Robotics 1 Project Proposal: Dobot Pick and Place

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1 Summary

This project is divided into three major sections: camera calibration, path planning/MATLAB simulation, and motion generation. Firstly, the item to be picked up needs to be recognized using a camera and detection program. Color filtering will be used to detect different items. In a environment where high contrast in color exists, color filtering can strain out all unnecessary items except for the one that the robotic arm aims to recognize. This camera recognition program will return an (x, y) coordinate, which will then be used to perform forward/inverse kinematics to move the Dobot arm.

Meanwhile, a MATLAB model of the Dobot arm needs to be constructed in order to simulate the pick and place process, primarily by simulating the kinematics of the arm. This MATLAB model will perform simulations based on the coordinate returned by the camera program previously discussed. A path between the pick up location and the placing location needs to be defined and simulated to test out the feasibility of such path and motion. Once a path of motion is proved possible using this simulation, the generated path will be ported to the Dobot arm to perform the physical pick and place motion.

2 Background and Motivation

This project will focus on a common practice in the manufacture industry where items need to be picked up and placed down on a specific location on the production line. The process of "pick and place" using a robotic arm significantly increases the manufacturing efficiency since it compensates the high cost and high error of human labor. According to the International Federation of Robotics, the use of industrial robots has been increasing in recent years. From 2015 to 2017, the number of industrial robots per 10,000 manufacturing workers grew from 66 to 85.

The types of robots being used for pick and place vary under different circumstances. The most commonly used robots for this task are the 6-axis Industrial Arms: Cartesian Robots, Delta, Collaborative Robots, Palletizing Robots and the SCARA arm. These robots provide a cost effective and efficient solution to manufacture at large scale. For this project specifically, the Dobot has 4 joints with 3 degrees of freedom. By Implementing a pick and place motion on Dobot, the group will gain insight into how the design of pick and place motion is done in industrial and professional settings. Other than the arm itself, the gripper attachment, located at the arm's end effector, also plays a significant role in the pick and place process. The gripper type/style needs to adequately correspond and be compatible to the material of the item being picked up. In general, material handling grippers that are being used in industrial settings are finger grippers, vacuum grippers, soft grippers and magnetic grippers. Various end effectors were provided alongside with the Dobot. Among them, the gripper is considered as the most suitable end effector for this project since it ensures stability during the whole motion.

In terms of the path planning process, the path between the pick up location and placing location will be predetermined once the item's location is obtained. The motion along the path should be as smooth as possible to make sure the item being picked up does not fall out of the gripper due to arm jerking. In order to guarantee this smoothness, it is important to control the path acceleration. After the Dobot recognizes and picks up and item, the Dobot should be able to follow a specific path and place down the item at a designated location.

3 Goals

The overall objective and target goal for this project is to implement a pick and place motion on the Dobot, using a camera with color filtering to locate the item to be picked up. This objective can be broken down into multiple individual baseline and target goals.

As a baseline, a camera color filtering program will need to be developed in MATLAB and properly calibrated to work on the Dobot machine. The camera program will need to be able to scan the Dobot's surroundings to locate the item (yellow duck) and return it's coordinates. Additionally, the team wants to create a model of the Dobot in MATLAB. Using this model, forward and inverse kinematics can be simulated, providing a stepping stone to full Dobot motion implementation.

Once the baseline objectives are achieved, the next objective is full implementation of the camera and motion onto the Dobot. The Dobot will independently locate the object, and maneuver to it and then to the placing location using forward and inverse kinematic function previously coded onto the Dobot. If time permits, the motion of the Dobot can be regulated using a path acceleration constraint, limiting the erratic and jerky movements that are possible.

1. **Baseline**
   (a) Calibrate camera for object detection and set up connect Dobot and MATLAB with Arudino.
   (b) Define Dobot model in MATLAB, including its forward kinematics, inverse kinematics, and a path that links the pick up location and the placing location.
2. **Target**

(a) Define the picking motion, traveling motion, and placing motion for Dobot with velocity constraint given item's coordinates from camera program..

(b) Implement each motion on Dobot, fully connecting all parts needed for full automation. Debug system to full operation.

3. **Reach**

   (a) Redefine motion along the path with acceleration constraint.

   (b) Implement modified motion on Dobot and debug to full operation.

4 Approach

All of the project programming will be conducted in MATLAB, as it contains useful robotics and webcam toolboxes. MATLAB is also very user friendly with Arduino technology, which is used to control the Dobot. However, prior experience with color filtering will be relied on more than built-in MATLAB toolboxes. The project will begin with the camera's color detection program, will progress using MATLAB simulations, and will end with full Dobot implementation.

- The team will begin by programming a color detection program in MATLAB. This program will be calibrated for the item color (yellow duck). Any camera offsets in the (x, y) directions will be accounted for in the program.
- Once the camera program can return the coordinates of the item, the focus will shift towards modeling the Dobot in MATLAB. A full Dobot model will be created, and functions will be made to calculate forward and inverse kinematics.
- Once basic Dobot modeling has been done, a function to create a path of the Dobot's end effector motion will be created.
- Once the full Dobot model is made, it will be used to generate a path using the item's initial coordinates and the (predefined) placing location.
- After all calibration and simulations are complete, the focus will shift to real-life implementation. First, the camera program will be implemented to locate the yellow duck and determine its (x, y) coordinates.
- Once the duck has been found, the inverse kinematic function from the MATLAB model will be used in conjunction with a fixed z height to maneuver the end effector above the duck.
- Inverse kinematics and a lower z height will be used to move the Dobot end effector directly over the duck (within gripping distance)

- The team will code and implement a program to operate the gripper joint on the Dobot in order to grab and hold onto the duck.
- The forward kinematic function will be used to move the duck (end effector) over the target placing position.
- The team will code a releasing capability for the gripper joint, releasing the duck onto the placing position.
- If time permits, the team will program acceleration constraints into the path simulation, and then implement this acceleration path constraint onto the Dobot.

5 Division of Work

Due to there only being two team members, as well as a large part of this project being rooted in initial simulations/programming, there is a bit of overlap in the division of work. Kyle will focus his initial programming efforts on initial forward/inverse kinematics, while Jiexiang will focus his initial programming efforts on the webcam color detecting. Later, more collaboration will be used as the timeline calls for less programming and more implementation. This division of programming was decided through past experiences and strengths of team members.

Priority	Kyle Botsford	Jiexiang Liu
Primary	Programming and Simulation	Programming and Simulation
Secondary	Project Management/Progress Updates	Webcam Calibration
Tertiary	Modeling/Technical Writing	Modeling/Technical Writing

6 Timeline

Category	Task Definition	Target Date
Deliverables	Project Proposal	10/12/2021
Webcam Code	Download of MATLAB Webcam Toolboxes	10/13/2021
Preliminary Simulation	Dobot Modeling in MATLAB	10/19/2021
Webcam Code	Completion of Working Color-Detecting Program	10/19/2021
Preliminary Simulation	Dobot Forward and Inverse Kinematics in MATLAB complete	10/24/2021
Webcam Code	Calibrate Program for Yellow Duck Color	10/24/2021
Preliminary Simulation	Completion of Path and Motion Simulation	11/01/2021
Dobot Implementation and Webcam Code	Set up Webcam Program on Dobot	11/01/2021
Dobot Implementation and Webcam Code	Debug Until Duck is Accurately Found	11/05/2021
Dobot Implementation	Test motion and Path in Real Situation	11/08/2021
Dobot Implementation	Debug Motion for Precise End Effector Movement	11/12/2021
Background Programming	Calculate and Implement Exact Path for Robot End Effector	11/16/2021
Background Programming	Programming Functions to Operate Opening and Closing of Gripper Joint	11/21/2021
Dobot Implementation	Pick up / release duck	11/23/2021
Dobot Implementation	Combine Webcam Elements, Background Programming Elements, and Partial Implementations for Full Dobot Motion Implementation	12/01/2021
Reach Goals	Generate Simulation for Path with Acceleration Constraint	12/05/2021
Reach Goals	Implement Path with Acceleration Constraint on Dobot	12/08/2021
Deliverables	Video	12/10/2021
Deliverables	Presentation	12/12/2021
Deliverables	Report	12/16/2021

7 References

1. A. Owen-Hill, “The Ultimate Guide to Pick and Place Robots,” RoboDK, 01-Sep-2020. Accessed from: https://robodk.com/blog/guide-pick-and-place-robots/.

2. “Material handling,” OnRobot. [Online]. Available: https://onrobot.com/en/applications/material-handling. [Accessed: 12-Oct-2021].

3. R. D. Atkinson, “Robotics and the Future of Production and Work,” itif.org, 15-Oct-2019. Accessed from: https://itif.org/publications/2019/10/15/robotics-and-future-production-and-work.