

Spectral Imaging for Food Inspection

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Historically, food inspection has required trained technicians to perform visual screening operations. A drawback of manual visual inspection is that latent defects that are not visible to the human eye cannot be recognized. Newer approaches, such as automated inspection systems based on imaging technology, seek to more efficiently differentiate between good and defective product. These methods typically rely on color and spatial features to make proper classifications. Advanced CCD imaging solutions from QImaging® have been demonstrated to produce reliable inspection results via high-resolution spectral imaging.

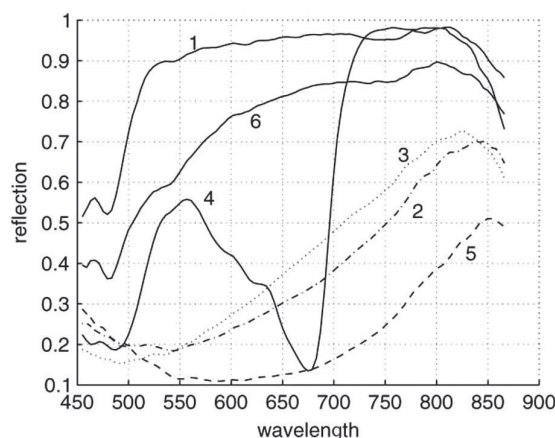
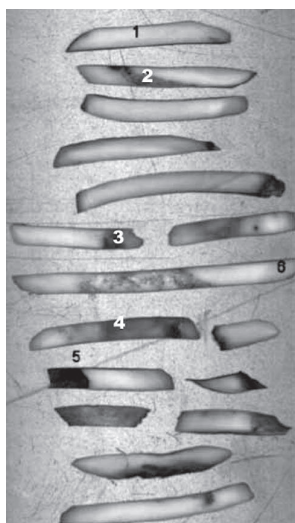


Figure 1. Image of several typical French fries. Defects and diseases have been marked by a French fry expert; the spectra are taken from the corresponding defective areas on the left: 1 = potato flesh, 2 = peel, 3 = damage, 4 = greening, 5 = external rot, and 6 = browning.

Spectral Imaging

Detection and Classification of Defects and Diseases on Raw French Fries

In 2005, Jacco Noordam, Willie van den Broek, and Lutgarde Buydens published a study that examined the utility of spectral imaging technology for food inspection.¹ One of the goals of the study was to investigate whether spectral imaging improves discrimination between potato flesh, potato peel, and potato defects on French fries.

The researchers compared spectral imaging and red/green/blue (RGB) color imaging technologies. The spectral imaging system was based on a slit-scanning approach in which a line of spatial information is dispersed into spectral components across a square detector (a Peltier-cooled monochrome CCD camera from QImaging was used). In the approach used, a single exposure contains all the spectral information from a single line across the specimen; a series of images is collected in order to generate a complete data set with "x and y" spatial and spectral information at each pixel.

A product expert evaluated and labeled the various classes of product condition, including potato flesh, visible greening, peel, green peel, rot, damaged, and internal red/brown discoloring. The mean reflectance spectra from diseased areas of the fries that were distinguished by the product expert were collected using the spectral imaging system (see **Figure 1**).

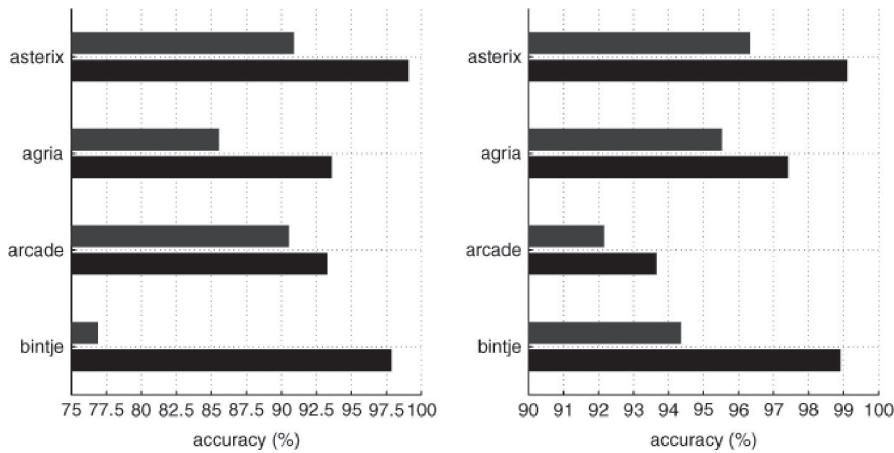
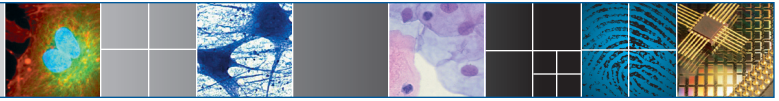


Figure 2. Accuracy difference between the RGB image results (upper bar) and the spectral image results (lower bar) for the best-performing preprocessing and classification algorithms. The plot on the left depicts the differences for the original data sets for French fries from four potato sources. The plot on the right depicts the differences for the four potato sources when the defects (greening, green peel, rot, damaged, and browning) are grouped into a single category.

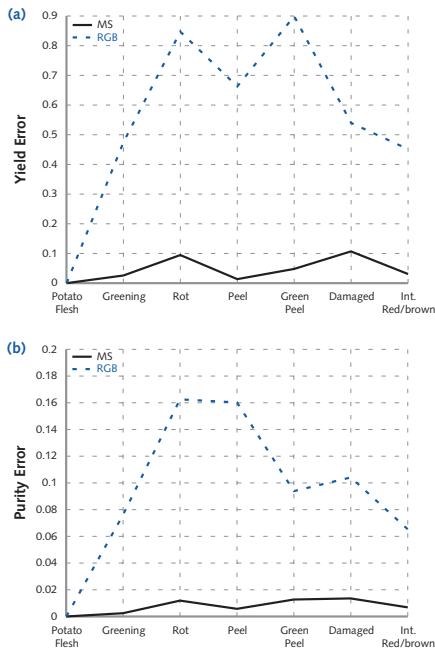
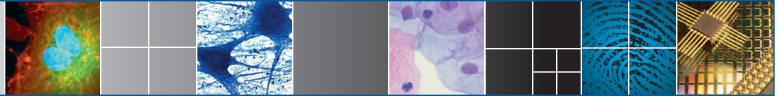


Figure 3. Averaged error of yield (a) and purity (b) for all potato sources for RGB (dashed line) and spectral (solid line) imaging modalities. Lower yield-error values indicate a smaller fraction of the class is misclassified as belonging to other classes. Lower purity-error values indicate that the class contains a smaller fraction of non-class members.

Spectral imaging outperformed both the product expert and the RGB-based classification system in detecting greening French fries. Latent defects were shown to be detectable in multispectral French fry images before becoming visible to the human eye or the RGB color camera. This detection difference is important in that potatoes turn green with cumulative exposure to light as a result of the formation of chlorophyll. Such tubers develop a bitter taste as well as an off-flavor and may cause health hazards associated with the glycoalkaloid that develops along with the chlorophyll.

The researchers also evaluated the suitability of various computational classification algorithms. Therefore, the second objective of the study was to select the best-performing classifier for both spectral and RGB color images, combined with different data-preprocessing techniques applied to the spectra prior to classification. The results indicated that a support vector classifier with modified standard normal variate preprocessing delivers the best performance for spectral images, while a k-nearest neighbors classifier performs best for raw RGB color images.

This study demonstrated that, in general, spectral imaging outperforms RGB imaging not only in terms of accuracy (see **Figure 2**), but also in terms of yield and purity of potato flesh and potato peel (see **Figures 3a** and **3b**).



Enabling Technology

The Retiga™ camera series from QImaging offers a variety of affordable, research-grade, cross-platform solutions for low-noise monochrome and color imaging. Innovative implementations of progressive-scan interline CCDs with megapixel detection arrays and 12-bit digital output deliver excellent resolution of spatial features and intensity levels. In addition, IEEE 1394 connectivity and QCapture software provide streamlined camera operation and ease of use. Optional thermoelectric cooling to -30°C minimizes noise attributable to dark current.

Information

To learn more about Dr. Jacco Noordam's research, please visit:
greenvision.wur.nl

To learn more about high-performance CCD cameras from QImaging, please visit:
www.qimaging.com

Citation

1. Noordam, J.C., van den Broek, W.H.A.M., and Buydens, L.M.C. (2005). Detection and classification of latent defects and diseases on raw French fries with multispectral imaging. *J. Sci. Food Agric.* **85**, 2249-2259.



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