ELECOMP CAPSTONE
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THE UNIVERSITY OF RHODE ISLAND

THINK BIG WE DO™

Part Identification and Post-Processing Using a Collaborative Robot

HEXAGON METROLOGY

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Project Motivation

One of the rapidly growing areas in manufacturing is automation. Companies today need to be globally competitive and thus must be able to justify highly skilled labor through the efficiency of their operation. To this end, collaborative robots (COBOTs) as well as other automated machinery, must be effectively integrated into each production process and work as independently of human intervention as possible. One such production process in virtually every manufacturing operation is the inspection or measurement process. Coordinate measuring machines (CMMs) have long been used to assist in providing critical measurement data to provide the necessary feedback to control all the other processes responsible for producing the product. Although CMMs are already computer automated and somewhat intelligent in their own operation, they still often rely on human operators to make decisions to prepare parts for inspection as well as analyze the results for corrective action. Hence, we will implement a vision system in our design which consists of Raspberry Pi camera and trained Machine Learning model. Altogether, they serve as an intelligent vision system that will automate the inspection process, and ultimately improve this arduous procedure.

Key Accomplishments

Research and Project Planning
Much of the beginning of the project involved research into what would be the best approach to tackling a series of different problems. Topics included Background Detection with Object Segmentation, Object Classification and Instance Segmentation, Object Orientation Detection, generating data for training and testing using real and simulated objects and images, and research into hardware components.

Initial Hardware Component Selection
A crucial part of the hardware component for this project is a high-quality that is capable of capturing clear image data, and allows object recognition system to locate, identify, and recognize the object in the image. Initial research for types of cameras includes Time of Flight (ToF) 3D cameras, embedded vision cameras, and 2D industrial cameras. Due to the usability and effectiveness in actual implementation, we decided to use Raspberry Pi Camera in our design.

Edge Detection In Images
An essential step in our design is to obtain an image of the drawer and be able to determine if one or more objects are present. The methods used attempt to distinguish the object by recognizing the edges which bound it. This process is tested on images of different objects under different lighting conditions and with different orientations of the viewpoint to determine reliability. From this information, we can also generate the appropriate outputs and labeling for each generated image, including object bounding box and mask information, which can be used to help classify the object. For this task, multiple algorithms were tested on a large subset of images to determine which was the most effective.

Foreground/Background Segmentation
Creating a script that given an image can return a bitmask of the same dimensions labeling the foreground and background of the image. This also aids in object segmentation as non-overlapping objects in an image will be separate and distinct in the scene. These objects can then be passed separately into the model for classification.

Build an Adaptive Linux Testing Environment
Examined the performance of the current testing system and research alternative methodologies to benchmark the performance against the current testing system; built a Linux testing system using a raspberry pi and multiple high-quality programmable cameras; developed an algorithm that would automatically capture image data within a given time; compared and contrasted the quality of image data of different testing systems.

Image Data Processing
Improved background mask performance and implementing multi-object segmentation; created single image slices and properly formatted them to be input into ML models; researched different methods to generate a mask for objects directly on the Linux system.

Integrating Hardware and Software
Built a script to generate JSON object using the model output to be sent to COBOT; researched methods to establish a connection between local Linux system and cloud drive, store large sets of image data onto a cloud drive; developed a method to combine all components together as a final prototype.

Anticipated Best Outcome

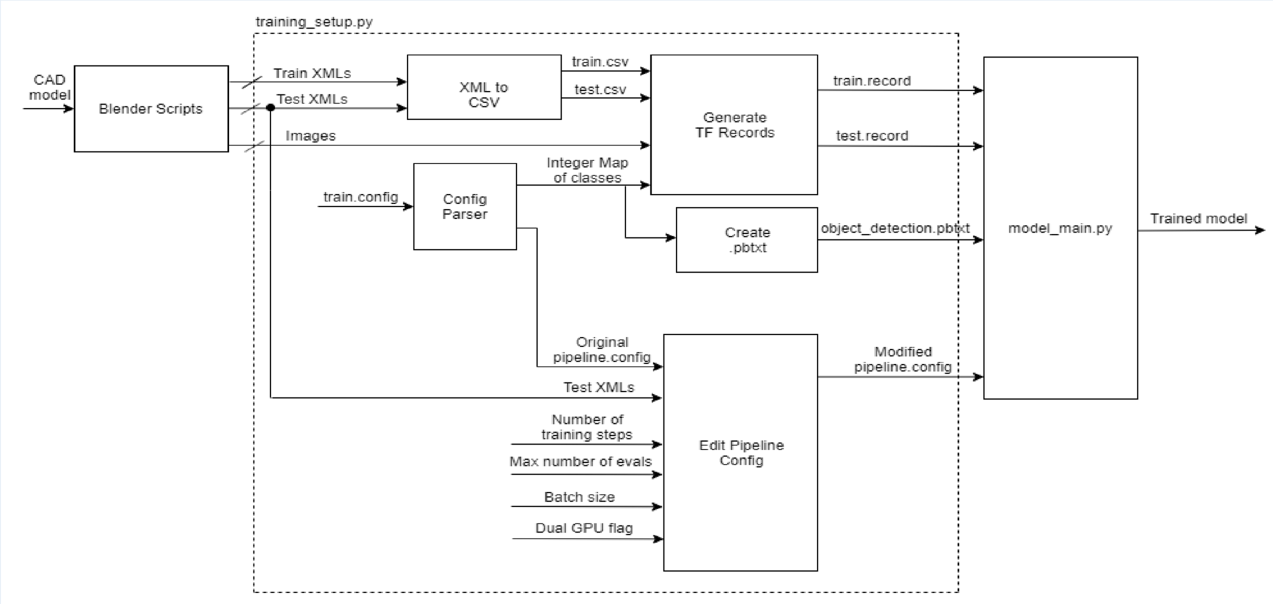
- A part recognition method that is reliable and fast enough for the inspection process, easy to teach for new parts and able to be easily integrated with existing hardware.
- The integration of the part recognition method must also be demonstrated to handle the various error conditions previously described which are typical for the inspection process.

Project Outcome

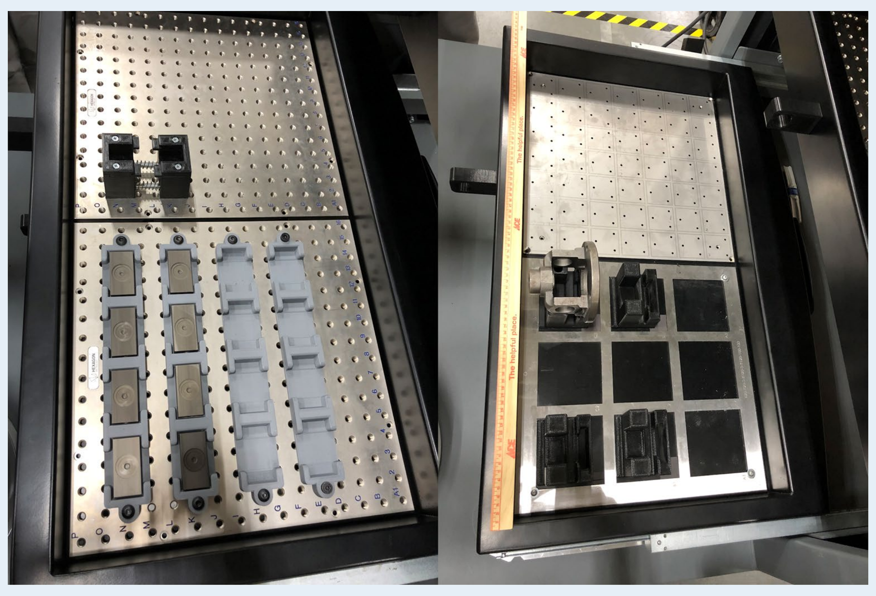
The Anticipated Best Outcome was achieved.

The trained Machine Learning model is capable of identifying the correct objects on an average above 95% of the time.

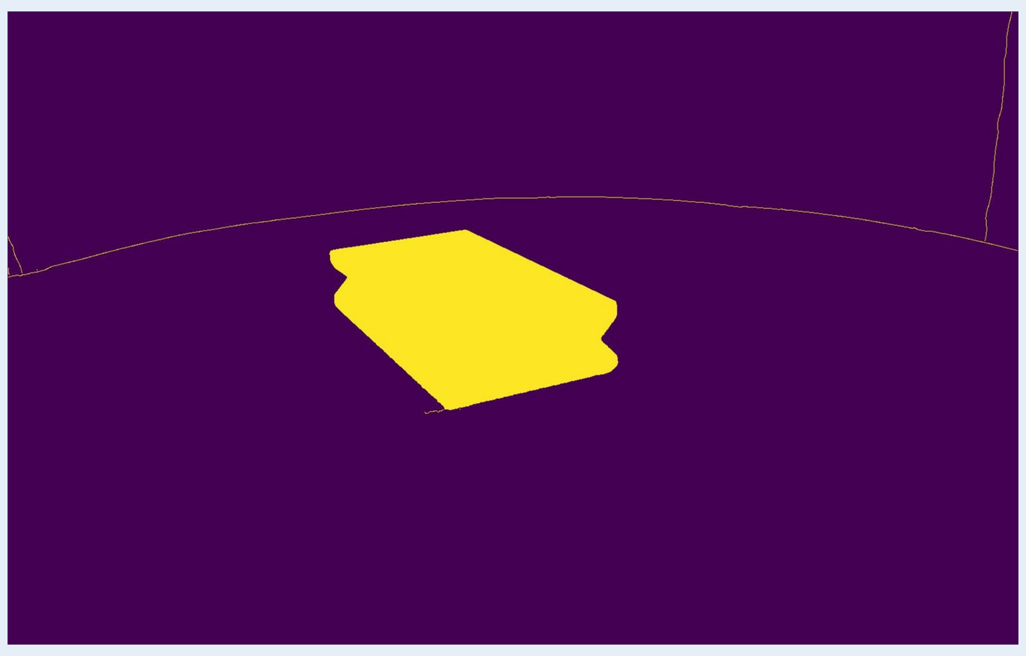
Figures



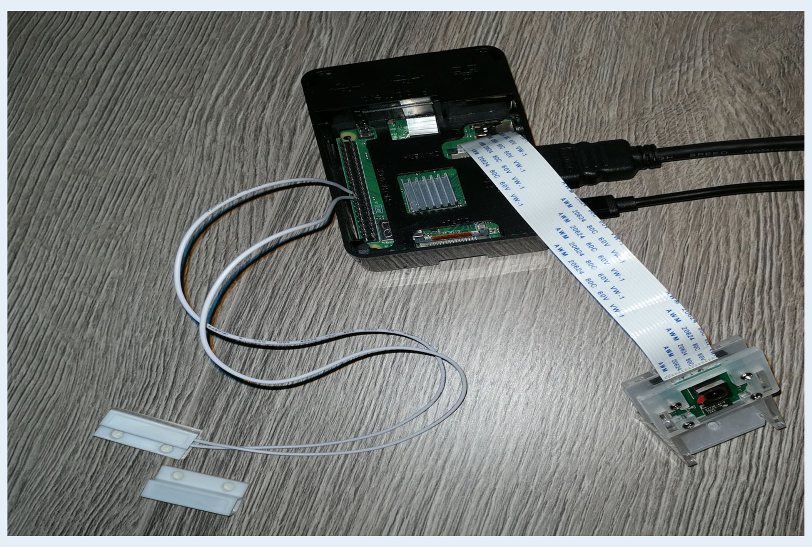
Flowchart Detailing Training Process for ResNet Model



Two Sample Drawer Layouts



Example Part After object detection



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