Prime time for machine vision

Looking for quality 'viewing' of your process? Tune into machine vision. Signal processing and software advances improve high-speed inspection, sorting, and quality assurance

Bob Sperber, Section Editor

President Bush is on record as having a little trouble with "the vision thing," but he's not alone. In sorting for product surface defects, size, shape, and color, and inspecting for package integrity, food companies face major visual inspection challenges, too. Applications range from high-speed sorting to on-line quality assurance.

The need for high-quality products, scrap reduction, and labor cost reductions—combined with the economic recession and competitive pressures—are driving demand for automated alternatives. Even though, as one engineer said, "For seasonal processors, cost justification comes hard, given shortened packing seasons and labor at only five percent of total product cost."

Price/performance ratios are more favorable than ever. By some estimates, vision systems can perform five times as well at half the price of systems installed less than a decade ago.

Components & systems

For sensing vision, black-and-white CCD video cameras with 256 levels of gray are prevalent. Color cameras and sensors, mated with high-speed signal processors, are seeing increased use for inspection of subtle food product color differences.

To give the camera a clear view of a product, lighting is important to enhance flaws and eliminate shadows and ambient interference. Sometimes shrouds are placed over the sensing area for better lighting control.

On high-speed lines, frame buffers or "grabbers" freeze about 30 video images per second. Line-scanners can acquire thousands of lines (of characters) per second. Strobes and cameras with electronically controlled shutters can freeze images to within one ten-thousandth of a second.

These images are made meaningful through electronic signal processing. The latest in image processing is the use of high-speed digital signal processors and application-specific integrated circuits to provide higher throughput speeds and improved functions at lower cost. Signal processors are combined with some form of operator interface software, which enables the user to configure, monitor, and control rejection of "bad" product.

Material handling considerations are a crucial factor. Once arranged in lines or lanes, a product can be rotated, set in front of mirrors, and/or viewed with multiple cameras for optimum scanning. Multiple parallel inspection stations are also used to increase sorting capacity. Pneumatic and electro-mechanical rejection devices are typically added to complete an installation.

Vision systems come in all forms, from generic-purpose hardware and software components to turnkey systems, with prices from a few thousand dollars to a few hundred thousand. In the low-priced arena, systems range from application-dedicated all-in-one packages that require only a threshold adjustment to generic systems with cameras mated to desktop computer (PC) smarts. Entry level systems may do the job, albeit more slowly, and with more software programming and configuration time up front.

Major citrus processor sorts oranges based on three-dimensional size, color, and visual defects. High-speed logic processor grades about eight oranges per sec. Up to eight processors are typically used for sorting oranges
Photo: Computer Recognition Systems

At the opposite end of the vision spectrum are turnkey systems complete with conveyors, dedicated computer memory and control, and recirculation conveyors that reclaim accidental rejects. Between the two

Planters LifeSavers' system uses a color camera and high-speed analog processing (from Thermal Electronics) to detect plastic bag material from peanuts in a 2000 lb per hour reclaim stream
Photo: Visual•Sense•Systems

extremes are systems that employ cameras and vision-dedicated signal processing computers, and are configured using menu-driven operator interface software.

On packaging lines, scanning and optical character recognition/verification (OCR/OCV) are commonly used to check the dates, lot codes, label alignment, and other quality measures at thousands of items per minute. Some alternatives to inspection systems stretch the definition of "optical" and "vision" inspection by using infrared or even laser-based sensing methods.

Lines of light

One application for inspecting an extruded meat mixture employed cameras to indirectly inspect the product. Actually, the cameras inspected a series of 30 lines of light projected at an angle across the product. Positioned to view the lines across the flat, sheeted meat exiting the extruder, the cameras were able to measure the "bends" in the lines, and consequently the width and volume of the product. The vision system paid for itself in four months based on scrap savings alone. A second phase of the project used this indirect, structured-light approach to identify variations in surface texture such as blistering. Direct product viewing using a gray-scale CCD camera further inspected for discolorations.

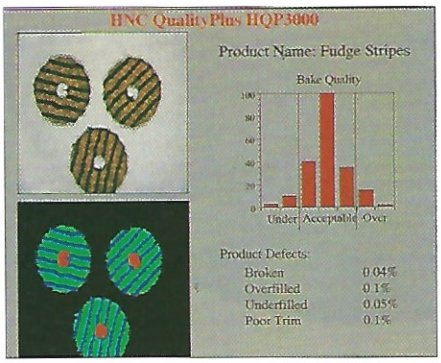
The same system (from Computer Recognition Systems) has been similarly applied to inspect chewing gum thicknesses. With various camera adaptations, the system is successfully inspecting Keebler's ice cream cones for holes and random samples of french fries for length.

How do you sample the length of randomly oriented french fries moving at 500 fpm? Answer: in near-real time.

The hardware's sizing and surface defect analysis capabilities were applied to pick-out and produce an outline around a single fry. Product dimensions were then a matter of high-speed linear number-crunching. The system was not set up to reject defects, but was successfully used as a quality assurance tool.

Shades of gray

Several food processors have successfully employed gray-scale vision systems to grade fresh fruit for size and "color" traits. Correctly sized, unblemished fruit with enough "greenness" is separated for supermarket orders, while small, blemished, or ripe fruit is used for canning and other further processing applications.



Beyond their train-by-show appeal, artificial neural network systems are emerging for identifying hard-to-quantify/subjective product attributes. Color video image is processed into regions (cookie, fudge stripe, hole), then characterized statistically or numerically
Photo: HNC

One national baked goods manufacturer uses the same system to check the "doneness" of cookies. Two cameras are set up to view cookies as they pass along the discharge conveyor, already arranged in neat rows of 12. Operators use the system to adjust bake time and ensure uniform oven operation. The same gray-scale algorithms can be used to measure complex dark and light shapes, for example, in ensuring the proper dispersal or quantity of chips in chocolate chip cookies.

The system (from Videk) has also been configured to inspect the peanut butter filling and chocolate enrobing of a popular candy product. Proper enrobement is vital not only to product quality but to shelf life and safety because it acts as a barrier to oxygen and bacteria.

True colors

Planters LifeSavers, in Ft. Smith, AR, is using a color vision system from Thermal Electronics. A customized

Food industry gained 30% more vision in 1991

In 1991, sales by North American machine vision companies grew $11 million to reach $646 million, according to a study by Automated Imaging Association, authored by analyst Nello Zuech of Vision Systems International. Printing and plastics bought more vision systems. And the semiconductor, electronics, container, and wood industries are larger users. But food is a growing market for vendors with vision.

According to the study's update, the market for food processing and packaging applications grew 30.3% in 1991 to $35.69 million in sales, and 18.2% in units to 312. The market is expected to increase an average of 12.4% per year leading to a 1996 business of $63.97 million and 595 units. "Both growers and processors are expected to substitute machine vision techniques for the less sophisticated electro-optical, multi-spectral techniques generally used today," the study reports.

An end-use industry analysis concludes, "As machine vision techniques prove to be more effective, they will be adapted to more products. In addition, processors are expected to increase their use of machine vision at the packaging side as a means of improving productivity and consumer satisfaction."

Machine Vision: A Market Study, Automated Imaging Association, 900 Victors Way, P.O. Box 3724, Ann Arbor, MI 48106. CIRCLE 351

Vision Systems International, 3 Milton Dr., Yardley, PA 19067. CIRCLE 352

RGB color camera generates four channels of signals: red, green, and blue, plus luminance or gray-scale intensity. The signals are enhanced and analyzed by proprietary analog signal processors.

For almost two years, Planters has used the system to locate clear and colored flexible plastic bag material that occasionally appears in a product rework stream. Before the system was installed, one person "had to watch the reclaim conveyor 100 percent of the time to catch bag material," said Virgil Payne, Environmental Services Manager, "Now, the color vision system keeps watch, alerting the operator if any foreign material is found."

The system uses a train-by-show method for simple setup. The operator places a sample of the defect (colored bag) on a conveyor full of peanuts and turns a setup dial to align the monitor's view of the bag with a cross-hair on the monitor.

"It's like adjusting your radio," according to Payne, who also said, "Since the system has been in operation, we have eliminated foreign material in-plant complaints, and customer returns have gone to zero."

The rework stream processes more than 2000 lb per hour and is rated at 5000 lb per hour. The system has also demonstrated an ability to identify all manner of foreign materials among peanuts with and (simultaneously) without red skins, said Ken White, who worked on the project.

White, past chairman of the Machine Vision Association (of SME) and former director of the RJR Nabisco Process Automation Center of Excellence, is a vision systems integrator/consultant. His firm,

Visual*Sense*Systems, has just announced a cross-referenced vision industry database that includes the products and applications of more than 2000 vendors.

Neural networks

Artificial neural networks, an artificial intelligence offshoot, are touted to hold promise for tomorrow's "learning" and "seeing" machines. One aspect of this type of program helps some of today's "seeing" machines automatically set their own threshold and pattern recognition parameters.

Expandable, 2-camera system features Microsoft Windows-based configuration software and image processing of 60 items per second
Photo: Pattern Processing Technologies

The peanut sorting application discussed above employs a "neural network-inspired" train-by-show routine for instrument calibration. So does a system from Pattern Processing Technologies, which uses Microsoft Windows-based configuration software. To "teach" a vision system to recognize flaws, an operator places various defects in the camera's view while adjusting a threshold dial for rejection sensitivity. The routine is repeated for each color/channel.

A system from Vision Harvest makes fuller use of artificial neural nets beyond training, typically for frequent SPC-oriented sampling. A similar PC-based system from HNC has been applied by food processors to inspect apples and grapefruit (for gross color and surface defects) at 6 per second and dried dates (for gross color and surface texture) at approximately 40-70 per second using a proprietary neural chip. Cookies have also been successfully inspected for size and visual defects.

Training-by-showing may require hundreds if not thousands of visual samples. For size and shape measurements, traditional pattern recognition algorithms are most efficient and accurate, but companies continue to research the applicability of neural networks for judging products of varying color and other subjective online judgments. FP

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