** *for providing right academic guidance that made our task possible.*

We would like to thank our guide ***Basavaraj.H Professor****,* **Dept. of Robotics and Automation Engineering**, **JAIN DEEMED-TO-BE UNIVERSITY**, *for sparing his valuable time to extend help in every step of our project work, which paved the way for smooth progress and fruitful culmination of the project.*

We would like to thank our Project Coordinator ***Mr. Sunil M P*** *and all the staff members of Robotics and Automation for their support.*

We are also grateful to our family and friends who provided us with every requirement throughout the course.

We would like to thank one and all who directly or indirectly helped us in completing the Project work successfully.

Signature of Students

ABSTRACT

Delta robot is a type of parallel robot which is increasingly being used in the industry. The robot has quick and fluid control over how it approaches different applications. Moving into different positions is therefore easy. They are capable of working quickly; some can pick up to 300 items per minute.

Since it is frequently used in industries, the student must be given the right information about the robot in order to learn about it. The curriculum in schools, however, does not promote genuine development. Typically, when teaching robotics in a classroom, only the fundamentals are presented. This project created a virtual simulation of a delta robot to help people comprehend and perceive delta type robotics.

This project's major goal is to assist users and students in visualizing delta robot operation and comprehending the kinematics of delta type robots. Simple computations for delta's forward and inverse kinematics.

Additionally, this project's goal is to avoid any mistakes that might be made in the design of a delta robot.

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NOMENCLATURE USED

WebGL	Web Graphic Library
OpenGL	Open Graphic Language
HTML	Hypertext Markup Language
CSS	Cascading Style Sheets
JS	JavaScript
DOF	Degree of Freedom
PID	Proportional Integral Derivative
CNC	Computer Numeric Control
API	Application Program Interface
HMI	Human Machine Interface

Chapter 1

1. Introduction to Topic

1.1. Introduction to Delta Robot

In the last two decades, there has been remarkable progress in both theoretical and practical advancements in the field of parallel manipulators. These systems have gained significant traction due to their superior speed, precision, and power. Among the parallel robots, the delta robot stands out, featuring three arms connected at the base through universal joints. The key design element in delta robots is the utilization of parallelograms in the arms, ensuring the alignment of the end effector is maintained throughout its movements. This design feature plays a pivotal role in achieving the robot's high accuracy and performance.

Delta robots have found wide-ranging applications in industrial settings, particularly in tasks involving picking and packaging. Their exceptional speed enables them to accomplish up to 300 picks per minute. These robots exhibit precise control over their approach to various applications, facilitating smooth and rapid movements. They are capable of versatile motion and are well-suited for manipulating workpieces. With a payload capacity of up to 500 grams, delta robots are particularly relevant in the food manufacturing industry. Hence, this study aims to demonstrate the development of a fully functional rotating delta robot.

To create a simulation model of the delta robot, it is essential to establish a comprehensive kinematic model specific to this robot type. Accurately representing the kinematics enables researchers and developers to simulate the robot's movements and behaviors. This virtual simulation serves as a valuable tool for comprehending the working principles and kinematic intricacies of delta robots. It aids in visualizing the robot's operations, allowing users and students to enhance their understanding of delta robot kinematics.

The main objective of this project is to provide users and students with a visual representation of delta robots and facilitate their understanding of the robot's kinematics. Additionally, this research offers useful calculations for both forward and inverse kinematics, enabling users to delve deeper into delta robot functionality. Another aim of this project is to address potential design failures that may occur during the development of a delta robot. By addressing these challenges and promoting a better understanding of delta robot design and kinematics, this research contributes to the improvement and optimization of delta robot technology.

It includes :

- Fixed Frame (Base)
- Proximal Link (Active Link)
- Distal Link(Passive Link)
- Joints
- Moving Platform (End Effector)

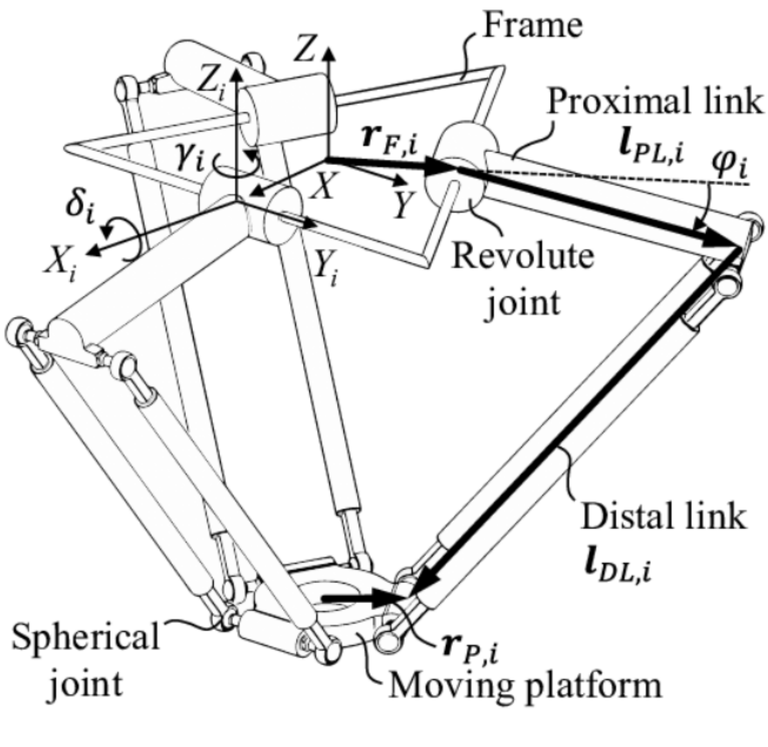


fig: Delta Robot schematic diagram

Many researchers have explored the motion control of a Delta robot during the past few decades. An adaptive controller was developed by Castan et al. to enable the trajectory tracking of a Delta robot with uncertainty.

Due to the lack of joint velocity measurements for the Delta robot, the adaptive controller also includes an observer. Ram'rez-Neria and colleagues investigated a robust trajectory tracking method in which the controller is based on a linear feedback control and is capable of actively rejecting disturbances by means of a linear disturbance observer. A Delta robot model was created by Guglielmetti and Longchamp, with the joint angle and the end-effector coordinates serving as the state variable.

1.2. Objectives

Delta robots have gained significant popularity, attracting the interest of researchers, engineers, and enthusiasts. However, the traditional school curriculum often lacks hands-on experience and practical development opportunities for these robots. Classroom teachings usually focus on theoretical concepts rather than practical robot design and implementation skills.

To bridge this educational gap, a research project developed a virtual simulation of a delta robot. By utilizing computer graphics and simulation technology, the project aimed to provide users, especially students, with an interactive platform to visualize and understand the inner workings of delta robots.

The main objective was to enhance users' understanding of delta robot kinematics by demonstrating the relationships between joints, actuators, and end effector movements. Through the virtual simulation, users could observe how these components collaborate to achieve precise and coordinated motion.

Additionally, the project aimed to offer practical calculations for forward and inverse kinematics of delta robots. By integrating these calculations into the virtual simulation, users could gain hands-on experience in solving the mathematical equations governing the robot's motion. This feature aimed to improve problem-solving skills and prepare users for real-world challenges in delta robot design and operation.

Moreover, the project sought to anticipate potential failures during the design phase of a delta robot. By providing a realistic virtual environment, users could explore different design parameters, test scenarios, and identify issues without the costs and risks associated with physical prototyping. This approach would empower users to make informed design decisions and address problems before physical implementation.

1.3. Methodology

The Delta robot's dimensions are first calculated. In order for the dimension to do the designated task, it must be calculated correctly. After determining the robot's dimensions, we must determine its forward and inverse kinematics. These kinematics make it possible to precisely move the robot to the specified location. After that, we design every part needed to assemble the robot. The Delta Robot's 3D design is completed by assembling all the parts together after they have been designed, including all the screws needed to join all the components together.

Once the 3D model is complete, it is exported in a suitable format so that it can be used in web pages. After that, we create the website and insert the 3D model into it. After that, we create a calculator that computes robot data such as joint angles, kinematics, transformation matrices, etc

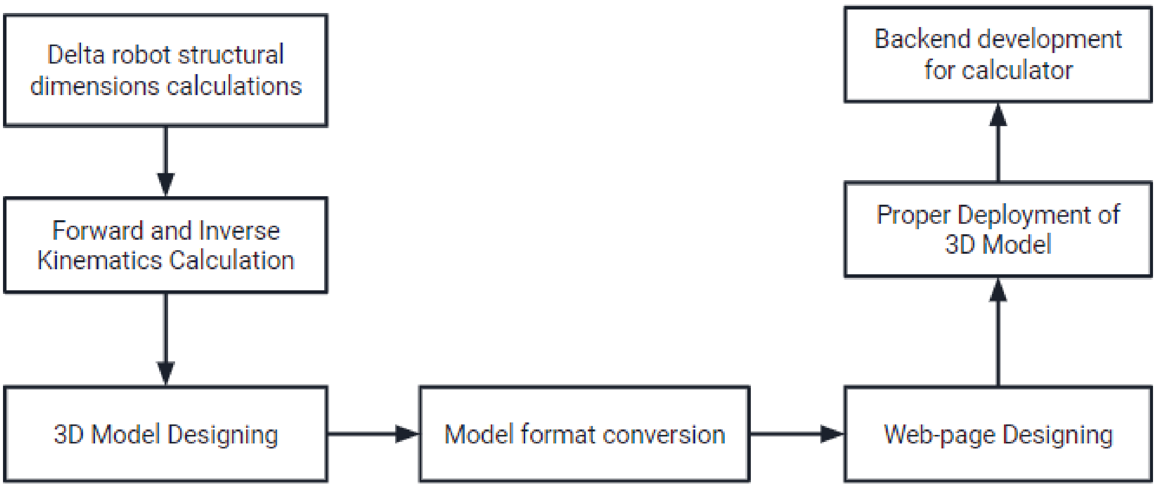


fig : block diagram of project methodology

WebGL is a cross-platform 3D graphics Application Programming Interface (API) that uses OpenGL as a shading language to create 3D drawing context for web-based graphics visualization. It allows developers to use the 3D rendering hardware of their computers from within their web browser using standard JavaScript and Hypertext Markup Language (HTML) .The WebGL standard is managed by the non-profit Khronos Group, who released its specification 1.0 on March 3, 2011 . The 3D graphics content can be cleanly combined with other web content that is layered on top or underneath the 3D content. This type of web-based graphics programming is ideally suited for creating dynamic, web-based 3D applications in the JavaScript programming language. WebGL is currently supported by many leading web browsers including Apple (Safari), Google (Chrome), Mozilla (Firefox), and Opera (Opera). The WebGL technology has been increasingly used in various web-based simulation applications for scientific visualization, education, entertainment and gaming purposes.

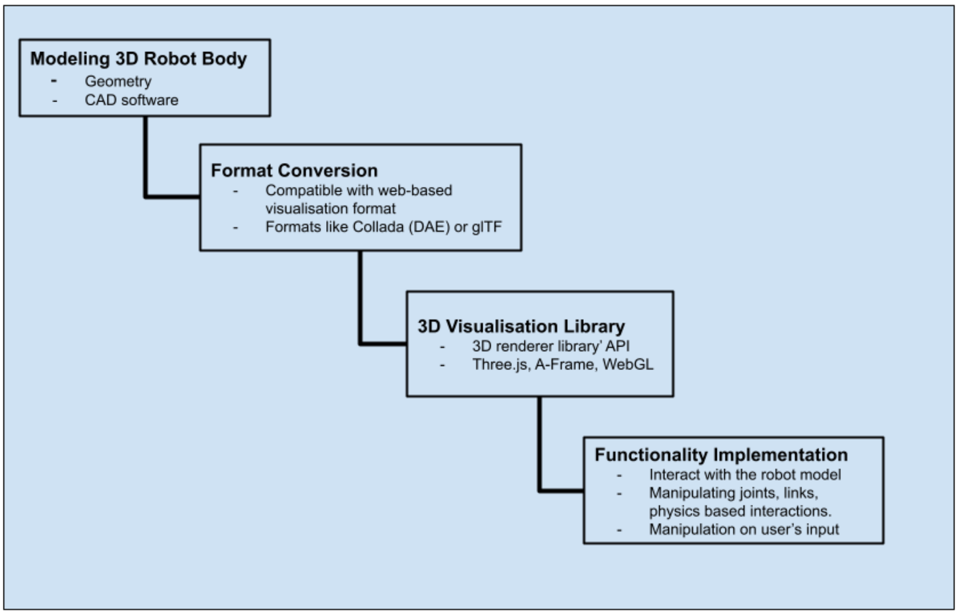


fig: Overall Methodology of building VR simulation models with WebGL

In order to ease the modeling and development process with WebGL, several high-level JavaScript programming libraries have been introduced. Three.js, GLGE, SceneJS, PhiloGL are among the popular WebGL libraries. These libraries are intended to make it easier to author complex 3D computer animations that display in the Web-browser without use of any plug-in. For developing the proposed virtual laboratory in this paper, we mainly used Three.js as an authoring library. The Three.JS is a single JavaScript file, which can be included within a web page by linking to a local or remote copy using the following statement :

```
<script src="js/three.min.js"></script>
```

Chapter 2

2. Literature Review

The development of a free body diagram was the first step in the concept design of the Delta robot, which was followed by the measurement of forward and inverse kinematics. The delta robot's designing mechanism has now been put into practise. Even if the design processes of all linked activities are the same, the end products vary. Particularly, the fundamentals of mechanical design are the same, but for purposes like food production, small workpieces, and cycle duration, the length of the arms and some mechanism specifics change. As a result, numerous studies have concentrated on improving the Delta robot. Improvements have been made to controller and programming in addition to speed and accuracy.

2.1. Experimental and simulation studies of motion control of a Delta robot using a model-based approach

This article demonstrates a straightforward model-based control strategy applied to a Delta robot with three DOFs for translation and three rotational motors. The position-based control system is typically used for manipulator robot positioning control. The robot control problem is split up into multiple independent motor control problems by this control technique. Due to the absence of the robot's dynamics in this control loop, the main drawback of the control system may be that it does not offer good positioning accuracy. The computed torque control, which computes applied torques based on the inverse dynamics of robots and the errors of joint angles as well as angular velocities, is one of the model-based controls that has been discussed in literature. In addition to computing the applied torques based on the kinematics and dynamics of the robots, the proposed model-based control method also uses the torques to compute the errors between the applied torques and the intended torques, which is used to implement the feedback control. Because torque and current sensors are not needed, the suggested technique is substantially simpler and may be thought of as an indirect torque control. This article compares and contrasts the simulation and experimental findings obtained using the mode-based control scheme with those obtained using the position-based control technique. The model-based control system offers improved positioning precision, according to the results.

2.2. Development of Pick and Place Delta Robot

This project demonstrated how the delta robot was created, and it can be used as the basis for future projects that teach about delta robot basics.Numerous robot applications, including packing, pick, and place, are used in industrial automation. Humans are capable of performing jobs that demand good location and accuracy, but doing so takes expertise and experience. However, reducing the issue of error in the manufacturing line and improving yield rate performance are the essential goals. The development of robots, which took the place of people in faster pick-and-place products to solve these issues and shorten working hours, is a new learning media education. As a result, studying the Delta robot is a fascinating subject because it has a unique design, calculation work area, and working mechanism. Therefore, researchers want to develop experimental mediums for robots with intricate designs so they can operate more efficiently and be used in automated production lines. Students may be able to examine and test the robot using the training set prototype. By creating the mechanisms and controller, the project-based learning with the Delta Robot can be applied to coursework that has been covered. Students can examine the forward/inverse kinematic model during learning exercises. Students are able to do the experiment using real work and can observe the outcomes of changing the model's parameter. This body of literature focuses on the delta robot and is helpful for researchers and students that are interested in robotics.

This project can be used to improve student understanding of the mathematics behind robot models. Additionally, it can be applied to or modified for usage with different robot types. It can also research how to create a robot product for an industrial use. The robot prototype still exhibits significant erroneous results, though. It is not suitable for industrial uses that call for errors of less than 0.1 mm. To increase the efficiency, the robot's accuracy and efficiency must be increased.

2.3. The Design and Simulation of Training Delta Robot

Due to their higher rigidity and higher positioning precision as compared to serial robots, parallel kinematic structures are intriguing. Although there are various applications for this type of mechanism, robots and numerically controlled machine tools account for the majority of them. The delta robot design has generated a lot of interest in academia as well as in industry. This study provides information on the mechanical subsystem development, kinematic analysis, and modeling of the Caertec rk 2010 training Delta robot at the University of Zilina. Three parallelogram mechanisms form the foundation of the robot's parallel kinematics. Inverse kinematics was used to count the kinematic loops in the Delta robot. Software was created for delta robot control and trajectory programming that enables simulation, workspace analysis, position programming, and communication management.

2.4. Delta Robots pick and place coloured objects

This section aims to compile several related studies on Delta Robots that make use of pick-and-place and item detection techniques. The results of these studies can be compared to those from the current project or even used as a foundation for the methodology. The Design and Implementation of a New DELTA Parallel Robot in Competitions project was first developed in 2015. A 3D printer was used to produce some of the parts for this project. The primary goal of this research was to create a low-cost delta robot that could pick and arrange objects using image recognition.

There were also 3 case scenarios that the robot needed to be able to handle. In the beginning, several domino pieces had to be picked up and placed. Second, the robot must meet certain requirements for writing and drawing. The third scenario, which involves choosing and placing an object based on its color.

Chapter 3

3. Research Gaps

3.1. Problem statement and solutions

A hot topic in industry and innovation is the Delta Robot. It operates quickly and has a very small structure. Due to their rapid speed and excellent precision, Delta robots are now used by numerous food industries. This is just one of the reasons behind the project. Although it's a hot topic, one robotics enthusiast finds it challenging to comprehend and picture how the Delta robot functions. These are a few of the issues:

- Lack of proper visualization of delta robot structure.
- No specific tool for delta's workspace and movement visualization
- No handy calculation of delta's forward and inverse kinematics
- Lack of easy tool for academic experiments and learning
- Lack of knowledge on functionality of Delta Robot
- Growing significance of Delta Robot

Some of the main issues that discourage robotics enthusiasts from learning more about Delta Robot include those just mentioned. In this project, we develop a straightforward website (virtual delta robot lab) that offers details about the Delta robot's operation, among other things. Additionally, it includes a simulation that aids the deep and precise visualization and understanding of robotics enthusiasts. Additionally, they can view the necessary parts together with their proportions, which will be useful when they are making their own models. Additionally, the website offers transformation matrices as well as forward and inverse kinematics. As a result, the website gives accurate information about Delta robots, enabling many robotics students to learn more effectively and without confusion.

3.2. Existing System

Workplace operations are changing as a result of robotics technology. They are also altering how people conduct themselves at home. Robotics technology is improving the productivity, security, and autonomy of companies and residences. They carry out monotonous and repetitive jobs so that people can focus on innovative and important activities. Robots of all sizes are having an impact on the physical and digital worlds.

Robotics is a popular subject in innovation and is crucial to many sectors. It was established as a curriculum in schools for that reason. However, there are extremely few materials available to learn Delta robots. Today, delta robots are primarily employed for pick-and-place operations in the food and other production sectors. Delta robots are now used by numerous food industries. Since delta robots are so commonly utilized, understanding how they operate is essential for businesses, yet there are no adequate models available. Many scientists have worked on efforts to assemble robots or figure out their kinematics. It is exceedingly challenging to fully comprehend the concepts behind Delta robots.. It takes a lot of time and effort for one robotics student to visit various websites and consult numerous research papers.

There aren't many websites that offer a virtual robot to help people learn about and comprehend robots better. A few of them also offer robot simulations, but they don't adequately educate the public about robotics. The delta robot isn't even present on the majority of the website. Even if they do, they do not adequately disclose the robot's specifications, operation, components, etc.

3.3. Proposed system

Delta robots have become a prominent choice in the industrial sector as a parallel robot configuration. Their usage continues to grow due to their exceptional characteristics and versatility. With their swift and seamless control, these robots can efficiently handle a wide range of applications. Their agility enables them to effortlessly transition between positions, making them ideal for dynamic environments. Notably, delta robots boast impressive speed and productivity, capable of handling an astonishing volume of up to 300 items per minute. This unparalleled efficiency renders them invaluable in industries requiring rapid and continuous object manipulation, offering substantial benefits for automated manufacturing processes.

Since it is frequently used in industries, the student must be given the right information about the robot in order to learn about it. The website assists in providing the necessary robot information and also enables students to envision the robot and observe its operation in a virtual setting. Additionally, the website offers crucial details like dimensions and parts used to assist those who want to construct their own robot. The website also offers the crucial details that aid in a deeper comprehension of the Delta robot, such as joint angles, transformation matrices, end-effector position, etc.The main objective of this project is to help users and students, to visualize the working of delta robots, and understand the kinematics of delta type robots. Handy calculations for forward and inverse kinematics of delta. The objective of this project is also to prevent

the failures that may occur while designing a Delta Robot.

The home page of the project looks like this. It contains various pages shown in tabs. Home tab contains the overview.

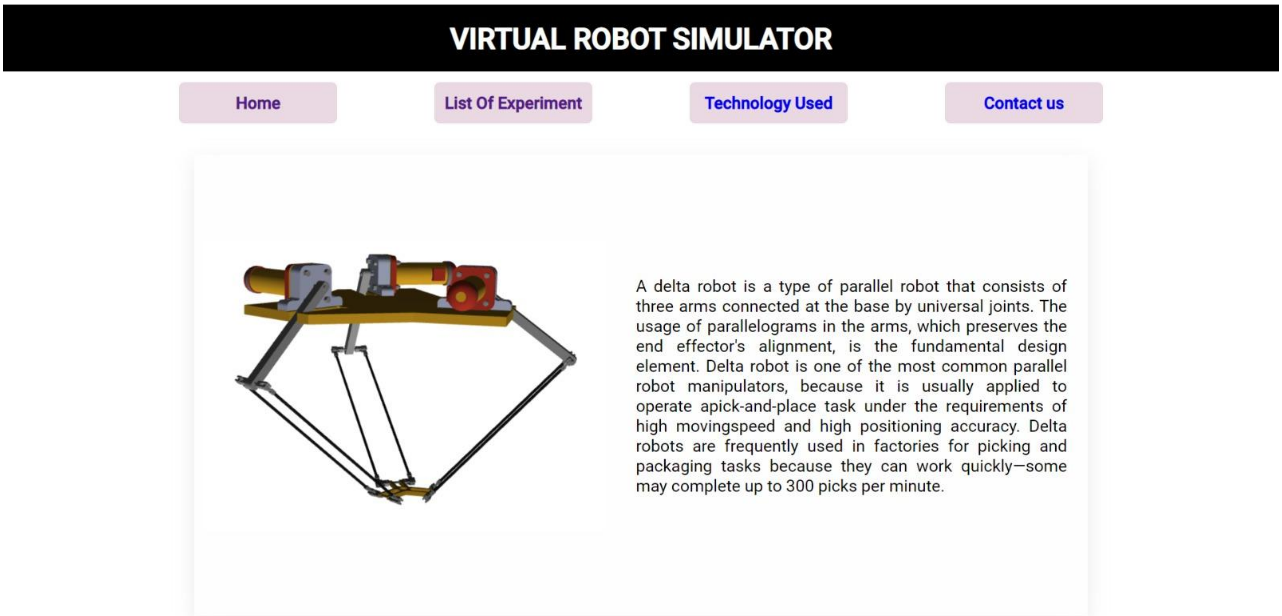


fig: Web view of Virtual Robot Simulator

Technology used contains the list of all the technologies used for creating this project.

fig: Web Page containingTechnology used

List of experiments contains the list of robots that can be visualized or experimented.

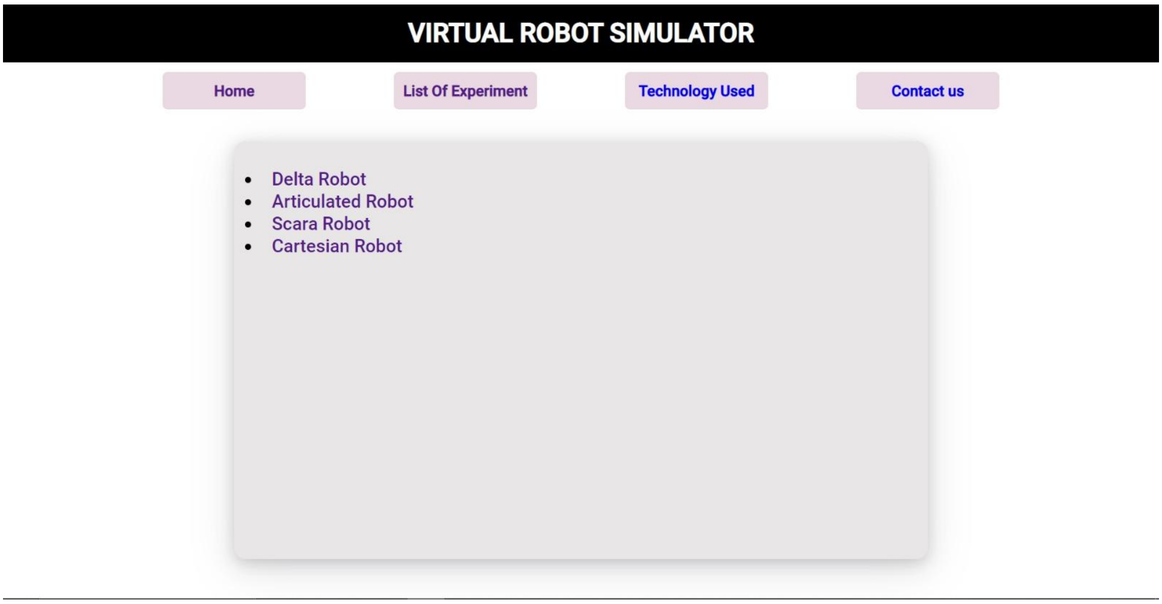


fig: Web Page containing list of experiments

After clicking on Delta Robot we land on this page. By default the theory of selected robots is shown. it contains various other tabs.

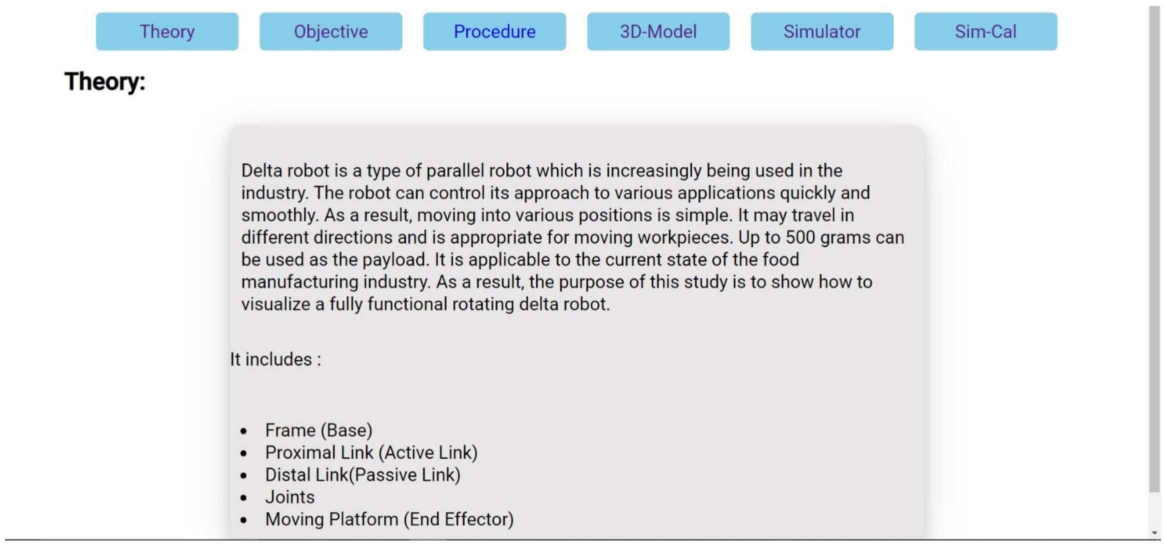


fig: Web page containing theory of experiment

The objective tab shows the main objective of this project.

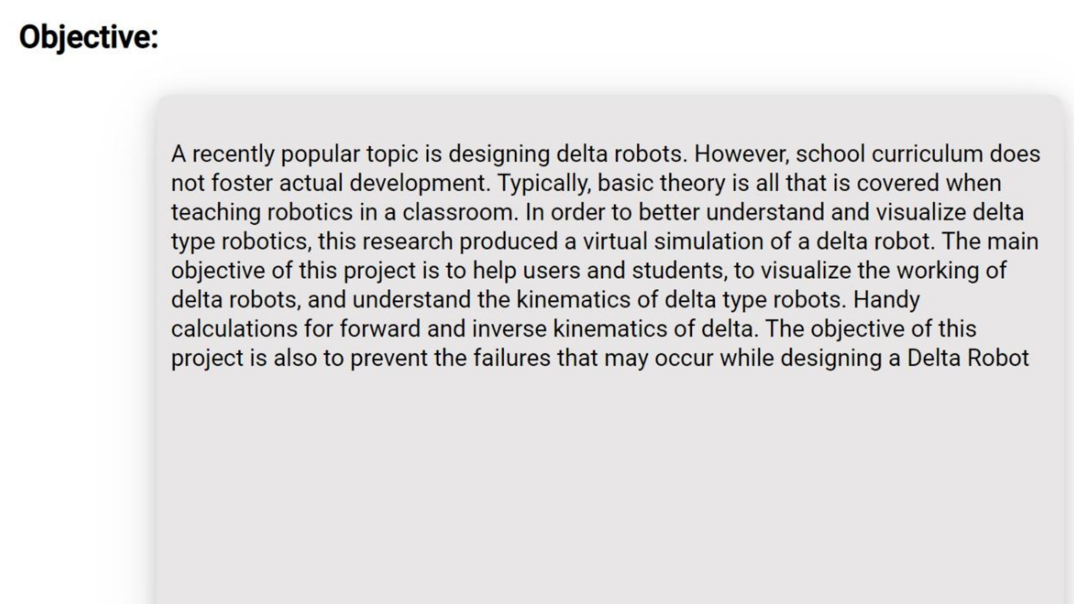


fig: Web page containing objective of the experiment

On clicking the simulation tab we can visualize robots in 3D.

fig: Web view of simulation of Delta Robot

On the left side of the page we can see all the components that are assembled to create the robot.

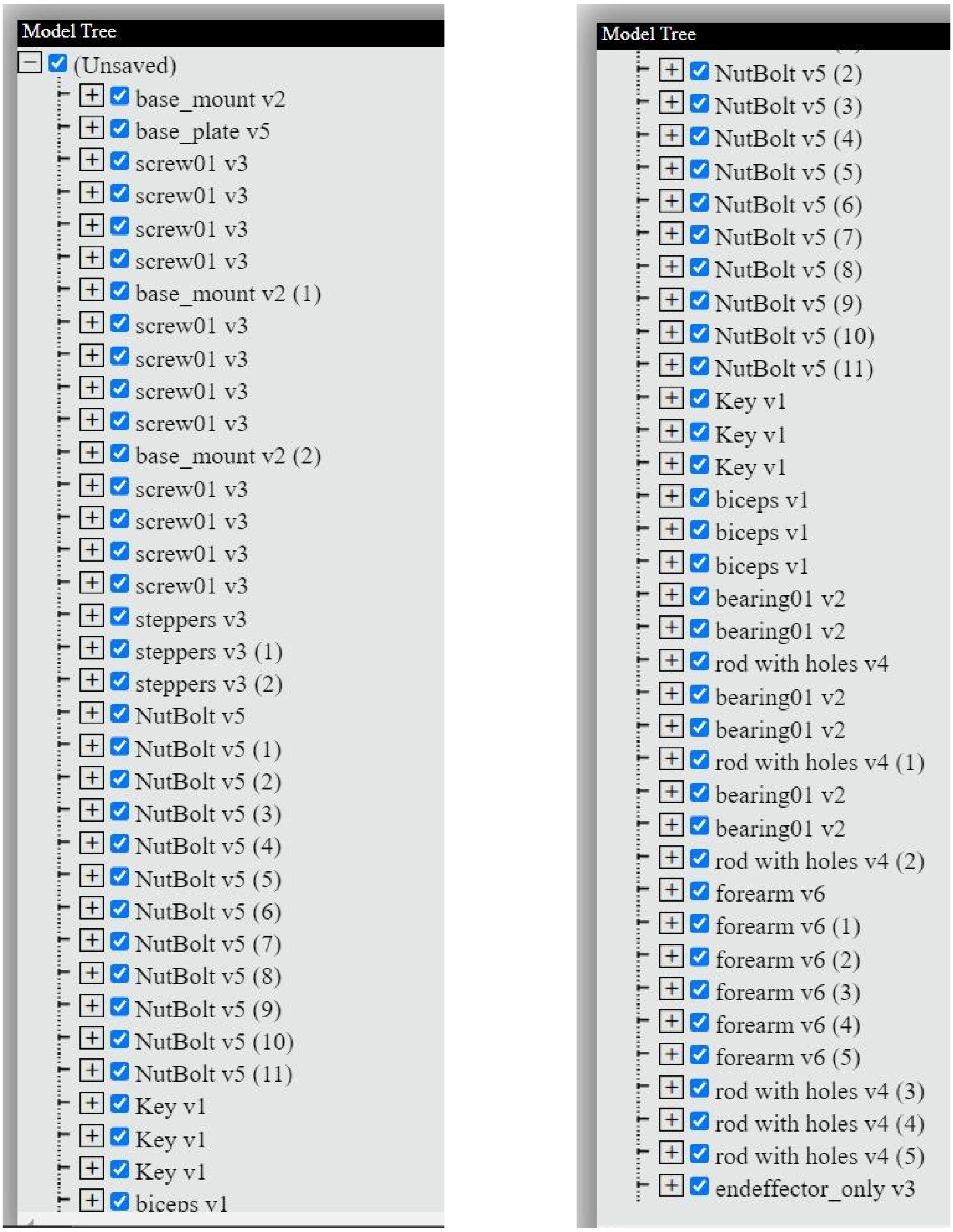


fig: Components used in assembly of delta robot

On the right top we can see the navigation control of the robot.

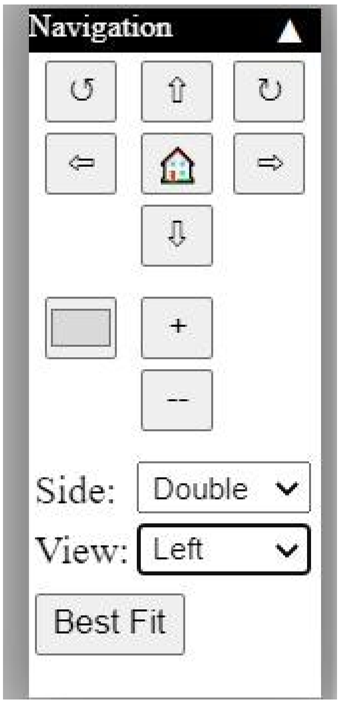


fig: Navigation control in web page

In the center we can see the 3D model of the robot.

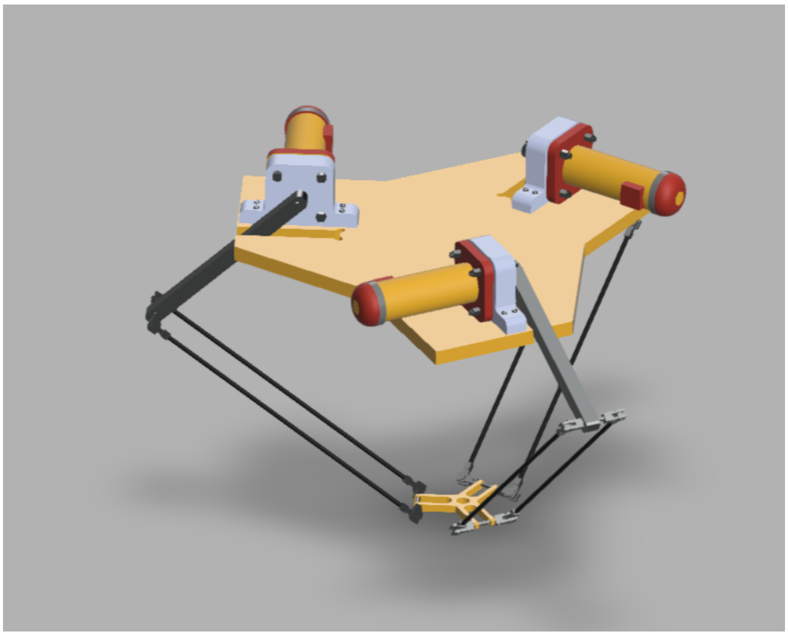
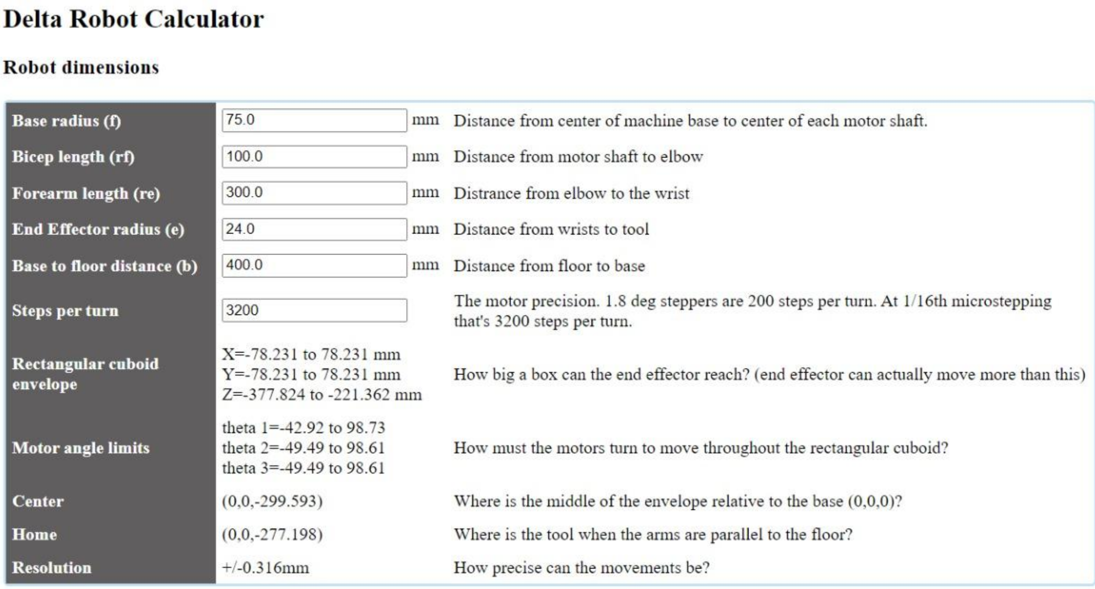


fig: 3D view of Delta Robot in web page

These are all the things available in the simulation page. In the Sim-call tab we can see the various calculating options. This page contains two sections. The above section contains the calculation about the robot dimensions.



Delta Robot Calculator

Robot dimensions

Base radius (f)	75.0	mm	Distance from center of machine base to center of each motor shaft.
Bicep length (rf)	100.0	mm	Distance from motor shaft to elbow
Forearm length (re)	300.0	mm	Distrance from elbow to the wrist
End Effector radius (e)	24.0	mm	Distance from wrists to tool
Base to floor distance (b)	400.0	mm	Distance from floor to base
Steps per turn	3200		The motor precision. 1.8 deg steppers are 200 steps per turn. At 1/16th microstepping that's 3200 steps per turn.
Rectangular cuboid envelope	X=-78.231 to 78.231 mm Y=-78.231 to 78.231 mm Z=-377.824 to -221.362 mm		How big a box can the end effector reach? (end effector can actually move more than this)
Motor angle limits	theta 1=-42.92 to 98.73 theta 2=-49.49 to 98.61 theta 3=-49.49 to 98.61		How must the motors turn to move throughout the rectangular cuboid?
Center	(0,0,-299.593)		Where is the middle of the envelope relative to the base (0,0,0)?
Home	(0,0,-277.198)		Where is the tool when the arms are parallel to the floor?
Resolution	+/-0.316mm		How precise can the movements be?

fig: Robot Dimension Calculator

It contains all the robot dimension informations such as

- Base radius
- Biceps length
- Forearm length
- End effector radius
- Base to floor distance
- Steps per turn
- Rectangle cuboid envelope
- Motor angle limits
- Center
- Home
- Resolution

Another section contains the calculation of the kinematics.

- Forward Kinematics
- Reverse Kinematics

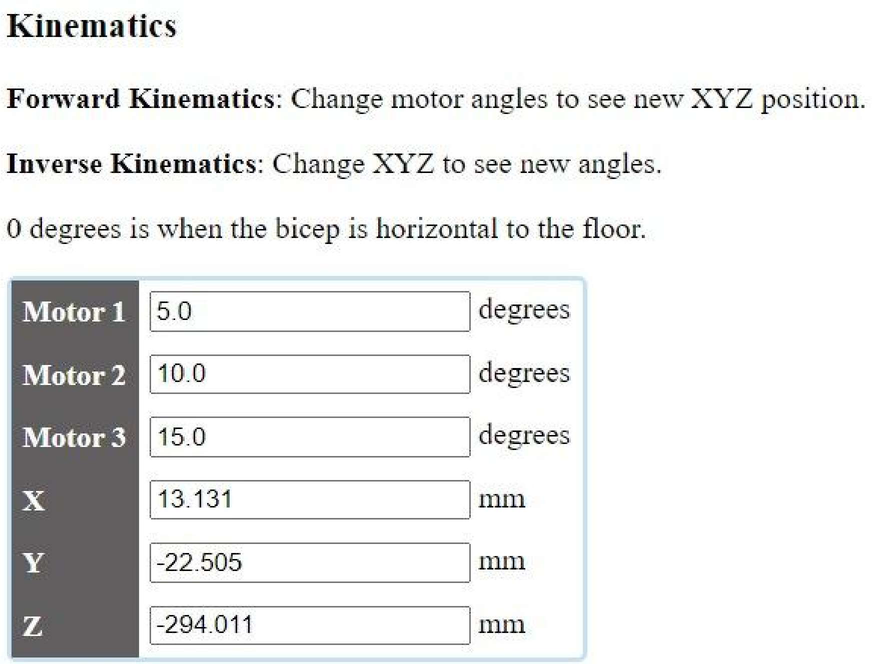


fig: Kinematics Calculator

Chapter 4

4. Hardware and Software Result and Discussion

4.1. Hardware

Although the project did not involve constructing a physical model of the delta robot, it is important to note the essential components required for building such a robot. To create a functional delta robot, key components such as a microcontroller, servo motors, and other necessary hardware are necessary. The microcontroller acts as the brain of the robot, enabling control and coordination of the robot's movements. Servo motors provide the mechanical power and precision required for the robot's joint movements. Additionally, other components like power supplies, sensors, and mechanical linkages are crucial for ensuring the robot's overall functionality. These components collectively form the foundation for building a physical delta robot that can perform intricate tasks with accuracy and agility.

- We suggest using aluminum or carbon fiber tubes for Links because they are light, rigid, and won't generate a lot of torque load or oscillate when stopped and started.
- We suggest using either servo or stepper motors with speed control that have strong torque and resolution. Due to their low resolution and inability to perform speed control, pre-designed closed loop PID conventional servo motors are not advised.

The components of the end effector in a delta robot can vary based on the specific application at hand. The end effector, which is responsible for interacting with objects or performing tasks, can be customized to meet the requirements of the task at hand. Factors such as the nature of the objects being handled, the desired manipulation or assembly tasks, and the operating environment play a role in determining the components of the end effector. These components may include grippers, suction cups, electromagnets, cameras, sensors, or specialized tools tailored to specific applications. Delta robots' flexibility allows for the adaptation of the end effector to suit diverse industries, making them highly versatile in various manufacturing and automation processes. Here are some examples:

- Pneumatic suction for picking and placing applications with light objects.
- For magnetic objects like metal boxes, tools, or nuts, use an electromagnet.
- Additional 3 degrees of freedom on the drill mechanism for CNC applications.
- Plastic Heater nozzle for 3D printers.

4.2. Software

Fusion 360, a versatile 3D modeling program, is utilized to design the delta robot's comprehensive 3D model. This software is widely known for its applications in manufacturing, engineering, and product design, serving both individual and business needs. By leveraging the capabilities of Fusion 360, designers can create and assemble all the necessary parts for the delta robot, including the biceps, forearm, links, joints, and screws. The software's user-friendly interface and powerful features enable precise visualization and refinement of the robot's structure, ensuring optimal performance. Whether for personal projects or industrial endeavors, Fusion 360 empowers users to transform their ideas into reality with accuracy and efficiency.

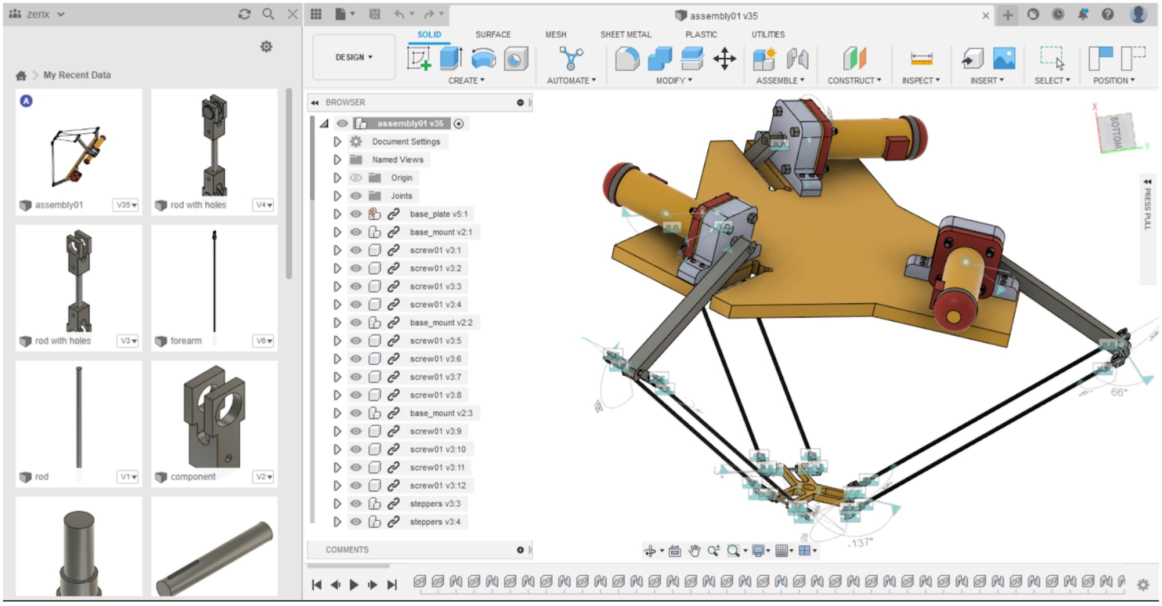


Fig: Delta Robot assembly in Fusion 360

Once the 3D design of the delta robot is completed in Fusion 360, it can be exported in formats like .stl, .obj, or .step. These formats are widely compatible and can be utilized in various applications, including websites that employ APIs like openGL, webGL, and three.js. These APIs provide powerful tools for rendering and displaying 3D graphics on the web. By exporting the design in the appropriate format, the delta robot's 3D model can be seamlessly integrated into these web environments, allowing users to interact with and explore the virtual representation of the robot. This integration enhances the visualization and understanding of the robot's kinematics, enabling educational and informative experiences for users on web platforms.

- OpenGL is a widely used API for rendering 2D and 3D graphics. It supports multiple programming languages and operating systems, offering versatile tools for creating visually appealing and interactive graphics. Its applications span various fields, such as gaming, CAD, and virtual reality. Developers can optimize graphics rendering using OpenGL's hardware capabilities, delivering seamless and immersive user experiences. The API's continued development ensures its ongoing significance in computer graphics and visual computing.
- WebGL, the standard for 3D web graphics, seamlessly integrates 2D and interactive 3D graphics. It is a cross-platform and cross-language API that enables real-time rendering of complex scenes. WebGL finds applications in gaming, virtual reality, architecture, and data visualization. As a web standard, it ensures compatibility across browsers without requiring plugins. With WebGL, users can experience dynamic and interactive 3D content directly in their web browsers. It revolutionizes web-based applications by delivering engaging visual experiences and expanding the possibilities of web graphics.
- Three.js is an open-source JavaScript library used to display 3D and 2D graphics in web browsers. It provides a powerful framework for rendering complex scenes, applying textures, lighting effects, and animations. With Three.js, developers can create immersive virtual environments, interactive data visualizations, and captivating web-based games. Its active community and continuous development make it a popular choice for delivering rich and visually engaging graphics experiences across different platforms and devices.

Chapter 5

5. ADVANTAGES AND FINDINGS

5.1. Advantages

Parallel kinematic structures are interesting because, compared to serial robots, they are more stiff and have higher positional accuracy. Although this kind of mechanism has several uses, robots and numerically controlled machine tools are the most common ones. Both academia and business are quite interested in the delta robot concept. This project aids in understanding the parts of the delta robot, how it functions, and its various uses.

Some of the advantages are listed below:

- It provides the visualization of the Delta robot.
- It helps in visualization of Delta workspace and movement.
- It helps in the calculation of forward and inverse kinematics.
- It can be used by students to conduct various experiments on the robot and its movements.
- It helps to provide the knowledge on the functionality of the Delta robot.

5.2. Findings

Numerous robot applications, including packing, pick, and place, are used in industrial automation. Humans are capable of performing jobs that demand good location and accuracy, but doing so takes expertise and experience. However, reducing the issue of error in the manufacturing line and improving yield rate performance are the essential goals. The development of robots, which took the place of people in faster pick-and-place products to solve these issues and shorten working hours, is a new learning media education. As a result, studying the Delta robot is a fascinating subject because it has a unique design, calculation work area, and working mechanism.Therefore, researchers want to develop experimental mediums for robots with intricate designs so they can operate more efficiently and be used in automated production lines. Students may be able to examine and test the robot using the training set prototype. By creating the mechanisms and controller, the project-based learning with the Delta Robot can be applied to coursework that has been covered. Students can examine the forward/inverse kinematic model during learning exercises. Students are able to do the experiment using real work and can observe the outcomes of changing the model's parameter. This body of literature focuses on the delta robot and is helpful for researchers and students that are interested in robotics.

CONCLUSION AND FUTURE WORKS

Due to their higher rigidity and higher positioning precision as compared to serial robots, parallel kinematic structures are intriguing. Although there are various applications for this type of mechanism, robots and numerically controlled machine tools account for the majority of them. The delta robot design has generated a lot of interest in academia as well as in industry.

A simple website was built with the necessary information to study about the delta robot. the website consists of introduction to the delta robot,its application , objective, components , etc. it also shows the 3d model of the robot

The robot's physical realization is what will need to be done in the future. The job will involve integrating the mechanical and electrical systems and creating an intuitive user interface for the end user once extensive material procurement is completed in order to materialize the robot in its physical form. The electrical components must be carefully picked and acquired, whereas the mechanical components are likely to be manufactured by the industry. Except for a few components, such as carbon fiber tubes for the arms, which will be purchased from other manufacturers, the majority of the mechanical parts will be manufactured within the industry itself. Servo motors, drives, and the control system needed to run them precisely and in sync are all included in the robot's electrical system.

The robot system needs to be tested in real-world settings when system integration is finished, and the system needs to be tweaked accordingly. A proper and user-friendly interface must be offered to the end user in addition to a functioning system. The user's hand holds a teach pendant or a small HMI that provides real-time information about the robot as the interface, or sometimes both.

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