Machine Learning Engineer Nanodegree
Capstone Proposal Naresh K.

Inventory Monitoring at Distribution Centers

Domain Background

In the recent times, Artificial Intelligence and Machine Learning technologies have been adopted by different verticals. One of the reason that they have become popular now a days is that we now have increased computing power to train large machine learning models and more data to train our models to get an increase in accuracy.

Modern supply chain management can greatly benefit by adopting these technologies. Machine learning in supply chain management can especially impact inventory levels, quality, supply and demand, production planning and transport management. This is important for supply chain management moving forward, particularly when applied to warehouse management.

A smart warehouse combines various interconnected technologies to form an ecosystem whereby an entire business operation, from supply to delivery, is governed by Artificial Inteligence. Goods are received at the warehouse, identified and sorted, processed, packaged, and pulled for shipment, all automatically and with minimal margin for error.

Incase of amazon, the distribution centers like Amazon Fulfillment Centers play an important role in delivering millions of products all over the world. These centers often use robots to move objects as a part of their operations. These products are randomly placed in bins, which are carried by robots. Occasionally, items are misplaced while being handled, resulting in a mismatch between the recorded bin inventory and its actual content.

This problem of mismatched inventory bins can be detected by adopting the Machine learning techniques, which will definetly help further in improving the productivity and efficiency of the distribution centre.

Problem Statement

Amazon uses a random storage scheme where items are placed into accessible bins with available space, so the contents of each bin are random, rather than organized by specific product types. Thus, each bin image may show only one type of product or a diverse range of products. Occasionally, items are misplaced while being handled, so the contents of some bin images may not match the recorded inventory of that bin.

Now, the project is to build a machine learning model that can classify the image based on the number of objects in the bin. A system like this can be used to track inventory and make sure that delivery consignments have the correct number of items.

Datasets and Inputs

For this project a subset of Amazon Bin Image Dataset [1] will be used.

The Amazon Bin Image Dataset contains over 500,000 images and metadata from bins of a pod in an operating Amazon Fulfillment Center. The bin images in this dataset are captured as robot units carry pods as part of normal Amazon Fulfillment Center operations. The dataset is available on Amazon S3. Images are located in the bin-images directory, and metadata for each image is located in the metadata directory.

The contents of each bin are random, rather than organized by specific product types. Thus, each bin image may show only one type of product or a diverse range of products.

Since this is a large dataset, only a subset of the data will be used for this project. The subset of bin images dataset will be choosen so that the number of objects in a bin range from '1' to '5' only.

The subset of data created will be arranged in subfolders. 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. Then dataset will be divided into training, testing and validation sets.

Sample images from the dataset;

Solution Statement

The solution is to train and build a Deep Learning model using a pretrained model that can classify the image based on the number of objects in the bin. The input to the model is an image of a bin with the products in it and the output is list of predicted scores for each category type in this case the number of objects in the bin. Individual instances need to be counted separately, which means if there are two same objects in the bin, count them as two.

Benchmark Model

Since this is a classification problem the model output needs to be evaluated by accuracy. The benchmark for this project is to be able to get the model accuracy of **55.67%** or more. This value has been taken from the Amazon Bin Image Dataset Challenge[3].

Evaluation Metrics

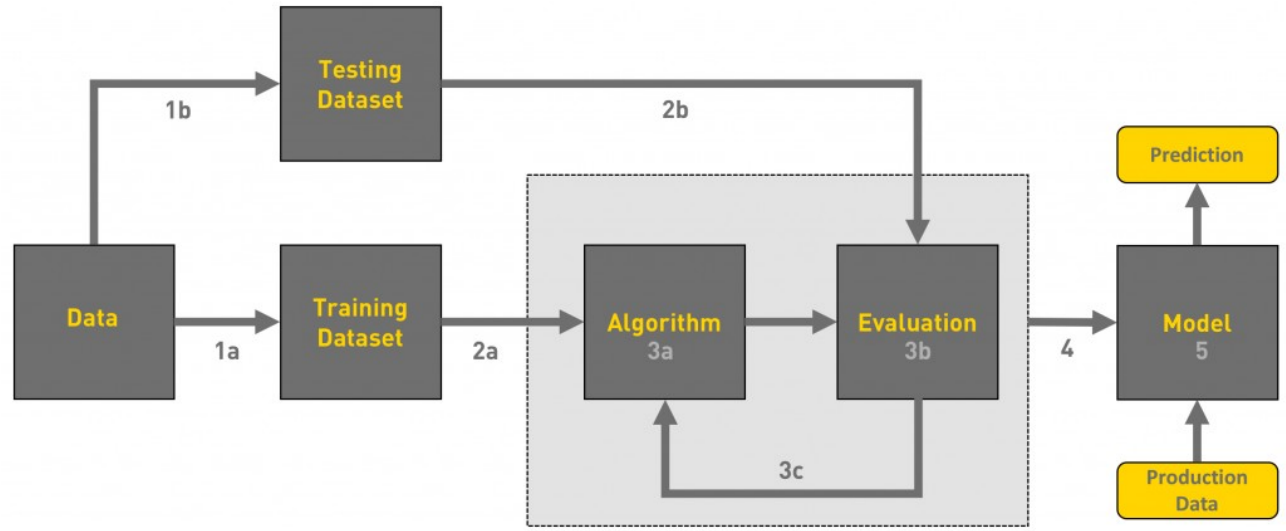
For this image classification based on the object count, the model predictions can be evaluated by a standrad metrics, accuracy(precision). 1 is indicator function, and p and g is prediction and ground truth respectively.

$$\text{Accuracy: } \frac{1}{N}\sum_{i=1}^{N} 1[p_i == g_i]$$

Project Design

This is an image classification problem. To perform this image classification a machine learning model will be built using a process called transfer learning. In this process a pretriained convolutional neural network model like **resnet50** will be used to fine tune on the Amzon Bin Image Dataset.

Workflow of ML



The major steps involved in this project are;

- Setting up AWS SageMaker
- Data Downloading to S3 and Preparation
- Creating Training Script and Submission Script
- Hyperparameter Tuning
- Fine Tuning the pretrained model with best Hyperparameters
- Model Deployment

Technologies that will be used in this project;

- AWS SageMaker
- AWS S3
- python
- pytorch
- AWS EC2
- AWS Cloudwatch etc.

Resources and references:

1. Amazon Bin Image Dataset : https://registry.opendata.aws/amazon-bin-imagery/

2. Documentaions : https://github.com/awslabs/open-data-docs/tree/main/docs/aft-vbi-pds

3. Amazon Bin Image Dataset(ABID) Challenge : https://github.com/silverbottlep/abid_challenge

4. Amazon Inventory Reconciliation using AI : https://github.com/pablo-tech/Image-Inventory-Reconciliation-with-SVM-and-CNN

5. Project Starter files : https://github.com/udacity/nd009t-capstone-starter

6. https://towardsdatascience.com/

7. https://supplychaingamechanger.com/