Detection and Ripeness Classification of Bananas Using Deep Learning Methods

Group 5

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Outline

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Problem Description

- Automate the ripeness classification of bananas
- Predict when a banana will be at the ripeness level desired by a user

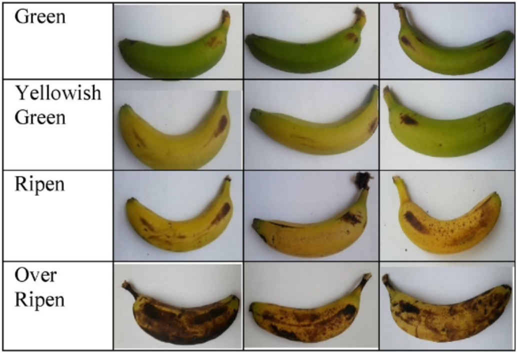

Figure 1: Samples from the dataset from *Saranya et. al.*

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Why is the Problem Important?

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- Is responsible for 10% of global greenhouse gases emissions.

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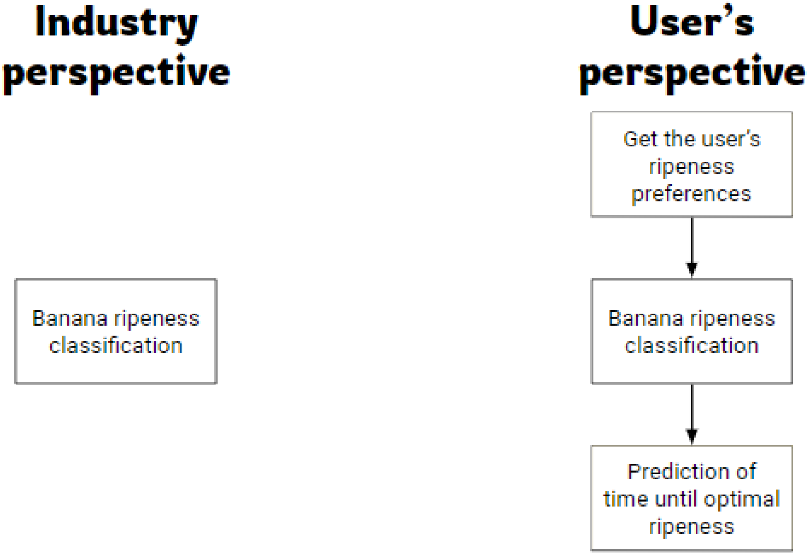
General Workflow: Industry vs user perspective



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Data

- Combining multiple datasets
  - From the *Saranya et. al.* article
  - Manually labeled data from our dataset
- Data augmentation techniques

Ripeness preference algorithm

- Dating app-like method to obtain the user's ripeness preferences
- Allows for personalized outputs

Figure 2: Banana ripeness preference module in the GUI

Object Detection & Segmentation

- Deep Learning
- YOLO is the state-of-the-art

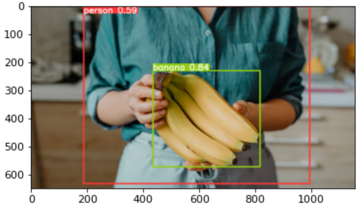

Figure 3: Yolo in action

Segmentation and cropping

Figure 4: Before and after segmentation and cropping of bananas from the dataset built

Data Pre-processing

- Convert the images to HSV colour-space
- Resize all images into 62×62 dimensions and normalize these

Ripeness Classifier: CNN

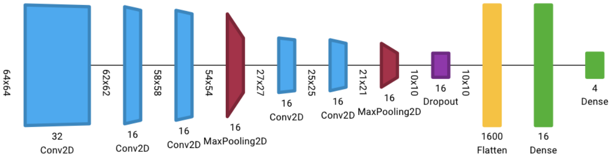

Figure 5: CNN diagram

- Loss: Ordinal categorical cross-entropy
- Hyperparameter tuning

Ripeness Evolution Through Time Module

- Didn't use the CNN outputs from our dataset because of their volatility
- Used manually labeled data from our dataset

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Results

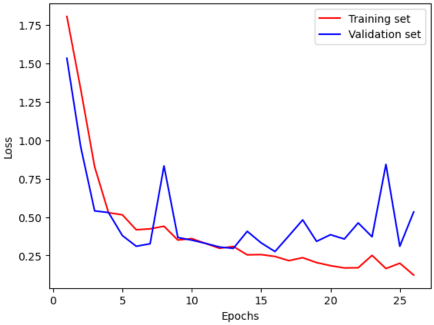

Figure 6: Loss during training

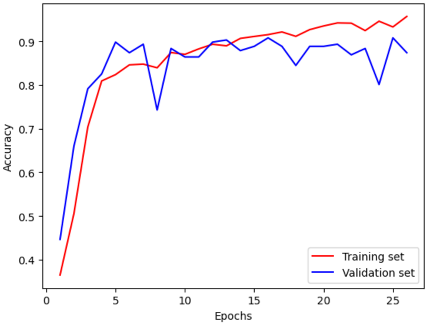

Figure 7: Accuracy during training

Metrics of the model

Class	Precision	Recall	F1 score	Support
Green (0)	0.99	0.95	0.97	74
Yellowish Green (1)	0.77	0.91	0.83	47
Ripe (2)	0.95	0.83	0.88	63
Over-ripe (3)	0.92	1.00	0.96	22

Table 1: Per class metrics of the model

Ripeness Evolution Through Time Module

- Result: $m = 0.00777 \text{ class units/hour} = 0.1865 \text{ class units/day}$ or change ripeness stage roughly every 5.36 days

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Future Work

- Host the project in a web page for easier access
- Gather more data to decrease the CNN volatility

Conclusions

- The results were very reasonable taking into account the lack of variability in the original dataset.
- Many methods were developed to solve this issue greatly increasing the accuracy of the model in unseen data
- The GUI proved to be concise and user-friendly, allowing the project to be more easily used in real world scenarios

References I

https://www.ozharvest.org/food-waste-facts/

https://www.chicagotribune.com/opinion/commentary/ct-opinion-food-waste-20210409-3k3llled4fbmlp3nwhiej3o354-story.html

C. Yang, A. Bochkovskiy, H. M. Lia0 (2022). 'YOLOv7: Trainable bag-of-freebies sets new state-of-the-art for real-time object detectors'. arXiv:2207.02696.

J. Terven, D. Cordova-Esparza (2023). 'A Comprehensive Review of YOLO: From YOLOv1 to YOLOv8 and Beyond'. arXiv:2304.00501.

S. Rath (2022). 'Fine Tuning YOLO v7'. https://https://learnopencv.com/fine-tuning-yolov7-on-custom-dataset/

A. Kirillov et al (2023). 'Segment Anything'. arXiv:2304.02643.

References II

Y. Amit, P. Felzenszwalb, R. Girshick (2020). 'Object Detection'. In: 'Computer Vision'. Springer, Cham. https://doi.org/10.1007/978-3-030-03243-2_660-1

N. Saranya, K. Srinivasan, S. K. Pravin Kumar (2021). 'Banana ripeness stage identification: a deep learning approach'. Journal of Ambient Intelligence and Humanized Computing. https://doi.org/10.1007/s12652-021-03267-w

Y. Zhang, J. Lian, M. Fan and Y. Zheng (2018). 'Deep indicator for fine-grained classification of banana's ripening stages'. EURASIP Journal on Image and Video Processing. https://doi.org/10.1186/s13640-018-0284-8

References III

F. M. A. Mazen, A. A. Nashat (2018). 'Ripeness Classification of Bananas Using an Artificial Neural Network'. Arabian Journal for Science and Engineering. https://doi.org/10.1007/s13369-018-03695-5

L. Luiz, C. A. Nascimento, M. J. V. Bell, R. T. Batista, S. Meruva, V. Anjos (2021). 'Use of mid infrared spectroscopy to analyze the ripening of Brazilian bananas'. Food Science and Technology. https://doi.org/10.1590/fst.74221

M. Soltani, R. Alimardani, M. Omid (2011). Evaluating banana ripening status from measuring dielectric properties. Journal of Food Engineering. www.elsevier.com/locate/jfoodeng

References IV

P. Baglat, A. Hayat , F. Mendonça, A. Gupta, S. S. Mostafa and F. Morgado-Dias (2023). Non-Destructive Banana Ripeness Detection Using Shallow and Deep Learning: A Systematic Review. https://doi.org/10.3390/s23020738

A. Bäuerle, C. van Onzenoodt and T. Ropinski, "Net2Vis – A Visual Grammar for Automatically Generating Publication-Tailored CNN Architecture Visualizations," in IEEE Transactions on Visualization and Computer Graphics, vol. 27, no. 6, pp. 2980-2991, 1 June 2021, doi: 10.1109/TVCG.2021.3057483.