SYNOPSYS CHAMPIONSHIP PROJECT ABSTRACT

The Abstract is a required part of your project. Bring 10 -15 copies to Project Check-In.

One copy will be attached to your application. One copy will be displayed with your project. Other copies will be for judges to take away. Your abstract should be written after you finish your research and experimentation and should include:

- Project title and the full name of every team member
- Purpose of your project
- Hypothesis or evaluation criteria

- Brief statement about the procedures and equipment
- Results (analysis of data)
- Conclusions

Type or print neatly using 10- or 12- point black font, single spaced. Your abstract should be 500 words or less and fit within the frame.

Project number: 112-H40-81

Detection and Classification of Recyclable Items to Help Recyclable Facility Robots Identify and Pick Them Up Correctly
Niranjan Bhatia

The project's goal is to solve America's growing recycling problem. Many recyclable objects end up in landfills. Sorting them is a hazardous job. Pick-and-place robots, using computer vision, can recognize the objects and bin them accurately. This reduces the need for manual labor preventing injuries.

Convolutional Neural Networks (or ConvNets) have good performance in recognizing and classifying images. The project's purpose is to compare the performance of GoogLeNet Inception-v3, Resnet50, and VGG-16 ConvNet models in classifying recyclable items. The ConvNet's prediction will be used by a pick-and-place robot for classifying and binning the items.

The project's hypothesis is that GoogLeNet Inception-v3 will have the best training performance due to the many built-in optimizations (batch normalization, global average pooling, loss functions). Resnet50 will have the best prediction accuracy. It will learn better due to its deep layer architecture and optimizations done to improve performance (batch normalization, global average pooling, skip connections). VGG16 will have the lowest prediction accuracy and training performance due to the high number of parameters and the fully connected layers.

As part of the project methods, the ConvNets need to be trained to recognize images. Pictures were taken of 7 recyclable and 4 non-recyclable objects. The recyclable objects include milk carton, aluminum foil, coke can, plastic bottle, plastic spoon, cardboard container, and cardboard box. Non-recyclable objects include straws, glass bottle, M&M's candy tube, and steel spoon.

The ConvNet program was initially written in a Jupyter notebook in Google Collab in which the required TensorFlow and Keras libraries were imported. A classifier was added on top of the base model and trained until the desired accuracy was obtained.

It was found that Inception-v3 had the best training performance without GPU acceleration. For 15 epochs, it took 18 min to train versus 28 min for Resnet50 and 58.5 min for VGG16. The performance was relatively even with GPU acceleration. It was also found that as the number of training epochs increased from 15 to 200, Resnet50 had the highest prediction accuracy in the range of 68-77%, which was less than our engineering goal of 95%. The Resnet 50 prediction response time was 0.27 – 0.33 sec which was more than the engineering goals of <0.1 sec. The prediction accuracy of Inception v3 dropped dramatically from 68.19% to 26.14% while that of VGG16 increased from 55.17% to 65%.

Since Jetson Nano Kit has a GPU, the prediction accuracy is a more critical selection factor. Hence, Resnet50 model was selected as the best of the three. The trained model was loaded on to the Jetson Nano kit for testing the pick-and-place robot. The kit was connected to a Raspberry Pi Camera for taking pictures and to a nano microcontroller which controlled the motors and robot arm. A program loaded in the microcontroller to direct the motor movement which moved the robot's arm to pick-and-place the items for binning.