INTRODUCTION TO
MACHINE-VISION INSPECTION

Machine vision is used in virtually all manufacturing industries to boost quality, productivity, efficiency, and regulatory compliance. Simply put, machine-vision combines the picture-taking ability of a camera with the processing power of a computer to make decisions about the position, quality, and completeness of a manufactured product and its parts. Most machine-vision systems include a library of software tools that perform different types of inspections and let you incorporate multiple inspections from captured images.

WHY USE
MACHINE VISION?

The widespread adoption of machine vision is linked to three factors: machine vision benefits, consumer demand, and regulatory requirements in manufacturing. Whereas human vision is best for qualitative interpretation of a complex, unstructured scene, machine vision excels at quantitative measurement of a structured scene because of its speed, accuracy, and repeatability. For example, on a production line, a machine-vision system can provide 100% coverage, inspecting hundreds or even thousands of parts per minute. When it comes to assuring product quality, machine vision is available full-time and never takes a coffee break. Machine vision can make decisions in milliseconds, enabling you to run production lines faster. And it can accommodate a wide range of products and applications.

Today's consumers expect the highest quality and unconditional safety in all aspects of their lives. At the same time, the regulatory climate in most industries makes robust, reliable product inspection a must have. For example, the Food Safety Modernization Act (FSMA) implemented by Congress in 2011 has spurred demand for machine-vision systems in the food and beverage industries. And companies in the pharmaceutical and medical device industries must address consumer safety and government regulations while guarding against counterfeiting.

The alternatives to machine vision for inspection—low-cost photo sensors and human inspectors—have their drawbacks. Low-cost photo sensors can perform only a limited number of simple tasks such as position verification, counting, and color checks. In addition, because of their rigid mounting setup, they can only provide go/no-go decisions. Human inspectors can get bored or distracted and may not be able to keep up with production line speeds. Moreover, some manufacturing environments may not be safe for human inspectors.

Those considering a machine-vision system can be concerned about capital costs, the need for lighting expertise, and getting up to speed on how machine-vision systems work. The good news is that system costs are becoming ever more affordable and companies like Cognex offer a growing range of resources to help you with your machine-vision and lighting setups.

WHAT CAN
MACHINE-VISION INSPECTION DO?

The versatility and industry range of machine-vision inspection can be seen in the following list of typical machine-vision inspection tasks:

• Determine the position of an object, for example, to verify proper label placement

• Ensure the package integrity of medical products, such as checking that medicine vials are fully closed and secured with tamper-proof seals

• Verify that an object's properties meet quality standards, such as the position and volume of glue beads used in automobile transmissions

• Inspect manufactured goods and identify flaws, such as surface scratches, bent needle tips, and incomplete solder traces

• Count items, such as pills in a blister pack, bottles in a case, and components of a kit

• Check on characteristics of completed assemblies, such as the inclusion of consumer safety inserts and the completion of an assembly operation

• Detect tool wear in machining operations before parts are out of spec

• Measure dimensions on a microscopic level, such as the gap on a spark plug

By looking at a few specific examples of applications in the food, beverage, pharmaceutical, medical device and automotive industries, you can start to get a feel for how machine vision could support your manufacturing processes.

FOOD AND BEVERAGE APPLICATIONS

Figure 1 shows how machine vision is used on a bottling line to check each bottle for fill level, cap closure, safety ring presence, and label position. Shipping products with this type of defect can lead to leakage in shipment, product returns from the retailer, and even a recall order from the FDA.

Figure 1. Machine vision for fill-level inspection.
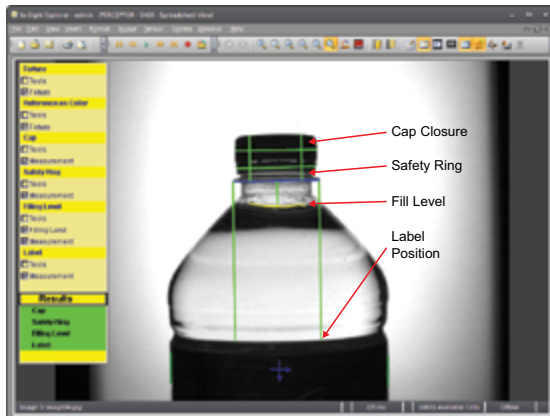
(a) Good bottle with diagnostic graphics (green lines) that show the features being inspected. The small operator dashboard on the left gives status information and options for turning the diagnostic graphics on and off.
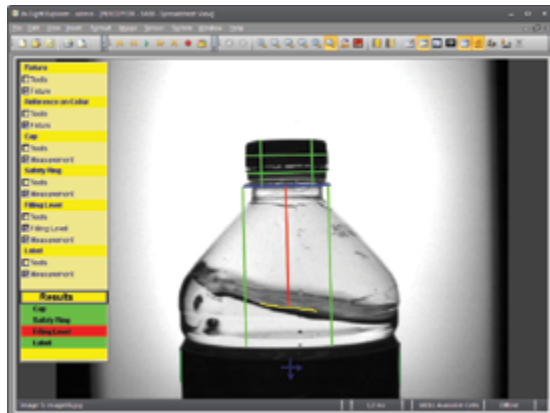
(b) Bottle with a fill-level defect, which will be diverted off the production line before reaching the case packer.
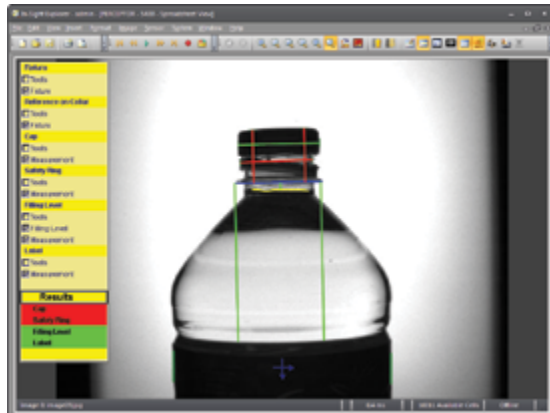
(c) Capping error example. The cap is not properly seated and the safety seal is not secured to the cap.

Figures 2, 3, and 4 show results from the following three inspection tasks for meat patties on a meat-packaging line:

- Check portion size

- Determine whether package is properly sealed

- Ensure accurate package labeling

This food industry application gives insight into the many production steps that can go wrong during an assembly-line operation, the consequences of packaging defects, and the opportunities for reducing process errors. For example, if the meat patties are not placed properly into the Styrofoam containers, as shown in Figure 2, a consumer is likely to reject the defective package and seek out a normal one where both patties are the same size and fully visible.

After the filling operation, packages are sealed by a shrink-wrapping machine to protect the meat against premature spoilage and contamination. A consumer is also likely to reject a meat package if a defect appears in its shrink-wrapping, shown in Figure 3, which means that the meat could be contaminated. A sealing defect might be caused by improper temperature control on the sealing machine or defective containers. Extraneous meat might indicate that a filling machine needs maintenance. Data produced by the machine-vision system can be used for preventative maintenance and improved process control.

After the sealing operation, the packages go through a labeling machine where two different labels are applied. Inspecting for labeling errors, shown in Figure 4, is paramount to quality control, as labeling errors are the most common cause of food recalls in the U.S. and represent a growing focus of the U.S. Food and Drug Administration (FDA). Consider, for example, the health risks posed by a consumer product containing peanuts that is mislabeled as being peanut-free.

Figure 2. Machine vision for verifying product position and size of two meat patties in a Styrofoam tray.
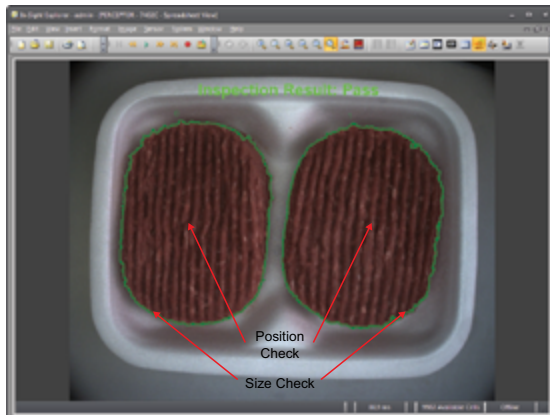

(a) Inspected and passed meat package.
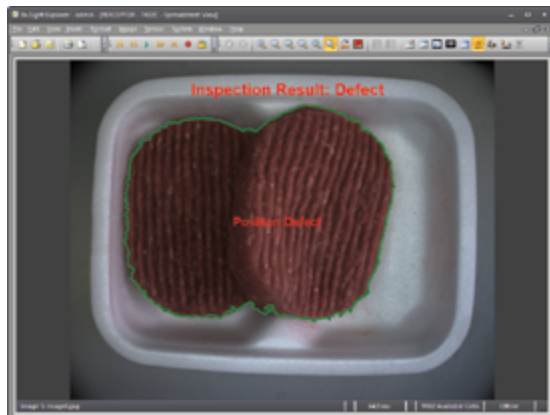
(b) Position defect in meat patties. Although the product size could be accurate, a consumer typically rejects such a package in favor of one that clearly shows both patties.
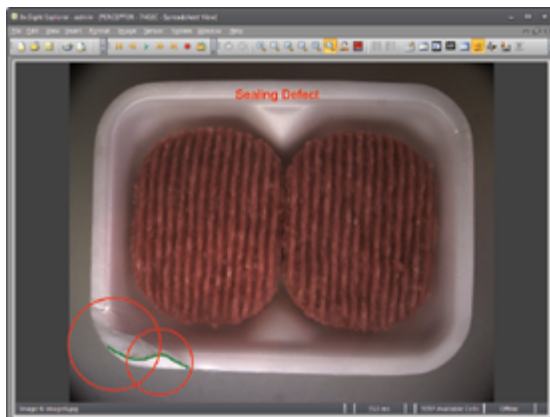

(c) Size defect in meat patties. A consumer typically rejects such a package for being underweight.

Figure 3. Machine vision for verifying the position and protective sealing of two meat patties in a Styrofoam tray.
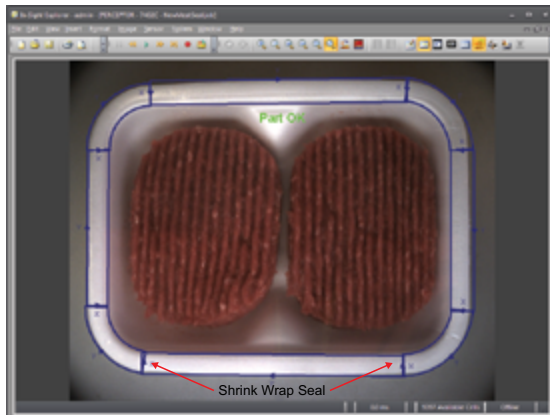

(a) "OK" inspection for completely sealed package.

(b) Defective seal on lower left of tray. This sealing defect might be caused by improper temperature control on the sealing machine or a batch of defective containers.
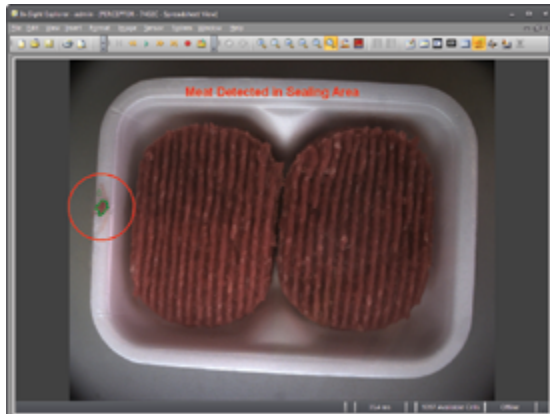
(c) Scrap of meat caught in the seal on the lower left side of tray, preventing proper closure. Extraneous meat might indicate that a filling machine needs maintenance.

Figure 4. Machine vision for verifying correct labeling on a meat product. The top label with a picture of the product is preprinted and denotes the fat lean content of the meat. The bottom label is printed at the time of packaging and contains lot and date codes plus product weight.
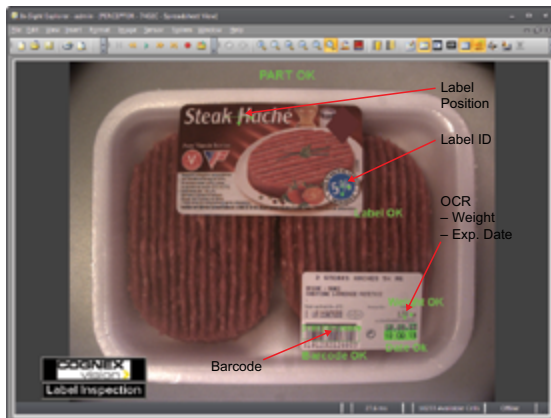
(a) Correct information on both product labels.

(b) Product label at bottom rejected because actual product weight is .25 kilograms, but listed product weight is .5 kilograms.


(c) Product label at top rejected because incorrect preprinted labels were installed on the labeling machine. The blue, circular fat content icon shows 0% fat rather than the actual 5% fat, misrepresenting the product to consumers.

PHARMACEUTICAL AND MEDICAL DEVICE APPLICATIONS

Figure 5 shows a traceability application in which optical character recognition (OCR) verifies the batch codes on soft plastic IV bags. Recognizing the codes on parts and products enables companies to track parts through the production facility and the supply chain. The vision system used here was trained to recognize numbers and letters as well as tolerate minor shape variations that can occur because of the pliable bag. Although tolerating minor shape variations is something our human brains can do well, it is a challenge for computers. To improve traceability with OCR and machine vision, Cognex created OCRMax™, which tolerates typical printing variations while delivering the industry's highest read rates. The batch code can be entered into the vision system by an operator at the start of production or downloaded to the vision system from a programmable logic controller (PLC).

Figure 5. Machine-vision inspection using optical character recognition (OCR) to verify batch codes on soft plastic IV bags. This traceability application lets manufacturers track parts and products through the production facility and the supply chain.
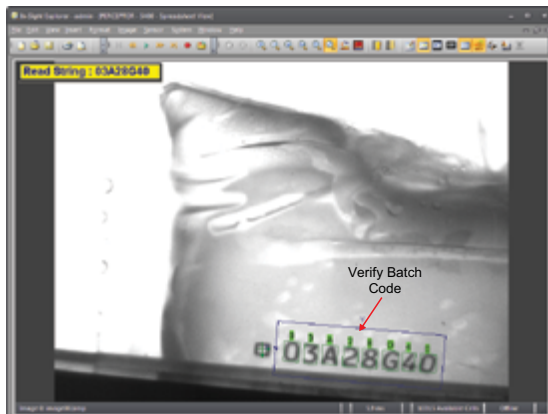

(a) Correct OCR of batch code.

(b) Misread of code caused by misprinting of the letter G, which makes it look more like the letter C. This bag is rejected to avoid confusion.

AUTOMOTIVE INDUSTRY APPLICATIONS

The automotive industry is one of the largest users of machine vision, executing inspections for parts traceability and compliance with strict quality controls, especially in powertrain components and safety equipment such as brakes and air bags. On an automotive production line, it's common to see hundreds of vision systems and ID readers installed for error proofing and traceability. At the same time, many assembly tasks are still done by hand. In these cases, machine vision is used to check for human errors.

Figure 6 shows how machine vision is used to inspect images of a part assembled by an operator installing two screws and two nuts. The inspection ensures that the screws are completely inserted and that the nuts are installed correctly.
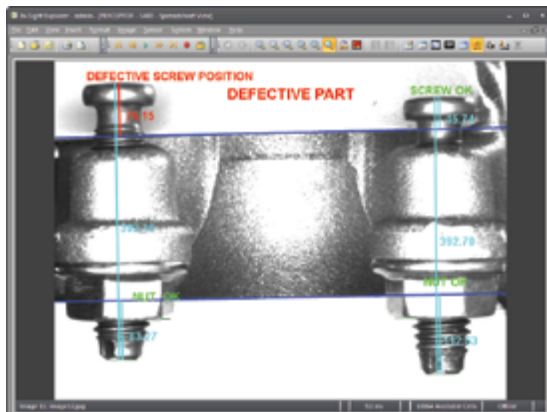
Figure 6. Machine vision inspection of a part just after an operator has installed two screws and two nuts. The inspection ensures that the screws are completely inserted and that the nuts are installed correctly.
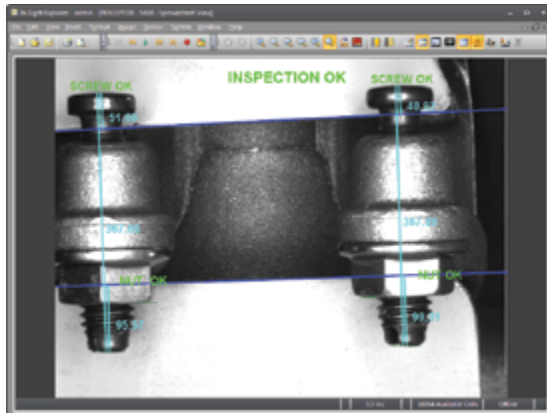
(a) Correctly assembled parts.
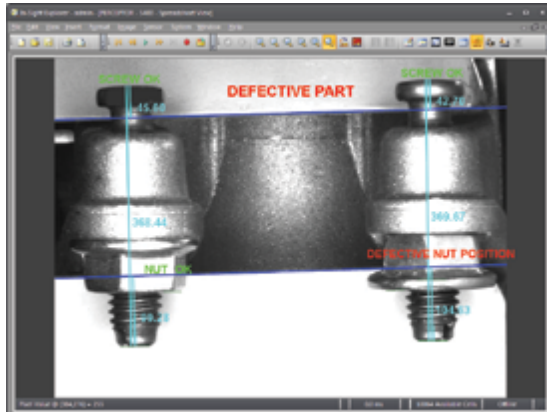
(b) Image of a defective part on right assembled by hand with an upside-down nut at bottom.

(c) Image of a defective part on left assembled by hand in which the screw has not been fully inserted.

CONCLUSION

These brief examples only hint at the deeper power of implementing machine vision. As you move from tactical to strategic use of machine-vision inspection, you can go beyond rejecting defective parts. The data you collect about defects gives you the opportunity to identify and fix performance issues on your production line. In today's machine-vision market, it's never been easier to achieve sophisticated inspection applications. Advances in cameras, lighting, and optics; the availability of good lenses and filters; and user-friendly point-and-click application development environments enable you to perform machine-vision inspections without being a machine-vision expert.