Team 30
Max Young: geyo0706@colorado.edu
Austin Ritz: auri2603@colorado.edu
Chandler Phillips: chph9375@colorado.edu

Final Project: Ned Building Blocks

Abstract

For the final project our team attempted to implement a Ned robotic arm controller, that would be used to stack different blocks in a webots environment based on color in a certain way. In order to do this we planned on using computer vision with the Ned robot, which would have an external camera and inverse kinematics to pick up the blocks and stack them all in a certain area. However this project idea was very hard to achieve based on a few different aspects which we will detail in the following original List of deliverables and implementation plan, but in the end we ended up creating a robot that can very accurately move and "grab" colored blocks in any order. The order is specified by inputting the locations of the blocks in the order you want them picked up. This would have been done with computer vision, but we were unable to complete this portion.

Equipment:

Robot: Ned (Robot Arm https://cyberbotics.com/doc/guide/ned)
Sensor: Camera attached to Ned

List of deliverables and Implementation Plan

1. **Create an environment -** ***Lead: Chandler Phillips, Deadline: Wednesday November 10th 2021***
    a. **create blocks of differing colors**
    b. **Position blocks**
    c. **Position Robot**

- **Final Results:** The Environment was created very early for our final project, it is a pretty simple yet effective world in webots with four different colored blocks (Yellow, Green, Blue, and Red) placed on top of a table with a clear goal of where we wanted to place the blocks in the end. We then added a Ned robot object to the world very close to the table so it would be easy for our robot once the controller was implemented in order to achieve what we wanted it to do.

2. **Configure Camera -** ***Lead: Chandler Phillips, Deadline: Wednesday November 10th 2021***

    a. **Add a camera to the environment to use for computer vision.**
- **Final Results:** In order to achieve adding a camera to the environment, we had to use a totally new protofile for the Ned robot to include a node called “ToolSlot” because webots unfortunately doesn't originally have a “child” node for the camera. Once this was implemented we were able to create a camera node that had to be attached to the robot so we placed it in between the gripper.

3. **Mapping -** ***Lead: Chandler Phillips , Deadline: Saturday November 20th 2021***
    a. **Create Lidar map that shows position of blocks**
    b. **Ensure Camera aligns with Lidar readings**
- **Final Results:** Tried to implement but couldn’t get it in the end. Getting the camera set up with the controller was fairly easy however setting up the computer vision in order to detect the position of the blocks was where our issues came in. Since the camera had to be attached to the Ned Robot that's where the problems had begun, since the blocks were at a fixed height we were planning on just using an external camera. Instead we were just planning on changing the world around and bringing the blocks closer together, and then making a pose for the Ned robot which would fit everything into the frame of the camera so that we could use computer vision. From here it was difficult on how we would be able to use the computer vision, we had questions that couldn't be answered such as how we would get the position of the blocks since we didn’t have an external camera, how computer vision would work and be different from the homework being that we were using a real world application of it versus just a picture. So in the end we decided not to go with the computer vision and had to hard code the position of the blocks in the real world and robot coordinates instead.

4. **Inverse Kinematics -** ***Lead: George “Max” Young, Deadline: Sunday November 23rd***
    a. **Create system of equations to align manipulator with world coordinates**
    b. **Create function that moves manipulator to desired location and orientation**
- **Final Results:** To implement the inverse kinematics for the NED robot we used the IKPY package for python. I originally used the IKPY guide that was posted on piazza but we were not able to get the proper results we needed using the orientation mode. After learning how the example IKPY world in webots worked we were able to get IKPY working with the NED robot. From here we were able to feed in world coordinates to the IK system to manipulate the robot because our robot was centered at the center of the world with the same coordinate system.

5. **Blocks and Manipulator -** ***Lead: Austin Ritz, Deadline: Sunday November 28th***
    a. **Create function to grab a block**
    b. **Extend function to move block to a desired location and orientation**
- **Final Results:** Using the IK that Max made, I was able to create a simple function that would follow targets to grab the blocks and move them to a specific location. But, for

some unknown reason the claw on the NED robot would not grab the blocks. Because of that, the blocks could only be touched by the robot, not grabbed. We demonstrate this in our final video.

6. **Stack Blocks -** ***Lead: Austin Ritz, Deadline: Sunday December 5th***
    a. **Create function to stack blocks in order by color**

- **Final Results:** Again, using the IK and the constant block heights, it was fairly simple to make the robot go through the motions of moving the blocks to a specific position. But as I mentioned above, the blocks could not be grabbed by the robot. Because of this, the robot's stacking must be imagined. The order that the blocks are picked up is variable, and can be changed easily. This would have worked well in tandem with the computer vision, but that part of the project was not realized in time.