Processing Student Image Data with Kubernetes and HPCC Systems GNN on Azure

American Heritage High School Boca/Delray (AHS)
Carina Wang

Abstract

In order to foster a safe learning environment, measures to bolster campus security have emerged as a top priority around the world. Through this internship project, HPCC Systems was leveraged to process student images with Kubernetes running on the cloud while utilizing the Generalized Neural Network (GNN) bundle for image classification. The prevailing obstacles in Machine Learning are insufficient real-world data and developing models from scratch. To combat these challenges, this project took an alternative approach to data collection (converting videos to still images), and evaluated multiple pre-trained models to identify the model with peak accuracy levels and time efficiency. Simultaneously, the HPCC Systems Thor functionality was tested by varying parameters on the GNN bundle. The result is a trained image classification model which can be implemented on the AHS student-built security robot to help campus security personnel identify visitors, students, and staff.

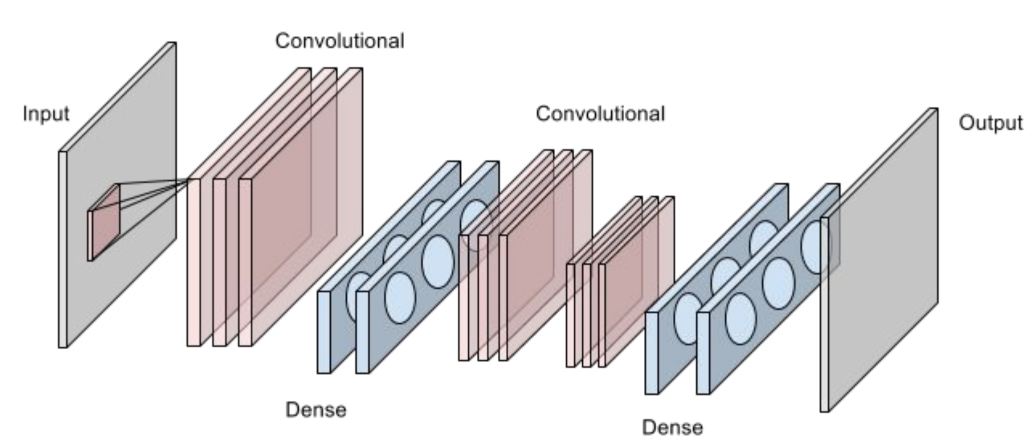

Figure 1. CNN Diagram

Introduction to CNN and GNN

Emerging from the study of human vision, Convolutional Neural Networks (CNNs) efficiently process pixel data and thus are commonly used for image classification. As shown in Figure 1, the convolutional layer usually is not fully connected; perceptrons in the pink layer only receive part of the input. Generalized Neural Networks (GNNs) that coordinate Keras and TensorFlow are the HPCC Systems implementation of Deep Neural Networks.

Project Goals

- Collect and process student images on Azure
- Train a model to output "AHS student" or "Not an AHS student" based on the individual in the image
- Evaluate various models to optimize accuracy and efficiency by tweaking parameters
- Bolster capabilities on the cloud as HPCC Systems transitions from Bare Metal to the Cloud Native Platform
- Develop a standard procedure for using GNN
- Leverage HPCC Systems in the cloud environment by testing GNN and Thor clusters to train a dataset while identifying bugs/improvements through opening JIRA tickets

Obtaining Data

Instead of artificially altering the angle of a person's head tilt in each image, videos were taken using the camera on the Security Robot and converted to still images. Each individual moved their head around in circles (Figure 2), comparable to the process for setting up Face ID on an iPhone, to simulate real images the robot would capture.

Figure 2. Video to Image Process and Computer play of Model Predictions

Improvements to HPCC Systems

- The GNN bundle now supports Keras Applications
  - Developers can use reliable, industry standard models instead of developing their own
- Opened 15 JIRA tickets (8 bugs, 7 improvements)
  - All enhance the HPCC Systems Cloud Platform
- Improved HPCC Systems GNN model development and training related tasks for user functionality
- Created flowcharts (Figure 6) to streamline findings into a complete set of procedures for anyone using the HPCC Systems GNN bundle
- Solved the "OOMKilled" and "Index Out of Range" error messages in the GNN training code

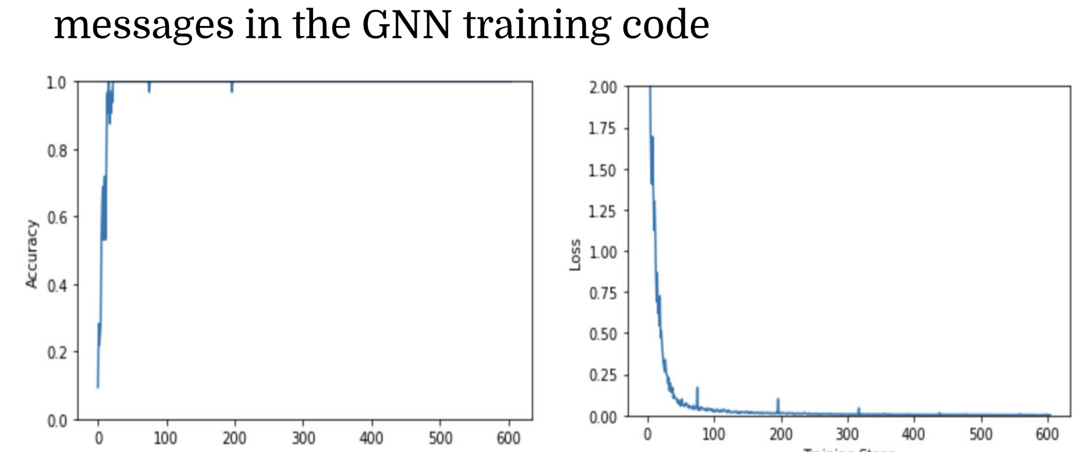

Figure 3. MobileNet V2 Accuracy (100%) and Loss (0%) Graphs

Evaluating Models

Multiple industry-standard models (listed in Keras Applications) were tested locally on Jupyter Notebook to compare training speed and accuracy with 5 epochs. The goal is to minimize the loss function. Using the student dataset, all of the models achieved 100% accuracy (nearly 0% loss) with MobileNetV2 processing images at the quickest speed (Figure 3).

GNN Training Time

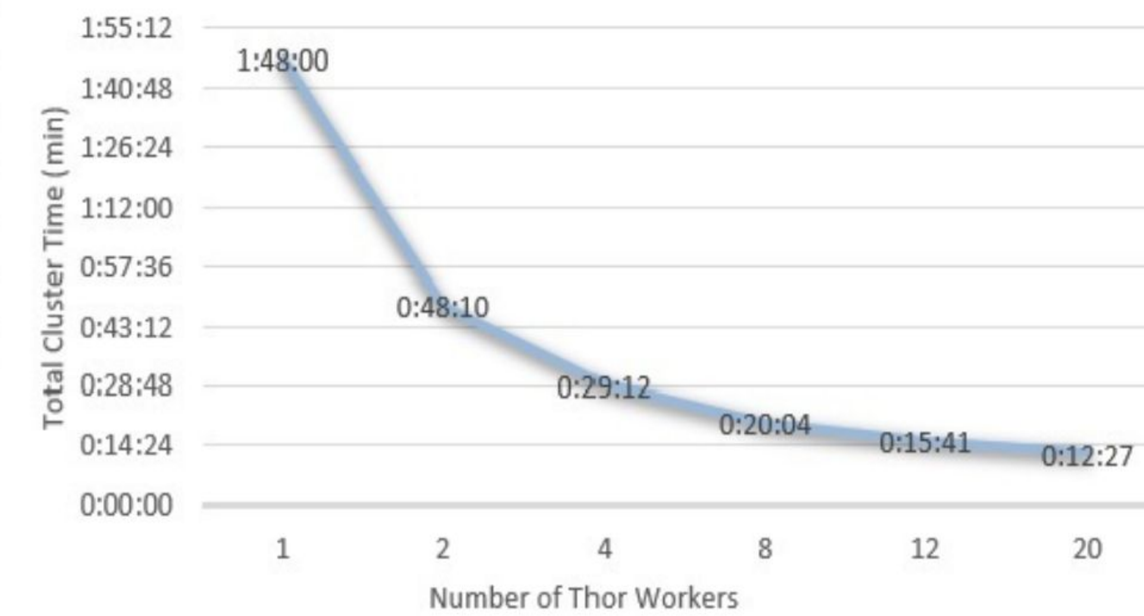

Figure 4. Total Cluster Time vs. Number of Thor Workers

Training with GNN on Azure

The GNN code (from the HPCC Systems GNN Tutorial) was modified to support Keras Applications. The number of HPCC Thor Workers used was adjusted to test for optimal performance parameters. All testing trials used 5 epochs, 224x224x3 as the image size, and MobileNet V2. Results (displayed in Figure 4) show that, as expected, more Thor Workers results in quicker training times because more resources are being used to process the same amount of data. Since HPCC Systems is known for processing big data, a long Thor test was completed to ensure that the developments from this project would still be applicable with a larger dataset. The test was completed in 5 hours with 100% accuracy and no errors in ECL Watch. This work set up any future project using the HPCC Systems GNN bundle on the cloud by troubleshooting and identifying optimal parameters.

Performance and Efficiency

- Dataset of 4,840+ images (classified as student or non-student)
- All models tested locally reached 100% accuracy within the first 2 epochs
- MobileNet V2 consistently trained a model with 100% accuracy locally within 4 minutes
- All of the MobileNet V2 model predictions correctly outputted the student or visitor ID corresponding to the individual in the image
- Testing results concluded that using the GNN bundle and 20 Thor Workers can train a model at 100% accuracy in 12 minutes (compared to 48 minutes for the same results with default settings)
- Spot instances reduced costs of keeping the data and work units on the cloud by over 80% (Figure 5)

Figure 5. Spot Instances

Resources

Links: GitHub | Blog | Flowcharts
Email: bd557401@ahschool.com

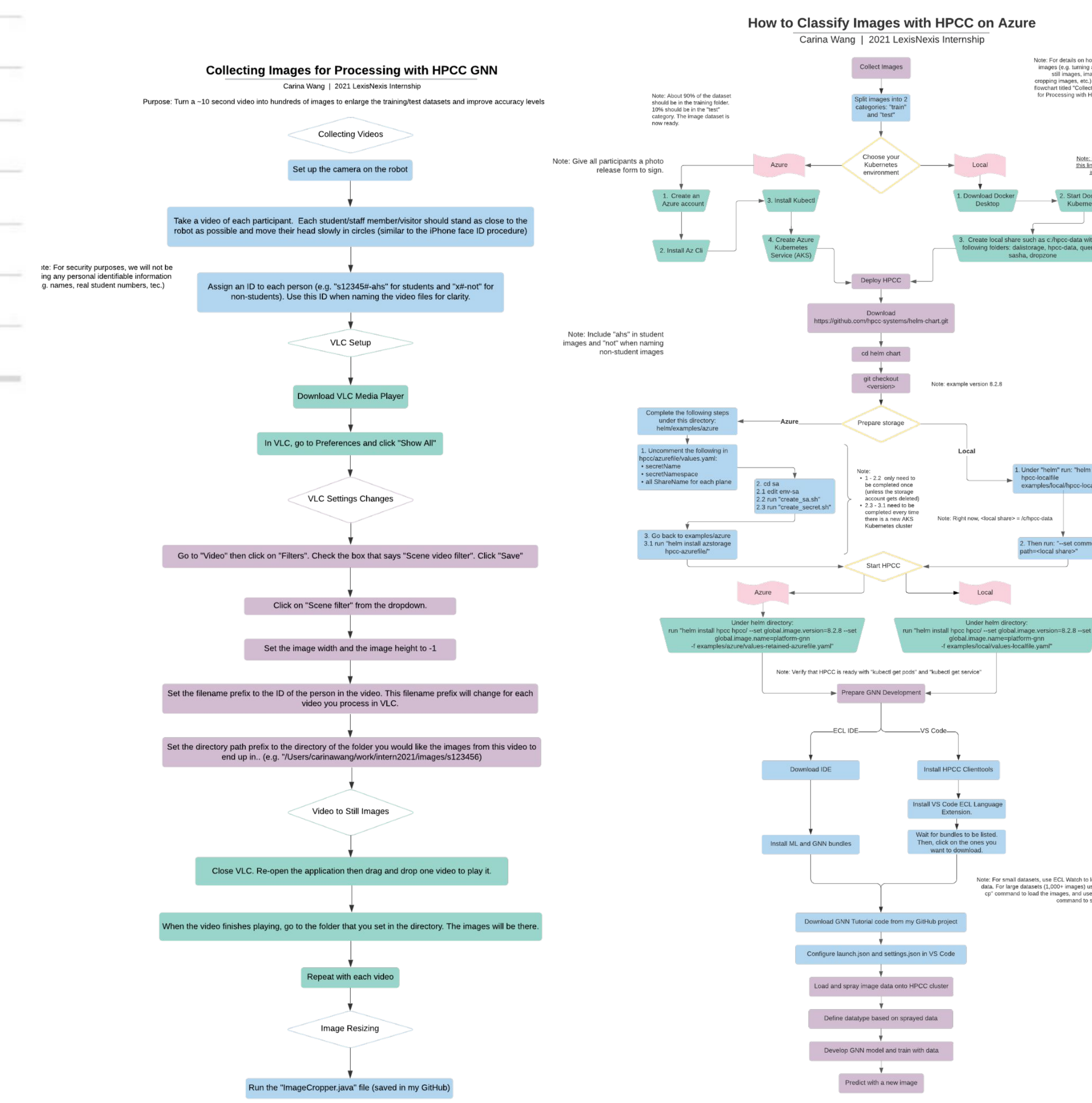

Figure 6. Flowcharts

References

[1] Géron, Aurélien. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems. United States, O'Reilly Media, 2019.
[2] Sandler, M., Howard, A., Zhu, M., Zhmoginov, A., and Chen, L.-C. Mobilenetv2: Inverted residuals and linear bottlenecks. CVPR, *https://arxiv.org/pdf/1704.04861.pdf*, 2018

Conclusion and Implementation

Through testing in the local environment and on the cloud, results show that the use of industry-standard models such as Keras Applications for GNN model development can achieve optimal performance results. Images were collected and processed while following LexisNexis Risk Solutions Group Azure Access and American Heritage School (AHS) security protocols when working with secure data including student images. By testing HPCC Systems Thor and GNN functionalities on Azure, problems and improvement tasks were identified. Two flowcharts were developed for all future integration of user applications with GNN and the HPCC Systems Cloud Native Platform. The image classification model will work in conjunction with devices mounted on our security robot (including a touchscreen, voice commands, fingerprint scanners, a PTZ camera, and more) as part of a larger, interactive security feature.