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Automated Defect Detection and Grading of Piarom Dates Using Deep Learning

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Abstract

Grading and quality control of Piarom dates—a premium and high-value variety cultivated predominantly in Iran—present significant challenges due to the complexity and variability of defects, as well as the absence of specialized automated systems tailored to this fruit. Traditional manual inspection methods are labor-intensive, time-consuming, and prone to human error, while existing AI-based sorting solutions are insufficient for addressing the nuanced characteristics of Piarom dates. In this study, we propose an innovative deep learning framework designed specifically for the real-time detection, classification, and grading of Piarom dates. Leveraging a custom dataset comprising over 9,900 high-resolution images annotated across 11 distinct defect categories, our framework integrates state-of-the-art object detection algorithms and Convolutional Neural Networks (CNNs) to achieve high precision in defect identification. Furthermore, we employ advanced segmentation techniques to estimate the area and weight of each date, thereby optimizing the grading process according to industry standards. Experimental results demonstrate that our system significantly outperforms existing methods in terms of accuracy and computational efficiency, making it highly suitable for industrial applications requiring real-time processing. This work not only provides a robust and scalable solution for automating quality control in the Piarom date industry but also contributes to the broader field of AI-driven food inspection technologies, with potential applications across various agricultural products.

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