Application of Labels Using Robotic Arm
Robotic Arms Identifying and Labeling Packages

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Problem Statement and Constraints

Problem Statement:
- “Use a robotic arm with object detection to identify and label packages.” – Dr. Zhen Yu

Constraints:
COVID-19 Remote Teamwork
- Due to the COVID-19 Pandemic, we will need to work remotely.
Robotic Arm Design and Printing
- Using the robotic arm design from the previous team, we will reprint and redesign the manipulator.

Goal:
- Create and use a robotic arm to label packages.
- Use software and create a program to identify labels and packages.

The Robotic Manipulator

The Robotic Manipulator shown below will be used to apply labels to boxes autonomously:
- This manipulator has 3 Degrees of Freedom (DoF).
- Constructed with 3D-printed components.
- Equipped with DYNAMIXEL XM-430 actuators created by ROBOTIS INC.
- The OpenManipulator design was provided by ROBOTIS AMERICA

Introduction

The Semi-autonomous Labeling Robot is a collaboration project with ROBOTIS and the Robotics Team of the BANSHEE UAV project. Many tasks, such as labeling boxes, are tedious, boring, and an error prone job for human workers. The goal of the project is to develop a robot capable of autonomously identifying and labeling packages. The Robotics Team aims to achieve this goal by designing a robotic arm that uses a webcam and OpenCV, an object detection software, for visual tracking. Dynamixel XM430 motors for robotic movement, and a server run on a Raspberry Pi to control the robot.

The Arm Control Server can be broken down into three components: Communications and Management, Coordinate Translation, and Basic Mapped Motion.

- **Communications and Management** runs as a basic socket server that contains a state machine and basic information about the arm. The state machine determines the actions taken based on client input.
- **Coordinate Translation** uses a series of algorithms to guess and then calculate the angles required for the arm to move. They are based on the triangles created by the arm and the polar distance calculations.
- **Basic Mapped Motion** was designed to help prevent hitting the label on another surface before it is dropped. The arm will always attempt to move up first, then above the location, then straight down. This is currently a simple implementation based on steps in order not to overtax the serial communications with the motors.

The Computer Vision task is to:
- Identify the location of the arm and target box.
- Locate their geometric centroid and the label destination.
- Calculate the distance (differential) between the arm and target box.
- This allows us to know where the robotic arm needs to go to pick up the desired components.
- Using OpenCV, a real-time library optimized for computer vision and hardware, we will use to gather all required data.
- Contour Detection: Defines the object contours in the image.
- Adaptive Threshold: Filtration method that targets and isolates subspaces of high-intensity pixels
- HSV Filter: Filtration method that targets and isolates regions on the image that have specific colors
- Image Localization: Determines the locations of encapsulated objects.
- Contour Sorting: In the case of multiple contours being detected, place all contours into a list and sort them by size. Target the smallest contour and assign the object with ID: 0
- Image Detection Speed: using a 30 FPS camera we were able to get rapid image processing rates of 25-30 FPS depending on the lighting.

Arm Control Server

Arm Control Server

Figure 1: Labeling Robot Logic Diagram

Figure 2: Labeling Robot Design provided by ROBOTIS AMERICA

Figure 3: Dynamixel XM430-WS50 R Motors provided by ROBOTIS AMERICA

Figure 4: Team Organization

Figure 5: Camera View of Setup

Figure 6: Camera View of Setup with Correction

Figure 7: Server Logic Diagram

Figure 8: Motor Interface Logic Diagram

Figure 9: 3D Printed End Effector

Figure 10: Label on Package with Contour

Figure 11: Label on Package without Contour

Figure 12: Label on Package with Correction

Arm Control Server

Figure 13: Motor Interface Logic Diagram

End Effector Design

Purpose: Improve grasping of label from printer and application to package’s surface

Current Design: The current design consists of an air hockey inspired sled, where there are a multitude of holes on the bottom of the end effector that will uniformly provide suction across the entire label.

Design Process: The design process began with the understanding of the physics of suction. From there, how could we enhance the suction while spreading the force such that the label will not be damaged?

Results and Impact

Impact: We hope that this project will encourage people and companies to introduce more automation into their tasks to free up resources. Automation will allow for resources and people to be redeployed to more important tasks. We also hope this project shows that automation can be cheap and reliable. The estimated cost of this project was $1100 and has reliable performance.

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