HYPERSPECTRAL IMAGING FOR FOOD QUALITY ANALYSIS AND CONTROL

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Quality assurance is one of the most important goals of any industry. The ability to manufacture high-quality products consistently is the basis for success in the highly competitive food industry. It encourages loyalty in customers and results in an expanding market share. The quality assurance methods used in the food industry have traditionally involved human visual inspection. Such methods are tedious, laborious, time-consuming, and inconsistent. As plant throughput increased and quality tolerance tightened, it became necessary to employ automatic methods for quality assurance and quality control. Also, the increased awareness and sophistication of consumers have created the expectation for improved quality food products. With increased expectations for food products with high quality and safety, the need for accurate, fast, and objective quality determination of these characteristics continues to grow.

During the past few decades a number of different techniques have been explored as possible instrumental methods for quality evaluation of food products. In recent years, hyperspectral imaging technique has been regarded as a smart and promising analytical tool for analyses conducted in research, control, and industries. Hyperspectral imaging is a technique that generates a spatial map of spectral variation, making it a useful tool in many applications. The use of hyperspectral imaging for both automatic target detection and recognizing its analytical composition is relatively new and is an amazing area of research.

Based on the integration of image processing and spectroscopy techniques, hyperspectral imaging is a novel technology for obtaining both spatial and spectral information from an object. In recent years, hyperspectral imaging has rapidly emerged as and matured into one of the most powerful and fastest-growing non-destructive tools for food quality analysis and control. Using the hyperspectral imaging technique, the spectrum associated with each pixel in a food image can be used as a fingerprint to characterize the biochemical composition of the pixel, thus enabling the visualization of the constituents of the food sample at pixel level. As a result, hyperspectral imagery provides the potential for more accurate and detailed information extraction than is possible with any other type of technology for the food industry.

The main impetus for developing a hyperspectral imaging system was to integrate spectroscopic and imaging techniques to enable direct identification of different components and their spatial distribution in the tested sample.

The advantages of hyperspectral imaging over the traditional methods include minimal sample preparation, nondestructive nature, fast acquisition times, and visualizing spatial distribution of numerous chemical compositions simultaneously. The hyperspectral imaging technique is currently tackling many challenges to be accepted as the most preferable analytical tool in identifying compositional fingerprints of food products and their authentication. The need for fast and reliable methods of authenticity and object identification has increased the interest in the application of hyperspectral imaging for quality control in the agricultural, pharmaceutical, and food industries. Moreover, enhancement in instrumental developments, the availability of high-speed computers, and the development of appropriate chemometric procedures will allow this technique to be dominant in the future.

Most recently, the emphasis has been on developing sensors for real-time, nondestructive systems. As a result, automated visual inspection by computer-based systems has been developed in the food industry to replace the traditional inspection by human inspectors because of its cost-effectiveness, consistency, superior speed, and accuracy. Computer vision technology utilizing image processing routines is one alternative which became an integral part of the industry's move towards automation.

Since machine vision is operated at visible wavelengths, it can only produce an image registering the external view of the object and not its internal view. Situations exist whereby food technologists need to look inside the object in a noninvasive and nondestructive manner. For instance, food technologists need to measure and map the water content of food in order to assess its microbiological stability and to implement risk analysis as defined by the hazard analysis critical control point. Therefore, external attributes such as size, shape, colour, surface texture, and external defects can easily be evaluated by ordinary means (e.g. RGB colour camera). However, internal structures are difficult to detect with relatively simple and traditional imaging means, which cannot provide enough information for detecting internal attributes. Since quality is not a single attribute but comprises many properties or characteristics, measurement of the optical properties of food products has been one of the most successful nondestructive techniques for quality assessment to provide several quality details simultaneously.

One of the strategic advantages of hyperspectral imaging is that it allows for the visualization of different biochemical constituents presented in a sample based on their spectral signatures because regions of similar spectral properties should have similar chemical composition.

References:

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