3 DOF CARTESIAN ROBOT OF PAINTING APPLICATION USING MACHINE LEARNING

A SENIOR DESIGN PROJECT REPORT

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in the completion of Senior Design Project

Under the Guidance of:

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IN

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DEPARTMENT OF AUTOMATION AND ROBOTICS

Certified that the project work entitled

3 DOF CARTESIAN ROBOT FOR PAINTING APPLICATION USING THE CONCEPT OF MACHINE LEARNING

Is a bonafide work carried out by

Sohail Ahmed Nandihalli, Mohammed Saqib Noor Baig, Musaib Mujawar and Sharan S mattimani in partial fulfillment for the award of degree of Bachelor Engineering in AUTOMATION AND ROBOTICS of the KLE Technological University, Hubballi during the year 2023-24. It is certified that all corrections/suggestion indicated for internal assignment have been incorporated in the report deposited in the departmental library. The project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the Bachelor of Engineering Degree.

Signature of the guide — Signature of the HOD

Amit Talli — Arun C Giryapur

Name of the Examiners

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ACKNOWLEDGEMENT

We have put our sincere efforts in this project. However, it would not have been possible without the kind support and help of many individuals. We would like to extend our sincere thanks to all of them.

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ABSTRACT

The purpose of doing this project is to detect the shapes of an object and to paint according to their coordinates. The robot's design incorporates three degrees of freedom in the X, Y, and Z axes, enabling it to navigate and position itself in a three-dimensional workspace with unparalleled accuracy. It is equipped with a specialized painting tool or nozzle that can precisely dispense paint or coatings, making it ideal for tasks that demand meticulous surface coverage and finish quality. The robot's primary function is to automate the painting process, allowing for accurate and consistent application of paint.

A 3 Degree of Freedom (DOF) Cartesian Robot is a type of robotic manipulator with three linear axes of motion in the X, Y, and Z directions. The robot is capable of moving a payload or end-effector along these three axes in a coordinated manner, allowing it to perform various tasks such as pick-and-place operations, assembly, and welding. The design and control of 3 DOF Cartesian Robots require careful consideration of factors such as payload capacity, workspace, speed, and accuracy. Different types of actuators, sensors, and control systems can be used to achieve the desired performance and functionality.

The robot's mechanical structure, including its frame and actuation systems, is meticulously designed to ensure stability, repeatability, and a high payload capacity suitable for accommodating various painting tools and accessories. The control system incorporates advanced algorithms to optimize trajectory planning, speed control, and synchronization of movements, thereby ensuring precise and smooth operation during the painting process. And discusses the integration of safety features to mitigate potential hazards and enhance the overall reliability of the robotic system. The end-effector, specifically designed for painting applications, is seamlessly integrated, allowing for quick tool changes and adaptability to different painting tasks.

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CHAPTER 1

INTRODUCTION

A 3 Degree of Freedom (DOF) Cartesian Robot is a type of robotic system that operates within a three-dimensional Cartesian coordinate system. It is a type of industrial robot that is commonly used in manufacturing and assembly processes, as well as in laboratory and research environments. A Cartesian robot consists of a linear slide assembly that moves along the x, y, and z-axis, which provides the robot with three degrees of freedom. These degrees of freedom allow the robot to move in any direction within its workspace and to perform a wide range of tasks, such as pick-and-place operations, material handling, and precision positioning.

The robot's movements are controlled by a computer system that receives input from various sensors and can be programmed to perform specific tasks. The robot can also be equipped with various end-effectors, such as grippers, suction cups, or specialized tools, to enable it to perform specific tasks. The 3 DOF Cartesian robot is a versatile and flexible machine that can be adapted to a variety of applications. Its accuracy and repeatability make it ideal for tasks that require precise positioning and movement. The robot's movements are controlled by a computer system that receives input from various sensors and can be programmed to perform specific tasks. The robot can also be equipped with various end-effectors, such as grippers, suction cups, or specialized tools, to enable it to perform specific tasks. The 3 DOF Cartesian robot is a versatile and flexible machine that can be adapted to a variety of applications. Its accuracy and repeatability make it ideal for tasks that require precise positioning and movement.

It details the mechanical design, actuation systems, and control architecture of the robotic system, highlighting key features that contribute to its suitability for precision painting tasks. Additionally, safety considerations and the seamless integration of a purpose-built end-effector underscore the comprehensive approach taken in the development of this robotic platform. The design allows for intricate movements and positioning, crucial for achieving consistent and high-quality paint finishes on diverse surfaces. The integration of advanced control algorithms ensures not only the accuracy of the robot's movements but also the synchronization required for smooth and efficient painting processes

CHAPTER 2

PROBLEM STATEMENT

'Design a 3 DOF Cartesian Robot to Paint a Tile Automatically and should align the coordinate according to dimensions of the material' , this is the given problem statement

2.1 Motivation

The development of a 3-DOF (Degree of Freedom) Cartesian robot stems from the increasing demand for versatile and precise robotic systems in various industries. The motivation behind this research is grounded in addressing specific challenges and requirements that necessitate the design and implementation of a robot with three degrees of freedom in a Cartesian coordinate system.

2.2 Goals and Objectives

1. Automated Precision Painting

2. Versatile Coverage in Three Dimensions

3. Increased Efficiency in Painting Processes

4. Reduction of Human Exposure to Hazardous Environments

5. Customizable and Programmable

6. Cost-Effective Solution for Small to Medium-Scale Operations

7. Environmentally Friendly Painting Practices

8. Continuous Improvement and Adaptability

CHAPTER 3

LITERATURE SURVEY

A market study of 3 degree-of-freedom (DOF) Cartesian robots would typically involve research on the current state of the market, trends, opportunities, and challenges. Here are some key points that might be included in such a study:

1. Introduction to Automatic Tile Painting Systems:

Explore the fundamentals of automated painting processes and their applications in the ceramic tile industry[1]

2. Robotic Systems in Industrial Painting:

Investigate the role of robotic arms and spray nozzles in automating the tile painting process

3. Sensors and Precision in Tile Positioning:

Examine the use of sensors for accurate tile positioning during the painting process.

4. Programming and Control Units:

Review the role of control units in programming and coordinating the automated tile painting system.

5. Quality Control and Defect Detection:

Investigate methods and technologies for ensuring the quality of painted tiles through automated inspection.

6. Recent Advances and Future Trends:

Explore the latest innovations in automatic tile painting systems and potential future developments.

3.2 Relevant technologies-Techniques and sensor technology used

1. Robotic Arm Design:

- Technique: Kinematic Modeling and Inverse Kinematics

- Technology: CAD/CAM for designing the robotic arm structure and simulation software for kinematic analysis. Inverse Kinematics algorithms are employed to calculate joint angles based on

2. Actuation System:

- Technique: Electric Servo Motors

- Technology: High-torque electric servo motors are employed for precise control of each joint. These motors provide the necessary power and accuracy required for controlled movement.

3. Path Planning and Trajectory Generation:

- Technique: Computational Geometry Algorithms

- Technology: Algorithms such as Rapidly-exploring Random Trees (RRT) are utilized for path planning. Trajectory generation algorithms help optimize the robot's movement path for efficient paint coverage.

4. End-Effector Design:

- Technique: Tool and Nozzle Configuration

- Technology: Custom-designed paint nozzles and tools for uniform paint distribution. Adaptive end-effectors that can adjust to different surfaces and shapes for optimal painting.

5. Vision Systems:

- Technique: Computer Vision

- Technology: Cameras and image processing techniques are used for object recognition, surface analysis, and quality inspection. This assists the robot in identifying workpieces and adapting its painting strategy based on surface characteristics.

CHAPTER 4

Certainly! Requirement modeling and analysis for a 3-DOF Cartesian robot in a painting application involve identifying and defining the specifications and characteristics necessary for successful implementation. Here's a breakdown of the process:

TABLE 1. REQUIREMENTS MODELLING AND ANALYSIS

SI NO	SOURCE	REQUIREMENTS	DEMAND/WISH	CATEGORY
1	Survey	The robot should be sturdy.	Demand	Material
2	Team	It should have high rpm motors	Wish	Energy
3	Client	It should sustain in all critical conditions.	Demand	Weather
4	Team	The robot should be of low-density material	Demand	Material
5	Survey	Design should be compact	Demand	Geometry
6	Survey	The material used should be water resistant	Demand	Quality
7	Client	The overall cost must be minimum.	Demand	Cost
8	Team	The robot must be easy to operate.	Demand	Operation
9	Survey	The end effector of robot should paint smoothly	Wish	Ergonomics
10	Team	The robot must have less weight.	Demand	
11	Client	The robot should make less noise	Demand	Signal
12	Client	It should be power efficient	Demand	Energy
13	Client	Cycle time should be minimum	Wish	Operation
14	Survey	Should be precise at its work	Demand	Ergonomics
15	Team	The paint should be mixed with water in appropriate proportion	Demand	Energy
16	Survey	Should be easy to maintain	Demand	Maintenance
17	Client	The end effector should not cross its	Demand	Ergonomics

		predefined workspace		
18	Team	The overall measurement of the robot must be 12 by 12 inch of structural architectures with a minimum tolerance	Wish	Geometry
19	Team	The controllable pressurize end effector to handle the operation	Demand	Operation
20	Team	The end effector of the cartesian robot should travel with a speed of 2 inches/second	Wish	Transport
21	Client	The robot must have a extra working controllers like pneumatic and hydraulic for moving its arm	Demand	Operation
22	Team	Material waste should be minimal compared to manual work	Wish	
23	Team	The cartesian robot should have a minimum working area of 50x50 (in cm)	Demand	Geometry
24	Team	It should have a ground clearance of minimum 3 inches	Demand	Geometry
25	Survey	The painting surface should be flat, smooth, precleaned without any obstructions	Demand	Geometry
26	Client	The painting fluid should be prefilled in an overhead container	Wish	Storage
27	Client	Maintenance and cleaning of painting mechanism should not be autonomous	Demand	Operation
28	Team	The painting cycle and motion are instructed by user through the interface	Demand	Kinematics
29	Team	The interface used in this mechanism is a mobile application	Wish	Operation
30	Survey	The prismatic joints should deliver linear motion along the respective axis	Demand	Kinematics

31	Client	The robot should be normally employed in material handling	Wish	Operation
32	Survey	The robot should be normally employed in computer numeric control	Demand	Operation
33	Survey	The robot must have machine load and unload property	Demand	Storage
34	Team	The robot must paint all axis accurately	Demand	Geometry
35	Client	The robot must be consistent in paint flow and quality	Demand	Quality
36	Client	The material should be rust resistant	Wish	Quality
37	Survey	The Robot should have low risk factor	Demand	Safety
38	Team	The robot should be eco friendly	Demand	Safety
39	Team	Emergency over ride must be provided	Demand	Safety
40	Client	The robot should be aesthetically pleasant	Wish	Geometry

4.3 Brainstorming

Analyzed all the initial needs and requirements. Our team carried out various meeting and carried brainstorming process with respect to exact application and dimensional specification of prototype to paint an object.

4.3.1 Outcomes of brainstorming:

- Application of the robot: Small scale industries
- Component required:
  1.Basic components:
  2.Intelligence: Machine learning, deep learning, efficient controller
  3.To drive mechanism: Raspberry pi, servo motor, motor drivers, pulley, power source

TABLE 2. SPECIFICATIONS

SI NO	SPECIFICATION	DIMENSION/VALUE
1.	Height	8 inch
2.	Length	20 inch
3.	Breadth	20 inch
4.	Weight	6 kg

CHAPTER 5

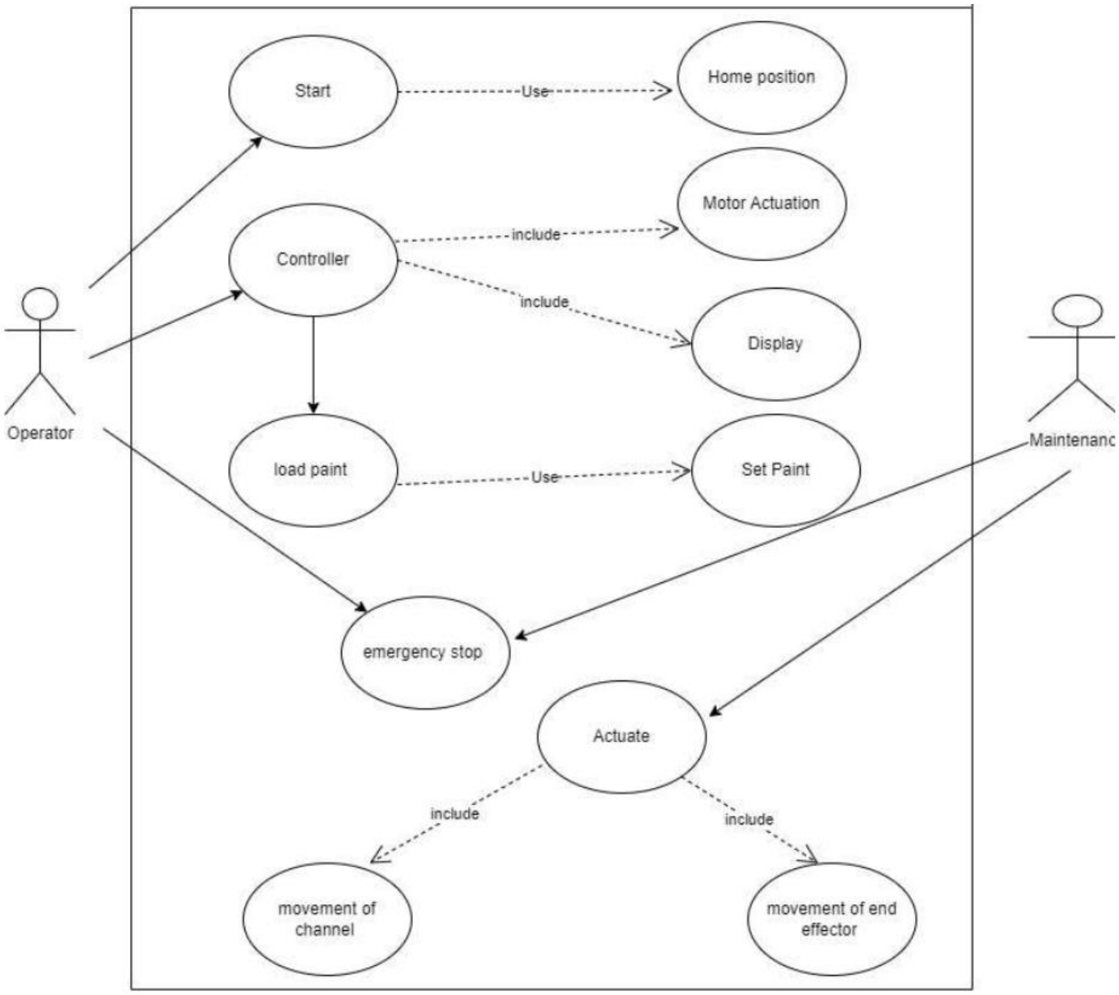


Figure 1 Architecture layout

A architecture layout involves a loading area of tile, a paint space for painting mechanism. The system architecture integrates these components to ensure efficient and accurate tile painting mechanism. It is interaction between the operator and the system.

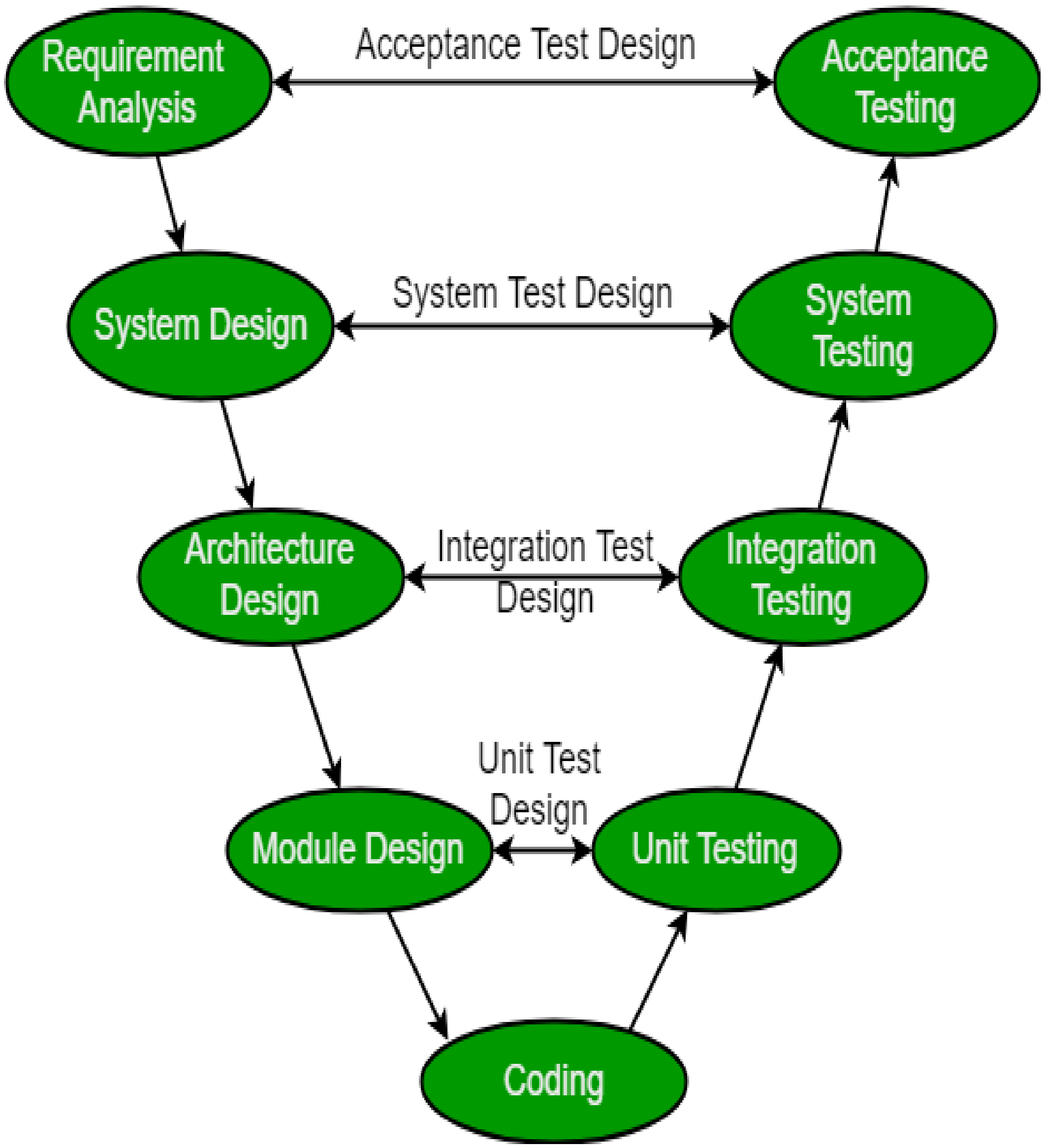


Figure 2 Architecture Model

Architecture Model involves combination of both Hardware and Software components which includes certain steps as follows Requirement Analysis, System design, Architecture design, Module design, Coding, Unit testing, Integrating and Testing the components, System testing and Acceptance testing.

CHAPTER 6

METHODOLOGY

The methodology of a 3 DOF Cartesian robot depends on its design and configuration.

1.Power on the robot and initialize its control system

2.Set the robot's home position, which is the position where it starts and ends its movements.

3.Define the coordinates for the robot's movement. This can be done either manually by inputting the coordinates into the control system or through programming.

4.Use the control system to move the robot along the desired path. This can be done by controlling the robot's movement along each of the three axes.

5.Once the robot has completed its movement, return it to the home position.

6.Turn off the robot and its control system

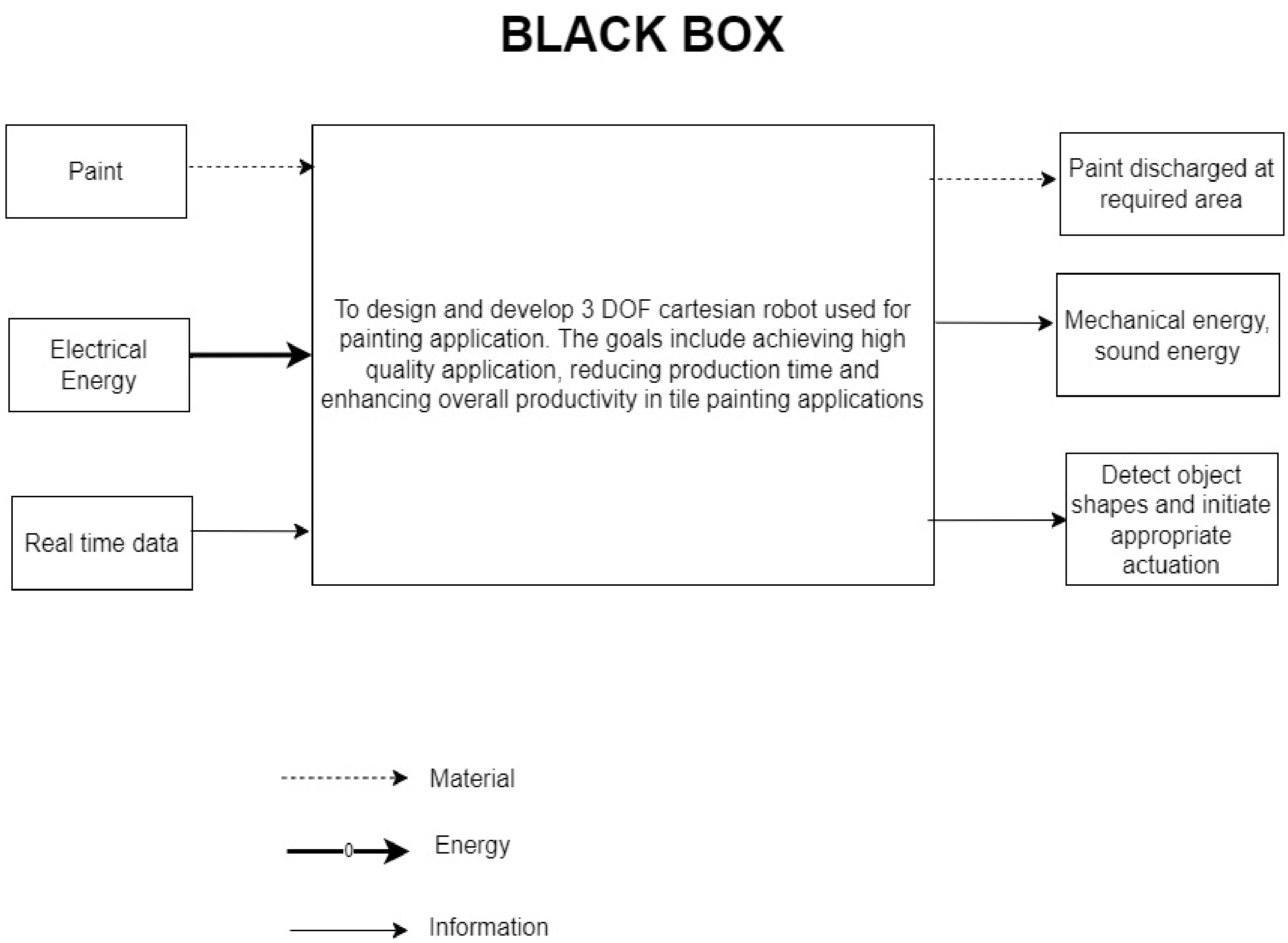


FIGURE 3. BLACK BOX

The black box of an Automatic Tile Painting System refers to its internal processes and mechanism that are not visible to the user. In this context, it represents the system's functionalities without delving into detailed technical aspects. It encapsulates the system's internal workings, focusing on the user's interaction and overall outcome rather than the intricate details of each component.

Needs and Capabilities

Needs:

ON 2_1: The system should be able to paint the sheet with a maximum dimension of 30*20 cm , and minimum dimension of 12*6 cm and a maximum weight of 5kg.
ON 2_2: The painting robot needs to be programmed to apply the paint in correct pattern and thickness and move in proper direction.
ON 2_3: The surface preparation is essential to ensure that the paint adheres properly and provides a durable finish.
ON 2_4: Selecting the type of paint for job must be appropriate for surface to be painted.
ON 2_5: Painting process must be carefully planned and executed to ensure consistent and smooth finish.
ON 2_6: Safety of painting can involve exposure to hazardous chemicals and fumes, so proper safety precautions must be taken to protect it.
ON 2_7: Proper cleanup and disposal of paint, which involves properly storing and disposal of paint.

TABLE 2 . Capabilities

Capability	Description
C1 Perform the mission autonomously	The robot should be able to process the painting function autonomously
C1.1. Programming	The robot is first programmed with instructions for the painting task.
C2. Paint storage	The robot should be able to store the paint in a container
C2.1. Paint supply	The paint is supplied to the robot's arms through a system of tubes and valves
C2.2. spraying the paint	The paint is supplied to the end effector from the spray can and spraying mechanism is carried out
C3. Movement	The robot's arms move along a pre-programmed path, following the instructions in the programming
C3.1. Movement of channel	The movement of channel is initiated from home position to the desired location
C3.2. Movement of end effector	Movement of end effector is controlled by motors and gears

C4. Coating	The robot's arms apply the paint to the object being painted, following the pre-programmed path. The amount of paint applied is controlled by the speed and movement of the robot's arms.
C4.1. Return	After the painting task is completed the robot must return to its home position
C5. Security	The working space of the robot should be covered with the protective shield so that the paint should not splash out
C6. Cleanup	Finally, the robot can be programmed to clean itself and the painting equipment after the task is completed. This may involve flushing out the paint supply system

TABLE 3 Operational Scenario

S1	System con-figuration and calibration	The operator installs the robot arm and the object in the frames, and moves the robot arm to the reference position ., so all end-effector poses are calibrated off-line for the robot to be able to reach all the parts.
S2	Configure new product	The operator adds a stack of a new product type, possibly of different dimensions (within a limited variation range), or replaces an existing type with the new one and informs the system through the operator interface. The system is capable of processing orders that include the new product type.
S3	System start	The operator powers up all subsystems. The robot arm calibrates its joints.
S4	Fill the paint	The end effector accepts the paint from the container.
S5	Motion of channel	Movement of channel in the from the home position to the desired location in X direction
S6	Motion of end effector	The movement of the end effector in Y direction.

S7	Spraying the paint	At reaching the particular position to spray the paint at that location.
S8	Refill product	When the container gets empty , the sensor indicates that the container is empty , then as result the paint will be refilled in the container manually
S9	Return	When the operation is completed, the channel moves to its original position
S10	Shut down	The operator shuts down the system through the user interface. As a result, the status of the containers is stored in persistent storage and the robot arm moves to the home position.
S11	Emergency stop	By Implementing an Emergency stop, resulting in safety of the operator and also to control the robot.

4. 1. Capabilities and High-Level Functional Requirements

TABLE 4 High-Level Functional Requirements

F1 Handle Operator Interface	The system handles communication with the human operator through a suitable device so that the operator can: request an order, monitor the status of the order processing, and cancel it
F2 Calibration of the system.	The system calibration is designed to quantify and compensate for the total measurement error in industrial control systems. Condition changes, circuit drifts, and sensor errors, etc., may induce measurement error. By applying known inputs and reviewing the resultant measurements, an error model is developed.
F3 Sensing the material	The robot uses a strain gauge sensor to sense the material. Once the robot senses the material the painting operation can be initiated.
F4 Fill in the paint reservoir	The operator must fill the paint reservoir manually at desired level until the level sensor indicates
F5 Intialization the movement of the channel	The movement of channel is initiated from home position to the location for which to be end effector to be moved.
F6 Movement of end effector	Movement of end effector is controlled by motors and gears that are installed in the base of the robot and be moved to that desired location to paint accurately.
F7 Spraying the paint	The paint from the end effector is to be sprayed to the material accurately
F8 Indication	While the operation is going on the system indicates every phase during the operation.

F9 Emergency override	The system will shut down when the emergency button pressed during uneven cases
F10 Cleaning	The robot can be programmed to clean itself and the painting equipment after the task is completed. This may involve flushing out the paint supply system
F11 Harm Protection	When there is no material, the system will detect it and make the movement of the robot to stop. Once the material is placed the end effector is ready to move.

TABLE 5 System Requirements

Functional	Non Functional
It should have high rpm motors	The robot should be sturdy.
The robot must be easy to operate.	It should sustain in all critical conditions.
The end effector of robot should paint smoothly	The robot should be of low-density material
Cycle time should be minimum	It should be reliable
Should be precise at its work	The material used should be water resistant
The end effector should not cross its predefined workspace	The overall cost must be minimum.
The controllable pressurize end effector to handle the operation	The robot must have less weight.
The end effector of the cartesian robot should travel with a speed of 2 inches/second	The robot should make less noise
The prismatic joints should deliver linear motion along the respective axis	It should be power efficient
The painting fluid should be prefilled in an overhead container	The Robot should have low risk factor

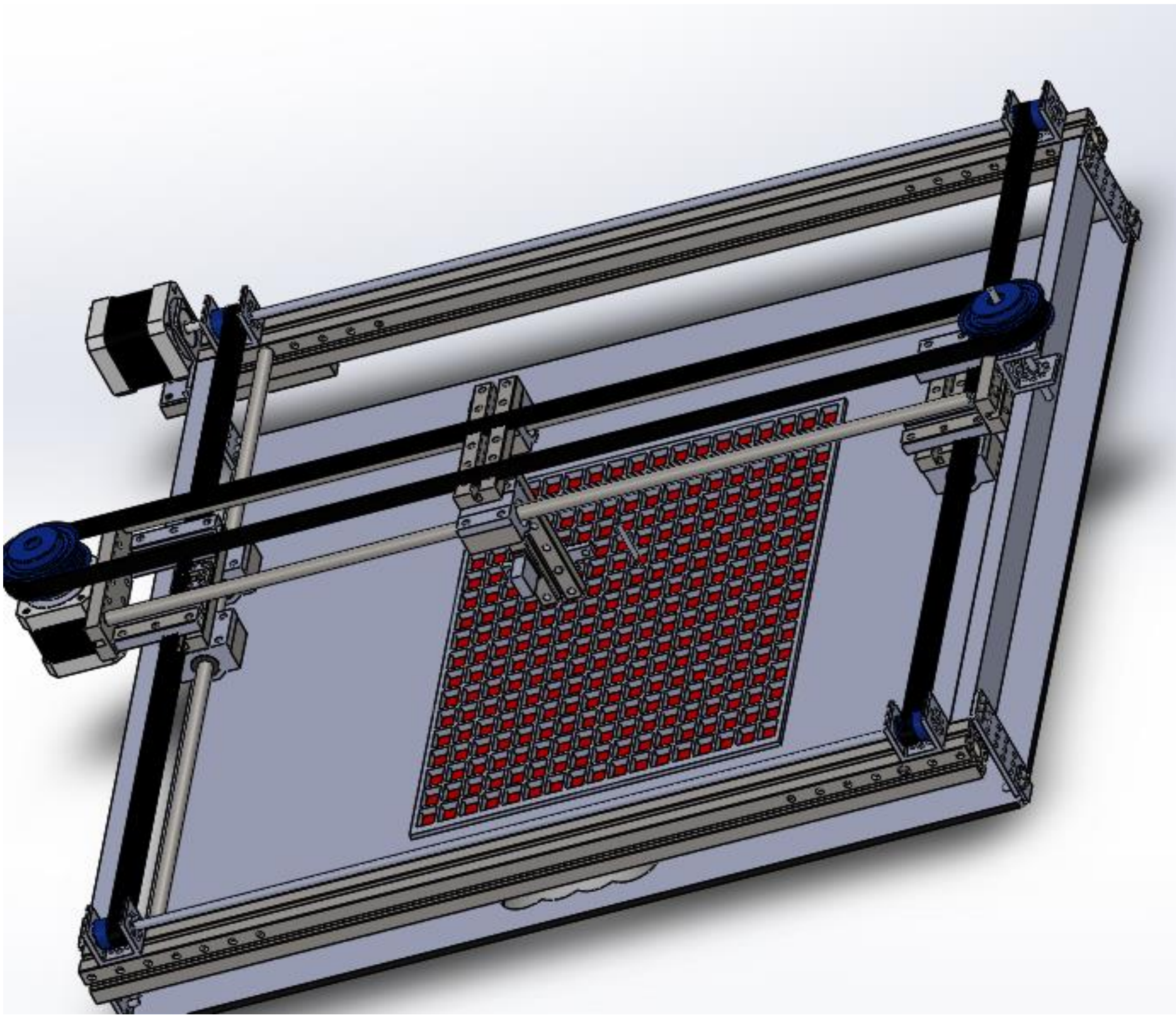


Figure 5 SOLID WORK DESIGN

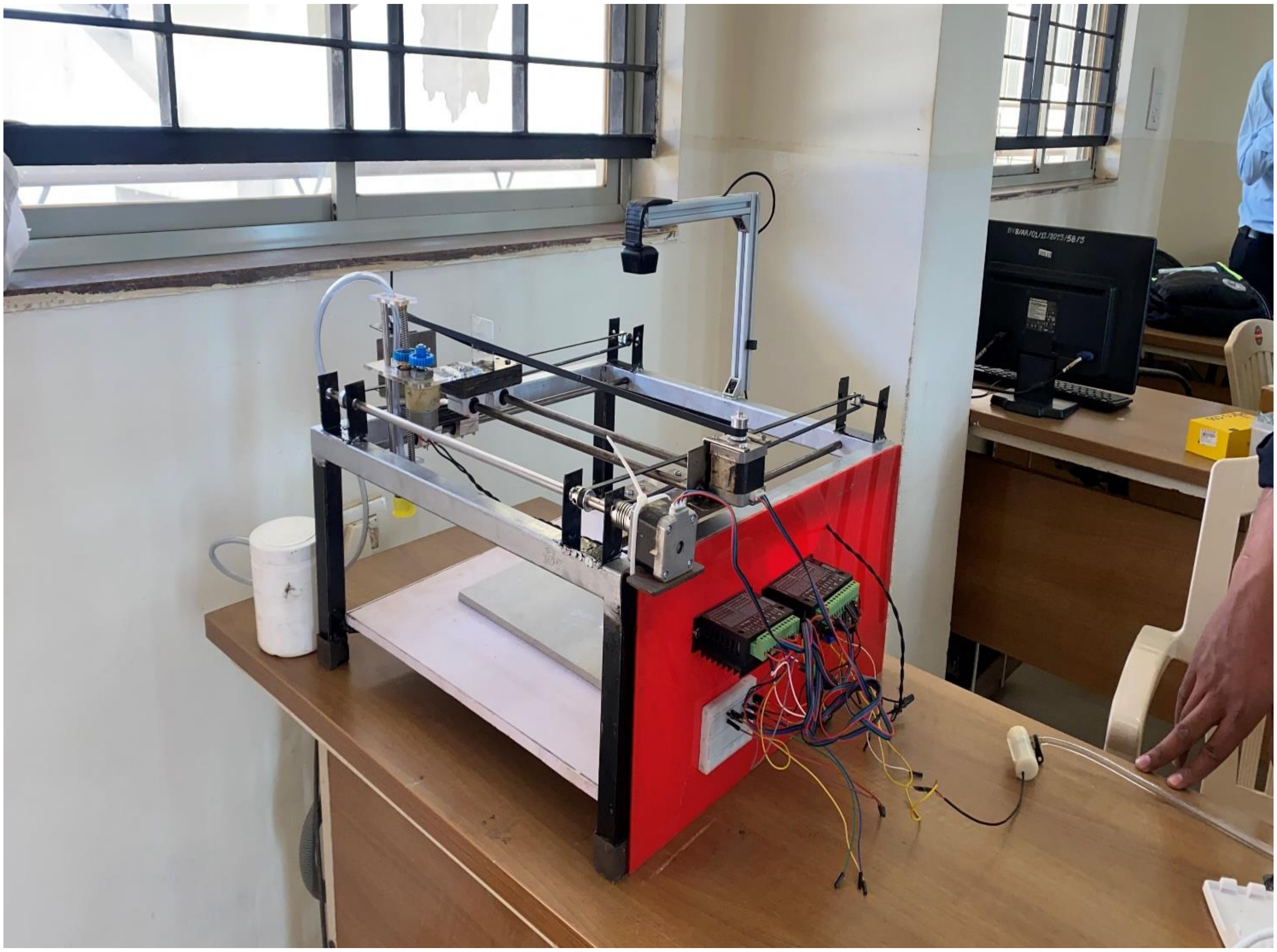


FIGURE 6. REAL TIME MODEL

TABLE 6 MORPHOLOGICAL CHART

Sub function	Idea 1	Idea2	Idea3
Vision Camera			
Processing the commands			
Sprayer			

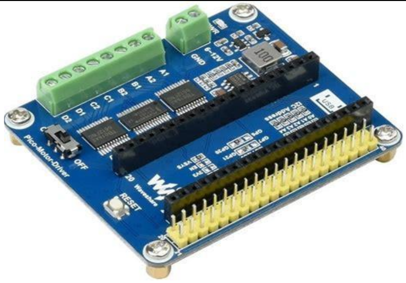
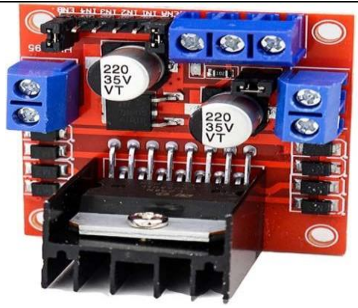
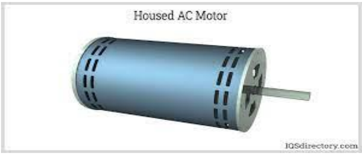
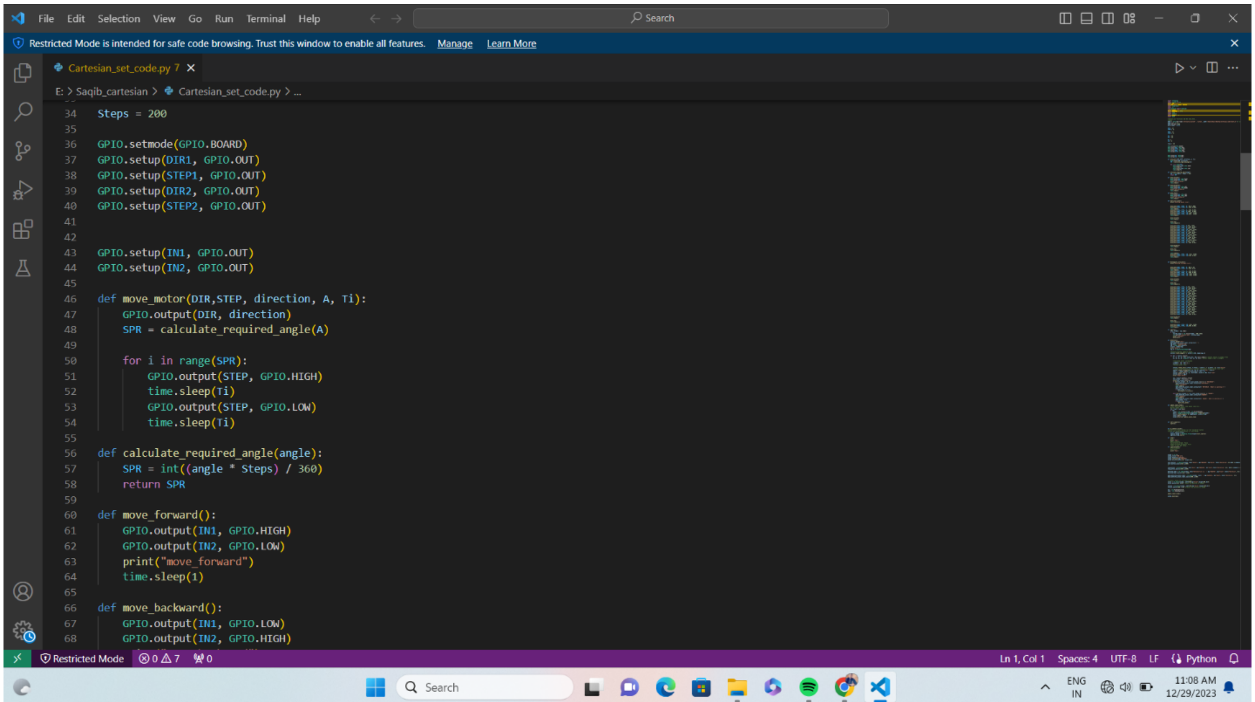
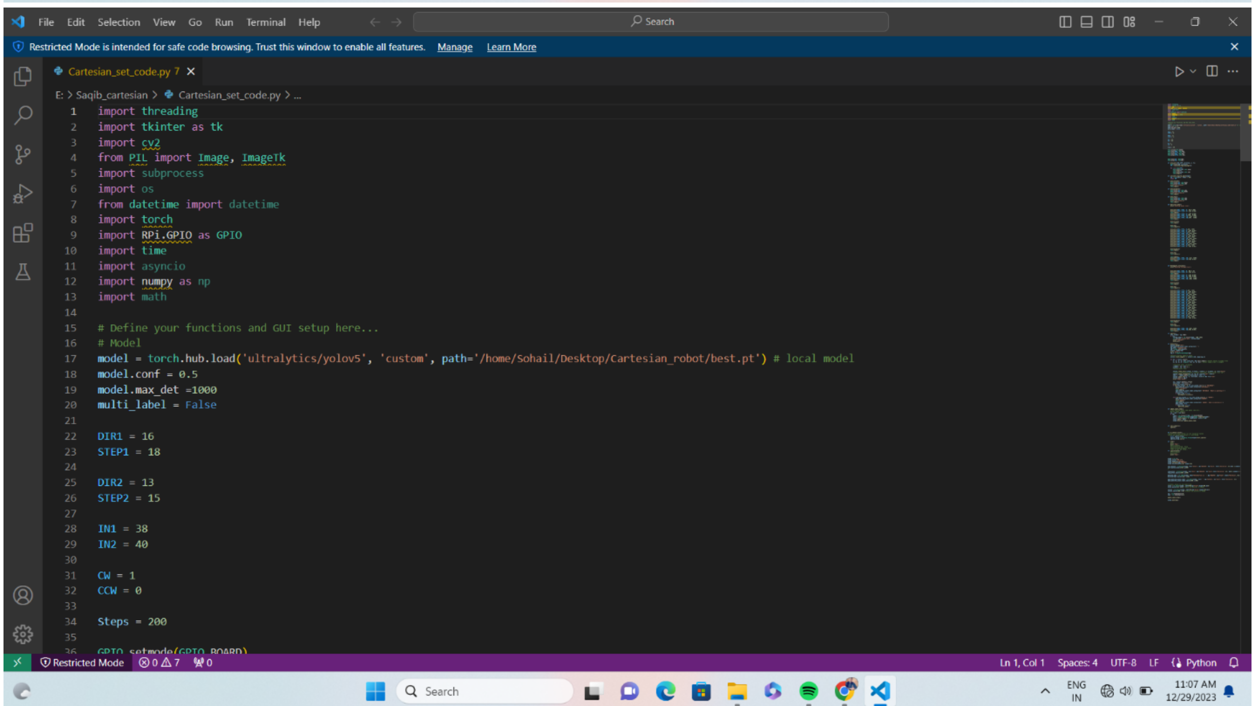
Conversion of electrical energy into mechanical energy			
Power Source			
Torque generator			

TABLE 7. Bill of materials

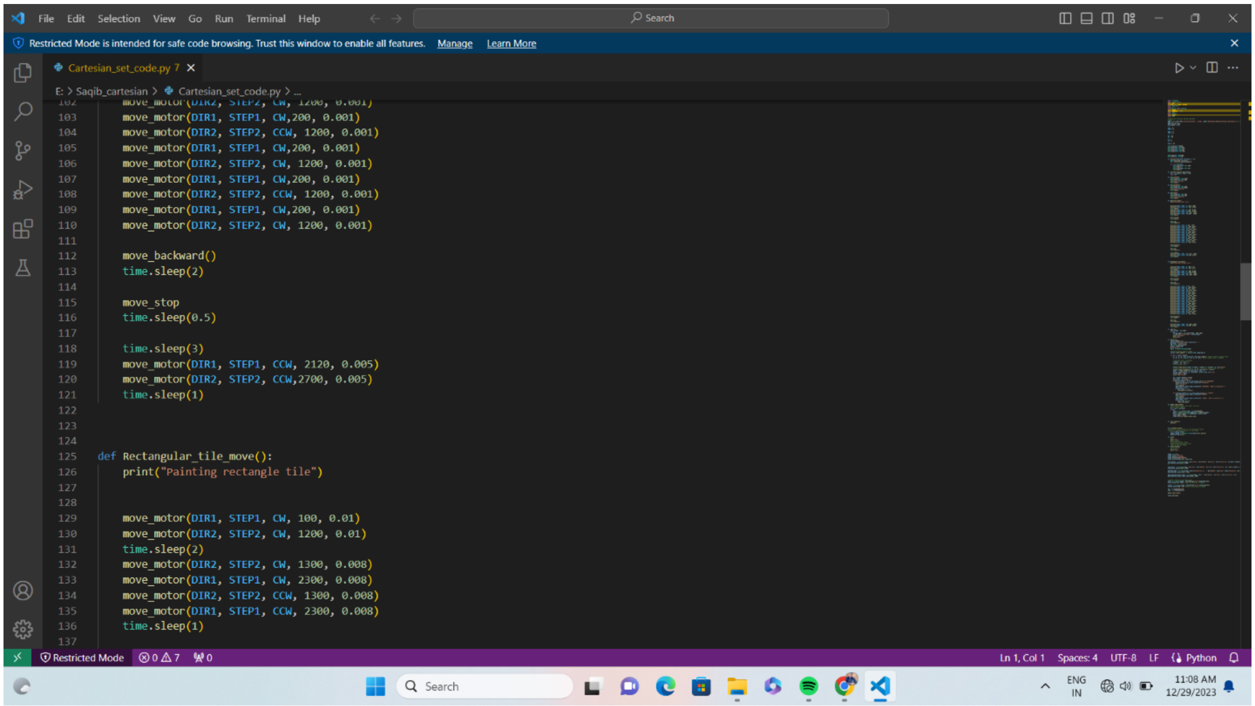
SI NO	COMPONENT NAME	QUANTITY	COST
1	STEPPER MOTOR	3	**1800**
2	MOTOR DRIVER	3	**1800**
3	LINEAR BEARING	6	**960**
4	JUMPER WIRES	-	**120**
5	BELT	3.5M	**325**
6	SCREWS	-	**300**
7	PULLEYS	6	**720**
8	CLAMPS	12	**72**
	TOTAL	-	**6000**

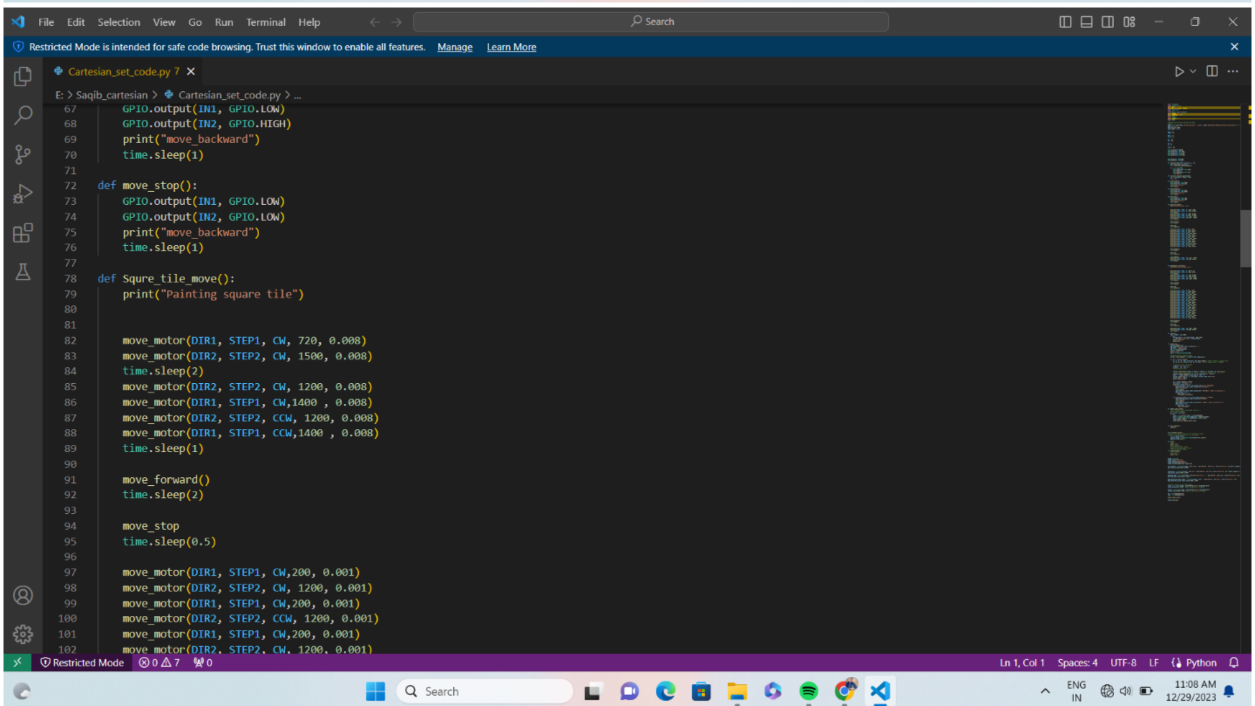


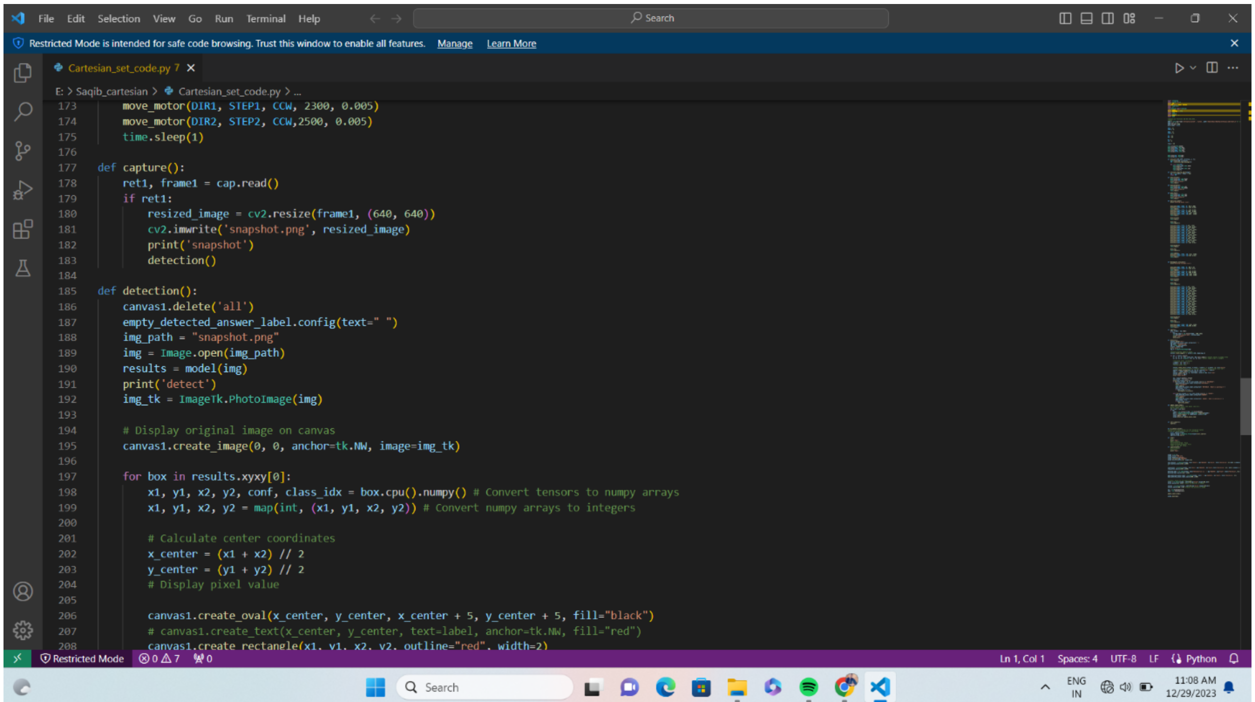
```python
Steps = 200

GPIO.setmode(GPIO.BOARD)
GPIO.setup(DIR1, GPIO.OUT)
GPIO.setup(STEP1, GPIO.OUT)
GPIO.setup(DIR2, GPIO.OUT)
GPIO.setup(STEP2, GPIO.OUT)


GPIO.setup(IN1, GPIO.OUT)
GPIO.setup(IN2, GPIO.OUT)

def move_motor(DIR,STEP, direction, A, Ti):
    GPIO.output(DIR, direction)
    SPR = calculate_required_angle(A)

    for i in range(SPR):
        GPIO.output(STEP, GPIO.HIGH)
        time.sleep(Ti)
        GPIO.output(STEP, GPIO.LOW)
        time.sleep(Ti)

def calculate_required_angle(angle):
    SPR = int((angle * Steps) / 360)
    return SPR

def move_forward():
    GPIO.output(IN1, GPIO.HIGH)
    GPIO.output(IN2, GPIO.LOW)
    print("move_forward")
    time.sleep(1)

def move_backward():
    GPIO.output(IN1, GPIO.LOW)
    GPIO.output(IN2, GPIO.HIGH)
```



```python
import threading
import tkinter as tk
import cv2
from PIL import Image, ImageTk
import subprocess
import os
from datetime import datetime
import torch
import RPi.GPIO as GPIO
import time
import asyncio
import numpy as np
import math

# Define your functions and GUI setup here...
# Model
model = torch.hub.load('ultralytics/yolov5', 'custom', path='/home/Sohail/Desktop/Cartesian_robot/best.pt') # local model
model.conf = 0.5
model.max_det =1000
multi_label = False

DIR1 = 16
STEP1 = 18

DIR2 = 13
STEP2 = 15

IN1 = 38
IN2 = 40

CW = 1
CCW = 0

Steps = 200
```


Cartesian_set_code.py
    move_motor(DIR1, STEP1, CW,200, 0.001)
    move_motor(DIR2, STEP2, CCW, 1200, 0.001)
    move_motor(DIR1, STEP1, CW,200, 0.001)
    move_motor(DIR2, STEP2, CW, 1200, 0.001)
    move_motor(DIR1, STEP1, CW,200, 0.001)
    move_motor(DIR2, STEP2, CCW, 1200, 0.001)
    move_motor(DIR1, STEP1, CW,200, 0.001)
    move_motor(DIR2, STEP2, CW, 1200, 0.001)
    move_backward()
    time.sleep(2)
    move_stop
    time.sleep(0.5)
    time.sleep(3)
    move_motor(DIR1, STEP1, CCW, 2120, 0.005)
    move_motor(DIR2, STEP2, CCW,2700, 0.005)
    time.sleep(1)
def Rectangular_tile_move():
    print("Painting rectangle tile")
    move_motor(DIR1, STEP1, CW, 100, 0.01)
    move_motor(DIR2, STEP2, CW, 1200, 0.01)
    time.sleep(2)
    move_motor(DIR2, STEP2, CW, 1300, 0.008)
    move_motor(DIR1, STEP1, CW, 2300, 0.008)
    move_motor(DIR2, STEP2, CCW, 1300, 0.008)
    move_motor(DIR1, STEP1, CCW, 2300, 0.008)
    time.sleep(1)


Cartesian_set_code.py
    GPIO.output(IN1, GPIO.LOW)
    GPIO.output(IN2, GPIO.HIGH)
    print("move_backward")
    time.sleep(1)
def move_stop():
    GPIO.output(IN1, GPIO.LOW)
    GPIO.output(IN2, GPIO.LOW)
    print("move_backward")
    time.sleep(1)
def Squre_tile_move():
    print("Painting square tile")
    move_motor(DIR1, STEP1, CW, 720, 0.008)
    move_motor(DIR2, STEP2, CW, 1500, 0.008)
    time.sleep(2)
    move_motor(DIR2, STEP2, CW, 1200, 0.008)
    move_motor(DIR1, STEP1, CW,1400 , 0.008)
    move_motor(DIR2, STEP2, CCW, 1200, 0.008)
    move_motor(DIR1, STEP1, CCW,1400 , 0.008)
    time.sleep(1)
    move_forward()
    time.sleep(2)
    move_stop
    time.sleep(0.5)
    move_motor(DIR1, STEP1, CW,200, 0.001)
    move_motor(DIR2, STEP2, CW, 1200, 0.001)
    move_motor(DIR1, STEP1, CW,200, 0.001)
    move_motor(DIR2, STEP2, CCW, 1200, 0.001)
    move_motor(DIR1, STEP1, CW,200, 0.001)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Cartesian_set_code.py 7
E: > Saqib_cartesian > Cartesian_set_code.py > ...
    move_motor(DIR1, STEP1, CCW, 2300, 0.005)
    move_motor(DIR2, STEP2, CCW,2500, 0.005)
    time.sleep(1)
def capture():
    ret1, frame1 = cap.read()
    if ret1:
        resized_image = cv2.resize(frame1, (640, 640))
        cv2.imwrite('snapshot.png', resized_image)
        print('snapshot')
        detection()
def detection():
    canvas1.delete('all')
    empty_detected_answer_label.config(text=" ")
    img_path = "snapshot.png"
    img = Image.open(img_path)
    results = model(img)
    print('detect')
    img_tk = ImageTk.PhotoImage(img)
    # Display original image on canvas
    canvas1.create_image(0, 0, anchor=tk.NW, image=img_tk)
    for box in results.xyxy[0]:
        x1, y1, x2, y2, conf, class_idx = box.cpu().numpy() # Convert tensors to numpy arrays
        x1, y1, x2, y2 = map(int, (x1, y1, x2, y2)) # Convert numpy arrays to integers
        # Calculate center coordinates
        x_center = (x1 + x2) // 2
        y_center = (y1 + y2) // 2
        # Display pixel value
        canvas1.create_oval(x_center, y_center, x_center + 5, y_center + 5, fill="black")
        # canvas1.create_text(x_center, y_center, text=label, anchor=tk.NW, fill="red")
        canvas1.create_rectangle(x1, y1, x2, y2, outline="red", width=2)
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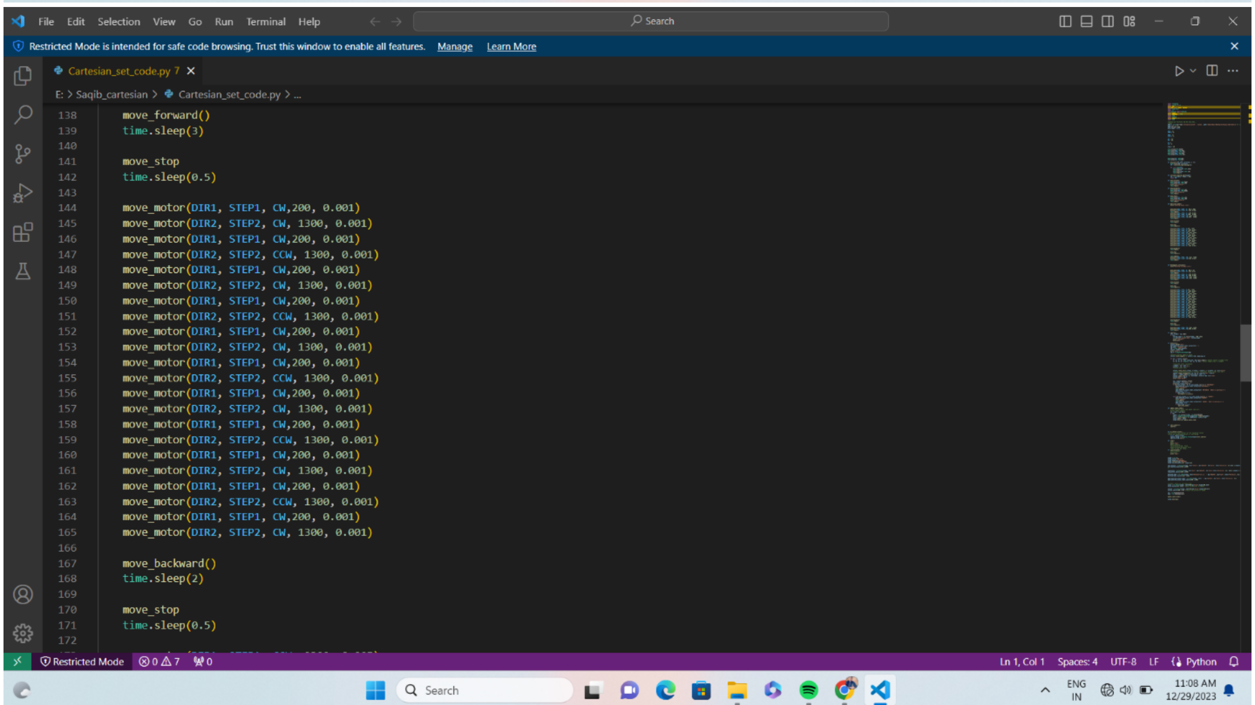
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Restricted Mode is intended for safe code browsing. Trust this window to enable all features. Manage Learn More
Cartesian_set_code.py 7
E: > Saqib_cartesian > Cartesian_set_code.py > ...
    move_forward()
    time.sleep(3)
    move_stop
    time.sleep(0.5)
    move_motor(DIR1, STEP1, CW,200, 0.001)
    move_motor(DIR2, STEP2, CW, 1300, 0.001)
    move_motor(DIR1, STEP1, CW,200, 0.001)
    move_motor(DIR2, STEP2, CCW, 1300, 0.001)
    move_motor(DIR1, STEP1, CW,200, 0.001)
    move_motor(DIR2, STEP2, CW, 1300, 0.001)
    move_motor(DIR1, STEP1, CW,200, 0.001)
    move_motor(DIR2, STEP2, CCW, 1300, 0.001)
    move_motor(DIR1, STEP1, CW,200, 0.001)
    move_motor(DIR2, STEP2, CW, 1300, 0.001)
    move_motor(DIR1, STEP1, CW,200, 0.001)
    move_motor(DIR2, STEP2, CCW, 1300, 0.001)
    move_motor(DIR1, STEP1, CW,200, 0.001)
    move_motor(DIR2, STEP2, CW, 1300, 0.001)
    move_motor(DIR1, STEP1, CW,200, 0.001)
    move_motor(DIR2, STEP2, CCW, 1300, 0.001)
    move_motor(DIR1, STEP1, CW,200, 0.001)
    move_motor(DIR2, STEP2, CW, 1300, 0.001)
    move_motor(DIR1, STEP1, CW,200, 0.001)
    move_motor(DIR2, STEP2, CCW, 1300, 0.001)
    move_motor(DIR1, STEP1, CW,200, 0.001)
    move_motor(DIR2, STEP2, CW, 1300, 0.001)
    move_backward()
    time.sleep(2)
    move_stop
    time.sleep(0.5)
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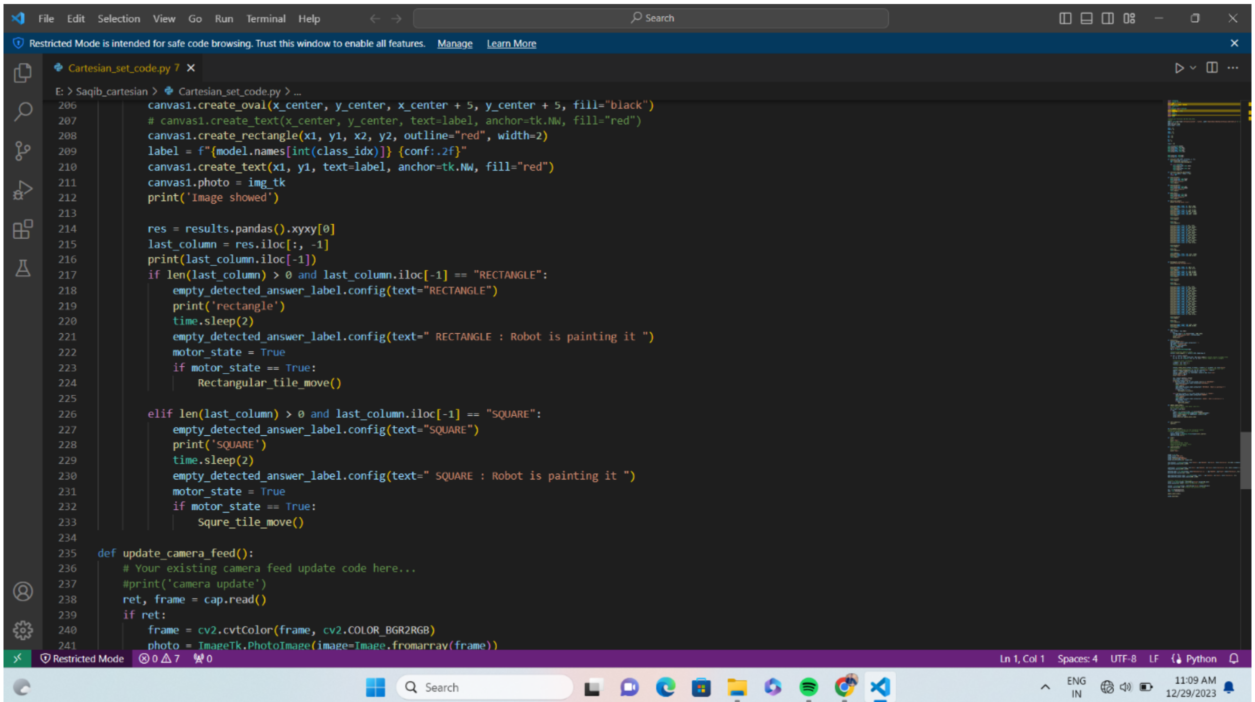
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Restricted Mode is intended for safe code browsing. Trust this window to enable all features. Manage Learn More
Cartesian_set_code.py 7
E: > Saqib_cartesian > Cartesian_set_code.py > ...
canvas1.create_oval(x_center, y_center, x_center + 5, y_center + 5, fill="black")
# canvas1.create_text(x_center, y_center, text=label, anchor=tk.NW, fill="red")
canvas1.create_rectangle(x1, y1, x2, y2, outline="red", width=2)
label = f"{model.names[int(class_idx)]} {conf:.2f}"
canvas1.create_text(x1, y1, text=label, anchor=tk.NW, fill="red")
canvas1.photo = img_tk
print('Image showed')
res = results.pandas().xyxy[0]
last_column = res.iloc[:, -1]
print(last_column.iloc[-1])
if len(last_column) > 0 and last_column.iloc[-1] == "RECTANGLE":
empty_detected_answer_label.config(text="RECTANGLE")
print('rectangle')
time.sleep(2)
empty_detected_answer_label.config(text=" RECTANGLE : Robot is painting it ")
motor_state = True
if motor_state == True:
Rectangular_tile_move()
elif len(last_column) > 0 and last_column.iloc[-1] == "SQUARE":
empty_detected_answer_label.config(text="SQUARE")
print('SQUARE')
time.sleep(2)
empty_detected_answer_label.config(text=" SQUARE : Robot is painting it ")
motor_state = True
if motor_state == True:
Squre_tile_move()
def update_camera_feed():
# Your existing camera feed update code here...
#print('camera update')
ret, frame = cap.read()
if ret:
frame = cv2.cvtColor(frame, cv2.COLOR_BGR2RGB)
photo = ImageTk.PhotoImage(image=Image.fromarray(frame))
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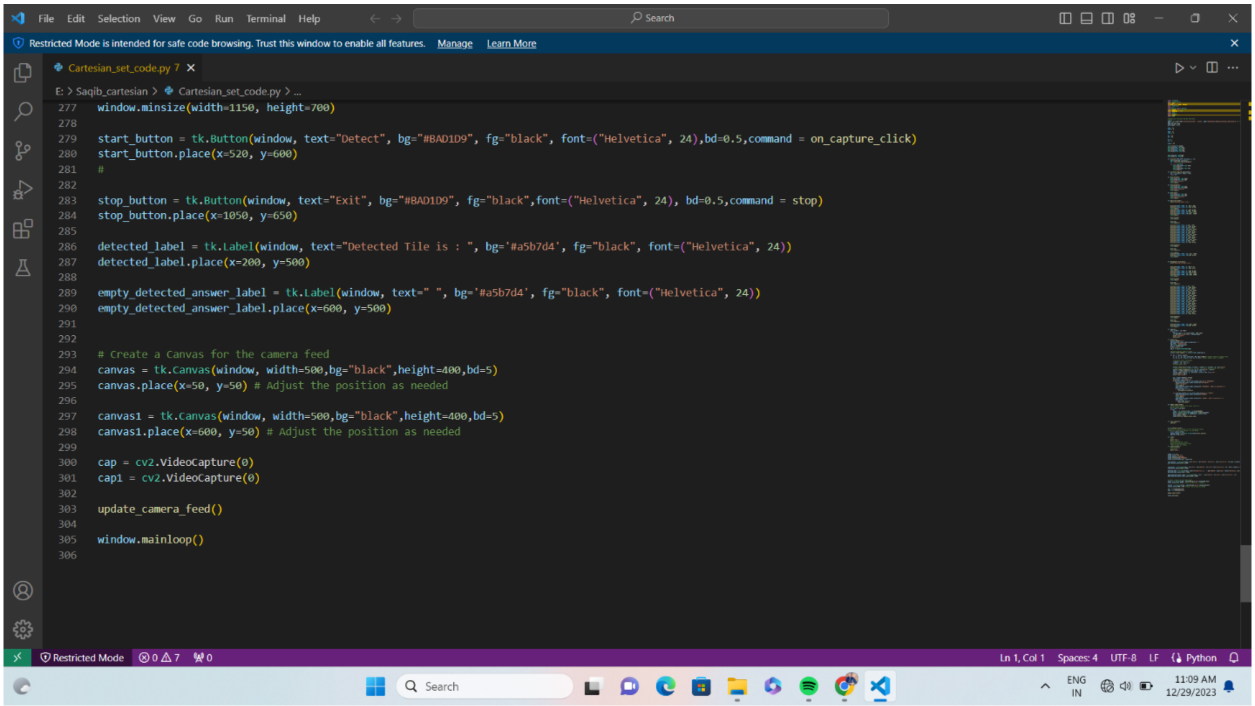
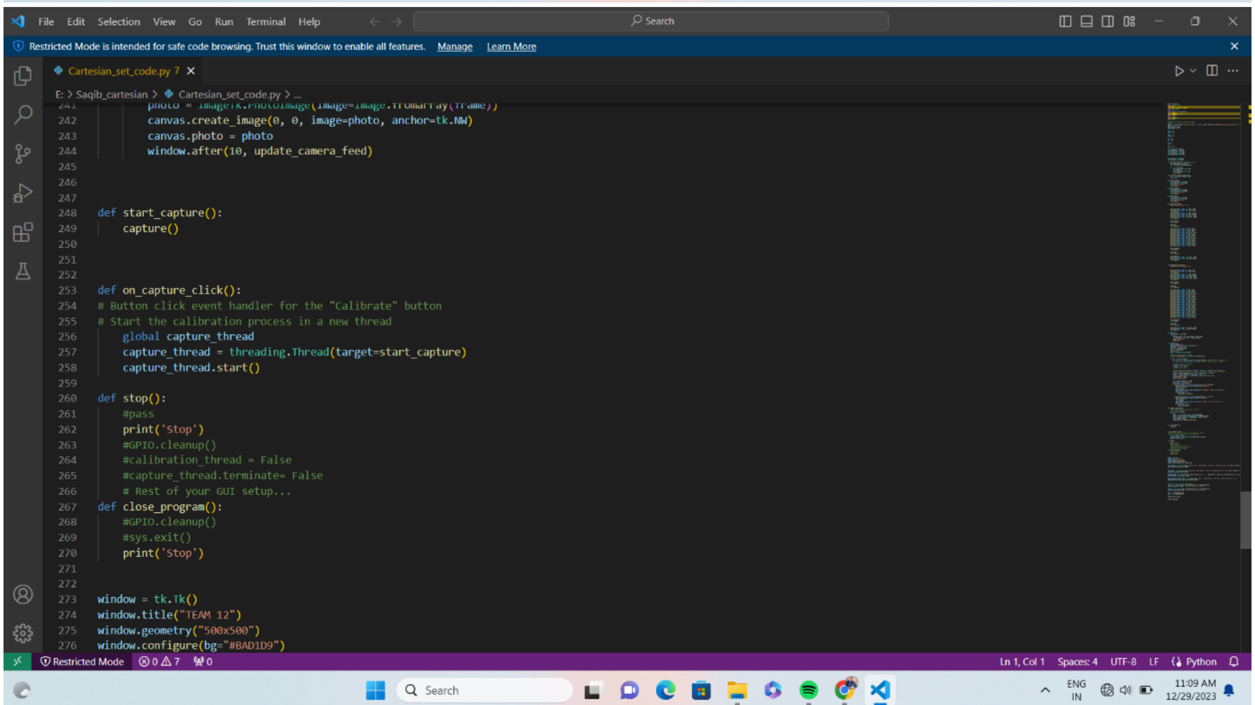



```python
window.minsize(width=1150, height=700)

start_button = tk.Button(window, text="Detect", bg="#BAD1D9", fg="black", font=("Helvetica", 24),bd=0.5,command = on_capture_click)
start_button.place(x=520, y=600)
#

stop_button = tk.Button(window, text="Exit", bg="#BAD1D9", fg="black",font=("Helvetica", 24), bd=0.5,command = stop)
stop_button.place(x=1050, y=650)

detected_label = tk.Label(window, text="Detected Tile is : ", bg='#a5b7d4', fg="black", font=("Helvetica", 24))
detected_label.place(x=200, y=500)

empty_detected_answer_label = tk.Label(window, text=" ", bg='#a5b7d4', fg="black", font=("Helvetica", 24))
empty_detected_answer_label.place(x=600, y=500)


# Create a Canvas for the camera feed
canvas = tk.Canvas(window, width=500,bg="black",height=400,bd=5)
canvas.place(x=50, y=50) # Adjust the position as needed

canvas1 = tk.Canvas(window, width=500,bg="black",height=400,bd=5)
canvas1.place(x=600, y=50) # Adjust the position as needed

cap = cv2.VideoCapture(0)
cap1 = cv2.VideoCapture(0)

update_camera_feed()

window.mainloop()
```



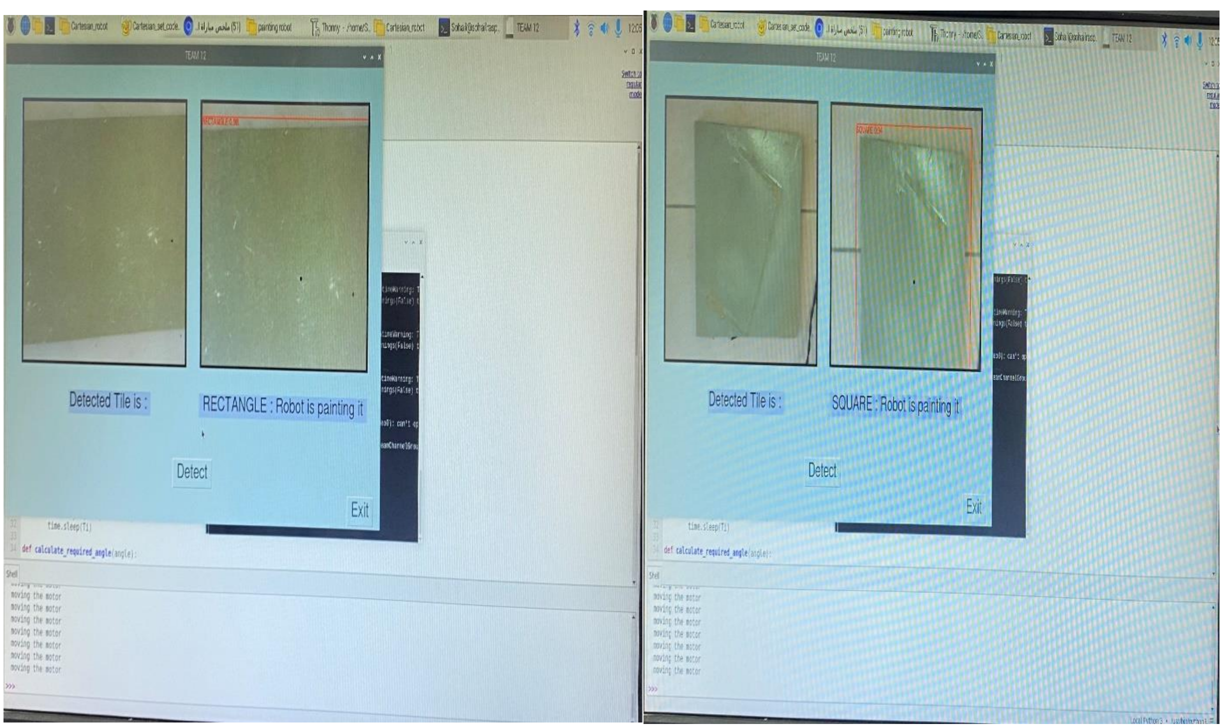

```python
        photo = ImageTk.PhotoImage(image=Image.fromarray(frame))
        canvas.create_image(0, 0, image=photo, anchor=tk.NW)
        canvas.photo = photo
        window.after(10, update_camera_feed)



def start_capture():
    capture()



def on_capture_click():
# Button click event handler for the "Calibrate" button
# Start the calibration process in a new thread
    global capture_thread
    capture_thread = threading.Thread(target=start_capture)
    capture_thread.start()

def stop():
    #pass
    print('Stop')
    #GPIO.cleanup()
    #calibration_thread = False
    #capture_thread.terminate= False
    # Rest of your GUI setup...
def close_program():
    #GPIO.cleanup()
    #sys.exit()
    print('Stop')


window = tk.Tk()
window.title("TEAM 12")
window.geometry("500x500")
window.configure(bg="#BAD1D9")
```

6. Conclusions

In conclusion, the 3 DOF Cartesian Robot is a valuable tool in various industries that require precise and flexible automation. With its ability to move in three dimensions, it can perform a wide range of tasks, from material handling and pick-and-place operations to precision positioning and assembly. Its accuracy and repeatability make it an ideal machine for applications that require high levels of precision and control.

6. 1. Results

The robot's versatility and adaptability make it an attractive option for manufacturers and researchers who need a machine that can be customized to suit their specific needs. As technology advances, we can expect to see even more advanced and sophisticated Cartesian robots that can perform more complex tasks and operate with greater autonomy. Overall, the 3 DOF Cartesian Robot is a powerful and essential tool in the world of automation and robotics.



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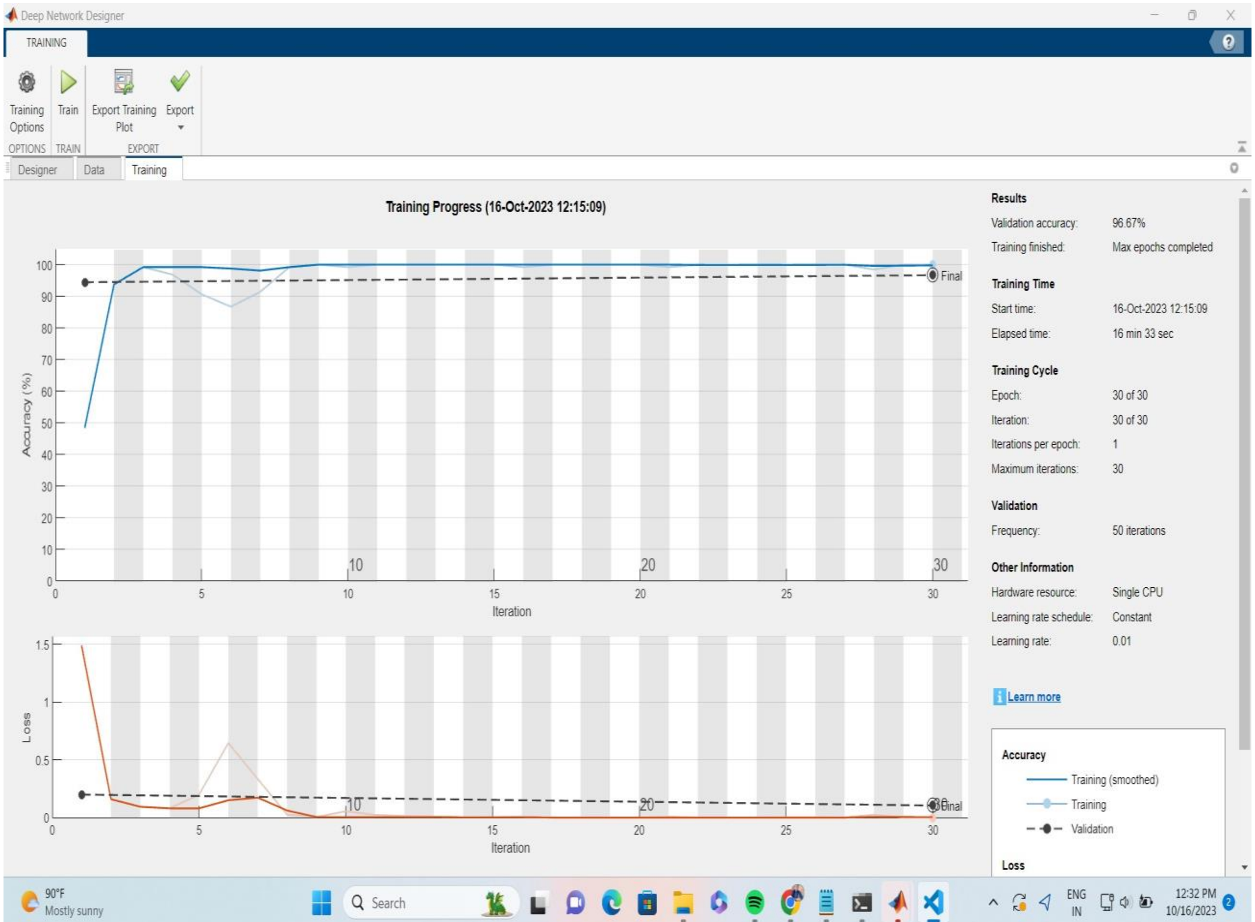

Future Scopes

- The future scope of an automatic tile painting system involves we can use it for larger scale applications, so that it can paint multiple tiles within a minimum time
- By using well equipped actuators and encoders we can increase the accuracy and precision of a robot
- By using modern technology, we can paint the robot based on the 3D simulation.
- Making a provision to paint multiple colors when need.

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