Capstone Proposal for project: Inventory Monitoring at Distribution Centers

Domain Background

Amazon is the largest eCommerce company in the world. Amazon ships approximately 1.6 million packages a day[1] and it offers order delivery within two days at no additional cost to its Prime members. Handling the logistics of such a large number of packages and ensuring that items can be delivered to customers in time to ensure the best user experience is a huge challenge for Amazon.
Amazon has responded to this challenge by building a large and efficient supply chain to ensure the best user experience. According to Amazon's official website, the eCommerce giant has more than 175 fulfillment centers, occupying approximately 150 million sq feet of space, spread across the world[2]. In addition, Amazon is estimated to operate roughly 500 warehouses worldwide[3]. Distribution centers play an important role in the process of delivering goods to customers in a timely manner, and the intelligence and automation is key to optimize operations and speed up delivery .

Problem Statement

Inventory management, a critical element of the supply chain, is the tracking of inventory from manufacturers to warehouses and from these facilities to a point of sale. Quickly synchronizing data between orders and available inventory quantities is the key to quickly and efficiently meeting consumer demand. This requires distribution centers to be able to quickly and accurately count and record the number of objects delivered and received, which can often be in the millions.
However, trying to count millions of objects manually is not enough to meet the demand for real-time or quasi-real-time inventory data updates, and can also bring huge expenses to the company. This requires the introduction of artificial intelligence, such as intelligent robots, to help companies accomplish these tasks efficiently.

Solution Proposal

Robots are primarily used to move objects from point A to point B in order to facilitate inventory management. Objects are carried in bins which can contain multiple objects. We can train the robots to identify the number of objects inside each bin and record this data for automation and intelligence. Since the images of the objects inside each bin have been collected, we will use the Image Classification method to count the objects. We will use Sagemaker, a fully managed service for machine learning solution by Amazon, to train and deploy image classification model. For the model, we will use the pre-trained model Resnet50 to train our image classification model to identify the number of objects inside the bin.

Dataset and Input

The dataset we currently use is sourced from the Amazon Bin Image Dataset, which contains over 500,000 images and metadata from bins of a pod in an operating Amazon Fulfillment Center. In this project, Udacity provides 10.4K images with a json metadata file which contains upto 5 objects in the bins. We will create a folder called train_data, and download training data and arranges it in subfolders according to the json file provided by Udacity. Each of these subfolders contain images where the number of objects is equal to the name of the folder. For instance, all images in folder `1` has images with 1 object in them. Finally, we will divide the train_data into training, test and validation sets.

Benchmark Model

The Amazon Bin Image Dataset (ABID) Challenge provides a benchmark for moderate task that counts upto 5 objects, and the accuracy is one of the evaluation metric. Considering the same prediction target and metric, I will use the 55.67% of accuracy

as the benchmark. It run 40 epochs, and every 10 epochs learning rate will decay by a factor of 0.1. Batch size is 128. Benchmark accuracy can be seen in below.

Accuracy(%)	RMSE(Root Mean Square Error)
55.67	0.930

But we won't apply the hyperparameters it uses directly. 5 epochs will be good for us.

Evaluation Metrics

The accuracy will be the evaluation metric. It can be used to evaluate exactly how accurately our model counts the number of objects in bins.

Project Design

I'll train and deploy our pre-trained Resnet50 image classification model using AWS Sagemaker because SageMaker enables developers to create, train, and deploy machine-learning models in the cloud and also enables developers to deploy ML models on embedded systems and edge-devices[4].

I will follow the below process to design the project:

1. **Data Preparation**
    a. Downloading from Amazon Bin Image Dataset
    b. Spliting them into train, test and validation
    c. Uploading divided data to S3 bucke
2. **Explore the Dataset**
    a. Identifying the data size for each class in each dataset like train/test/validation
    b. Have a look some images randomly
3. **Training Model**
    a. Train with the pre-trained model, Resnet50.
4. **Hyperparameter Tuning**

    Below two hyperparameters will be considered:

    a. learning rate
    b. batch_size
5. **Model Evaluation**

    a. Check out the accuracy for the best model and compare with the bechmark.
6. **Model Deployment**

    a. Predict images by invoking the inference endpoint.

Reference

[1] https://landingcube.com/amazon-statistics/

[2] https://www.aboutamazon.co.uk/amazon-fulfilment/fulfilment-in-our-buildings
[3] https://feedvisor.com/resources/amazon-shipping-fba/3-key-elements-to-amazons-supply-chain-strategy/
[4] https://en.wikipedia.org/wiki/Amazon_SageMaker