

Avoiding quality control disasters with machine vision



Contents

- Track and trace to avoid quality control disasters
- Dispelling the myths about machine vision systems
- Machine vision for quality assurance

ebook

processonline
.com.au

Automation, control & instrumentation



Track and trace to avoid quality control disasters

John Immelman

It is a critical aspect of quality assurance and food safety to identify a product at its origin and track and trace the forward movement through the entire process of the food supply chain, including food processing, filling, closure and packaging. To retrospectively identify where and when a problem may have occurred, and to date and time stamp the event, is a prerequisite.

The ability to automatically recognise defects up and down the supply chain has become an integral part of quality control in the food industry business and is a legal requirement in many processes.

Remarkably, the vast majority of food processing facilities around Australia still rely on human beings to do the track and trace inspections.

The problem is that human beings cannot, for the most part, keep pace with industry requirements for increased production speeds and increased product quality. Operators get tired, lose focus and make mistakes. This loss of concentration could result in them failing to detect potentially defective products; the criteria that they apply during inspections are inevitably subjective.

Machine vision (MV) is the technology to replace or complement manual inspections and measurements with digital cameras and image processing. The technology is used in a variety of different industries to automate the production processes, increase production speed and yield, and to improve product quality.

Typical applications of machine vision in the Australian market:

- Code validation - confirming that all the codes on the product are readable.
- Label inspection - ascertaining that the labels are placed correctly.
- Label validation - validating that the correct label is affixed to the product.

- Packaging integrity - ensuring that any recycled packaging material is adequate.
- Filling monitoring - validating that the correct product and correct amount is filled.
- Closure inspection - ensuring that lids and caps are positioned and tightened correctly.
- Sealing validation - ensuring that foil covers and anti-tamper seals are present and correctly applied.

Code validation

Machine vision solutions for code inspection are used to verify code presence, position, formation and readability, and sometimes to also provide code reading and matching. Such systems can automatically identify and reject containers or packages with missing, incorrect or unreadable codes to ensure only properly coded items are produced.

Codes that can be validated are date codes, batch codes, barcodes and 2D data matrix codes, all ensuring that non-compliance can be traced and acted on.

Label inspection

High-speed labelling of products, of all types, shapes and sizes, can result in a wide variety of possible defects. These defects can lead to labelling errors that can be harmful to a brand or even present liability issues for a brand owner. Labels can be inspected for label presence, wrinkles,

tears, skewed labels, double labels, flagged or missing labels, as well as incorrect label pairs (back and front) on containers and packages.

Overwrap alignment is another form of label inspection in which wraparound labels are checked for straightness and proper position. With appropriate MV system design, a 360° inspection on round bottles can be performed.

Label validation

The importance of correct labelling on a food product grows each day as scientists and doctors discover more food properties that need to be identified and displayed: peanut allergies, gluten-free, salt content - the list is extensive.

Machine vision technology for label inspection can be set up to help ensure correct labelling, and packages and containers with incorrect or defective labelling can then be automatically rejected in the production line.

Incorrect product labelling on the supermarket shelves could result in costly litigation, or worse.



Packaging integrity

Inspection of recycled packaging equipment can be easily achieved using MV technologies.

In beer bottling lines it is common practice that the beer crates are checked for wholeness, and if the crate has any damages, such as a hole in the bottom, it can be rejected before a bottle is inserted and falls through.

A further application has been implemented by a leading confectionery company in Melbourne that uses MV to check that the confectionery trays are clean for re-use before reintroduction into the manufacturing process of the next batch.

Filling monitoring

Ensuring that the correct product is filled into the correct container, and that the correct amount is filled, can be achieved using MV together with the code validation technologies.

This application is used by a global pet-food producer with process plants in Australia. Here the importance of correct filling is even higher due to the fact that much of the production is exported to Asian markets where brand reputation is paramount. Product recall, in this instance, can be very costly, both in terms of product waste and brand damage.

Incorrect product labelling on the supermarket shelves could result in costly litigation, or worse.

Closure validation

Obviously the integrity of closures and seals on bottles and other containers is important for the quality of the product and the safety of the consumer. MV systems can be used to visually check the closures and seals for integrity.

A simple application, albeit in a related industry, is using MV technology to check that the correct colour cap is placed on the correct home brand bleach bottle at a Queensland-based contract bottle filling company. And, more importantly, that the sealing is perfect - leaking bleach in the boot of a car could have some unpleasant consequences.

Checking the closure's colour and dimensions verifies that the right closure has been applied to the container, while visually checking liner formation and placement ensures the product is properly sealed and protected from contamination and leakage. In the same way, tamper seals can be checked to make sure they are not broken.

Sealing inspection

There are many other applications where the integrity of the sealing process is paramount. The sealing of all wet food needs to be checked - any small flaw in the seal will result in the product possibly leaking contents, and the definite likelihood of the product spoiling. Additionally, tamper-proof seals can be checked for correct application prior to packaging and a photographic record kept of every product inspected.

We have reviewed a small selection of applications for the use of MV technology. Further applications of machine vision in other markets include:

- Checking product quality - bruises, cuts, damage to fruit and vegetables, cracked eggs.
- Sorting fresh produce by size, colour and type - nuts, oranges, eggs, coffee.
- Checking for defective bottles and hygiene inspection in the bottle-washing process.
- Additional checks on bottle crates - logo inspection (correct crate for specified product), edge inspection to avoid sharp edges causing injury.
- Fish filleting using MV in conjunction with robots.

MV technology is developing as a rapid rate, providing faster, smarter and more accurate measurements. This evolution ensures that the food industry can apply the technology to more complex track and trace applications thereby assuring an even higher degree of quality assurance and food safety.

As the food and beverage authorities tighten the regulations, MV solutions are the best way to ensure compliance.



Dispelling the myths about machine vision systems

Machine vision is a branch of engineering that uses cameras in the context of process control. Images are collected and analysed and the data extracted used for controlling an automated process or action. When we refer to machine vision systems we are typically referring to smart cameras or vision sensors - devices that possess image capture capability, are able to extract information from captured images and make decisions that are used in wider automation systems.

Sean Carter, Product Market Manager, Advanced Industrial Sensors & Encoders, Sick Australia

Developers of equipment realised early on that the possibilities for applying machine vision technology were almost limitless and very quickly appreciated that almost any material handling or logistic process that involved object inspection would suit a vision system.

Typical applications have grown to include detection of faults and flaws, non-contact measurement, part sorting, code reading, continuous flow dimensional gauging and position detection and rotation.

Resistance

Unfortunately, machine vision systems have developed a reputation amongst some managers and engineers as being expensive, unnecessary, superfluous and possibly even incapable of performing the very tasks they are expected to execute. These are all attitudes that have come about because early vision systems were indeed inflexible, cumbersome and costly.

Many vision systems were installed in the early days at great expense but, because of inexperience and limitations with the technology, they may have been used briefly before being left to gather dust in a corner. However, machine vision has come a very long way in the 30 years since it first appeared, even more in just the last half decade.

From rudimentary beginnings, machine vision suppliers have developed machine vision systems into 'smart cameras', integrated vision systems which combine image capture capability and decision-making technology into one compact device.

A typical machine vision set up today might include a 2D or 3D smart camera or sensor, lenses and filters, lighting, an image acquisition

and analysis software package, plus the cables and brackets necessary for integration into a production line or machine.

Modern smart cameras are self-contained, stand-alone units with built-in CCD or CMOS image sensors, image processors, image memories, communication interfaces and industry-standard outputs for connection to PLCs where further processing of the image or information can take place. Most devices are now no larger than an ordinary industrial or surveillance camera but rival PCs in terms of their processing capabilities.

The six myths

While resistance to machine vision systems manifests in many forms, it is possible to distill it down to six clearly defined misconceptions - fallacies which can be easily dispelled.

Machine vision is too expensive

Never has this been further from the truth.

While many managers and engineers balk at the costs of purchasing vision systems and integrating them into their production processes, they ignore the real costs to their business in terms of wastage, rework, returns or lost productivity due to employee illness or absence and forget about the real benefit of improved productivity thanks to greater processing speed.

It is far better to think of machine vision systems in terms of the return on investment and to take into account the entire effect on one's production system, not just the initial capital outlay.

Vision systems are now not just economical to purchase, but are robust, compact, reliable, practical, flexible and easy to integrate.

The technology is not up to it

The pace of development, even in just the last half decade, has been tremendous and products are now readily available that are flexible enough to be able to fulfil a multitude of inspection tasks, or specialised enough to be able to perform one inspection task exceptionally well.

Modern machine vision systems are fast - some capable of speeds of up to 5000 inspections per minute, they can be accurate down to hundredths of a millimetre and they are reliable, with modern devices that have fully integrated lighting and ethernet communications capabilities.

Troubleshooting is difficult

Modern software packages employ digital image processing techniques that are designed to perform many and varied analyses. The user interfaces are designed to work within standard PC environments, be easy to learn and present only the information that is relevant to the inspection task at hand. Predefined inspection packages are provided and emulator tools provide easy methods of finetuning and testing of solutions without disturbing production.

Commonly used techniques include pixel counting, edge detection, template matching, thresholding, segmentation, blob extraction, pattern recognition, barcode reading and optical character recognition.

Ideally, vision systems should also incorporate image logs for analysing production problems.

All this results in trouble-free and fast solving of a diverse range of part inspection applications and the ability to resolve production issues on the spot.



Early Automatix Inc machine vision system at a trade show in 1983. The camera on a tripod is pointing down at a light table to produce a backlit image, which is then processed in the monolithic controller, probably employing a 68000 microprocessor.

Support is non-existent when problems do occur

As sure as many companies appeared in the early days proclaiming that they were 'vision experts', they rapidly disappeared. Unfortunately, this left many end users with vision systems that were unsupported.

Most integrators and component suppliers have now been in the business long enough to establish themselves as genuine 'specialists' in the field and are capable of providing not just the original solution, but the service component that goes along with it.

Trust only those companies that do have long experience in the field and are able to demonstrate their ability to solve applications similar to yours.

From rudimentary beginnings, machine vision suppliers have developed machine vision systems into 'smart cameras', integrated vision systems which combine image capture capability and decision-making technology into one compact device.

There is a loss of flexibility in the production process

Modern vision sensors are designed to be easy to adapt and integrate so it is possible for them to be reconfigured to suit different products and situations. Some are able to store images and actually perform product changes 'on the fly' with only minimal disruption to production.

It is even possible for them to be shifted from one production station to another and settings altered if a production line needs to be modified.

It puts people out of work

Rather than render employees redundant, anecdotal evidence suggests that the use of vision systems in production processes actually frees employees up to be utilised in jobs that are more beneficial for the company and more worthwhile and fulfilling for the employees themselves, a much better use of an extremely valuable resource.

Rather than replace staff, some vision systems are now so cost-effective that they can be used in addition to manual labour as a cross-check for inspection of manually assembled products.

Is there a place for a vision system in your production?

Always remember that when choosing and implementing machine vision technology, a simple solution that works is a preferable solution.

Ask yourself the following questions:

- What outcome is required? Often the sole driver of vision projects is the need to increase production speed but it can just as easily be a desire to reduce labour costs, improve quality and increase production yield - all factors that are vitally important in the food and beverage industry.
- Which technology should be used? Define your task. Speak to experts who have the experience and knowledge of your application and who can advise whether standard hardware or a customised solution is applicable.
- What does a typical vision project look like? Ask for typical application information and make sure that whomever you engage is fully committed to guiding you with your project.
- What environmental and set-up problems will be encountered along the way? Often there are heat, vibration, dust and humidity concerns. Mounting space, cycle times and illumination must be taken into account. As should the special requirements of food production areas such as waterproof housings, stainless steel construction etc.

If you've asked yourself all these questions and have decided that a vision system is the answer, then proof of concept is easy with modern devices. Trials with vision sensors can be very quickly set up in a workshop and translated to the production facility with only finetuning of the site illumination and other minor integration tasks.



Machine vision for quality assurance

Glenn Johnson, Editor, What's New in Process Technology

Machine vision (MV) is the technology and techniques used in industrial environments to provide imaging-based automatic inspection, detection and analysis. The most common uses for machine vision are automatic inspection and industrial robot guidance, while in recent times, vision-based sensors for detection purposes have become available to replace sensors such as photoelectric sensors. Common MV applications include quality assurance, sorting, material handling, robot guidance and optical gauging.

Machine vision outputs

The most common output from a machine vision system is a pass/fail decision. Such an output may in turn trigger mechanisms that reject failed items or sound an alarm. Other common information that can be provided by an MV system includes object position and orientation information, which is commonly used for guidance systems, as well as numerical measurement data, data read from codes and characters, displays of the process or results, stored images, alarms from automated space monitoring MV systems, and process control signals.

General operation

The first step in the MV sequence of operation is acquisition of an image, typically using cameras, lenses and lighting that has been designed to provide the differentiation required by subsequent processing. For example:

- Different types of lighting (different colours or infrared for example) render different qualities of objects that may be of interest for detection or inspection.
- Strobe lighting synchronised with the rate of flow of objects past the camera allows fast snapshots to be taken of each object without motion blur.

MV software packages then employ various digital image-processing techniques to extract the required information and often make decisions (such as pass/fail) based on the extracted information.

While conventional 2D visible light imaging is most commonly used in MV, alternatives include imaging in various infrared bands, line scan imaging, 3D imaging of surfaces and X-ray imaging.

2D visible light imaging can be performed in monochrome or colour, and various resolutions. The use of colour and the depth of resolution affect the performance requirements of the image processing hardware and software, and therefore the cost of the solution.

The imaging device (usually a camera) can either be separate from the main image processing unit or combined with it, in which case the combination is generally called a smart camera or smart sensor. When separated, the connection may be made to intermediate hardware, such as a frame grabber, using either a standardised (Camera Link) or custom interface. There are now also digital cameras available that are capable of direct connections (without a frame grabber) to a computer via FireWire, USB or gigabit ethernet interfaces.

Processing methods

After an image is acquired it is processed. Machine vision image processing methods include:

- Pixel counting: counting the number of light or dark pixels.
- Thresholding: converting an image with grey tones to simply black and white or using separation based on a greyscale value.
- Segmentation: partitioning a digital image into multiple segments to simplify or change the representation of an image into something that is more meaningful and easier to analyse.
- Blob discovery and manipulation: inspecting an image for discrete blobs of connected pixels (such as a black hole in a grey object) as image landmarks. These blobs frequently represent optical targets for machining, robotic capture or manufacturing failure.
- Pattern recognition and template matching: finding, matching or counting specific patterns. This may include the location of an object that may be rotated, partially hidden by another object or varying in size.

- Barcode, data matrix and 2D barcode reading: reading codes for data input or simply to check correct labelling on finished products or shipping boxes and pallets.
- Optical character recognition: the automated reading of text such as serial numbers.
- Gauging: the measurement of object dimensions (in pixels or millimetres).
- Edge detection: the finding of object edges to detect their presence and orientation.

Quality-assurance applications

The main uses of vision systems for quality assurance are to analyse images to perform appearance inspection, character inspection, position detection and defect inspection. Some of the main applications are:

- Detecting the presence, position and formation of a code such as a date code or barcode
- Validating the presence and positioning of labels
- Checking closures for tamper seals, correct caps by colour and dimensions
- Inspecting product for fill levels, product content or other parameters
- Sorting products based on marking

Advantages for quality assurance

The major benefits of machine vision inspection solutions are:

- Cost savings due to reduced rework, more reliable product quality and less wasted product
- Automation of quality to provide more objective QA compared with manual inspection
- Greater transparency throughout the inspection process and improved process control
- Real-time quality metrics can be made available for OEE data

Examples of QA applications

Code validation

Machine vision solutions for code inspection are used to verify code presence, position and formation, and sometimes to also provide code reading and matching. Such systems can also automatically identify and reject containers or packages with missing, incorrect or unreadable codes to ensure only properly coded items are produced.

Examples of the use of code validation are the validation of date codes, batch codes, barcodes and 2D data matrix codes.

Date-code verification verifies that a code is present and is completely formed in the correct location, while batch-code verification checks the quality of the printed batch information, ensuring it cannot be misread, possibly resulting in product recalls.

Barcode verification checks that barcodes are readable and correct, helping to ensure correct product tracking through the supply chain. 2D data matrix validation verifies that information which is not human-readable is still valid, and is properly decoded and understood by the quality system.

Label inspection and validation

High-speed labelling of products, of all types, shapes and sizes, can

Machine vision technology for label inspection can be set up to help ensure perfect product presentation and correct labelling.

result in a wide variety of possible defects. These defects can lead to label errors that can be harmful to a brand or even present liability issues for a brand owner. Labels can be inspected for label presence, wrinkles, tears, skewed labels, double labels, flagged or missing labels, as well as incorrect label pairs on containers and packages.

Machine vision technology for label inspection can be set up to help ensure perfect product presentation and correct labelling. Packages and containers with incorrect or defective labelling can then be automatically rejected in the production line.

Label presence and pairing can be checked, both to ensure labels are present and also that front and back labels are paired correctly with each other.

Skewed and dog-eared label detection ensures that labels are applied correctly and straight, and in the correct position, while double label inspection can make sure that only one label has been applied to the same location on the package.

Overwrap alignment is another form of label inspection in which wraparound labels are checked for straightness and proper position. With appropriate MV system design, a 360-degree inspection on round bottles can be performed.

Confirming that the correct label has been applied is often performed using graphical label verification (in which a unique graphical item on the label is used to confirm that the proper label has been applied) or by using 2D data matrix code verification where 2D dm codes are being used on the labels. Similarly, barcode verification confirms that the proper label has been applied by verifying that the correct barcode is present.

Closure and seal validation

Obviously the integrity of closures and seals on bottles and other containers is important for the quality of the product and the safety of the consumer. MV systems can be used to visually check the closures and seals for integrity.

Checking the closure's colour and dimensions verifies that the right closure has been applied to the container, while visually checking liner formation and placement ensures the product is properly sealed and protected from contamination and leakage. In the same way, tamper seals can be checked to make sure they are not broken.

Packaging and filling

Machine vision systems can inspect filled bottles, trays, pouches, cases, cartons and other packages to verify that the packaging process was completed to the specifications required.

Bottles can be inspected to ensure that they are properly filled, labelled and capped to minimise product spoilage and ensure perfect product presentation, and case-quality inspection can also be performed to verify that cases are properly sealed and undamaged, to allow fast and reliable palletising and packing.

MV technology can also be used to check the content of products made of discrete items, confirming that the specified contents are present, thereby demonstrating due diligence and reducing the costs associated with missing or additional components, parts or other items.

resources

from our sponsor



About SICK

SICK is one of the world's leading manufacturers of sensors, safety systems and automatic identification products for Factory Automation, Logistic Automation and Process Automation applications. Whether automating factories or optimising distribution centres, or monitoring emissions from a stack, SICK provides cost-effective solutions.

SICK Pty Ltd

Address: 5 Helen Street, Heidelberg West VIC 3081

Phone: 03 9457 0600 **Fax:** 03 9457 2023

Toll free: 1800 334 802 **Email:** sales@sick.com.au

Website: www.sick.com.au

Packaging solutions for the food industry

www.sick.com/au/en-us/home/solutions/industries/food/pages/food.aspx

Detection solutions for the food industry

www.sick.com/au/en-us/home/solutions/industries/food_and_beverages/Pages/food_and_beverages.aspx

Other primary and secondary quality control and packaging applications

www.sick.com/au/en-us/home/solutions/industries/consumer_goods/Pages/consumer_goods.aspx

SICK's customer magazine for industry focus, applications, products, views and voices

www.sickinsight-online.com

SICK Australia and New Zealand Facebook page

<https://www.facebook.com/SICKausnz>

SICK YouTube channel

<http://www.youtube.com/user/SICKSensors>

another ebook from
www.processonline.com.au

published by

