Geometrical Shape Drawing Using 3-Axis Delta Robot with PLC and MAPP Technology

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Abstract

This project focuses on the design and implementation of a 3-Axis Delta Robot capable of drawing precise geometrical shapes using coordinated multi-axis motion. The system integrates B&R's Automation Studio, mapp Technology, and a Programmable Logic Controller (PLC) to deliver a reliable and flexible platform for real-time motion control and automated drawing operations. Geometrical shapes are executed based on prewritten CNC-style instruction files, interpreted and carried out via synchronized motion along the X, Y, and Z axes.The motion system is driven by stepper motor modules. A user-friendly Human-Machine Interface (HMI) powered by mapp View allows real-time visualization, program selection, and live monitoring. The robot supports both simulation mode (via ARsim and Scene Viewer) and real hardware deployment, enabling seamless transitions between testing and implementation. Its modular software design ensures code reusability and straightforward maintenance, while CNC and structured text programming allow for easy customization and extension.This project demonstrates a practical application of industrial automation in precision drawing systems, showcasing how intelligent mechatronics can replace manual repetitive tasks with speed, accuracy, and scalability.

Keywords: Delta Robot, PLC, mapp Technology, Automation Studio, Structured Text.

1. INTRODUCTION

Automation is an important part of modern industries because it helps perform repetitive tasks quickly, accurately, and with less human effort. Among various industrial robots, Delta robots are widely used for tasks like pick-and-place, sorting, and shape drawing due to their lightweight structure, high speed, and precise movements [1]. A 3-axis Delta robot is especially useful because it can move smoothly in three degrees of freedom, making it suitable for applications that demand quick and accurate positioning [2].In earlier setups, robots required separate dedicated controllers and control cabinets, which made the system costly, space-consuming, and more complex to manage [3]. In our project, we used the concept of machine-centric robotics, where one PLC controls the whole robot system. This makes it easier to connect all the motors, sensors, and actuators on the same industrial network, which improves timing, reduces wiring, and makes the robot respond faster [4]. We also used Mapp Technology and an HMI to make the robot easier to control. Mapp has ready-made blocks for things like moving the robot, setting alarms, and saving data. With B&R Automation Studio and Scene Viewer, we could test the robot's movements, change between manual and automatic modes, and even design shapes directly on the HMI screen. Our 3-Axis Delta Robot can draw different shapes using PLC and Mapp Technology. This makes it affordable, easy to use, and useful for both industry and learning purposes.

2. LITERATURE REVIEW

Delta robot are widely utilized in automation industry to perform sorting, packeging, pick and place, and path based operations. Delta robot are characterized by their speed and parallel structure. Compact PLC-based systems have replaced traditional robotic controllers, providing better integration and control. The delta robot has been studied with a consistent parallel-arm assembly. While the structure is mostly the same, the applications vary from pick and place to path-following tasks, such as geometrical shape drawing, which we demonstrated in our project.

PLCs have many uses in industry and are key components in various machines. One example is the drilling machine, where automation using PLC and HMI handled tasks like spindle control, depth management, and feed movement through ladder logic and structured programming [4]. Our project also uses PLC-based control, but it focuses on operating a 3-axis delta robot to draw geometric shapes. The automation methods and tools, such as PLC, HMI, and mapp technology, are similar to those in earlier research on delta robots, which offer speed and precision. One implementation involved a 3-axis delta robot controlled by a B&R PLC, using structured text, G-code, and M-code. The robot was programmed in Automation Studio 4.7 and simulated with Scene Viewer, allowing for motion testing without needing the actual hardware [1]. Another study expanded this to a 4-axis delta setup with user-controlled motion paths uploaded through the HMI. Integrating OPC UA with Scene Viewer allowed real-time motion verification. The robot could trace shapes like hexagons or letters, all managed from a single interface [2].In related automation, another study used mapp Robotics, HMI, and PLC for real-time pick-and-place control. Using structured text and modular programming provided flexibility and a scalable design [3]. Simulating movements before deployment improved safety and reduced errors. Our project builds on these foundations by developing a 3-axis delta robot for drawing 2D geometrical shapes like circles, triangles, and squares. We improved flexibility by allowing dynamic shape file loading through HMI, enabling the system to draw different shapes without reprogramming the PLC. This approach combines robotic precision with smart automation tools, offering a versatile and user-friendly solution for educational and industrial demonstrations.

3. SYSTEM AND DESIGN

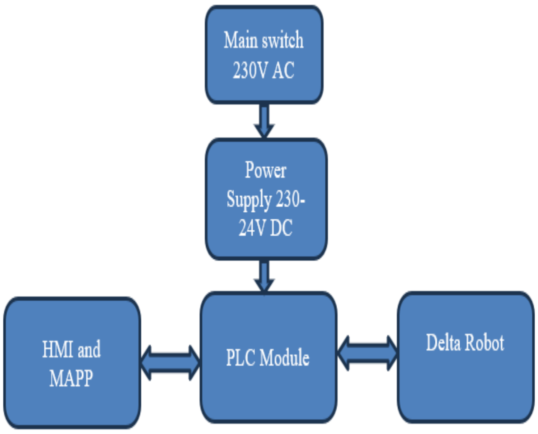

Fig.2.1 Block Diagram of Delta Robot

4. METHODOLOGY

In this project, we made a 3-Axis Delta Robot that can draw 2D shapes neatly and easily. The brain of the robot is a controller called as B&R X20CP0484 PLC. The robot moves with the help of stepper motors (80MPD1.300S000-01), which are controlled by X20SM1436 motion modules. These parts help the robot move smoothly and accurately. It uses a safe and steady power supply of 230V AC to 24V DC (X20PS9600) to run the system without any risk. All parts of the system talk to each other using real-time Ethernet, which sends data very fast. We used software named as Automation Studio V4.12 to build the system. The robot's movements are controlled using mappMotion, and the screen that shows information is made using mappView, which works in a browser like Google Chrome. The programs for drawing are written in a coding language that is Structured Text, and the paths to draw shapes are saved in CNC files . This makes it easy to change shapes without changing the whole program. The robot works in three steps: first (_INIT), it sets up and selects the program; second (_CYCLIC), it starts drawing and gives updates; and third (_EXIT), it shuts down safely. Users can control the robot through a simple screen where they can choose different modes like automatic, manual, jogging (small moves), or teach-in (teaching positions). The screen also shows live updates and any problems. Before running the real robot, we test everything on the computer using ARsim and SceneViewer. This lets us see how the robot will move in 3D, helping us fix mistakes before using the real hardware**.**

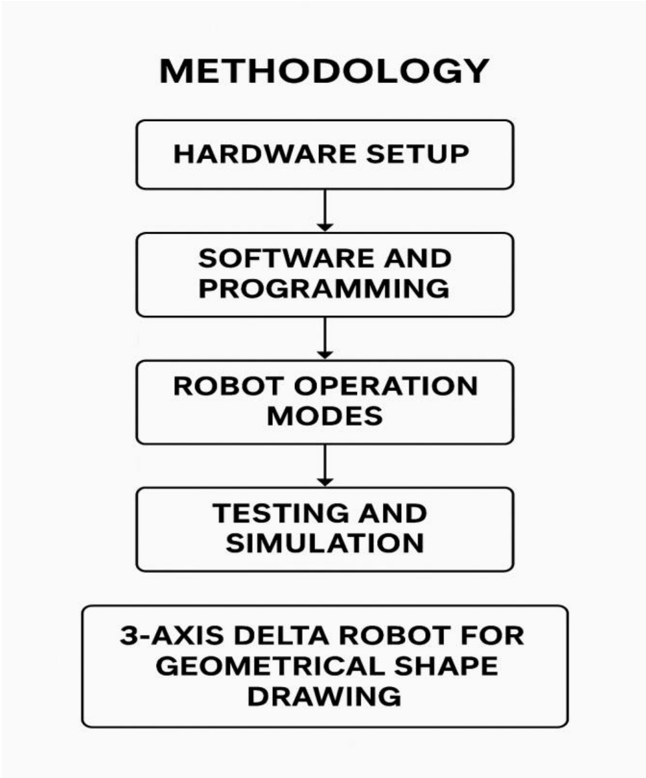

Fig.3.1

5. IMPLEMENTATION

5.1 Hardware Description

The hardware configuration of this project is designed to ensure modularity, precision, and real-time performance. All core components are sourced from B&R Automation, forming a compact yet scalable control system for the Delta.

- Central controller:
  The system is managed by the B&R X20CP0484-1 PLC, a high-performance unit supporting real-time execution, multi-tasking, and synchronization between motion control, program logic, and HMI communication.

Fig.5.1.1

- Stepper Motors:
  Three 80MPD1.300S000-01 stepper motors are used to drive the Delta robot's parallel linkage arms. These motors ensure accurate positioning required for geometrical drawing.

Fig.5.1.2

- Motion Control Drives:
  Each motor is powered and controlled by a X20SM1436 drive module, which enables precise closed-loop control and synchronized multi-axis motion.

Fig.5.1.3

- Power Supply:
  The system is powered by a X20PS9600 power supply, converting 230V AC input to regulated 24V DC output, compliant with industrial safety norms.

Fig.5.1.4

- Communication Network:
  POWERLINK real-time Ethernet ensures fast and synchronized communication between PLC, drives, and HMI components.

Fig.5.1.5

- Mechanical Workspace:
  The Delta robot features a parallel kinematic structure with three rotational axes (Axis 1, 2, and 3) arranged at 120° intervals. The top view shows the X-Y plane of motion, while the side view highlights the Z-axis movement achieved by coordinated arm rotation.Each arm is powered by a stepper motor and linked to the end-effector through lightweight passive rods, enabling smooth and precise 3D positioning.This setup provides **fast**, **accurate**, and **repeatable** movement, with workspace calibration and motion limits configured via **Automation Studio**.

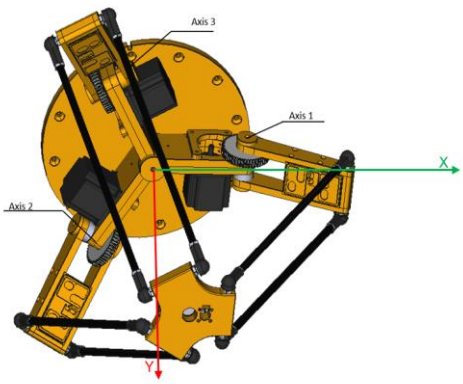

Fig.5.1.6

5.2 Software Description

1.Init Robot Main Program in ST
Launch Automation Studio.

- Open the project located at C:\projects\PlotbotDelta_V2011\....
- Navigate to Main.st under InitRobot folder.
- This ST code initializes motion blocks and parameters such as acceleration, deceleration, override, and program directory**.**

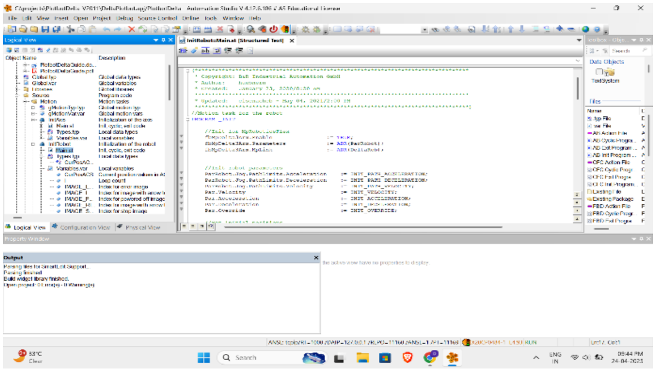

Fig.5.2.1

2.Transfer to Target

- Click the Transfer button on the top toolbar (or Project > Transfer).
- Make sure the target controller is connected (check that Configuration ID and AR Version match).
- Confirm options:
  - ✅ Copy files to USER partition
  - ✅ Overwrite existing files
- Click Transfer.
- Wait until the progress bar reaches 100%.

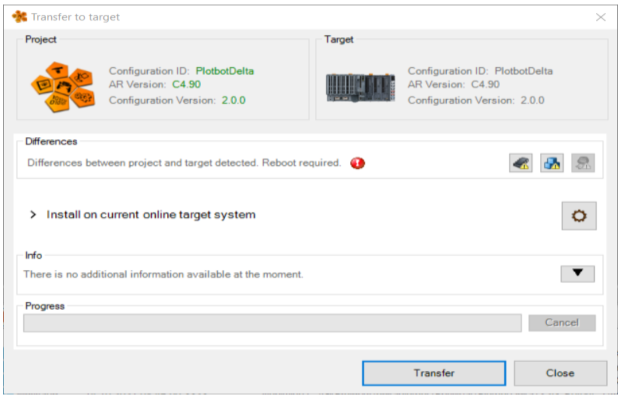

Fig.5.2.2

3. Web Interface (HMI)

- Open Google Chrome.
- Go to:

For simulation: http://127.0.0.1:81/index.html?visuId=VisDelta
For hardware: http://192.168.0.1:81/index.html?visuId=isDelta

- Use login credentials:
- Username: Admin, Password: admin
- Use control buttons:
  - 🔌 Power – turns on robot
  - 🏠 Home – runs homing cycle (move to reference position)
  - ▶ Start – executes program

⬣ Stop – stops execution

In the Manual Mode screen :

- Input X, Y, Z values
- Click “Move direct” to test motion
- Adjust speed/acceleration at the bottom right

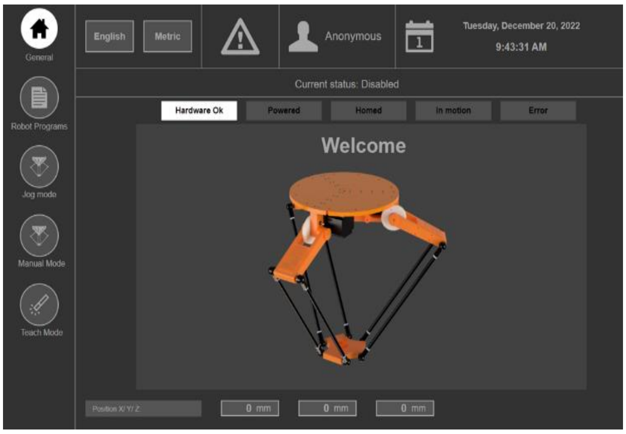

Fig.5.2.3

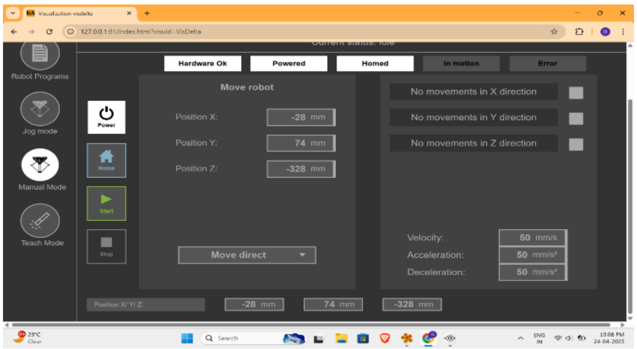

Fig.5.2.4

4.SceneViewer

- Launch SceneViewer .
- Open the simulation file: PlotbotDelta.scn.
- Go to Online > OPC UA > Connect.
- If discovery fails:

  Ensure the project is running in Automation Studio (green RUN at bottom bar).

  Try restarting the controller or SceneViewer.
- If successful:

  You’ll see the live position of the Delta robot in 3D.

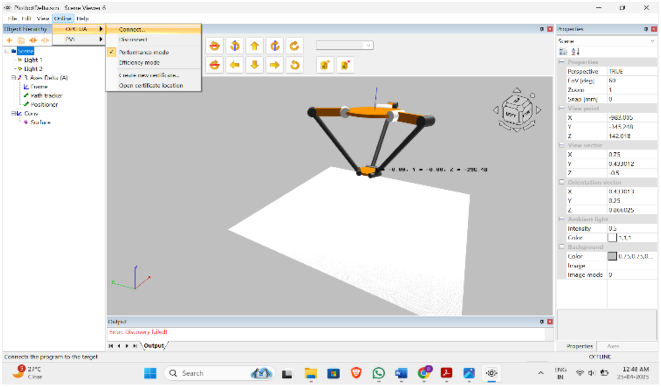

Fig.5.2.5

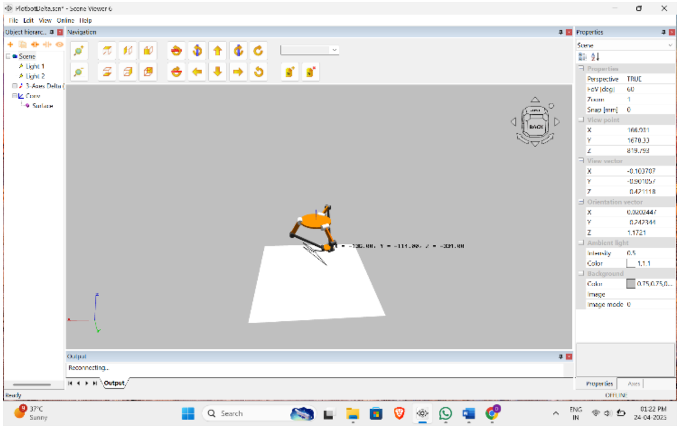

Fig.5.2.6

6. RESULTS

The project shows how to set up a 3-Axis Delta Robot using B&R Automation Studio 4.12. It draws 2D geometric shapes accurately and repeatedly by interpreting G-code (.cnc) and Structured Text (.st) files. The robot's motion control, powered by mappMotion and inverse kinematics, ran custom path instructions smoothly. An easy-to-use web-based HMI built with mappView allowed users to control the robot in different modes, including Automatic, Manual, Jog, and Teach. Users could execute programs and monitor real-time feedback. Simulation through Scene Viewer helped create a digital twin, ensuring safe and accurate testing before deployment. The modular design relies on B&R's X20 components and structured software, which supports future growth. The system worked well in both simulation environments, ARsim and Scene Viewer, and in real hardware, making it practical for education and industrial use.

7. ADVANTAGES

- **Precision**: Sub-millimeter accuracy for intricate designs.
- **Flexibility**: Quick program swaps via ST files.
- **Cost-Effective**
- **User Friendly HMI**: The browser-based mappView interface allows easy mode selection, parameter adjustment, and real-time monitoring. No coding is required.

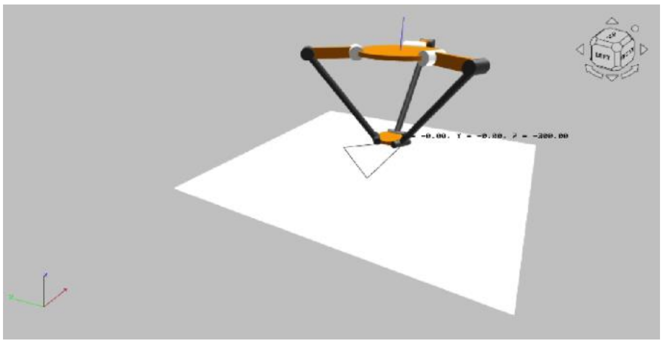

Fig.6.1

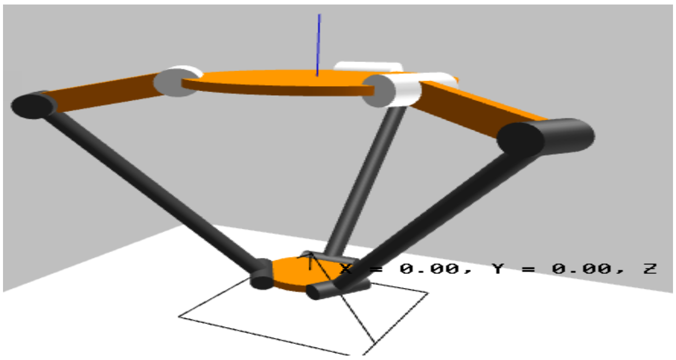

Fig.6.2

- **Modular Design**: Based on B&R's X20 modules, the system is flexible and can be easily expanded with additional sensors or actuators.

8. APPLICATIONS

 Educational Use:

- It is a great tool for engineering students and researchers to learn about robotics, PLC programming, and industrial automation.
- Can be used for demonstrating kinematics and motion control in labs.

 Manufacturing and Production:

- Useful for pick and place, sorting, and light packaging operations, especially for small or delicate items where speed and accuracy matter.
- Can be used for drawing custom paths or simple patterns for small scale manufacturing and product personalization.

Packaging and Labelling:

- Modified to draw logos, batch codes, or simple designs directly on packaging materials.

Industrial Prototyping:

- Allows for rapid development of shape drawing prototypes for product design and custom manufacturing.
- Can be used to draw outlines or engravings before moving to larger-scale production.

9. CONCLUSION

Our project focused on creating a 3 axis Delta Robot that could draw 2D shapes accurately. We aimed for it to be low cost, reliable, and a great educational tool. We used a B&R PLC as the main controller of the robot, which was essential for its operation. Stepper motors provided the power, and we used mappMotion technology to manage the precise movements. This setup made the robot easy to control and surprisingly versatile. We also included an HMI (Human Machine Interface), making the system simple to operate for anyone, no matter their technical background.

A crucial part in our process was testing the robot's motion before construction. We used simulation tools like ARsim and SceneViewer to run virtual tests. This changed everything. It allowed us to identify and fix potential errors in our code and design without needing to build and rebuild the physical robot. This saved a lot of time and resources and ensured that the final implementation was safe and effective.

At the end after so many efforts and learnings, we created a robotic system that is useful for tasks like automation and research and serves as a reliable demonstration platform.

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