The 11th Asian-Australasian Conference on Precision Agriculture (ACPA 11)
October 14-16, 2025, Chiayi, Taiwan

Using Floral Bract Withering to Identify Green-Ripe Pineapples with Deep Learning

Guo-Fong Hong, Sumesh Nair, Chun-Yu Lin, and Shean-Jen Chen*

College of Photonics, National Yang Ming Chiao Tung University, Tainan 711, Taiwan

* sheanjen@nycu.edu.tw

ABSTRACT

Green-ripe pineapples are ideal for extended transportation and storage during summer but are challenging to identify during on-site harvesting. This study introduces a deep learning-based approach using the YOLO-NAS algorithm to detect green-ripe pineapples by analyzing the withering rate of floral bracts at the fruit's base. A high-mounted tracked vehicle, equipped with an Intel D405 depth camera, captures images at a distance of 300–400 mm as it navigates pineapple ridges. The system detects approximately 20 floral bracts per pineapple, each around 30×30 pixels, and determines their 3D relative positions for subsequent automated harvesting. To mitigate the effects of varying background lighting, a 24V/5A white LED is used for consistent illumination. Experimental results demonstrate that incorporating floral bract withering analysis improves detection precision by 13.6% compared to methods that only analyze the green-ripe bottom, achieving an accuracy of up to 95.4%. This novel technique enhances the identification of green-ripe pineapples, offering a reliable solution for automated harvesting systems
Keywords: Green-ripe fruit, deep learning, pineapple maturity, YOLO-NAS.

INTRODUCTION

Each pineapple typically has 13 spirals of eyes, and its maturity level is determined by the extent of yellowing in these spirals, starting from the bottom and progressing upward. A pineapple that is not ripe is categorized as Level 0, while a green-ripe one is classified as Level 1. As the fruit ripens and the eyes begin to yellow, its maturity level increases from Level 2 to Level 6. Specifically, if one spiral turns yellow, the pineapple is classified as Level 2; if 4 to 6 spirals are yellow, it reaches Level 4; and when 11 to 13 spirals turn yellow, it is classified as Level 6 [1,2,3]. Overseas transportation typically takes between 15 to 20 days, and may take up to a month in some cases. Harvesting too early results in low sugar content (below 14° Brix), which reduces the fruit’s quality.

MATERIALS AND METHODS

The first method classifies the pineapple’s maturity based on the color of its bottom. The second method goes further by not only detecting the bottom of the pineapple but also analyzing the wilting rate of the floral bracts at its base to assess its maturity. If yellow is

detected, the fruit is classified as ripe (Level 2-6). If the pineapple is green, the system proceeds to analyze the bracts at the base, examining approximately 20 bracts in around 181 milliseconds. If the wilting rate of the bracts is ≥30%, the pineapple is classified as green-ripe (Level 1); if it's ≤10%, it is classified as unripe (Level 0). The entire process is illustrated in Fig. 1.

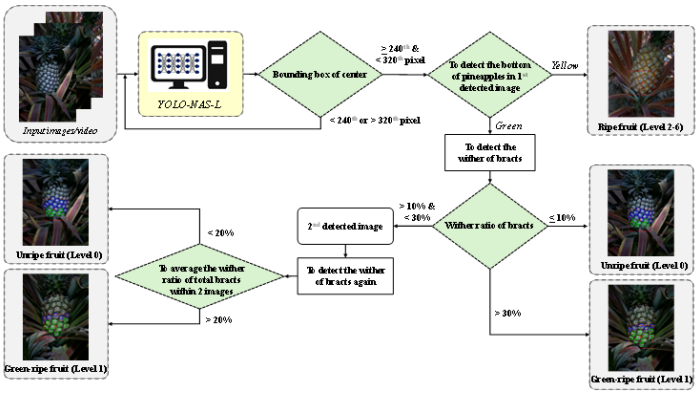

Fig. 1. Green-ripe fruit pineapple detection decision framework process

RESULTS & DISCUSSION

In the field, 100 pineapples from each ripeness category (unripe, green-ripe, ripe) were tested. Results in Table 1 show that the bottom detection method achieved 82.6% accuracy for unripe pineapples, 81.8% for green-ripe pineapples, and 100% for ripe pineapples. In contrast, the floral bract wilting rate detection method achieved 95.6% accuracy for unripe pineapples, 95.4% for green-ripe pineapples, demonstrating a 13.6% improvement in accuracy.

Tab. 1. Detection accuracy percentage.

Method	Bottom detection accuracy	Bottom bract detection accuracy
Unripe fruit (Level 0)	82.6 %	95.6 %
Green-ripe fruit (Level 1)	81.8 %	95.4 %
Fully ripe fruit (Level 2-6)	100 %	-

ACKNOWLEDGEMENTS (optional)

This work was supported by the National Science and Technology Council (NSTC) in Taiwan with the grant number NSTC 113-2622-E-110-002, and thanks to Fubo Pineapple Farm for providing relevant experience and guidelines for green-ripe fruit identification.

REFERENCES

[1] S. J. Chen, Z. H. Shü, C. S. Kuan, & C. H. Tang, 2011, Current situation of pineapple production in Chinese Taipei, Acta Horticulturae, 1(902) 63-67.

[2] P. Siricharoen, W. Yomsatieankul, & T. Bunsri, 2023, Fruit maturity grading framework for small dataset using single image multi-object sampling and Mask R-CNN, Smart Agricultural Technology 3 100130.

[3] C. Y. Chang, C. S. Kuan, H. Y. Tseng, P. H. Lee, S. H. Tsai, & S.-J. Chen, 2022, Using deep learning to identify maturity and 3D distance in pineapple fields, Scientific Reports 12(1) 8749.