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A Visualization Classification Method for Identifying the Decayed Citrus Fruit Infected by Fungi Based on Hyperspectral Imaging

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Abstract : Early detection of fungal infection in citrus fruit is one of the major problems in the postharvest commercialization process. The automatic and nondestructive detection of infected fruits is still a challenge for the citrus industry. At present, the visual inspection of rotten citrus fruits is commonly performed by workers through the ultraviolet induction fluorescence technology or manual sorting in citrus packinghouses to remove fruit subject with fungal infection. However, the former entails a number of problems because exposing people to this kind of lighting is potentially hazardous to human health, and the latter is very inefficient. Orange is used as a research object. This study would focus on this problem and proposed an effective method based on Vis-NIR hyperspectral imaging in the wavelength range of 400-1000 nm with a spectroscopic resolution of 2.8 nm. In this work, three normalization approaches are applied prior to analysis to reduce the effect of sample curvature on spectral profiles, and it is found that mean normalization was the most effective pretreatment for decreasing spectral variability due to curvature. Then, principal component analysis (PCA) was applied to a dataset composing of average spectra from decayed and normal tissue to reduce the dimensionality of data and observe the ability of Vis-NIR hyper-spectra to discriminate data from two classes. In this case, it was observed that normal and decayed spectra were separable along the resultant first principal component (PC1) axis. Subsequently, five wavelengths (band) centered at 577, 702, 751, 808, and 923 nm were selected as the characteristic wavelengths by analyzing the loadings of PC1. A multispectral combination image was generated based on five selected characteristic wavelength images. Based on the obtained multispectral combination image, the intensity slicing pseudocolor image processing method is used to generate a 2-D visual classification image that would enhance the contrast between normal and decayed tissue. Finally, an image segmentation algorithm for detection of decayed fruit was developed based on the pseudocolor image coupled with a simple thresholding method. For the investigated 238 independent set samples including infected fruits infected by Penicillium digitatum and normal fruits, the total success rate is 100% and 97.5%, respectively, and, the proposed algorithm also used to identify the orange infected by penicillium italicum with a 100% identification accuracy, indicating that the proposed multispectral algorithm here is an effective method and it is potential to be applied in citrus industry.

Keywords : citrus fruit, early rotten, fungal infection, hyperspectral imaging
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