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PRELIMINARY TESTS FOR POTATO YIELD MONITORING USING A CONTROLLED TEST BENCH

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ABSTRACT

Accurate yield estimation is a critical aspect of precision agriculture, particularly for root crops such as potatoes, where direct measurement during harvest can be challenging and labor-intensive. Developing precise and automated methods to enhance the efficiency and accuracy of yield assessments is thus imperative. This study explores the potential of integrating vision-based imaging and non-contact sensing technologies to achieve accurate potato mass estimation under controlled laboratory conditions. A laboratory-scale conveyor belt test bench was designed and equipped with two RGB imaging sensors, an array of ultrasonic sensors, and a load cell for mass measurement. RGB cameras continuously record video footage, enabling the extraction of two-dimensional projected areas of potatoes through advanced image processing algorithms. Ultrasonic sensors were installed at a fixed height above the conveyor belt to accurately measure potato heights. The load cell, positioned at the endpoint of the conveyor system, provided actual potato mass measurements, serving as ground-truth data for validating predictive mass estimation models derived from sensor data. A second-order polynomial regression model, incorporating projected area, potato height, quadratic, and interaction terms, was developed to estimate potato volume and consequently predict mass. The predictive model achieved a coefficient of determination (R^2) of 0.85 and a root mean squared error (RMSE) of 3.95 g, demonstrating robust predictive performance and high estimation accuracy.

Keywords: Precision agriculture, yield measurement, image sensor, ultrasonic sensor, polynomial regression

INTRODUCTION

Yield estimation is a fundamental component of precision agriculture, serving as a basis for informed decision-making in crop management, resource allocation, and market planning. Potatoes, a globally important root vegetable, presents a challenge for real-time yield data acquisition due to their growth under soil. Manual yield measurements are inefficient and labor-intensive, failing to provide timely information during harvest (Ampatzidis et al., 2012). Non-contact sensing techniques, such as vision and ultrasonic sensors, offer automated and non-

invasive approaches for yield monitoring, enabling the estimation of size, volume, and mass of irregularly shaped produce such as potatoes. This study aimed to evaluate the combined effectiveness of imaging and ultrasonic sensors for real-time potato yield estimation under controlled laboratory conditions.

MATERIALS AND METHODS

A laboratory conveyor belt test bench was used to simulate potato collection procedure during harvesting period. Two RGB cameras were attached to capture video streams for projected conveyor areas, ultrasonic sensor array was set to measure potato height, and a mass measuring device for ground-truth data. Data fusion combined projected area and height to derive three-dimensional (3D) information. A second-order polynomial regression (PR) model was developed using measured features, including quadratic terms and interaction effects, to estimate potato volume and predict mass. The model accuracy was assessed using coefficient of determination (R^2) and root mean square error (RMSE).

RESULTS & DISCUSSION

The polynomial regression model achieved accuracy in estimating potato mass. The results indicated a strong correlation between sensor-derived features and actual potato mass, with an R^2 value of 0.85 and an RMSE of 3.95 g. Predicted potato masses were consistent with load cell ground-truth measurements, with most predictions deviating by less than ± 5 g. Furthermore, the combined use of projected area and ultrasonic height features improved estimation performance compared to models using individual features alone.

CONCLUSIONS

This study demonstrated the feasibility of a multi-sensor platform for potato yield monitoring. Using a laboratory conveyor test bench with integrated imaging, and ultrasonic sensors, the platform accurately estimated potato mass, highlighting the potential for real-time, non-contact yield measurement.

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