FRESHNESS DETECTION FOR FRUITS AND VEGETABLES

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Background

- Agriculture accounts for 40% of Ethiopia's GDP while employing more than 80% of the population.
- Ethiopia generates 90% of its foreign currency from agricultural exports.
- In 2021, the food quality and safety score in Ethiopia was 41.6 points out of 100. (A decrease compared to 2019, when it was 44.6).
- In Ethiopia in 2023, 22.25% of the population was estimated to be food insecure and the World Food Program (WFP) estimates that 14–15 million people in Ethiopia are experiencing severe food insecurity

Long-term Objectives

- A computer system that utilizes Artificial Intelligence and Computer Vision to address and improve food quality control in the country's agricultural sector.
- Boost consumer confidence in food safety.
- Potentially increase agricultural exports.

Project Objectives

- Focus on a small-scale implementation, concentrating on specific varieties of fruits and vegetables commonly found in local markets. (Oranges, Mangoes, Bananas, Apples, Cucumbers, Carrots, Potatoes)
- Scope is limited to a mobile application but an ideal application of the system is best suited for an IoT device with a dedicated GPU

Data Collection

- Initially compiled our dataset by combining multiple open source datasets from different sources.
- But later resorted to a YOLO version 8 style dataset due to the inapplicability of the earlier data for a robust object detection system.

Training for classification

- Initially, trained our data for an image classification system by using more traditional CNN architectures.
- But the models we gained from such architectures, performed very poorly on actual images we took on our phone.
- We also tried more advanced architectures like VGG-16, Resnet-18 and Resnet-50 with pre-trained weights, but the results were unsatisfactory.

Results from classification

- The different Convolutional Neural Network architectures we used were not able to generalize properly on real life data.
- We tried different techniques including image augmentation to increase the variety of the data but the end results were still unsatisfactory in terms of testing outside of the sample space.

YOLO (You Only Look Once)

- So, we changed the problem from Image Classification to Object detection.
- Because of its single-shot detection capability, we found YOLO to be more suitable than other techniques like the sliding-window method.
- Single-shot detection = Process an entire image with a single forward pass to detect and locate objects

Training with YOLO

Input:

- The dataset has to be prepared in a unique format.
- A text file containing the class of the object, the coordinates of the center of object and its dimensions (height and width)

Output:

- A model capable of detecting an object from any image, labeling it based on the training data, and drawing its coordinates.

Previous Work with YOLOv4

- Department of Computer Engineering, Gachon University, South Korea, October 2022
- Results:

Table 5. Comparison of fruit and vegetable classification models training precision with original fruit and vegetable images.

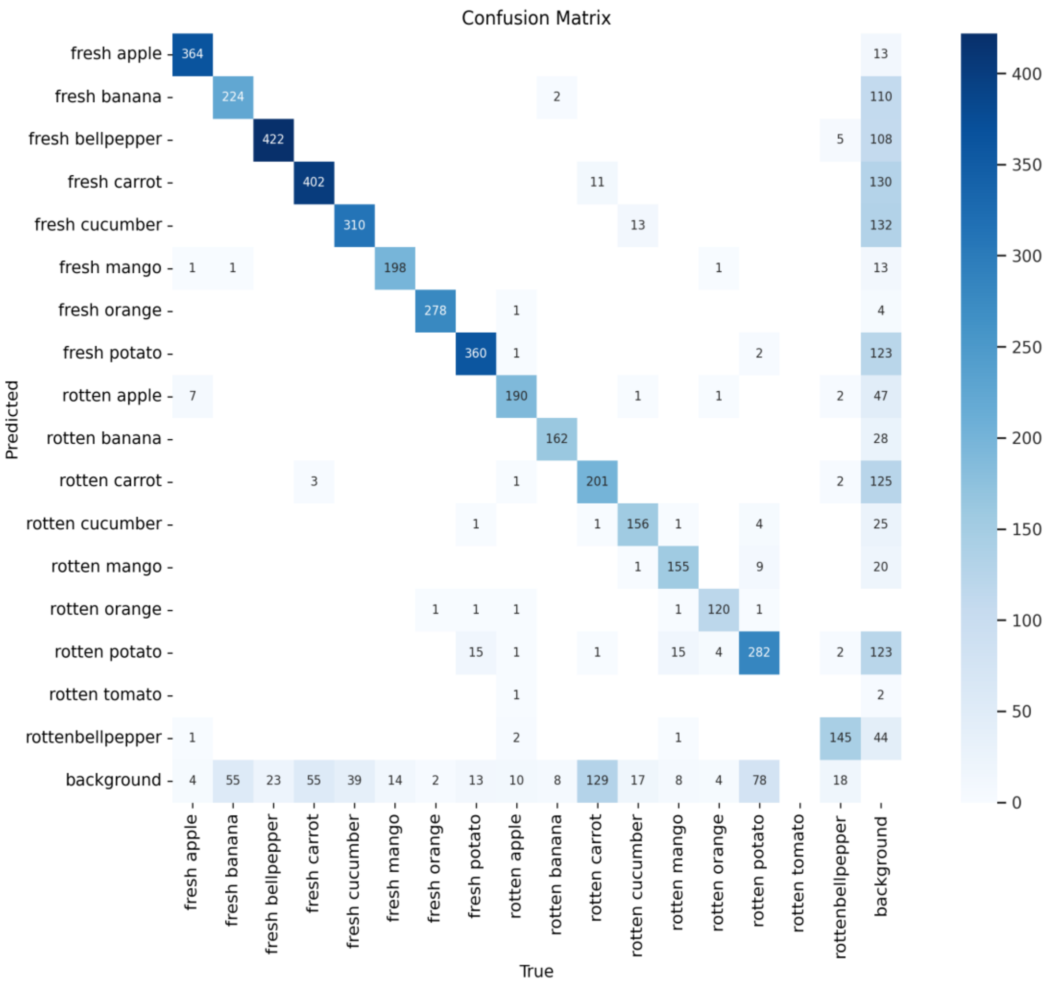
Models	Training Image Size	Training Results ($AP50$)	Testing Image Size	Testing Result ($AP50$)	Training Time	Iteration Number
YOLOv3 [45]		63.7%		60.8%	82 h	
YOLOv3-tiny [45]		43.4%		37.8%	11 h	
YOLOv4 [11]	416 × 416	71.3%		68.2%	71 h	
YOLOv4-tiny [11]		48.6%		45.1%	8 h	
Parico et al. [36]		70.7%	608 × 608	67.6%	72 h	225
Fu et al. [46]	224 × 224	62.4%		58.5%	42 h	
Liang et al. [47]	416 × 416	64.3%		62.6%	80 h	
Improved YOLOv4		72.5%		69.2%	68 h	

Limitations

- Resources:
- The two platforms we used for free GPU access were Google and Kaggle. Google only allows a maximum of 12 hours of use per day for regular users. And we also had difficulties with the internet connection, often resulting in being interrupted before training finishes.
- So we were only able to train for 50 epochs compared to the 225 by the researchers from Korea.
- And an un-interrupted training time of about 2 hours. (up to 80 hrs by the researchers)
- We have also ended up using a smaller data size to accommodate our resources.

Results with YOLOv8

- What helped us compensate for the limitations we faced was the use of YOLO version 8 instead of version 4.
- mAP50 – mean average precision at 50% Intersection over Union (measure of overlap between predicted bounding box and ground truth bounding box)
- IoU = area of intersection divided by area of the union
- MAP50 => the mean of the average precision at 50% for each class
- Results:
  - Training mAP50 = 88.2%
  - Testing mAP50 = 63.6%



CONFUSION MATRIX

- Higher accuracy in getting the fresh products right
- Struggles more to get the rotten (stale) products right

Conclusion

- The proposed system will definitely improve the existing food quality control measures in Ethiopia if applied with the right resources.
- The system can be extended to include other locally-grown and widely consumed products like onions, tomatoes, papayas, … etc.
- It could even be applied to other agricultural products like Coffee (which accounts for more than 25% of the country's exports) and teff.