Inventory Monitoring at Distribution Centers

AWS Machine Learning Capstone Proposal

By

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Domain Background

AI and Machine learning has become an integrated part of our society and has been used in things never been imagined before with the advances in technology. The scope is AI and ML is vast and it has been a catalyst in solving many problems and savings billions for the industries. In the past decade, there has been tremendous increase in online shopping, and it has impacted many industries like supply chain logistics, warehouse etc. For all the industries to work in harmony and have a smooth operation, it is important to adopt new technologies to keep with the growing demand along with maintaining the efficiency and throughput. There have been many advances in the warehouses due to advances in robotics (Automated Guided/Retrieval System). Modern supply chain is slowing implementing AI&ML in their day to day to improve their operation and reduce errors. For example, Amazon solely handles the supply chain of its products, from warehouse to delivery which makes them a perfect example on why it is important for them to use AI and solve problem and redundancies throughout the process[1,2].

Problem Statement

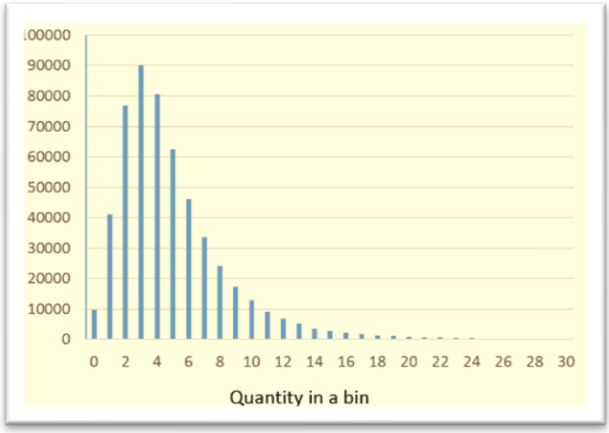
Amazon currently have a manual process of loading items into the bins depending on the order in the warehouse. It has deployed robots within few warehouses which remove the question of human error but still most of the warehouses are operated by humans. Investing in robots is a huge front investment and it might have a few years to be implemented throughout all the warehouses. When the work is done by human, there comes multiple challenges like placing the right item, right color, right quantity etc. Also, humans get fatigue after long working hours and tends to make more mistakes. We will discuss a few ways to solve this problem – implementing automated warehouse system with robots which could solve it but as discussed above but it might take a long time to be implemented. Second solution would be to find a way to implement AI/ML in such a manner that the human employee is able to track different metrics on a screen which can help in reducing errors.

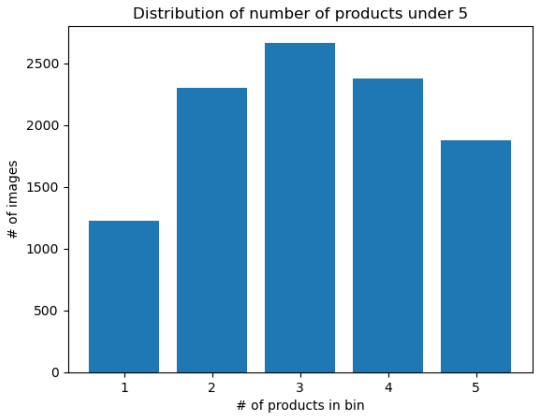
Solution Statement

In order to solve the above problem, we will go with the second solution. We will be using CNN model to process the Amazon Bin Image Set to classify them. PyTorch Deep Learning framework will be used and different services of AWS like Sagemaker, S3, Endpoints etc. will be used to help us achieve the required solution. This solution will help classify the data. We will be using ResNet pre-trained model and tune hyperparameter as per our requirement to achieve the best possible model to give us the count of items in the bin.

Datasets and Inputs

For this project, we will be using the Amazon Bin Image Dataset[3]. This dataset includes over 500,000 bin JPEG images and corresponding JSON metadata files describing items in bins in Amazon Fulfillment Centers. The dataset is available on Amazon S3 and can be imported from there. In this project we will focusing on bin sizes which can contain up to 5 pieces as including all the data would consume heavy resources and as per the histogram most of the images have pieces less than 10 so 5 would be a ideal choice for this exercise. It contains ~10,000 images which would not consume a lot of resources. Below is the histogram and we can see up to 5 pieces, 3 pieces bins has the highest quantity.





Benchmark Model

For benchmarking this model, we will be using the model from here[4]. It is created by abid_challenge. The model can be downloaded and be used to compare the performance with ours. The model has the accuracy of ~56% and a Root Mean Square Error of 0.9 at 21 epochs after which it saturates and starts to overfit. These metrics will be used as a benchmark for our model.

Evaluation Metrics

As mentioned above, we will be using accuracy and RMSE to evaluate the model and try to make it as accuracy as possible without overfitting.

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accuracy = correct predictions / total predictions
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RMSE = sqrt(sum((predicted_count - true_count)^2) / n)
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n = Total number of observations
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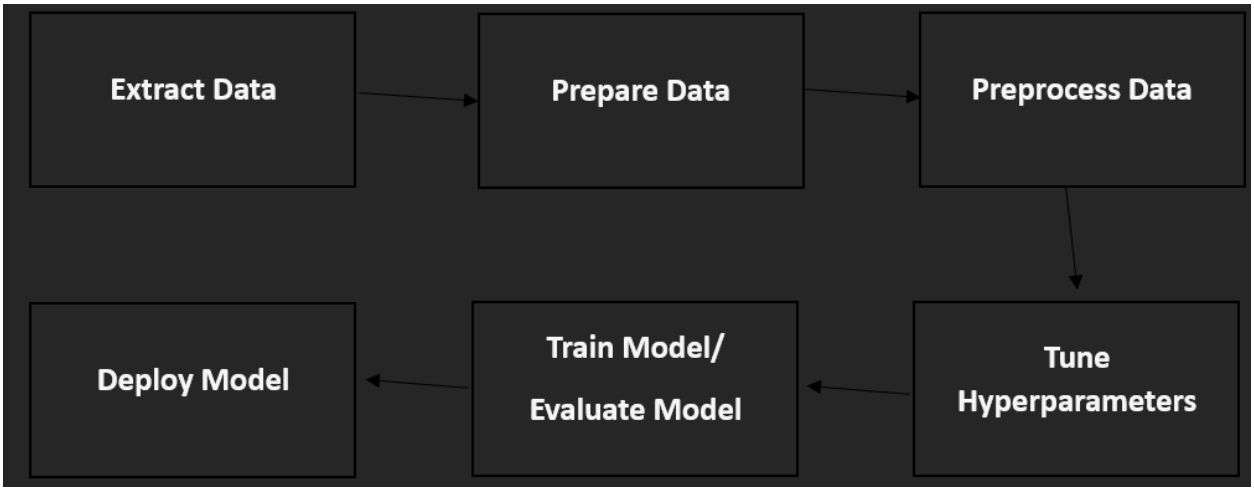
Project Design

The project will flow as below:



1. **Extract Data**: This step involves extracting data from the Amazon Bin Image Dataset. The dataset contains images and metadata from bins of a pod in an operating Amazon Fulfillment Center. We will only focus on photo with upto 5 products in a bin.
2. **Prepare Data**: This step involves preparing the extracted data for use in the Amazon Bin Image Dataset. The data is cleaned, formatted, and transformed into a format that can be used by the model.
3. **Preprocess Data**: This step involves preprocessing the prepared data to make it suitable for use in the model. This includes tasks such as normalization, scaling, or feature extraction.
4. **Tune Hyperparameters**: This step involves tuning the hyperparameters of the model to improve its accuracy and performance. This is done by adjusting the values of the model's parameters to optimize its performance.
5. **Train Model/Evaluate Model**: This step involves training the model on the preprocessed data. The model is then evaluated to determine its accuracy and performance.
6. **Deploy Model**: This step involves deploying the model to a production environment. This is done to ensure that the model is available for use by other applications and services.

References

1. Howe, P. (2023, October 27). *Wakefern achieves inventory management with computer vision and ai*. RFID JOURNAL. https://www.rfidjournal.com/wakefern-achieves-inventory-management-with-computer-vision-and-ai

2. *How to use Computer Vision for inventory monitoring in Supply Chain*. EPAM. (2023, February 28). https://www.epam.com/insights/blogs/how-to-use-computer-vision-for-inventory-monitoring-in-supply-chain
3. *Amazon bin image dataset*. Amazon Bin Image Dataset - Registry of Open Data on AWS. (n.d.). https://registry.opendata.aws/amazon-bin-imagery/
4. Silverbottlep. (n.d.). *Silverbottlep/abid_challenge: Amazon bin image dataset challenge*. GitHub. https://github.com/silverbottlep/abid_challenge