centre universitaire Condorcet

Vibot

ROBOTICS PROJECT

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The revolution is coming! Vive la révolution!

CONTENTS

INTRODUCTION

- This project serves as an integration of Computer Vision with Robotics
- Showcases the use of autonomous driving of the TurtleBot 3 along with Pick and Place using the NED 2.

METHODOLGY

IMAGE ACQUISITION, CAMERA CALIBRATION

- Image acquisition refers to the process of capturing visual data, typically in the form of photographs or frames, using a device such as a camera or sensor
- We are using a fish-eye camera, characterized by its wide-angle and notably distorted view of the scene. Fish-eye lenses introduce considerable barrel distortion.
- Camera calibration is a crucial process in computer vision and image processing, aiming to determine the intrinsic and extrinsic parameters of a camera system and for distorting the images, especially for the fish eye camera.
- A modified version of Brown-Conrady distortion model is implemented with OpenCV to calibrate our camera and to remove the distortion from the images.
- Bird view is achieved by using a perspective transformation and this helps us with top-down perspective of a scene or an object

ARUCO DETECTION AND LANE DETECTION

- The Aruco marker is used to measure the distance between itself and the TB3. This distance is used to stop the TB3 at an apropriate distance from NED 2 to perform the pick and place.
- Aruco Markers work on the principle of:
  - Pattern Encoding
  - Grid Structure
  - Translation Invariance
- Aruco detection involves:
  - Corner Detection
  - Pattern Matching
  - Pose Estimation
- For distance calculation, we utilize parameters like K, distortion coefficients, along with rvec and tvec obtained from pose estimation.
- Lane detection is used for autonomous driving.
- Lane detection involves:
  - Color Space Conversion
  - Thresholding and masking
  - Adaptive Calibration
  - Counting Short Lines
  - Lane fitting

METHODOLGY

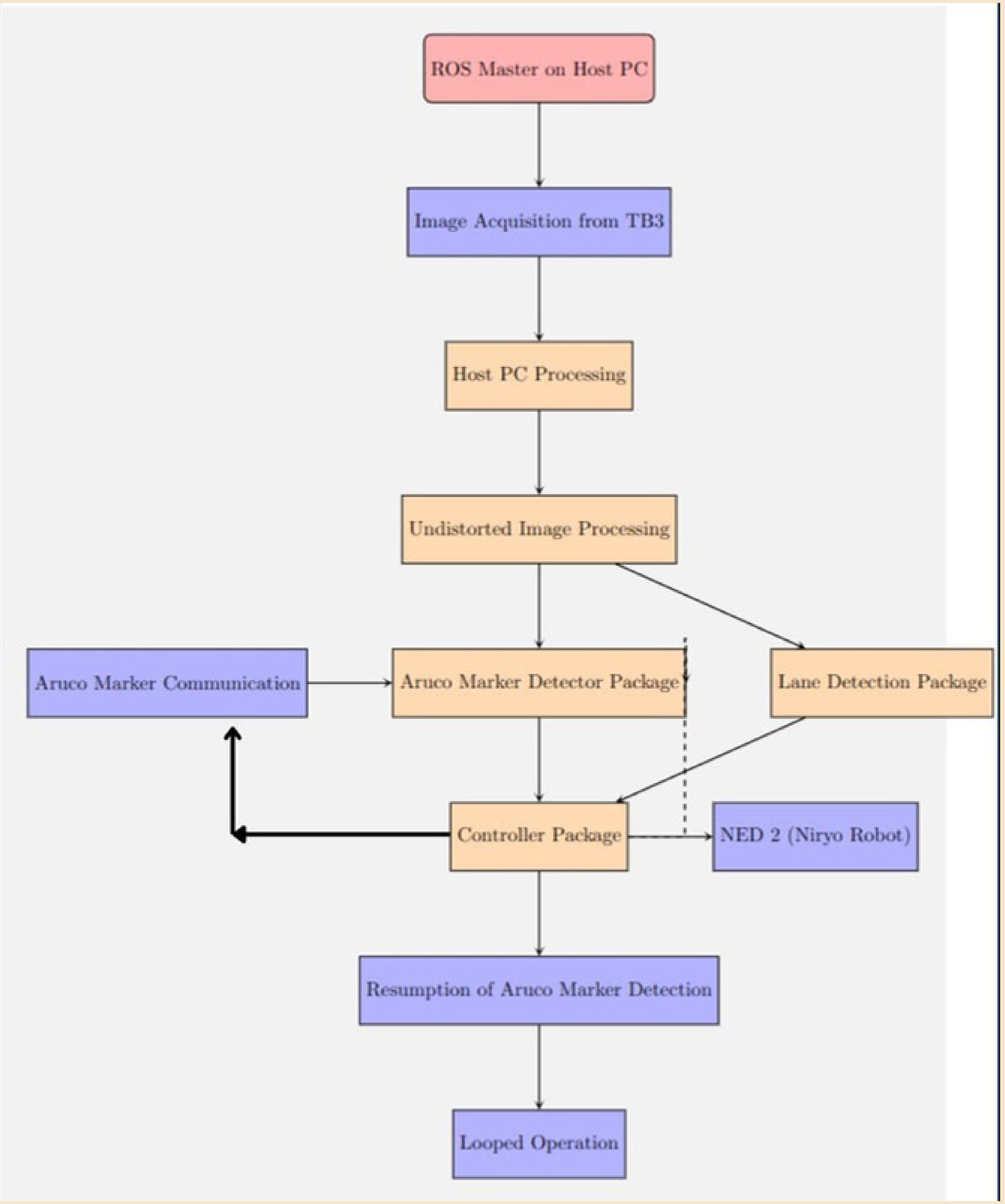
CONTROLLER

- In robotics, a controller is a system or algorithms guiding a robot's actions by manipulating its actuators based on sensory input or commands.
- In our case, we use a PD (Proportional-Derivative) controller to govern TB3's movement.
- Choosing a PD controller for ground robots offers advantages in specific scenarios. PD effectively address challenges like damping oscillations and respond promptly to error rate changes, enhancing stability and mitigating overshooting.
- For ground robots in well-defined environments, PD controllers prove efficient without introducing the integral term, avoiding issues like integrator windup.
- The Controller is also used to stop the robot when the stopping distance criteria is met.

NIRYO ROBOT PICK AND PLACE

- In a 6-degree-of-freedom (DoF) manipulator robot like the Niryo NED 2, visual servoing is crucial for precise pick-and-place tasks.
- Utilizing feedback from its integrated camera system, the robot employs computer vision techniques to locate and grasp target objects.
- The controller calculates joint angles and end-effector poses based on the identified object, continually adjusting movements in real-time for accurate positioning.

METHODOLOGY



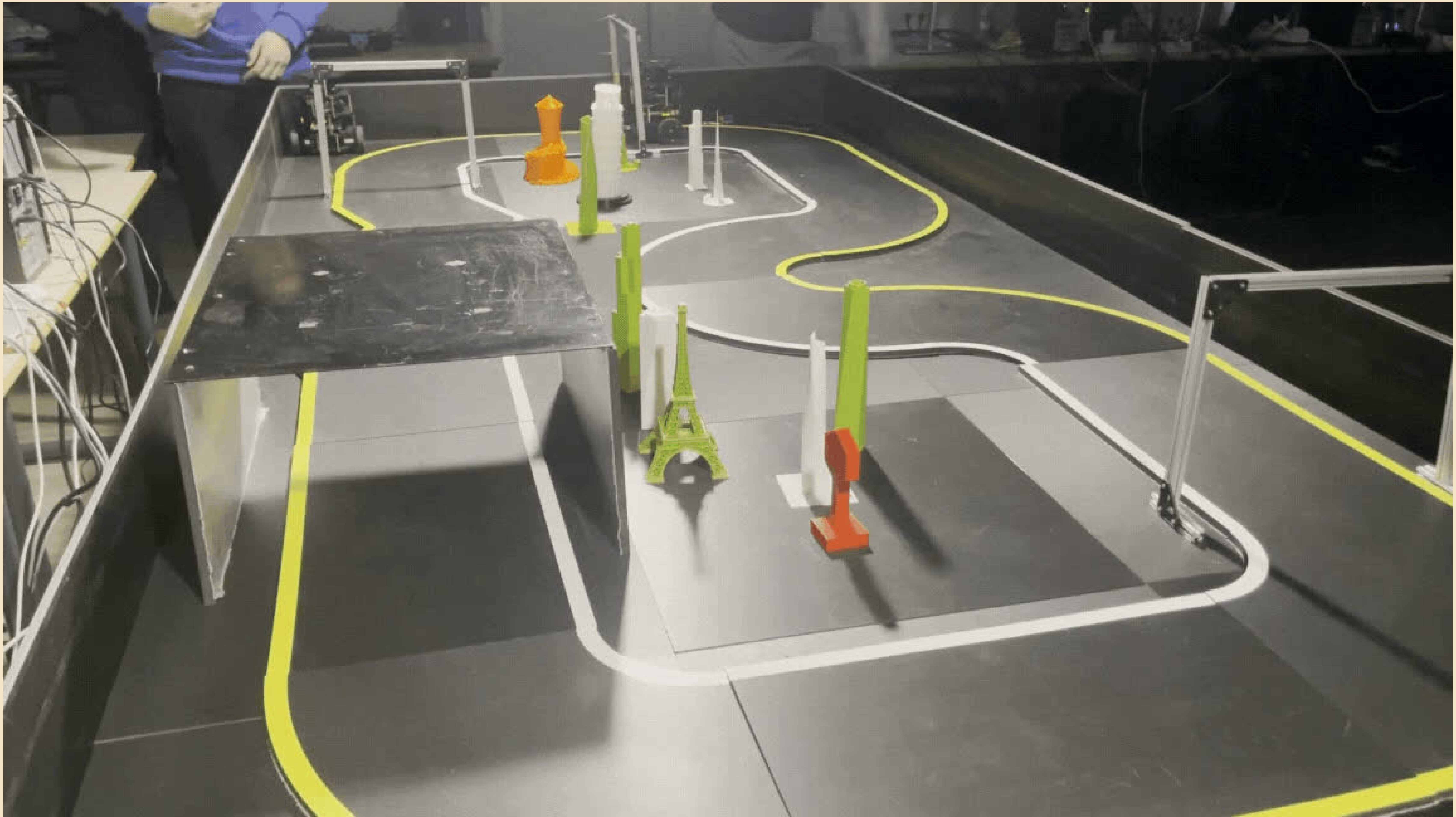
RESULTS

- We will now present the following implementations and results:
  - Camera Calibration
  - Lane detection
  - Aruco detection and distance
  - Robot stopping
  - TB3 lane following and Niryo pick and place

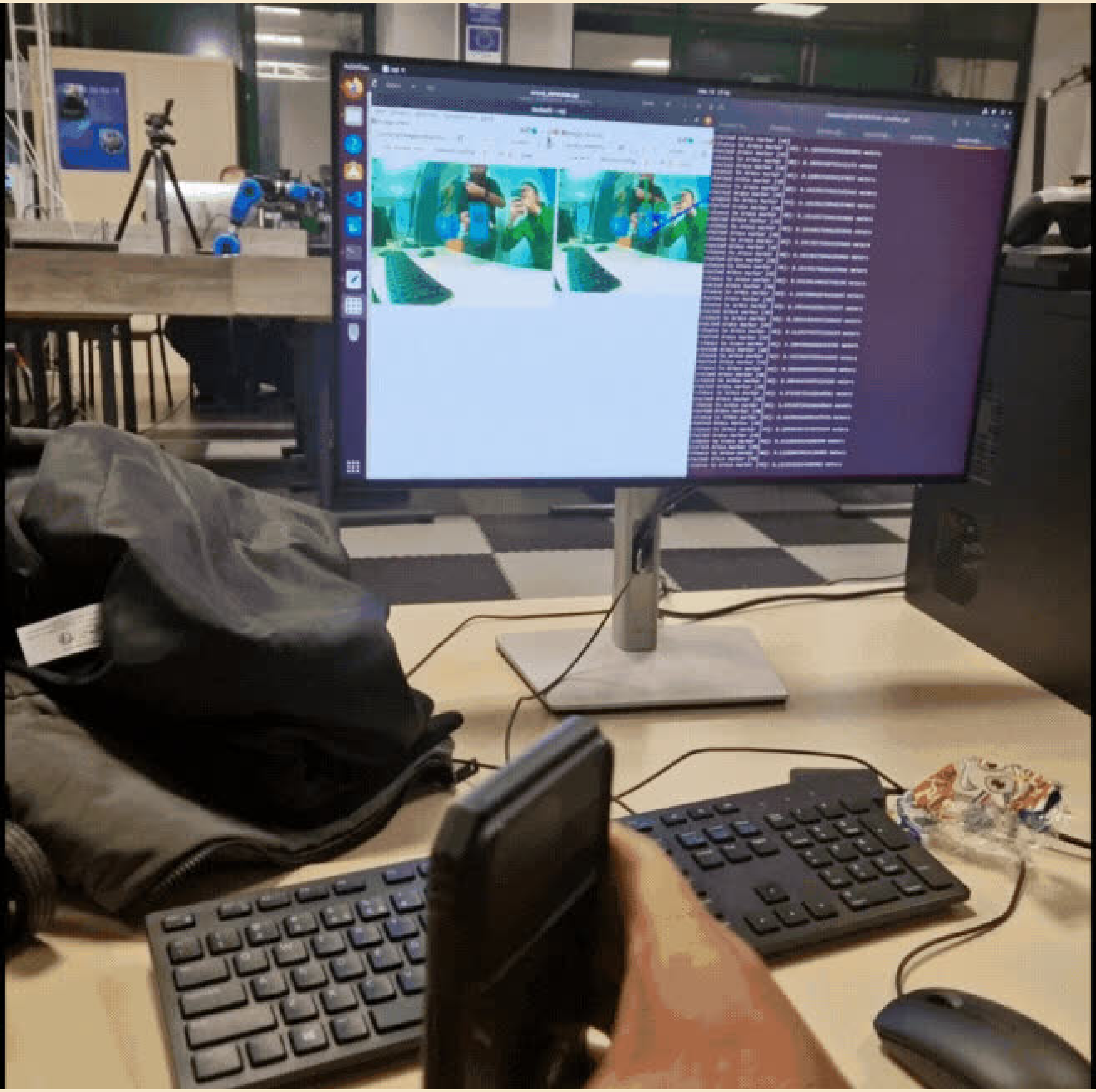
CAMERA CALIBRATION

UNDISTORTED IMAGE RECONSTRUCTION

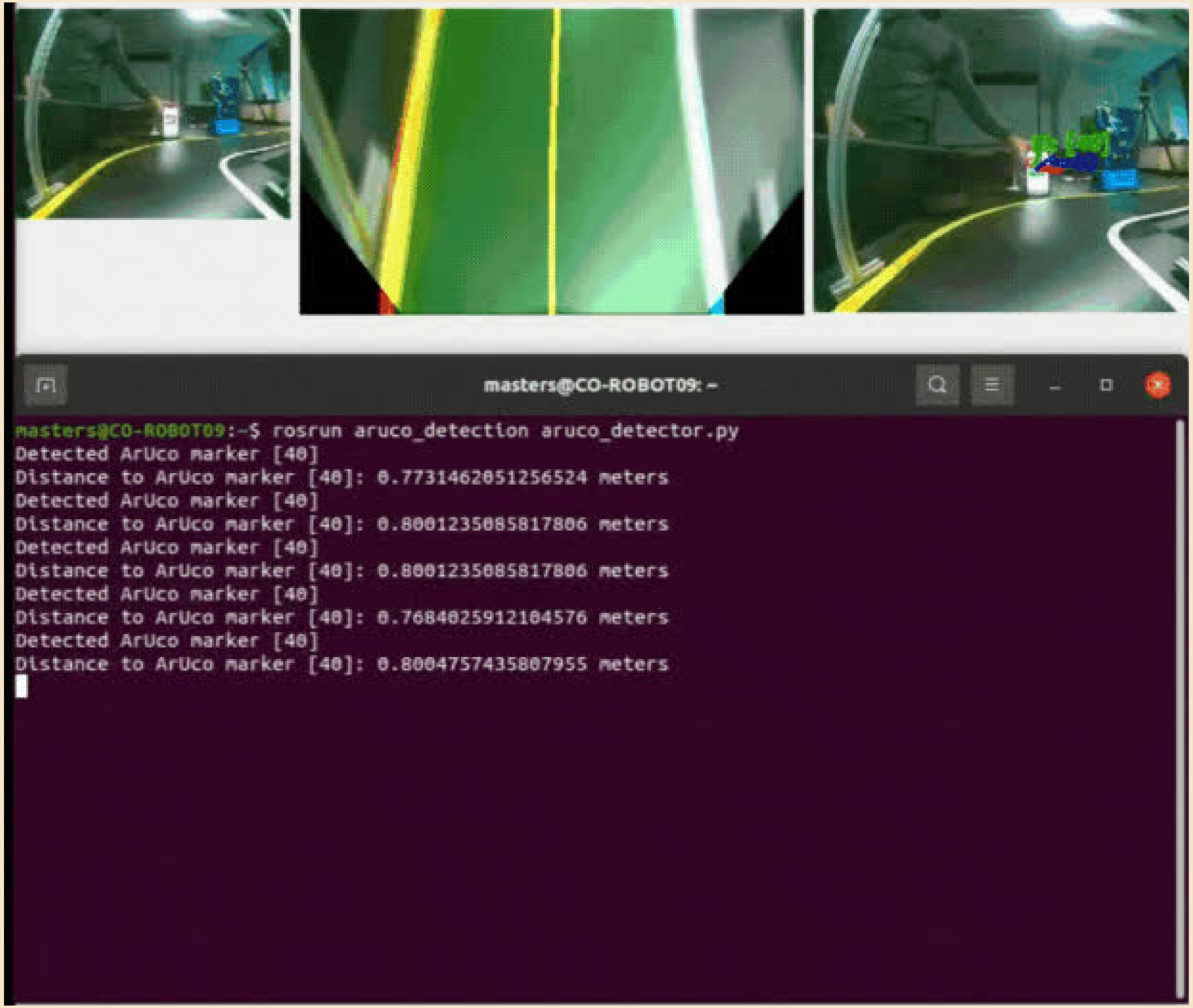
LANE DETECTION



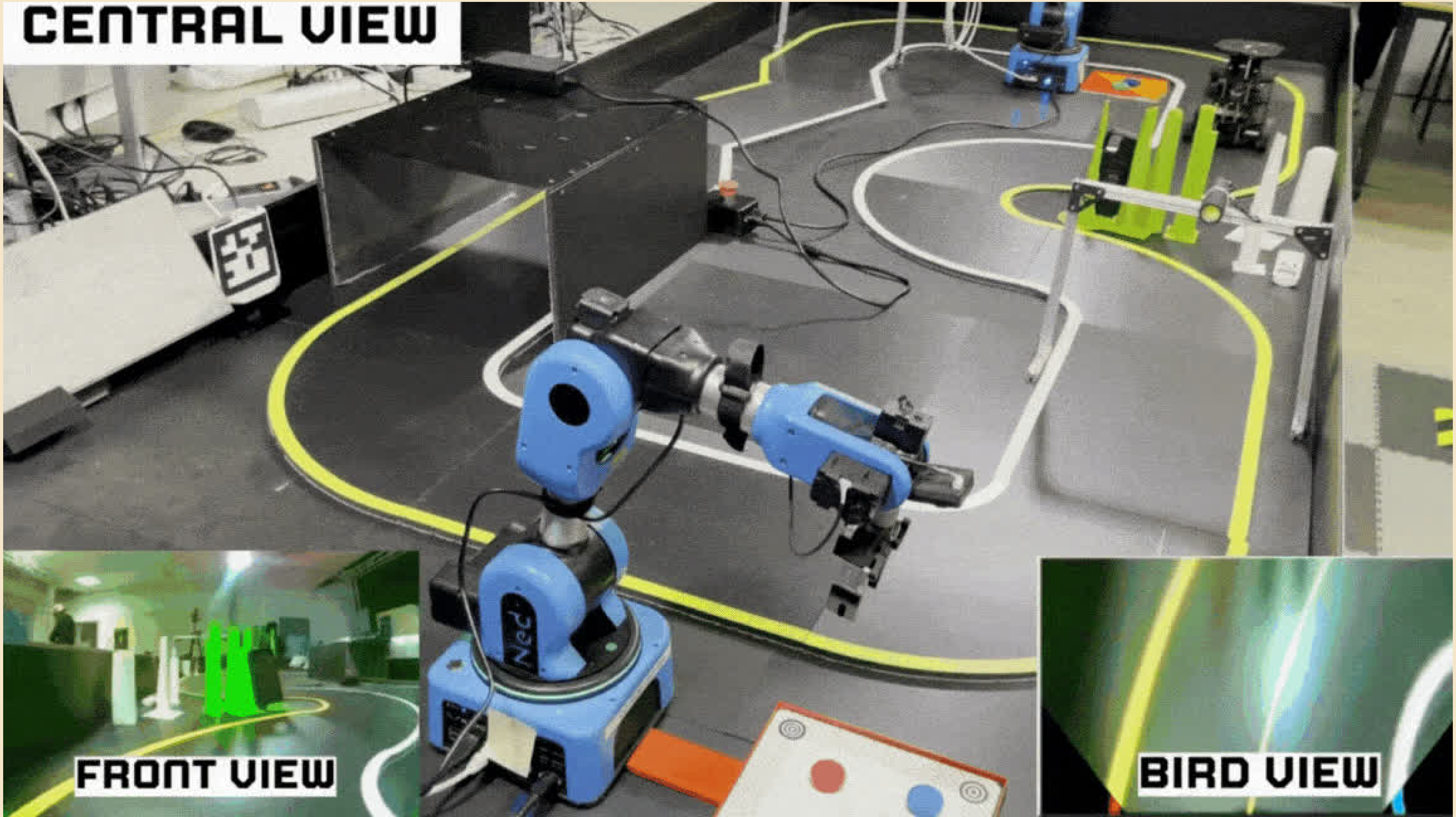
ARUCO DETECTION AND DISTANCE



ROBOT STOPPING



TB3 LANE FOLLOWING AND NIRYO PICK AND PLACE



LIMITATIONS

- The camera's hardware exhibits limitations, resulting in sub-optimal image quality.
  - Despite attempts to employ various image processing techniques for enhancement, the inherent deficiencies in the hardware rendered these efforts ineffectual.
  - Additionally, the camera's constraints extended to the inability to modify its hardware parameters.
- Fluctuations in lighting conditions, coupled with substandard camera quality, can pose considerable challenges in the accurate detection of lanes.
  - In instances of excessive illumination, induced by undesirable reflections, the yellow lane may manifest as a white lane.
    - The lane detection algorithm operates under the assumption that the yellow lane consistently corresponds to the left side, while the white lane consistently aligns with the right side. However, excessive ambient light conditions may lead to the yellow lane visually resembling the white lane, causing the robot to deviate from its intended path

LIMITATIONS

- Subsequent to the pick-and-place operation, the method employed to temporally disregard the Aruco marker until it exits the field of view of the TurtleBot3 lacks robustness.
  - Instead of addressing the scenario, we opt to suspend the detection of the Aruco Marker for a predetermined duration. While this strategy proves effective in the present configuration, any alteration in the NED 2's position or unforeseen responses from the NED 2 or TB3 could potentially compromise the efficacy of our approach.
- The lane detection algorithm is not robust enough.
  - Since this algorithm works on color detection rather than some other feature, its easy for the robot to go off track.

FUTURE WORK

In delineating future avenues for research and development, we posit the following recommendations:

- Development of a Proprietary Lane Detection Algorithm:
- Integration of Advanced Imaging Hardware:
- Multi-Robot System Deployment:
- Enhancement of Aruco Marker Handling Post Pick-and-Place:

CONCLUSION

The project's conclusion reveals a meticulously orchestrated workflow facilitated by the Robot Operating System (ROS). Commencing with the establishment of a ROS master on the host PC, the project encompasses the acquisition of images from TurtleBot3 (TB3), followed by host PC processing involving calibration and undistortion tailored for computer vision tasks. Subsequently, undistorted images undergo processing through the Aruco Marker Detector and Lane Detection packages. The Controller Package actively subscribes to distance and lane mask topics, adeptly guiding the TB3 within lanes and ensuring halts at optimal distances from NED 2. During these halts, the Controller communicates seamlessly with NED 2 for pick-and-place operations, concurrently signaling a pause in Aruco marker detection. Following this pause, Aruco marker detection resumes, thereby perpetuating a continuous loop of autonomous operation. This systematic integration ensures a nuanced and coordinated robotic functionality through the utilization of ROS.

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THANK YOU

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