Capstone project proposal:
Inventory Monitoring at Distribution Centers

F. Siavashi

Domain Background

Keeping the right number of parts and products in a packaging customer orders, is one of the challenges that distribution centers and warehouses face. Inventory monitoring is a process to check the number of products in inventories as well as the number of ordered items in packages. Distribution centers use robots to move items as a part of their operations. Items are carried in "**bins**" which can contain multiple items. Due to the massive amount of bins that should be delivered every day, computer vision is an excellent automation choice to verify the number of items in each bin before packaging and delivery.

This project aims to solve the challenge of monitoring the number of items in each bin. I want to investigate this problem because it matches my business plan. Even in smaller distribution centers, for example in grocery shops, this project is also practical. In this project, I will use a public dataset from Amazon Bin Image Dataset, which contains images and metadata from more than 500,000 bins. The dataset also is studied in two different projects (Amazon Bin Image Dataset(ABID) Challenge) and (Amazon Inventory Reconciliation using AI, n.d.).

Problem Statement

One of the challenges in warehouse and distribution centers is to make sure that the number of items in each package is correct. On one hand, if packages are delivered with some missing items, then the reputation of the service provider will be damaged. On the other hand, if there are extra items in a package, then the service provider will lose profits. To this end, it is required to keep track of the correct number of items in the bins. One way to solve this problem is to utilize computer vision and machine learning to detect the number of items. The advantage of using computer vision rather than employing humans is that it can learn from a large number of images and calculate the number of items much faster than a human with less error.

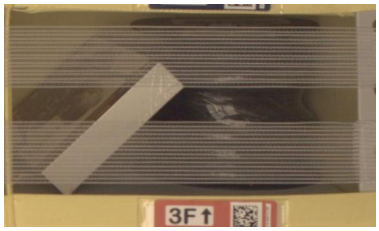
Solution Statement

To solve the problem, I need a training model that can detect different items. Since items are variable and have different shapes and sizes, image recognition and image classification are required. The dataset contains additional information about the images which will be used for preprocessing and cleaning the dataset. After preprocessing, I will use a pre-trained Deep learning model such as ResNet50 with pytorch that is available at Amazon Sagemaker studio.
I will apply some hyperparameter tuning and select the best result to train the model. The accuracy of the model can be measured by RMSE (Root Mean Square Error) for counting the items. Evaluation of the accuracy of the item detection (the second objective) can be done by other measurement tools such as IoU (Intersection of Union). I will deploy an endpoint which can be

called with a bin image as an HTTP request and responses with the calculated number of items in the image.

Datasets and Inputs

The Amazon Bin Image Dataset is a public dataset that can be accessed here. It contains more than 500,000 images and metadata. Examples of the images in the dataset are shown below. As it can be seen, items in some of the images are not clear. Therefore, we expect to have some errors in our trained model.



Metadata of each image provides more information about the bin. The tricky part in this image is that there are 3 items inside a clear packed item which is counted as 1 item. As it is shown in the metadata, the expected quantity is 1, although 3 items are detected.


```
{
  "BIN_FCSKU_DATA": {
    "B002900BWW": {
      "asin": "B002900BWW",
      "height": {
        "unit": "IN",
        "value": 2.3
      },
      "length": {
        "unit": "IN",
        "value": 6.299999999999999
      },
      "name": "Nature Made Potassium Gluconate 550mg, 100 Tablets (Pack of 3)",
      "quantity": 1,
      "weight": {
        "unit": "pounds",
        "value": 0.35
      },
      "width": {
        "unit": "IN",
        "value": 3.3999999999999995
      }
    }
  },
  "EXPECTED_QUANTITY": 1,
  "image_fname": "302.jpg"
}
```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Benchmark model

In the study that is conducted in (Amazon Inventory Reconciliation using AI), for the same dataset, different architectures of CNN are trained and compared. From the result of all trained models, ResNet34 with Adam optimization algorithm has the best performance. I will use this result as the benchmark to evaluate my proposed training model.

Evaluation Metrics

I will measure the training accuracy, validation accuracy and validation RMSE (root-mean-square error) as the evaluation metrics. RMSE is a standard way to measure the error of a model in predicting quantitative data. It is a great choice for a loss metric for deep neural networks.

Project Design

First, I will download a portion of the dataset since the dataset is very large (500,000 images). I will check the metadata and how it can be used for evaluation of the training model. Then, I will check the format and size of the images and normalize them if needed. To improve performance of the model I will use some of the data augmentation techniques such as color transformation, rotation and flipping the images. I will use pytorch which provides different image augmentation choices.
Next, I will split the data to train, validation and test sets. I will store the data into S3 and use Sagemaker studio for using a pre-trained ResNet50 model (I may change my model if needed). I will provide a range of hyperparameters and use a GPU to execute multiple training jobs to get the best values of the hyperparameters.

After training a model with the best hyperparameters, I will plot the train/validation accuracy as well as measure the RSME. At this point I can compare the model results to the benchmark and make adjustments to my model if not performing better than the benchmark. After refining the model, I will perform some graph visualization for better understanding of the data distribution. I will deploy it and create a Lambda function and an API to predict the number of items in a given image.

References

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

Amazon Inventory Reconciliation using AI. n.d. “Amazon Inventory Reconciliation using AI.” Amazon Inventory Reconciliation using AI. https://github.com/pablo-tech/Image-Inventory-Reconciliation-with-SVM-and-CNN.