Embedded Vision in Manufacturing

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Machine vision brings PTI compliance

Sun Pacific, the largest grower/packer/marketer of citrus fruits in the U.S., is reaping the benefits of machine vision in its packing houses.

By Pat Reynolds, VP Editor

The produce industry is moving to implement a systematic, industry-wide approach to closely track where fresh produce comes from and where it goes. One of the great challenges in this effort is the automatic recognition of a wide range of different package designs and hand stamps currently used to provide information about the produce. Sun Pacific, the largest grower, packer and marketer of citrus fruits in the United States, recently overcame this challenge by implementing the HarvestMark Product Traceability Initiative (PTI) solution with Saber Engineering VR-3000 vision inspection systems in several of its packing houses. These vision inspection systems utilize Cognex PatMax pattern recognition technology to consistently recognize case designs and hand stamps in spite of varying case positions and orientations, changes in ambient lighting, and other variables.

The produce industry handles an estimated 6 billion cases of produce in the United States each year. On very rare occasions, contaminated produce finds its way into the supply chain. The PTI is designed to identify the source of contaminated produce much faster and more accurately than is possible with conventional methods. The number one benefit is reducing the risk to consumers by ensuring that contaminated products are removed from the supply chain as quickly as possible. The PTI also has the potential for large cost savings by narrowing the impact of potential recalls and helping the supply chain resume normal operation much faster than is currently possible.

The PTI is based on a Global Trade Item Number (GTIN) that can be used for identifying trade items at all levels of packaging including item, case, and pallet. Under current best practices brand owners assign a 14-digit GTIN to every possible type of case based on the commodity, subtype, size, count, area of origin, grower, packer, etc. The GTIN along with the lot number is provided in human-readable form and encoded in a barcode on each case. Each subsequent handler then needs to have the capability to read and store the GTIN and lot number from each case of produce received. In case of a problem, this approach makes it possible to quickly trace goods through each handling step all the way back to their source.

But the produce industry faces challenges in achieving PTI compliance. Packers typically handle many different types of packages that are mixed together on their production lines. Often customers have their own case design and the produce is packed into many different customers’ cases in the packing plant. The workers in the packing line normally stamp the specifications such as the commodity, subtype, size, and count on the side of the case with a rubber stamp. The number one PTI compliance challenge for the packer is to automatically
read the rubber stamp and identify the product
associated with the package design and then au-
tomatically generate a label that contains all this
information in both human-readable and 2D bar-
code format and affix it to the side of the case.

Saber Engineering developed the self-con-
tained VR-3000 system that utilizes advanced
machine vision technology to distinguish be-
tween the different types of packages and
stamps with nearly perfect accuracy. The VR-
3000 recognizes and verifies attributes such as
type of shipping container, commodity, and size
and passes this information to the HarvestMark
database for processing. Trace-back, trace-
forward and production data is securely hosted
on the HarvestMark platform, delivering supply
chain reporting and enabling on-demand trace-
ability anywhere in the supply chain.

Saber Engineering’s vision solution uses a
custom Visual Basic human machine interface
(HMI) integrated with Cognex VisionPro vision
tools to recognize package designs and stamps.
The primary tool used is the PatMax part and
feature location tool that uses advanced geo-
metric pattern matching technology to reliably
and accurately identify and locate patterns.

Pattern matching can be extremely challeng-
ing because many variables can alter the way
an object appears to a vision system. Traditional
pattern matching technology relies upon a
pixel-grid analysis process commonly known as
normalized correlation. This method looks for
statistical similarity between a gray-level model
or reference image of an object and portions of
the image to determine the object’s X/Y posi-
tion. Though effective in certain situations, this
approach limits both the ability to find objects,
and the accuracy with which they can be found,
under conditions of varying appearance com-
mon to production lines, such as changes in
object angle, size, and shading.

PatMax technology, on the other hand, learns an
object’s geometry using a set of boundary curves
that are not tied to a pixel grid, and then looks
for similar shapes in the image without relying on
specific gray levels. The result is a revolutionary
improvement in the ability to accurately find ob-
jects despite changes in angle, size, and shading.
Continued
Machine vision brings PTI compliance

“We have tried all of the popular pattern recognition tools available,” said Dennis Hopkins, President of Saber Engineering. “PatMax works the best and none of the others even come close.”

Getting the lighting and camera angle right, also important for a successful vision application, can be difficult in a typical packing plant. Ambient lighting can change based on the position of the sun and cloud cover. The boxes are not precisely positioned on the line so they may be closer or further from the camera than expected and their orientation may also change. In many cases the camera needs to be able to read multiple sides of the box, for example, reading the hand stamp on one side of the box and artwork that indicated the type of package on another side. In this case, the camera needs to be oriented at an angle to the box so it can read multiple sides.

The VR-3000 uses an Ethernet camera with a 120 watt LED strobe light. “The light is very bright and diffuses well so it accommodates a lot of variance in box types,” Hopkins said. The system is designed for use in an industrial setting with a hand crank that provides 32 inches of vertical adjustment. The system can typically withstand up to 6 inches of misalignment without losing accuracy. It includes discrete I/O to communicate with a programmable logic controller (PLC) and an Ethernet output to communicate with the printer and the HarvestMark system.

Packers are continually adding different packages and stamps to their line. The VR-3000 makes it easy for operators to train the system to recognize new case designs and stamps simply by putting a box in front of the camera and pressing “learn” in the human machine interface (HMI). A picture of the box then appears on the HMI along with three windows superimposed on the box representing the area scrutinized by the PatMax inspection tools. The operator adjusts the tools so that they cover the areas that need to be inspected. These are typically distinctive design features that distinguish the case design and the stamp that indicates the subtype, size, and count of the produce. When Saber Engineering and HarvestMark install a new system, Saber characterizes the VR-3000 to handle all of the customer’s existing cases and stamps during the installation phase, while HarvestMark personnel perform the installation and training. In addition, Saber provides training to the new customer-designated employees on how to add additional cases and stamps for future changes to the production line.

Sun Pacific recently embarked on an initiative to achieve PTI compliance in its packing operations. The company set up a competition between Saber Engineering and another supplier of automated case identification and labeling solutions and ran them side by side for two months. Both solutions are designed to automatically recognize box artwork, stamps, and markings on cases of produce and, based on these, determine the GTIN associated with the box as it travels down the line at speeds up to 3,100 boxes per hour. The solution automatically generates the right label and applies it to the box at filling line speed.
In the competition, the VR-3000 read the customer’s boxes and stamps with a read rate of better than 99.5%. The only cases that were not read were those that the stamp was either missing or severely defaced. Based on the results of the competition, Sun Pacific ordered a total of 15 VR-3000 systems that are now deployed and operating in several packing houses located throughout central and southern California. “The customer tells us that the vision systems are performing extremely well,” Hopkins concluded.
How Embedded Vision Can Improve Inspection and Inventory Tracking

From providing new methods of improving product tracking to eliminating the bottlenecks often encountered with visual inspection, embedded vision technologies are poised to change the game in many core manufacturing applications.

By David Greenfield, Director of Content/Editor-in-Chief

There’s always been a great deal of interest in vision system technology in the manufacturing industries. Though the technology has been widely applied, some would argue that vision system technology application never quite reached critical mass in manufacturing because of the high costs associated with the purchase and installation of these systems. However, the plummeting cost of embedded technologies has greatly increased the opportunity to adapt embedded vision technologies into various manufacturing processes. Many of these applications have involved cutting-edge robotic applications, but embedded vision systems are equally adept for basic manufacturing applications such as inventory tracking and inspection.

When it comes to inventory tracking, most people think of using bar codes and RFID tags to track and route materials. But, as Yvonne Lin of Xilinx notes, those technologies cannot be used to detect damaged or flawed goods.

“Intelligent material and product tracking and handling in the era of embedded vision will be the foundation for the next generation of inventory management systems, as image sensor technologies continue to mature and as other vision processing components become increasingly integrated,” says Lin. “High-resolution cameras can already provide detailed images of work material and inventory tags, but complex, real-time software is needed to analyze the images, to identify objects within them, to identify ID tags associated with these objects, and to perform quality checks.”

Lin points out that her use of the term “real time” in this instance refers to an embedded vision systems’ capability of evaluating dozens of items per second.

At the core of embedded vision processing is a combination of software flexibility and hardware acceleration capabilities to address challenging system performance requirements while still allowing for algorithm optimization and evolution, Lin says. The need for these capabilities helped drive the development of Xilinx’s Zynq-7000 all-programmable system on chips (SoCs). These SoCs combine a dual-core, 32-bit ARM Cortex-A9 microprocessor and a programmable logic array on a single chip, notes Lin. “The processor cores can run complex image analysis and video analytics routines, while the
closely coupled programmable logic fabric implements high-speed algorithms, including lens correction and calibration, image preprocessing, and pattern recognition.”

Of course, use of SoCs is not the only way of handling vision processing. Lin says that other potential vision processing solutions include general-purpose CPUs, special-purpose imaging processors, DSPs, GPUs, and multi-core application processors.

“To meet the vision application’s real-time requirements, various tasks must often run in parallel,” she says. “On-the-fly quality checks can be used to spot damaged material and can be used to automatically update an inventory database with information about each object and details of any quality issues. Vision systems for inventory tracking and management can deliver robust capabilities without exceeding acceptable infrastructure costs, through the integration of multiple complex real-time video analytics extracted from a single video stream.”

The same capabilities embedded vision systems provide for inventory tracking can also be applied to automated inspection.

“Vision has many uses and delivers many benefits in automated inspection, performing tasks such as checking for the presence of components, reading text and barcodes, measuring dimensions and alignment, and locating defects and patterns,” says Carlton Heard of National Instruments. “Historically, quality assurance was often performed by randomly selecting samples from the production line for manual inspection, with statistical analysis then being used to extrapolate the results to the larger manufacturing run. This approach leaves unacceptable room for defective parts to cause jams in machines further down the manufacturing line or for defective products to be shipped. Automated inspection, on the other hand, provides 100 percent quality assurance.”

Heard adds that advances in vision processing performance, due to the increasing power of embedded technologies as well as their programmability via FPGAs, mean that automated visual inspection is often no longer the limiting factor in manufacturing throughput it was once considered to be.

To bring about automated inspection in your operation using embedded vision technologies, it’s important to realize that the vision system is just one piece of a multi-step puzzle and must be synchronized with other equipment and I/O protocols in order to work well within an application, Heard notes.

For example, consider a common inspection scenario that involves the sorting of faulty parts from correct ones as they transition through the production line. “These parts move along a conveyor belt with a known distance between the camera and the ejector location that removes faulty parts,” explains Heard. “As the parts migrate, their individual locations must be tracked and correlated with the image analysis results to ensure that the ejector correctly sorts out failures. Multiple methods exist for synchronizing the sorting process with the vision system, such as the use of timestamps with
known delays, and proximity sensors that also keep track of the number of parts that pass by. However, the most common method relies on encoders. When a part passes by the inspection point, a proximity sensor detects its presence and triggers the camera. After a known encoder count, the ejector will sort the part based on the results of the image analysis.”

Here’s where the advances in embedded vision technologies come into play, as the challenge with this technique is that the system processor must “constantly track the encoder value and proximity sensors while simultaneously running image processing algorithms to classify the parts and communicate with the ejection system,” Heard says. “This multi-function juggling can lead to a complex software architecture, add considerable amounts of latency and jitter, increase the risk of inaccuracy, and decrease throughput.”

High-performance processors such as FPGAs help address these issues by providing a hardware-timed method of tightly synchronizing inputs and outputs with vision inspection results.
Image-Based Readers Boost Shipping Efficiency

Automating a consumer electronics shipping line’s scanning and verification process saved resources, boosted productivity, and saw an ROI of just six months.

A third-party logistics provider specializing in consumer electronics products recently found that automating its scanning and verification processes saved valuable time and resources. With image-based barcode readers from Cognex (www.cognex.com), the company reduced headcount on one of its shipping lines from 12-16 people a day to only 2-3, increasing throughput meanwhile to 360 cases per hour.

Enjoying a read rate of 99.5%, the logistics provider is also well positioned for changing business needs because the readers can handle 2D codes and can read barcodes coming through in any orientation.

And, with cost savings of about $150,000 a year, the automation paid for itself in just six months.

Labor-intensive operations

The third-party logistics provider operates a 600,000-square-foot facility from which it ships up to 35,000 products per day directly to consumers and another 2,500-5,000 products to stores. The line that previously required up to 16 employees handles 6,000-15,000 consumer shipments daily.

In the original design of that line, employees used handheld laser-based scanners to capture barcode data. At the first scanning station, one person captured two codes—a serialized code and a SKU code—on the front face of each box. The data was sent to a warehouse management system that assigned the box to the next order in the queue. That order’s shipping manifest label was then printed and applied manually (to the top side of the box with the label wrapped onto the side of the cartons as well).

At the next scanning station, another person scanned the two codes on the front face of the box again, plus the shipping manifest label on the side. This cross-verification step made sure the shipping label corresponded to the correct item. If everything matched up, the box continued down the line.

Image-based automation

The company brought in StreamTech Engineering (www.streamtecheng.com), a logistics systems integrator based in St. Louis, to automate the shipping line. “They provided us with their design criteria, which included automatic dispensing, scanning, print and apply, automatic cross-verification of labels, and a QC auto-reject station,” explains Bob Miller, an engineer with StreamTech.

Another aspect of the project involved automating the way the boxes were fed onto the conveyor belt. At the time, each box was being pulled out of a carton and individually placed onto the belt.

An important requirement for the project was that the new, automated line would be able to adapt to future demands, including the use of 2D barcodes. Also, as the company took on additional customers, management was expecting to get barcodes in ladder orientations rather
than just the picket fence orientation they were seeing at the time. Although this would not be an issue for handheld scanners, automated readers needed to have the ability to capture codes in any orientation.

StreamTech was concerned about the ability of laser-based scanners to consistently read the labels on the packages because of variations in label position, skew orientation, and code type. They also felt their inability to read 2D codes or barcodes in various orientations would not address the customer’s concerns about unknown future needs. So Miller decided to go with the DataMan 302 image-based readers from Cognex.

These readers capture an image and use a series of algorithms to process it and make it easier to read. An algorithm searches the entire image for the code and identifies the position and orientation of the code for easy reading. Other algorithms handle degradations in code quality caused by differences in material types and surfaces. “The DataMan 302s give us omni-directional reading capability, so they can handle picket fence and ladder orientation and anything in between even if it’s skewed,” Miller explains.

The DataMan 302 offered the advantage of high throughput even when labels are damaged, and regardless of where they appear on the box or how they are oriented. This is because of its use of the new 1DMax+ algorithm, which incorporates Hotbars technology to handle difficult barcode-reading applications on high-speed lines.

Hotbars uses texture to locate barcodes at any orientation and then extracts high-resolution 1D signals for decoding. The Hotbars finder analyzes a raw source image and produces a list of regions where it is likely that an ID code exists along with the orientation and other properties of the code. Hotbars technology then extracts the 1D signal using as a mathematical foundation a model of the pixel grid itself that reduces blur while maintaining perfect accuracy and noise reduction.

**Better throughput and flexibility**

The new, automated line begins with a custom dispenser designed by StreamTech that holds 60 individual product cartons. The dispenser pneumatically fires the boxes onto the conveyor belt.

At the first scanning station, one DataMan 302 reads the two 1D codes on the front face of the carton. Next, two Zebra PAX4 printer engines print and apply the shipping labels to the cartons. After that comes the cross-verification check station. Although a DataMan 302 can read in two planes, StreamTech decided that there were enough idiosyncrasies about the way the boxes and barcodes arrived at the cross-verification station that Miller dedicated two DataMan 302s to this station. One reads the front face of the carton and the other reads the shipping label barcode on the side.

The read rate for the two barcode readers has consistently been 99.5 and 99.8 percent, a rate that the company finds very satisfactory.
Continued
Image-Based Readers Boost Shipping Efficiency

They also have confidence that the line is well positioned for the future. “The Dataman 302s are capable of reading 2D codes as well,” Miller notes. “The Cognex software has settings to accept or filter multiple 1D and 2D symbologies.”

The new automated line has increased throughput from 2,400 cases per hour to 2,760 cases per hour, yet the entire operation now requires only two or three people, who load the dispenser system, palletize the finished products, and tend the line (filling the printers with label stock, handling exceptions, etc.). The estimated cost savings from the labor reduction generated a fast ROI. In addition to having a line that runs faster at a lower cost, this customer has a line that should serve it well for many years to come.
Improving Food Safety—One Can at a Time

A major food processor needed a solution to improve inspection of product codes at high speeds, and also read the UPC barcode and ensure the labels were fully attached. Matrix Technologies provided a vision-based brightfield inspection system that would improve regulatory compliance and traceability.

By Les Haman

Lactose-free, gluten-free, contains peanuts, manufactured on equipment that processes tree nuts. In a facility that produces millions of cans of food and beverages a year, getting the wrong label on a product is more than a customer satisfaction issue; it’s a potential liability.

Food processors must match the character-based product code printed on the can with the universal product code (UPC) barcode on the label. Inspection is difficult because of the large volumes and high speeds involved, and because of the difficulty reading product codes against the bright metal background.

A major food processor approached Matrix Technologies for a vision system-based brightfield inspection solution that would improve inspection of product codes at the required line speeds. The solution also needed to read the UPC barcode and ensure the labels were fully attached. Ultimately, the solution would improve regulatory compliance and traceability.

New technology recognizes patterns

We created a solution using a new type of vision system, Cognex In-Sight, that is able to inspect product codes against bright can backgrounds at a speed of 1,000 products per minute. Matrix Technologies’ bright stock labeling solution inspects products immediately after a label is applied. A pattern-matching tool recognizes a pattern regardless of its location. Rather than reading individual characters, the application looks for an image that matches the three-digit product code. The vision system can be easily configured to detect a product code anywhere within its field of view.

Our bright stock inspection solution uses a laser scanner to read the barcode on each product’s label. A fiber-optic sensor identifies improperly glued labels by detecting a protruding flap. A proximity sensor triggers both the vision system and the barcode reader. The vision system, barcode scanner and fiber-optic sensor independently inspect each product and send pass and fail signals to the programmable logic controller (PLC) that oversees the inspection station. The pass or fail signals are buffered until the product travels to the reject mechanism.

Setup made easy

A human machine interface (HMI) running on a PC displays real-time image updates, inspection statistics, diagnostics and setup functions. Images are displayed on the screen with an overlay to indicate a pass or fail result. Running counts of passed and failed
inspections also are displayed, informing users about each failed inspection. The vision system records images of all products that fail inspection, usually due to the improper orientation of the product code.

Enterprise resource planning (ERP) connectivity relates product codes to UPC codes. The system uses Microsoft SQL Server to centralize configuration parameters and to retain failed inspection results. Setup mode leverages the ERP and SQL Server connections to ensure that the latest updates are deployed. When the operator presses a “setup mode” button, the barcode from the next product that runs through the system is retrieved and automatically used to download the correct product code. No data entry is required.

We have deployed 10 of these systems to our initial customer. The bright stacking solutions provide accurate inspection results with virtually no downtime. Matching the images of the product codes offers a more reliable solution than attempting to convert the images to characters.
E-Pedigree: How Automation Secures the Pharmaceutical Supply Chain

While some companies consider using their existing workforce to manually track and trace packages, vision systems enable serialization solutions that repeatably track every package, bundle, case and pallet. Packaging line manufacturer ESS Technologies shows how it’s done.

By Renee Robbins Bassett, Deputy Editor, Automation World

The complexity of the drug distribution supply chain makes it difficult to prevent product diversion and counterfeiting. To address this problem, drug manufacturers are turning to so-called e-pedigree solutions to repeatably track every package, bundle, case and pallet. In fact, California e-pedigree legislation requires that 50 percent of pharmaceuticals shipped to the state starting in 2015 be tracked down to the individual bottle level. This requirement is particularly challenging for relatively low-volume packaging operations that are currently using automated filling and labeling machines with manual case and pallet packaging systems.

ESS Technologies (www.esstechnologies.com), a packaging line manufacturer, has partnered with Xyntek Inc. (www.xyntekinc.com), a serialization, track and trace, and machine vision system integrator, to provide a robotic case erector/loader with integrated track and trace capability. This system allows pharmaceutical and medical device manufacturers to automate the case packing process and provide unit-level serialization, traceability and authentication for all of the products being case packed.

The e-pedigree consists of an electronic record of each transaction resulting in a change in ownership of the drug from the initial sale by the manufacturer through wholesalers and distributors and pharmacies until final sale to the consumer.

Pharmaceutical manufacturers are addressing this by implementing serialization solutions that affix a unique and traceable serial number to every package, bundle, case and pallet. This serial number is read many times as the product moves from manufacturer to consumer and, each time, an entry is made in a database to document the chain of custody. Manufacturers, wholesalers and pharmacies must collaborate on the serialization strategy.

When lines are not fully automated, they typically use automated filling and labeling machines but manual case and pallet packaging systems. They operate at relatively low speeds—about three to five cases per minute, with each case containing six, 12 or 24 individual packages.

Because manual operations are inherently vulnerable to untraceable errors, making it difficult or impossible to comply with e-pedigree regulations, automation offers a solution. The ESS/Xyntek ap-
The approach uses a Fanuc LR Mate 200iC/5L multi-axis robot with special end-of-arm tooling and four Cognex InSight 5603 vision systems. The vision systems provide a fast and accurate method of reading and verifying the quality of one- and two-dimensional barcodes.

**Dual codes provide verification**

When case packing, it’s important to determine at the moment of loading which particular bottles are going into each case. The serial number on the labels of the bottles cannot be read at this point because the bottles are bunched together, but dummy codes on the bottom of the bottles can be read easily.

So, after filling and labeling but prior to packing the bottles in cases, the Xyntek-Antares Bottle Tracking System uses the four Cognex (www.cognex.com) InSight 5603 vision systems to image all sides of the bottles. This enables the system to read the 2D DataMatrix code on the label regardless of its position, while a single InSight 5603 vision system reads the dummy barcodes on the bottom of the bottles. The serial number on the label and the dummy code on the bottom of each bottle are both entered into a database.

According to Xyntek engineers, the traditional approach to pharmaceutical serialization uses industrial cameras multiplexed to an industrial PC. These systems can be expensive to maintain and validate because of the need to maintain a complex and continually changing operating system and custom software. Xyntek selected the Cognex vision system because of its powerful, high-speed processor and the fact that it operates independent of a PC (which provides increased stability with less frequent updates and maintenance).

Cognex offers a large library of vision tools that can be used for code reading and other operations without programming. With the bottles arranged in a 4x3 pattern, and each bottle having a 2-inch diameter, a 6x8-inch field of view is needed to read the code on the bottom of all 12 bottles. At 1,600x1,200 pixel resolution, a single InSight 5603 can consistently read all 12 bottles within the time requirement.

The bottles come into the robotic cell on a conveyor and a servo device forms them into a pattern based on the type of container. The robot then picks up all bottles and loads them into the case. Vacuum sensors on the end-of-arm tooling check for the presence of each bottle and, if a bottle is missing, set off an error signal. Vacuum cups pick up a case blank from a magazine. The robot can use either regular slotted container (RSC) cases that are normally used in manual operations, or wraparound cases that are common in automated processes.

As the robot moves the bottles toward the case, it passes them over an InSight 5603 vision system that reads the dummy codes on the bottom of the bottles. Because these dummy codes have already been aggregated to the serial number of each bottle as recorded on
the label, reading them makes it possible to identify the unique serial number of the bottle. This aggregation enables 100 percent verification of the bottles as they are packed into the case.

The robot loads the bottles into the case and then folds the minor and major flaps and seals the container with tape. The Xyntek-Antares Tracking System software confirms the unique serial numbers based on the pack pattern and prints a case label to complete the bottle-to-case aggregation.

If the operation fails because a bottle is missing in the tooling or because a label could not be read, the line stops. If the operation is running 12 packs, then there are only 24 bottles to rework, which can quickly be performed by the line operator.