Automated Retail Product Checkout

A. Problem Statement

In the present days, the automated checkout system (ACO) is booming in retail company sectors. At this high time, we implement the Convolution Neural Network (CNN) models to pre-train the images in an attempt to automatically categorise the products. Henceforth, it reduces the manual work and so the retailer can utilise the labour force on things that matter. To achieve this real-time demand, in our project, we will discuss the relevant theory and evaluate the performance of the existing datasets like Retail Product Checkout(RPC) dataset, Freiburg groceries dataset and Grocery store image dataset by implying three classification models for each. The biggest challenge includes size, fine-graininess, variable lighting of images and difficulty in gathering training images due to frequent product updates [3]. Our project proposes a classification technique for the extensive training of varying and complex datasets to attain promising classification results with high degree of accuracy. When compared to existing models, if the products are placed on a surface for recognition, it could be difficult for a system to identify all the items exactly in certain situations like when the products overlap each other or when there is no specific distance between them. This motivated us to implement a model which can overcome this problem by integrating our models with OpenCV methods so that it can work efficiently without any margin of error in real-time.

B. Image Dataset Selection

RPC Dataset: In the RPC dataset, there is a collection of 200 retail SKUs(Stock Keeping Units). The collected SKUs can be divided into 17 meta-categories, i.e., puffed food, dried fruit, dried food, instant drink, instant noodles, dessert, drink, alcohol, milk, canned food, chocolate, gum, candy, seasoner, personal hygiene,.The dataset covers products with diverse appearances and shapes such as bottle-like, box-like, canister-like, bag-like, to name a few. [3]

Freiburg Groceries: Freiburg Groceries is a groceries classification dataset consisting of 5000 images of size 256x256, divided into 25 categories. It has imbalanced class sizes ranging from 97 to 370 images per class. Images were taken in various aspect ratios and padded to squares. [2]

Grocery store image dataset: This dataset contains natural images of grocery items. All natural images are taken with a smartphone camera in different grocery stores. There are a total of 5125 natural images from 81 different classes of fruits, vegetables, and carton items (e.g. juice, milk, yoghurt). The 81 classes are divided into 42 coarse-grained classes, where e.g. the fine-grained classes 'Royal Gala' and 'Granny Smith' belong to the same coarse-grained class 'Apple'. [1]

Table 1. Summary of all the three datasets

	RPC Dataset	Freiburg Groceries Dataset	Grocery Store Image Dataset
No. of classes	17	25	81
No. of images in training set	53,739	4,749	2640
No. of images in testing set	24,000	74	2485
No. of images in validation set	6,000	-	-
Image resolution	1800x1800	256x256	348X348
Image format	.JPEG	.JPEG	.JPEG

C. Possible Methodologies

We will be processing our data using different data enhancing techniques like rotational range, width shift range, height shape range, shear range, zoom range, horizontal flop, and fill mode to extend the direction and colour increase of the input images. Data preprocessing is done to resize and normalize the data to make it consistent and to understand the data, t-SNE is to be used to reduce the higher dimensionality of the data. We are looking forward to using transfer learning for knowledge transfer to use pre-trained models to speed up the training process and improve the performance of the models. Since our second dataset has imbalanced classes, we would like to address that by using class weight and Synthetic Minority Oversampling Technique (SMOTE) [2]. We are looking forward to implementing the following algorithms: Resnet101, googlenet, and Caffenet. The approach we will follow for these CNN algorithms is that we use image convolution and other filters to produce invariant functions transferred to the next level. The following layer features are mixed with various filters to provide more invariant and abstract features, and the procedure proceeds until the end feature/output is consistent in conclusions. We will also implement Hyperparameter tuning concentrating on learning rate, the number of epochs, loss function, and batch size to improve the models' accuracy. For our novelty, we will be using the methods of OpenCV in order to integrate our models with live cameras for live accurate and precision class recognition. We will also use the AUC ROC Curve, Confusion Matrix, and the results of the classification report to evaluate our models' performance. [1, 2]

References

[1] Hedvig Kjellstrom Marcus Klasson1, Cheng Zhang. A hierarchical grocery store image dataset with visual and semantic labels. *arXiv preprint arXiv:1901.00711*, 2019. 1

[2] Andreas Eitel Wolfram Burgard Philipp Jund, Nichola Abdo. The freiburg groceries dataset. *arXiv preprint arXiv:1611.05799v1*, 2016. 1

[3] Lei Yang1 Peng Wang Xiu-Shen Wei, Quan Cui and Lingqiao Liu3. Rpc: A large-scale retail product checkout dataset. *arXiv preprint arXiv:1901.07249v1*, 2016. 1

AI Project Gantt Chart

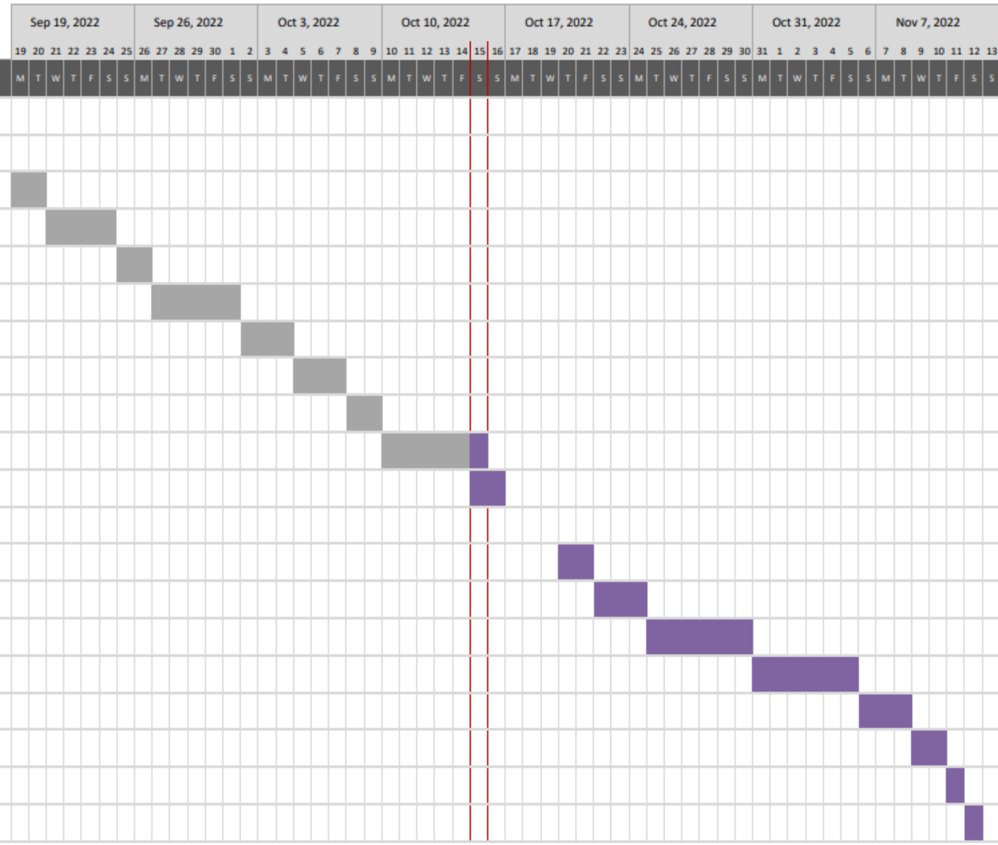
Team - I
Project Admin : Krishna

SIMPLE GANTT CHART by Vertex42.com
https://www.vertex42.com/ExcelTemplates/simple-gantt-chart.html

Project Start: Sat, 9/17/2022

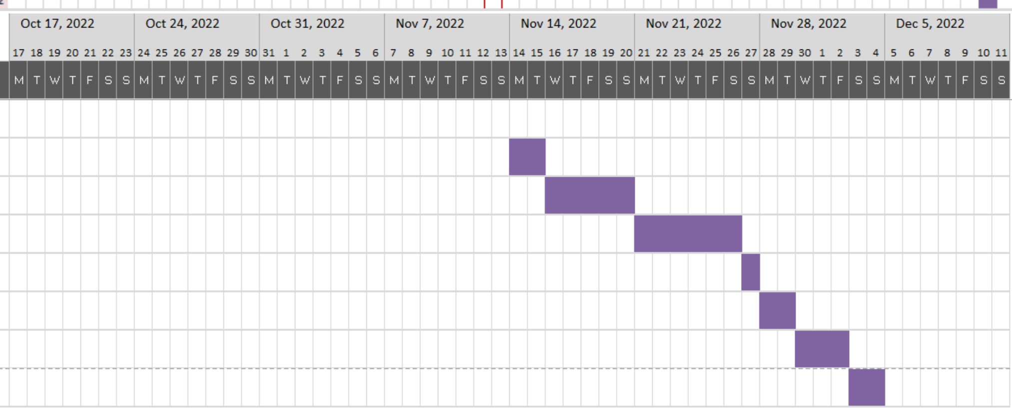
Display Week: 2

TASK	ASSIGNED TO	PROGRESS	START	END
Project Proposal				
Project Proposal	Krishna	100%	9/17/22	9/18/22
Team formation	Krishna, Ajay,Sharanya, Arul	100%	9/19/22	9/20/22
Dataset Search	Ajay,Sharanya	100%	9/21/22	9/24/22
Problem Identification	Krishna,Arul	100%	9/25/22	9/26/22
Novely Discussion	Krishna,Ajay,Sharanya,Arul	100%	9/27/22	10/1/22
Finalizing dataset	Krishna	100%	10/2/22	10/4/22
Proposal Draft	Krishna,Ajay,Sharanya,Arul	100%	10/5/22	10/7/22
Proposal submission	Krishna,Ajay,Sharanya,Arul	100%	10/8/22	10/9/22
Revision of Proposal	Krishna,Ajay,Sharanya,Arul	90%	10/10/22	10/15/22
Final Proposal Submission	Krishna,Ajay,Sharanya,Arul	20%	10/15/22	10/16/22
Progress Reporting				
Data Preprocessing	Sharanya	0%	10/20/22	10/21/22
Data vizualization	Ajay	0%	10/22/22	10/24/22
Data Analysis	Sharanya,Ajay	0%	10/25/22	10/30/22
Model Development	Krishna,Sharanya	0%	10/31/22	11/5/22
Result Analysis/ Evaluation	Arul,Krishna	0%	11/6/22	11/8/22
Testing the Model	Arul,Sharanya	0%	11/9/22	11/10/22
Future improvements discussion	Ajay,Sharanya,Krishna,Arul	0%	11/11/22	11/11/22
Progress Reporting	Ajay,Sharanya,Krishna,Arul	0%	11/12/22	11/13/22



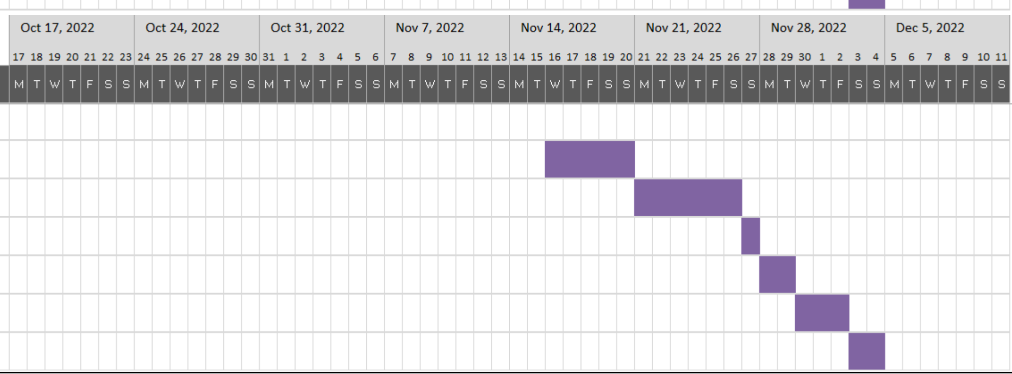
Display Week: 6

TASK	ASSIGNED TO	PROGRESS	sTART START	END
Final Reporting				
Preparation of first draft	Sharanya,Ajay,Krisnha,Arul	0%	11/14/22	11/15/22
Statistical assessment	Sharanya,Krishna	0%	11/16/22	11/20/22
Describing the computational comp	Ajay,Arul	0%	11/21/22	11/26/22
TA's assessment	Sharanya,Ajay,Krisnha,Arul	0%	11/27/22	11/27/22
optimization algorithm and metric e	Ajay,Krishna	0%	11/28/22	11/29/22
Final report drafting	Sharanya,Ajay,Krisnha,Arul	0%	11/30/22	12/2/22
Final report submission	Sharanya,Ajay,Krisnha,Arul	0%	12/3/22	12/4/22



Display Week: 6

TASK	ASSIGNED TO	PROGRESS	sTART START	END
Final Presentation				
Preparing slides	Arul, Sharanya	0%	11/16/22	11/20/22
First draft	Krishna,Ajay,Sharanya,Arul	0%	11/21/22	11/26/22
Finalise the presentation	Krishna,Ajay,Sharanya,Arul	0%	11/27/22	11/27/22
GitHub submission	Krishna,Arul	0%	11/28/22	11/29/22
Slide Presentation Video recordi	Krishna,Ajay,Sharanya,Arul	0%	11/30/22	12/2/22
Final video submission	Krishna	0%	12/3/22	12/4/22



Our Data Analysis would take about 2 and half weeks to complete which includes Data pre-processing, Data visualization, Dimensionality reduction and Statistical Inferences. Furthermore, it would take 1 week for developing the model using the specified CNN models and Open CV library as mentioned in the possible methodologies. Once the model is ready, we start testing the models against the three datasets and apply transfer learning where possible and to achieve the best possible results we start tweaking the hyper parameters like trying out different batch sizes, trying out different epoch values, etc. Then we move on with performance evaluation with AUC, ROC curves, confusion matrix, classification report.