Detection of early decayed oranges based on multispectral principal component image combining both bi-dimensional empirical mode decomposition and watershed segmentation method

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Abstract

Detection of early decay caused by fungal infections in citrus fruit still remains one of the major problems in the post-harvest processing and automatic quality grading. A new combination algorithm by merging multispectral principal component image, bi-dimensional empirical mode decomposition and image reconstruction as well as improved watershed segmentation was proposed to detect the early decay in oranges. Segmented principal component analysis based on three wavelength regions including visible and short wavelength near-infrared (500–1050 nm), visible (500–780 nm) and near-infrared (781–1050 nm) was performed to determine the optimal principal component (PC) image that was used to extract the effective wavelength images by weighting coefficient analysis. Seven wavelength images in the spectral region of 500–1050 nm were finally determined to build the multispectral PC images. The bi-dimensional empirical mode decomposition (BEMD) was used to remove noise in the multispectral PC images and further reconstruct images. An improved watershed segmentation method with morphological gradient reconstruction, marker extraction as well as image amendment, was proposed to segment decay regions in fruit by using the reconstructed multispectral PC images. All samples including 220 each of decayed and sound fruit were utilized to assess classification ability of the proposed combination algorithm. The results indicated that identification accuracies of decayed and sound fruit were 97.3% and 100%, respectively. The multispectral principal component image combining both bi-dimensional empirical mode decomposition and watershed segmentation method can be used as an effective tool for detection of early decayed oranges, and it was also promising for development of a fast and low-cost multispectral imaging system.