Hyperspectral imaging technology for food quality and saftey evaluation and inspection

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Over the years, optical sensing technologies have been investigated as potential tools for non-destructive evaluation and inspection for food quality and safety. In particularly, methods based on two mature technologies of imaging and spectroscopy have been widely studied and developed, resulting in many successful applications in the food industry. However further development of these conventional imaging and spectroscopy techniques is limited by their inabilities to obtain sufficient information from individual food items. Therefore by taking the most useful characteristics of these two mature technologies: imaging and spectroscopy, hyperspectral imaging (or imaging spectroscopy) has emerged as a technology with great potential for effective and non-destructive quality and safety evaluation and inspection in the area of food processing.

A conventional imaging system or more specifically computer vision is a common technique for detecting surface features. The system normally consists of lighting and an area detector, with the light source providing illumination to the sample and the area detector capturing mixed spectral contents from the sample. Spatial information of the sample is obtained in the forms of monochromatic or colour images, therefore conventional imaging system is used for colour, shape, size, surface texture evaluation of food products and for surface defects detection in food inspection, however it cannot identify or detect chemical properties or characteristics from a food product.

On the other hand, conventional spectroscopy system is a technique for evaluating chemical properties or characteristics of food products. Such a system generally includes a light source, a wavelength dispersion device, and a point detector. In this system, light is dispersed into different wavelengths after interaction with the sample in order for the point detector to collect the dispersed light to obtain spectral information from the sample. As the point detector has its size limitation, conventional spectroscopy system cannot cover a large area or a small area with high spatial resolution. Therefore the technique does not provide the spatial information which is regularly required for and is critical in food inspection.

With the integration of the main features of imaging and spectroscopy, hyperspectral imaging can simultaneously acquire both spatial and spectral information that is critical to the detection of food safety and evaluation of food quality attributes. A typical hyperspectral system consists of a light source, a wavelength dispersion device, and an area

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detector. The images are acquired over the visible and near-infrared (or infrared) wavelengths to specify the complete wavelength spectrum of a sample at each point in the imaging plane. These images are then combined and form a three dimensional hyperspectral cube, with two dimensions for describing spatial information and the third one for spectral information. In this hypercube, each spectral pixel corresponds to a spectral signature (or spectrum) of the corresponding spatial region, recording the entire measured spectrum of the imaged spatial point. Therefore the measured spectrum indicates the ability of the sample in absorbing or scattering the exciting light, representing the inherent chemical properties of a sample. As a result, the technology provides us with unprecedented detection capabilities, which otherwise cannot be achieved with either imaging or spectroscopy alone. If conventional imaging is to provide the answer to the question of where and conventional spectroscopy is to provide the answer to the question of what, hyperspectral imaging is a technique to provide the answer to the question of where is what.

Hyperspectral imaging techniques have received much attention for food quality and safety evaluation and inspection. Many approaches and applications have shown the usefulness of hyperspectral imaging in the food industry. These applications include meat quality assessment, automated poultry carcass inspection, quality evaluation of fish, bruise detection of apples, quality analysis and grading of citrus fruits, bruise detection of strawberry, visualization of sugar distribution of melons, measuring ripening of tomatoes, defect detection of pickling cucumber, and classification of wheat kernels. Interested readers are advised to refer to the following list of publications for further information.

References

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