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.

**SYNOPSYS CHAMPIONSHIP PROJECT ABSTRACT**

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

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

**America’s Growing Recyclable Problem – Robotic Convnets to the Rescue!**

**Niranjan Bhatia**

The project’s goal is to solve America’s growing recycling problem. Many recyclable objects end up in landfills and are mixed with non-recyclable objects. 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 as follows. 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 FC 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 image classes. The recyclable image classes include milk carton, aluminum foil, coke can, plastic bottle, plastic spoon, cardboard container, and cardboard box. Non-recyclable items 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 are available. 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%. 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 ConvNet’s prediction accuracy is a more critical factor in selection. Hence, Resnet50 model was selected. The trained model was loaded on to the Jetson Nano kit for test the pick-and-place robot. The kit was connected to a Raspberry Pi Module 2 Camera for taking pictures and to a nano microcontroller which controlled the motors and robot arm. A program loaded in the microcontroller controlled the movement of motors which moved the robot’s arm to pick-and-place items for binning.

When executed, a Python main program took a picture of the objects and passed it to the Resnet50 model for prediction. Based on the prediction, the program sent a signal to the microcontroller which directed the pick-and-place robot to bin the item.