PACKAGING INSPECTION APPLICATIONS GUIDE
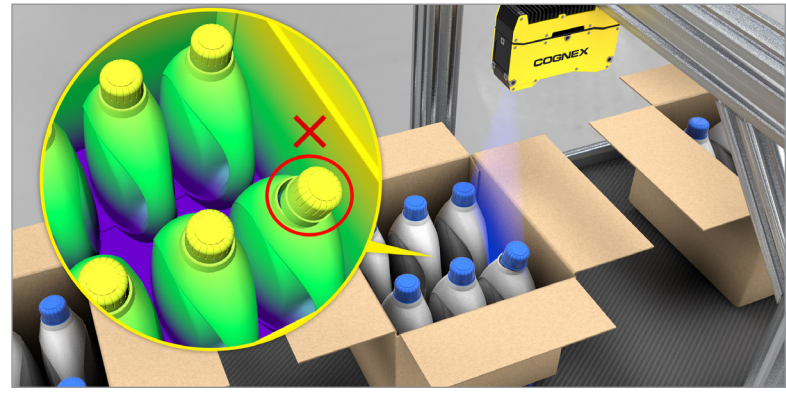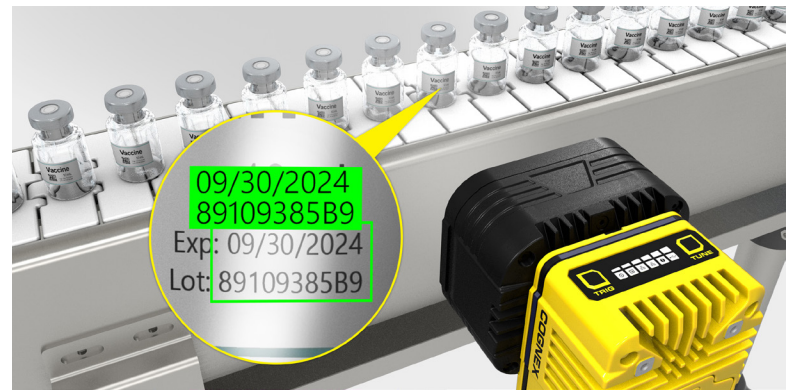
Prevent Product Recalls with Machine Vision, Barcode Reading, and AI-Based Solutions

COGNEX

PREVENT PRODUCT RECALLS
WITH COGNEX TECHNOLOGY AND SOLUTIONS

Packaging inspection applications in consumer packaged goods (CPG), food and beverage, pharmaceutical, and medical device industries are critical to ensuring product quality and safety. Faulty or damaged packaging can adversely affect how distributors and end users perceive product quality, safety, and value, or result in costly product recalls.

Industry 4.0 is the innovative approach of incorporating a greater level of automation and data exchange in manufacturing to solve packaging applications efficiently. The combination of machine vision, barcode reading, AI-based, and barcode verification technology can help ensure primary and secondary packaging is sealed properly, tamper-proof, correctly assembled, and defect-free to avoid rework and product recalls.

DIGITALIZATION
AND SELF-REGULATION

Industry 4.0 is driving change in the packaging industry as manufacturers seek to capitalize on emerging innovations in advanced automation. Machine vision, Big Data, cloud computing, and machine learning are revolutionizing manufacturing processes. Moving along the journey to Industry 4.0 presents an opportunity to digitalize processes that bolster productivity, reduce waste, improve product quality, enhance manufacturing flexibility, and decrease operating costs. Implementing a digitalization strategy also presents an opportunity to address ongoing labor shortage challenges.

As Industry 4.0 compatible edge systems and devices, Cognex machine vision and AI-based solutions create valuable digital data that serves two purposes. First, these systems capture real-time information such as inspection and measurement data that facilitates automatic in-line quality decisions. In addition, companies see great value in either feeding this data back into the process in real time or aggregating this data over time, performing off-line analytics, and using the resulting insights to drive process improvement and predictive maintenance. Cognex vision systems facilitate the digitalization of quality control processes through easy integration into industrial networks via standard communication and file transfer protocols such as TCP/IP, PROFINET, EtherNet/IP, SLMP, OPC/UA, and FTP.

Sample Use Case

The packaging industry is trending towards increased use of sustainable or recycled materials, which can be highly variable in their composition and appearance within a given production run. Given these variations, it is challenging to maintain consistent printing quality and contrast of valuable label information, such as regulatory codes and ingredients. To overcome this challenge, a machine vision or AI-based system can provide inspection data in a closed loop process with the marking system so it can automatically respond to the variations in contrast by adjusting the marking pressure in real time.
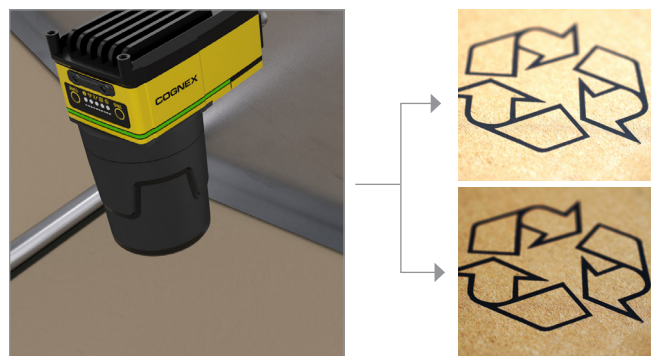
SAFEGUARD PACKAGING
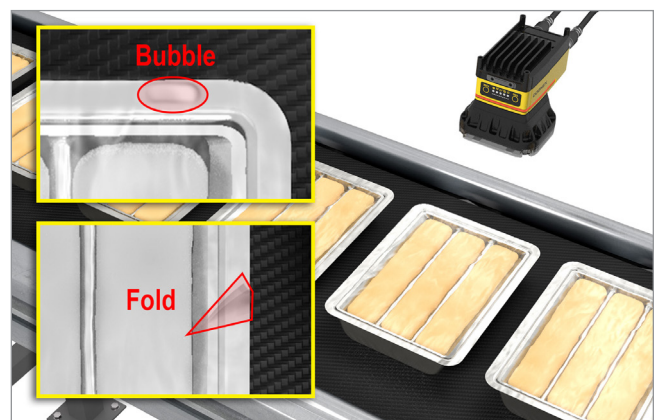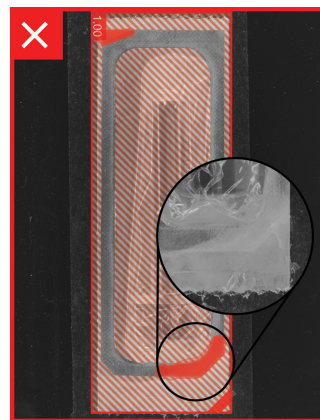
Package Seal Inspection

Challenge

Seal integrity is critical to ensure packages are sterile and contaminant-free. The cost of product recalls or returns caused by contamination, spoilage, or foreign materials can be significant. Seal inspection is notoriously challenging using conventional vision systems due to changes in appearance of defects and the high amount of possible failure modes that can occur when sealing products. Shifts in particle size, contrast variations and random defects that differ in appearance, lead to high rejection of good product or potentially dangerous products being shipped to customers. Rule-based vision systems struggle to adjust to the changes and cannot classify or quantify the specific reasons the seal failed.

Solution

Cognex AI-based technology reliably identifies foreign matter, void seals, contamination, and a host of other issues that can impact a product seal. With 100% visual inspection, operator errors are eliminated and efficiency is optimized. AI-enabled solutions can take this a step further by highlighting the issues in real time, allowing operators or machines to clearly point out the issue and later categorize the problem.

Benefits:

- Ensure sterile and contaminant-free packages

- Avoid product recalls and returns

- Optimize efficiency with automated inspection

- Label, categorize, and understand failure modes

Tamper Proof and Safety Seal Inspection
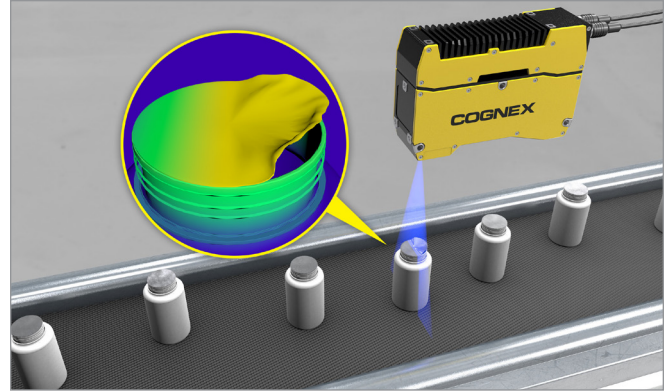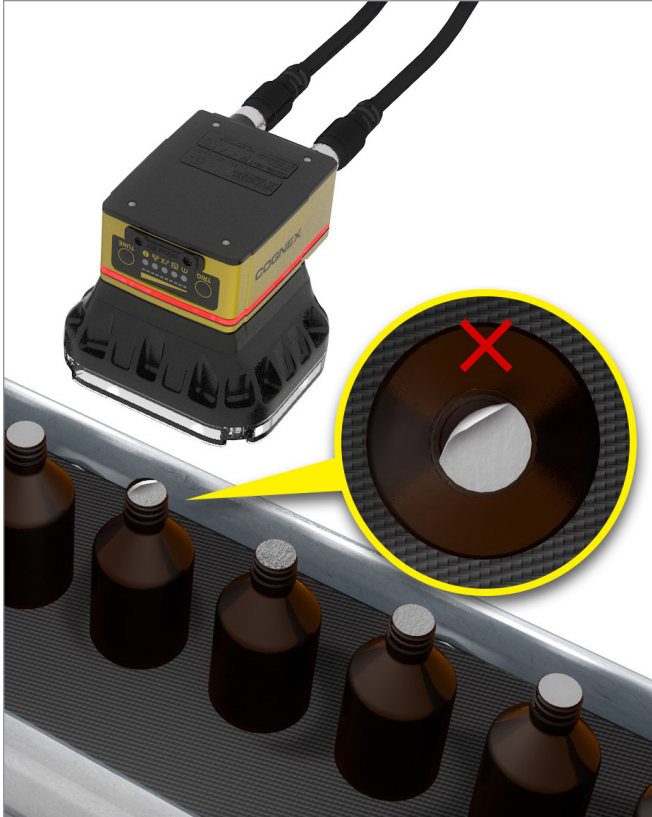
Challenge

Tamper proof packaging has become a universally adopted safety practice in the CPG and food and beverage industries. Tamper-evident seals, rings, and sachets guarantee the quality and freshness of a product to customers, as well as provide a level of security to manufacturers. Intact tamper technology conveys the safety and trustworthiness of a finished product, but production errors can occur in the final sealing stages of primary packaging, affecting safety seals. Normal wear and tear of production machines make it nearly impossible to manufacture 100% defect-free products, so a quality control and detection process becomes essential to keep those products from leaving the line and reaching the market.

Benefits:

- Safeguard tamper proof packaging
- Detect safety seal defects before items leave the line
- Avoid recall events
- Preserve brand trust

Solution

Machine vision systems detect defects and verify package integrity through accurate and repeatable inspection. 3D laser displacement systems ensure that the safety seal covers the entire opening, is free of bubbles or wrinkles around the rim, and does not exhibit any holes or punctures. Machine vision technology detects safety seal edges and measures the height, width, relative position, and gap size (if present), comparing them to the programmed limits. Tamper seal dimensions which do not comply with programmed limits are rejected, limiting risk of product recalls.

Contamination or Foreign Material Inspection

Challenge

Contamination and foreign material, such as air pockets, dust, particles, or hair, are still one of the major causes of product recalls in the medical device, pharmaceutical, and food and beverage industries. Ensuring consistent product quality with little operator intervention enhances and preserves brand reputation while maximizing productivity and investments.

Relying on human quality inspection can be costly, particularly when looking for defects in high-speed production environments. Operators are required to perform mundane and repetitive tasks such as looking through microscopes on a work bench. Due to the variation in product and potential defects, traditional machine vision is time-consuming to develop and optimize for an operator dependent inspection.

Benefits:

- Defend against contaminants and foreign materials
- Limit the risk of product recalls
- Extract, capture, and categorize data
- Preserve brand reputation

Solution

Cognex AI-powered technology locates, analyzes, and classifies complex contamination issues in real time to stop contaminants from entering the supply chain—everything from pack confirmation to micro-contamination on high volume lines. AI-based solutions combine the human-like inspection capabilities with the automation, scale, and repeatability of a computerized system. This can be augmented by the use of robotics to ensure machine handling and vision tools work together to inspect the most complex anomalies sometimes missed by operators. The end result is less recall events, lower rework costs, and full product image capture and traceability.
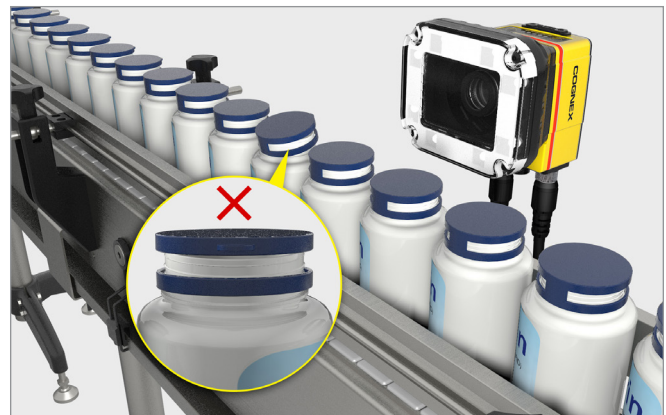
Bottle Cap Inspection

Challenge

Bottle manufacturers fill, cap, and seal products rapidly as they move along high-speed assembly lines. After liquid fill levels are inspected for uniformity, it is important to determine whether the cap is placed correctly and the safety ring is properly torqued. Caps that are not properly sealed compromise safety and quality and damage brand loyalty. Also, before boxes are sealed for shipment, bottle caps must be properly sealed to prevent spillage during shipping.

Benefits:

- Detect safety and quality issues
- Prevent spillage during shipping
- Preserve brand trust

Solution

Cognex vision systems verify cap height and skew with multi-dimensional imaging. In-Sight vision systems with edge detection technology measure the distance between the top of the cap and the neck of the bottle, as well as the horizontal position of the top of the cap, to confirm they meet the programmable limit. In this way, the vision system determines whether the cap is screwed on tightly to the safety seal. Bottles which fail the cap height and skew inspection are rejected.

3D laser displacement systems optimize product quality by providing accurate, micron-level 3D inspection. A laser displacement sensor placed above open boxes uses 3D measurements to ensure that the cap on every bottle inside is properly positioned. Mis-assembled caps are flagged before the box is closed and placed on a truck for delivery. This helps avoid spills and quarantines defective product before it leaves the facility.
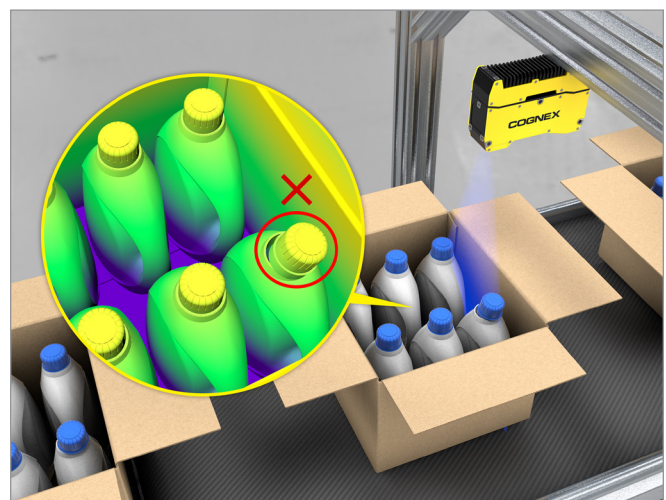
Cosmetic Defect Inspection

Challenge

Before shipping a product or component, it is imperative to give it a final check to ensure product consistency and quality. This inspection is especially important in regulated industries where poor packaging quality can lead to recall events or customer complaints.

Conventional vision technology can often miss complex cosmetic packaging defects such as bubbles in labels, color degradation, scratches, cracks, overprint, and over-wrap or under-wrap issues. These types of unpredictable defects or variations are easy to discern by human inspectors, but very difficult to program with rule-based machine vision algorithms.

Solution

Cognex AI-based image analysis software detects defects on rough and textured metal surfaces as reliably as human inspectors, but with the speed of a computerized system. The defect detection tool catches defects on coarse material with standard illumination, even when image quality is poor, by forming a reliable model of the part's shape and texture based on training images. From here, it identifies deviations in the surface texture as anomalies and uses a classification tool to classify them as hits or scratches.

Benefits:

- Ensure high quality packaging standards are met
- Capture defects on challenging surfaces
- Guarantee customer satisfaction
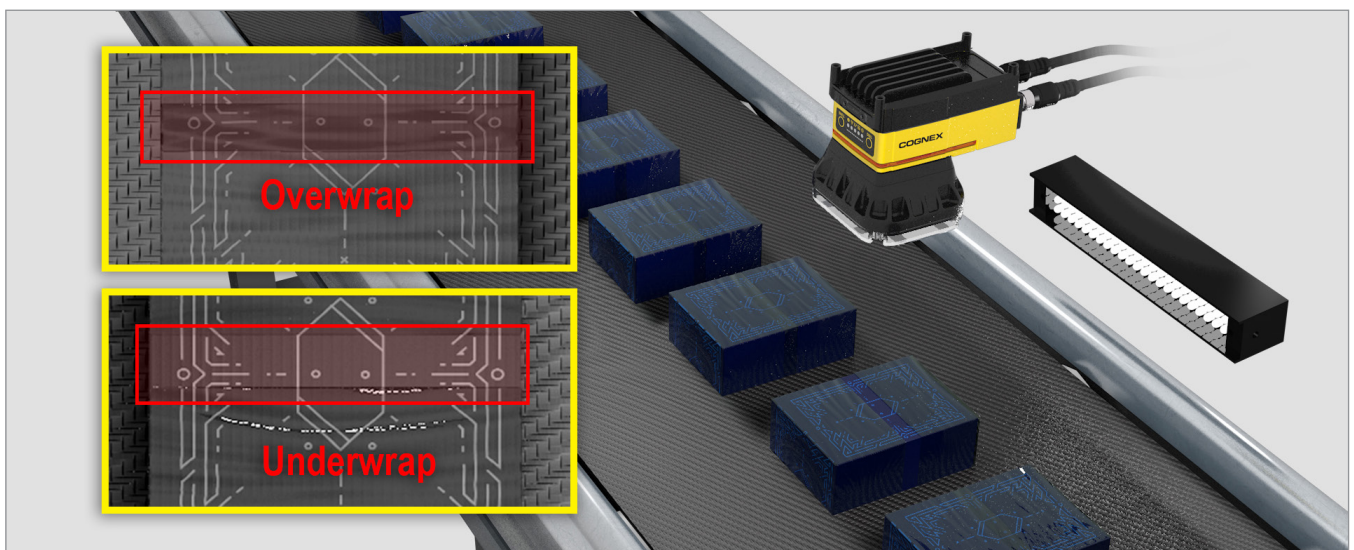
Packaging Traceability

Challenge

There are several reasons packaging traceability is important. The first is the overall safety of food and pharmaceutical products, which must be continuously monitored and occasionally recalled. Second is the security of products which are increasingly threatened by counterfeiting and theft like luxury goods, tobacco, and alcohol. And lastly, there are global regulations that must be met to provide a trail of information that follows each item through the supply chain. To ensure proper packaging traceability, producers must be able to quickly identify and locate products in the supply chain.

Benefits:

- Track and trace products through the supply chain
- Meet global traceability regulations
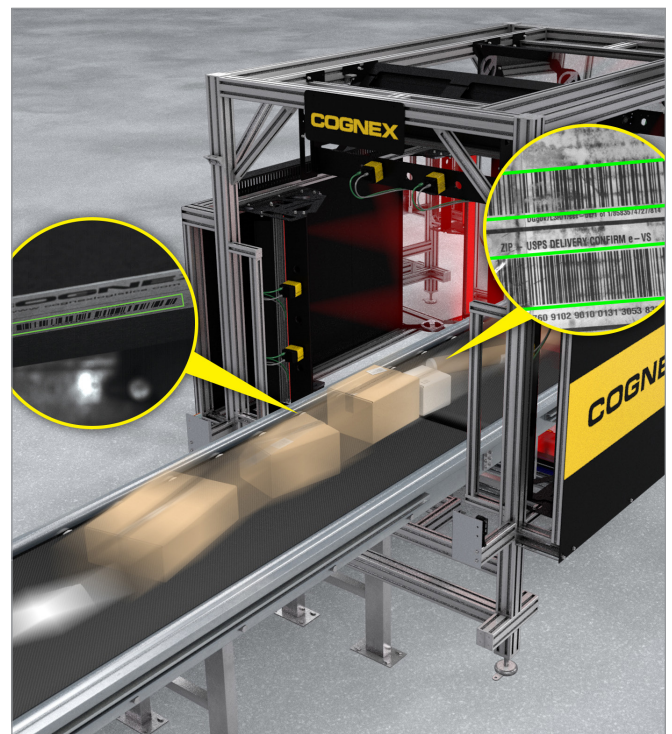- Reliably read 1D and 2D codes

Solution

To achieve this, many companies use 2D barcodes, vision systems, and image-based barcode readers as key components in a simple yet robust traceability system. Data Matrix codes have been adopted as standard in many applications because they allow the storage of information such as manufacturer, product ID, lot number, expiry, and even a unique serial number.

Track and trace solutions assure full compliance with safety and traceability laws by capturing an image of a code at each scan point and storing its encoded data in a central database. Cognex barcode readers reliably read 1D and 2D codes at read rates of 99.9% regardless of barcode quality or orientation. Image-based barcode readers have the speed and accuracy to ensure packages of all shapes and sizes are properly sorted, picked, stored, or shipped and can be easily identified and located in the event of a product recall. In-Sight vision systems with OCRMax technology read alphanumeric date/lot codes and store the information in a central database that can track and trace goods throughout the supply chain.

DETECT WRONG OR MISSING ITEMS

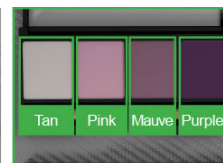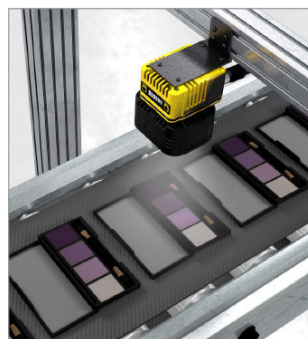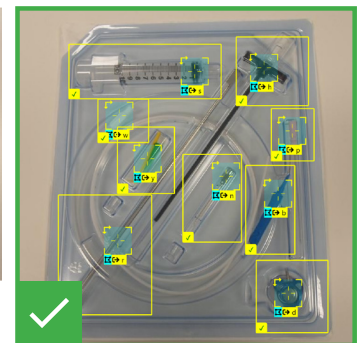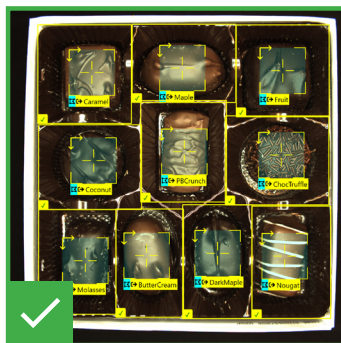## Packaging Assembly and Kitting Inspections

Challenge

For certain packaging applications, manufacturers must rely upon visual inspection to ensure the quality of final assembly. Visual variations of products can cause complications for an automated inspection system. The inspection system must successfully verify that the correct product, device, or piece of food is in the correct location in the package. This is the case for many consumer packaged goods and medical device kitting applications, where the inspection system must be able to identify, count, and classify different items pre-assembly with varying package orientations, reflective surfaces, and complex geometries.

Benefits:

- Ensure proper items are in correct location
- Eliminate rework
- Preserve brand reputation

Solution

Cognex AI-based technology automates the task of locating, identifying, and classifying multiple features within a single image. It generalizes the distinguishing features of various items based on their size, shape, and surface features. A user can train the part location and assembly verification tool to locate each type of item that will need to be found. Once trained, the image can be split into different regions where the tool will check for the presence of an item as well as verify that it is of the correct type. Multiple configurations can also be created for situations where a single line may have variations in packaging. In this way, a user can automate the verification of packaging using just one tool.

Missing Item Inspection

Challenge

Manufacturers must detect missing items and verify the completeness of final packages before they are distributed in order to avoid costly chargebacks and returns as well as damage to their brand. During secondary packaging, items are wrapped and packaged in their final form. Quality inspections confirm the presence or absence of items inside the packaging before they leave the facility.

Solution

Cognex vision sensors perform pass/fail inspections and trigger a rejection when a faulty item is detected. In-Sight vision sensors perform a simple count of the objects in a package, passing or failing packages based on the programmed value. They verify that all bottles, vials, or products are present even under shrink-wrapped packaging, helping manufacturers error-proof their operations and maintain customer satisfaction.

Benefits:

- Detect presence or absence of items
- Avoid costly returns
- Maintain customer satisfaction
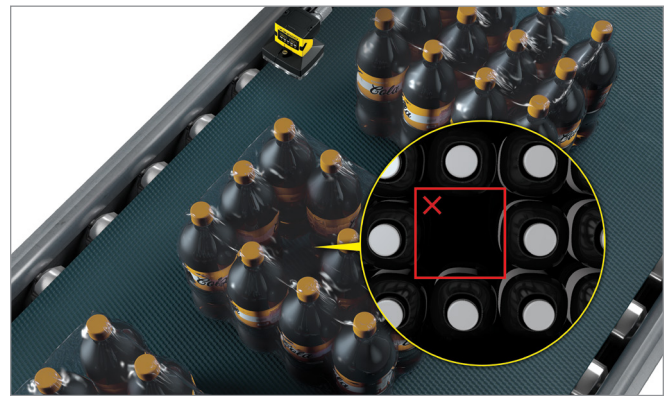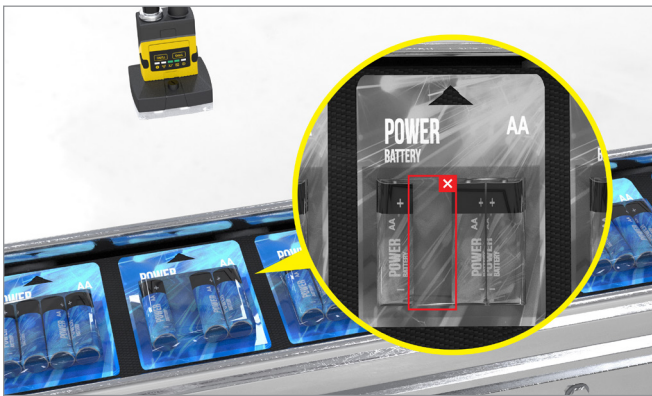
Cognex AI tools find complex features and objects by learning from annotated images. Self-learning algorithms locate different types of vessels or vials on very noisy backgrounds or other complex objects in bulk. To train the tool, the user provides images where the targeted features are marked.
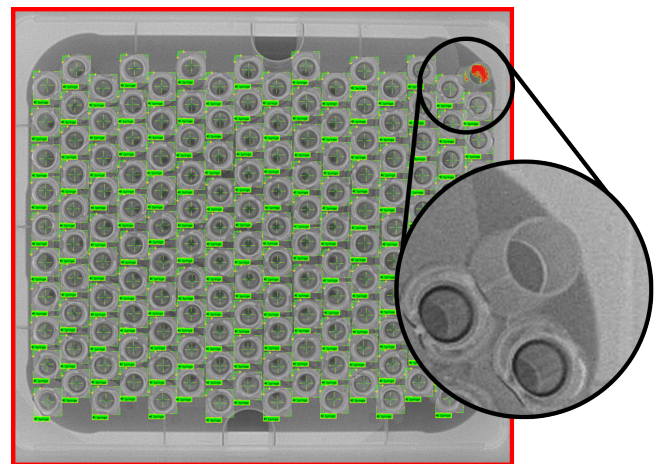
Anti-counterfeiting with Serialization and UV Codes

Challenge

Counterfeit products are a problem in many industries including pharmaceuticals, cosmetics, luxury goods, tobacco, food, and alcohol. These items are susceptible to counterfeiting when their origin and authenticity cannot be verified. The consequences of fake products can range from lost revenue to parts that break or malfunction, putting users at risk and leading to litigation. Counterfeiting concerns impact not just manufacturers, who are responsible for the individual serialization of their products, but also the distributors and retailers bringing them to market. Many governments have instituted mandatory regulations to deter counterfeiting.

Benefits:

- Track origin and authenticity of goods
- Reliably read ultra-small and UV codes
- Preserve brand reputation

Solution

To combat the distribution of falsified, mislabeled, and potentially hazardous items, manufacturers are turning to item-level serialization and ultraviolet (UV) or invisible codes. A Data Matrix symbology encodes information about the manufacturer, product ID, expiration, and a unique serial number in every finished good. Codes can be printed onto individual items, as well as their packaging. This makes commonly counterfeited goods traceable at multiple stages of handling and at the point of sale.

Cognex track and trace solutions authenticate and verify products along the supply chain. Image-based barcode readers read codes, even ultra-small codes, quickly and accurately to maximize throughput. They can capture and store images of no-reads or string validation failures to fight counterfeiting. For UV codes, barcode readers using a UV lighting module and lens filter illuminate and quickly decipher the code using high performance decoding algorithms.
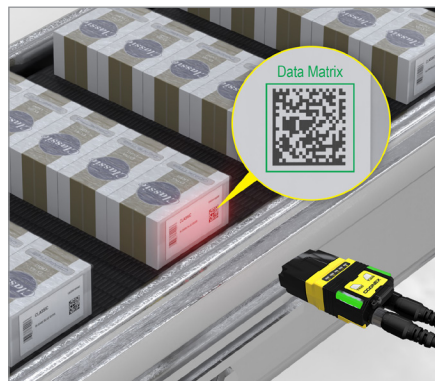
ENSURE LABEL AND CODE QUALITY

Label Quality Inspection

Challenge

Labels contain product-specific data such as origin, date, expiry, amount, or class which is applied to a container. In many factories, machine vision controls the alignment and placement of labels, as well as the inspection. Smudged ink and low-contrast printing commonly affect print and apply inkjet labels, jeopardizing the readability of many barcodes. Barcode printing errors and poor label quality require manual intervention, slowing down production and presenting challenges to vendors and partners.

Benefits:

- Detect label defects or errors
- Meet required quality standards
- Guarantee customer satisfaction

Solution

During the label application process, many defects are hard to detect due to the orientation on the belt and the curved surfaces of items. Quality inspections ensure product labeling is defect- and error-free. Machine vision systems with surface detection technology ensure labels are applied cleanly and squarely without wrinkles, air bubbles, rips, or other raised errors.

In-Sight vision systems with feature extraction technology use lighting and software algorithms to create high-contrast images which enhance the 3D features on a part. It catches errors and defects such as torn, ripped, or warped labels.
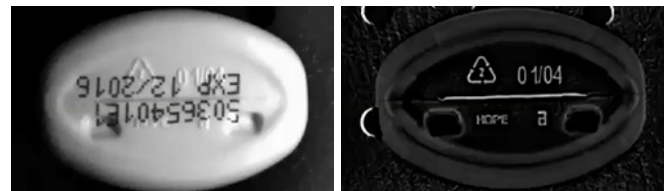
Monochrome and color models identify color errors and inspect labels for consistency and quality in size, shape, color, and texture. This quality control measure reduces the incidence of error, helps meet stringent quality standards, and guarantees customer satisfaction.

Allergen Label Inspection

Challenge

Mislabeled allergens threaten public health and can result in expensive and damaging recalls. Strict rules established by government agencies around the world require manufacturers to label and trace common allergens such as peanuts, soybeans, milk, eggs, shellfish, tree nuts, and wheat. To ensure product safety and efficient recalls, manufacturers must be able to quickly identify and locate non-compliant products in the supply chain posing hazards to consumers. Therefore, it is important for manufacturers to ensure the correct label is on the right package.

Benefits:

- Ensure allergens are correctly labeled
- Limit product recalls
- Preserve brand trust

Solution

In-Sight vision systems inspect for the presence or absence of allergen labels and ensure they are clearly printed. Pattern-matching technology locates allergen labels on packages, bottles, and other items and verifies that they are correct to ensure customer safety and limit the chance for a product recall.

Skewed Label Inspection

Challenge

During the manufacturing process, labels can be applied to products through a number of methods such as print and apply, laser marking, and thermal inkjet printing. When manufacturing at high speeds or on small, hard to mark products, labels can drift and change orientation over time. Poorly applied labels can lead to misaligned text, over-print, and other issues that impact legibility and label alignment on a product or part. Without visual inspection to ensure alignment, manufacturers can incur unwanted waste, costly rework, chargebacks, and non-compliance penalties related to strict industry and retailer marking and label regulations.

Benefits:

- Avoid recalls and quality issues
- Eliminate rework and waste
- Comply with marking requirements in regulated industry
- Protect brand reputation

Solution

By using In-Sight vision systems, manufacturers can ensure labels are correctly positioned on the product and avoid quality recalls or brand damage. Likewise, automated inspections identify errors before a misaligned label creates issues further along the supply chain. The label alignment inspection can be coupled with optical character recognition (OCR) and other In-Sight vision tools to ensure overall label legibility and compliance.

Optical Character Recognition (OCR) for Packaging

Challenge

Date and lot codes, batch codes, and expiration dates are required on products across industries to identify when and where a product was made. Items are marked with these codes early in the production process for quality control and traceability. These codes often combine 1D symbologies and plain text to encode information about the batch and manufacturing date. Codes on medical device and pharmaceutical products might also have challenging surfaces that are curved, highly reflective, or transparent. OCR is used for reliable process control, helping manufacturers meet labeling requirements and ensure customer safety. Quality inspections must verify that the codes are present and printed correctly to ensure traceability and more easily manage recalls.

Benefits:

- Detect presence or absence of codes
- Confirm accuracy of code data
- Ensure quality control and traceability

Solution

In-Sight vision systems with OCRMax technology detects the presence or absence of date and lot codes and verifies that its chain of numbers and letters is correct. For challenging OCR including laser-engraved, dot peen, or chemically-etched DPM text, Cognex AI-powered solutions ensure codes are accurately read and verified. AI-based technology deciphers deformed, skewed and poorly etched characters using OCR and optical character verification (OCV). The pretrained, omni-font library identifies most text without additional programming or font training.

High-speed and Multi-code Reading

Challenge

All packaging uses a 1D or 2D barcode to simplify identification and data capture. Labels located on various sides of packages often need to be read in rapid succession, simultaneously and from extreme angles. Organizations must be able to read codes quickly and accurately for maximum efficiency and throughput. But codes can be degraded, damaged, missing vital elements, or marked on curved or shiny surfaces that make them hard to read. This can result in delayed production, costly reprints, wasted product, and chargebacks.

Solution

Cognex image-based barcode readers use patented decoding algorithms to quickly and reliably decipher codes on high-speed lines, recessed parts, multiple sides of packages, at extreme angles, and from extended ranges. Cognex barcode readers decode even the most damaged, distorted, blurred, or low-contrast barcodes, delivering industry-leading 99.9% read rates. With a large depth-of-field and wide field-of-view, Cognex barcode readers can even read multiple codes simultaneously. Reading multiple barcodes within a large field of view is imperative in serialization, product packing, and traceability applications.

Benefits:

- Maximize efficiency and throughput

- Decipher codes on high-speed lines

- Read multiple codes simultaneously
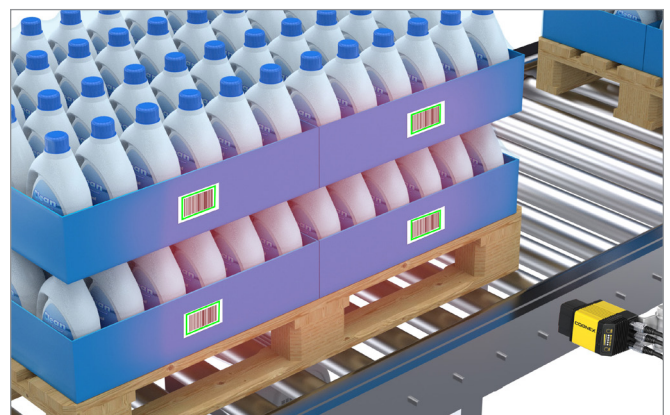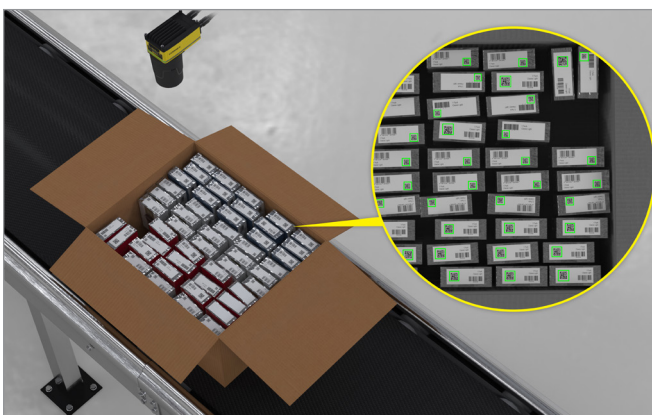
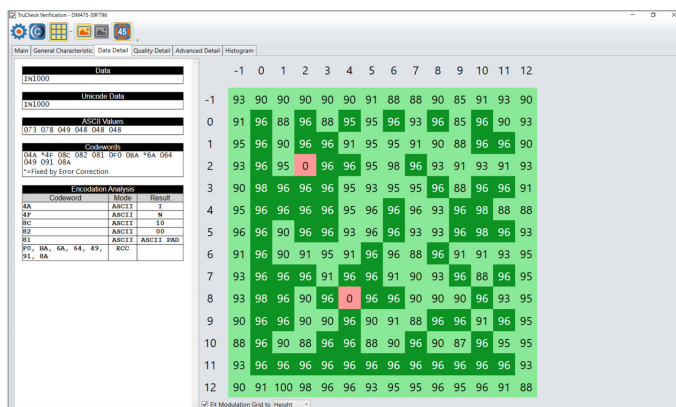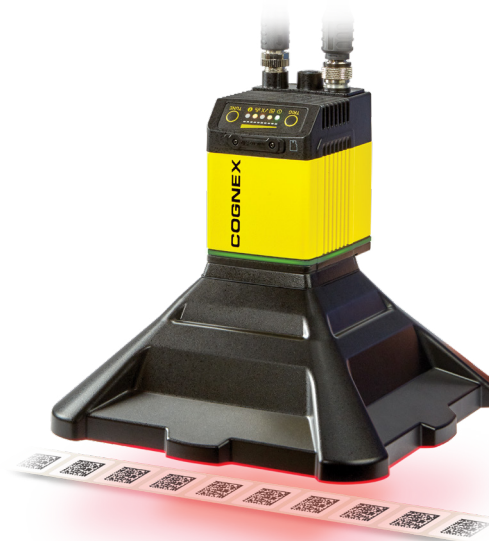# Barcode Quality Verification

Challenge

From brand owners and manufacturers to packagers and retailers, companies across industries use barcodes to track their products from production to the point of sale. Labels may have poorly printed, low-contrast, scratched, or otherwise hard-to-read codes. A failure to scan a code on a package along the supply chain can slow down production lines and cause costly reprints, wasted product, and chargebacks. And many industries with product safety concerns have industry quality standards or International Organization for Standardization (ISO) guidelines that must be met.

Benefits:

- Accurately grade barcode quality
- Avoid wasted products and chargebacks
- Ensure end-to-end traceability

Solution

Barcode verifiers grade the quality of codes to ensure they meet quality thresholds. Verifiers require calibration and use specified lighting to meet ISO standards. An overall grade (usually A through F) is assigned based on several parameters such as symbol contrast, modulation, pattern damage, and decodability. By monitoring verification results, code issues can be identified when quality starts to decline so corrective action can be taken right away. Verification software also generates reports to certify code quality.

Mislabeled Packaging Inspection

Challenge

Manufacturers take great measures to avoid labeling mix-ups that, at best, damage brand reputation and at worst can lead to expensive recalls and liability. Many product manufacturers print and scan 1D and 2D barcodes or text on items to ensure they are labeled accurately and advertise the correct contents. These barcodes or alpha numeric values are used to verify that packages contain all of the correct components.

Solution

Cognex In-Sight vision systems and AI-based OCR solutions can check that lids and containers match each other and accurately reflect the package contents, as well as confirm that labels comply with in-house procedures and standards imposed by regulatory bodies. Cognex technology ensures codes and text can be read and decoded at high speeds in the most challenging environments.

Benefits:

- Avoid product recalls due to mislabeling
- Ensure accurate labels and contents
- Meet regulatory label requirements
- Preserve brand trust

COGNEX AI

Cognex AI learns to spot patterns and anomalies from example images. It solves tasks that are too complicated and time-consuming to program with rule-based algorithms, while providing a consistency and speed that aren't possible with manual inspection.
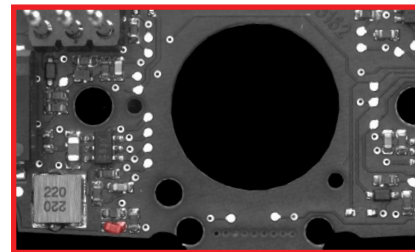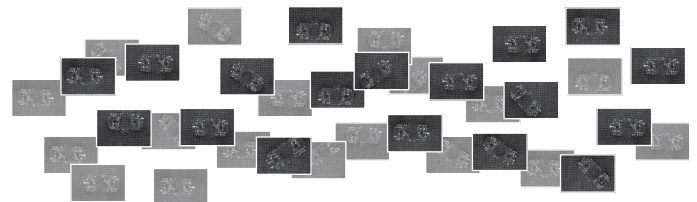
Edge learning:
Designed for ease of use

Edge learning is a subset of AI in which processing takes place on-device, or "at the edge," using a pre-trained set of algorithms. The technology is simple to setup, requiring smaller image sets and shorter training and validation periods than traditional deep learning-based solutions.
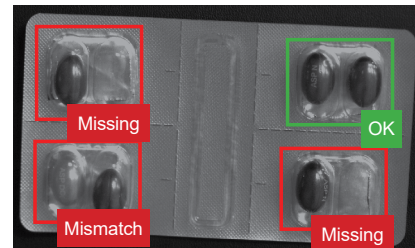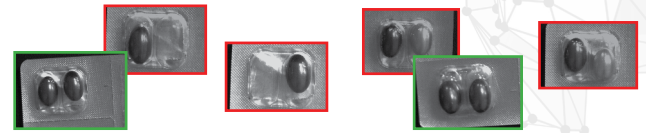
Deep learning:
Designed for complex applications

Capable of processing large, detailed image sets, deep learning is designed to automate complex or highly customized applications. The technology enables users to analyze vast image sets quickly and efficiently, while differentiating between acceptable and unacceptable anomalies, to deliver accurate results.
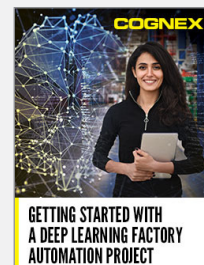

Cognex AI resources

Watch *Machine, Deep, or Edge Learning: What's the Difference?*
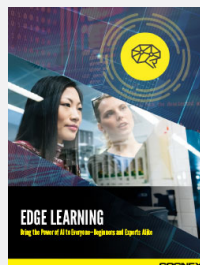
Read *Edge Learning: The Power of AI for Everyone*

Read *Getting Started with a Deep Learning Factory Automation Project*

COGNEX GLOBAL SERVICES

Technical Support ▪ Product Training ▪ Self-Service Portal ▪ Lifecycle Management

Cognex serves an international customer base from offices located throughout the Americas, Europe, and Asia and through a global network of highly-trained partners, system integrators, and distributors.

From development to deployment, Cognex is there to get your vision systems up and running as fast as possible. Whether you're considering machine vision for the first time or are already an expert user, Cognex global services provide the expertise to help your organization succeed.

www.cognex.com/support/cognex-services
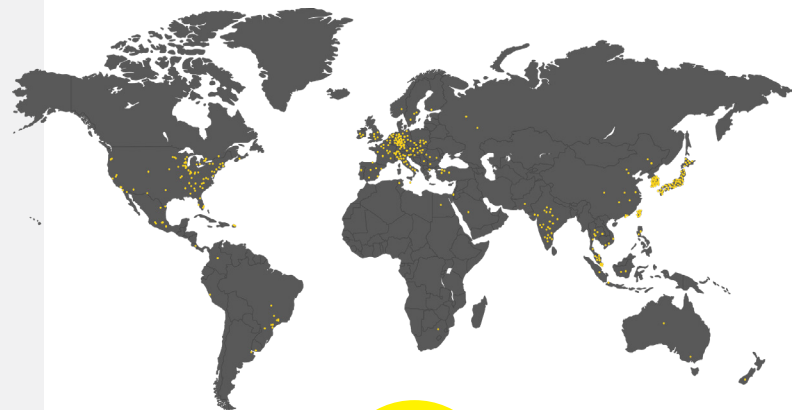
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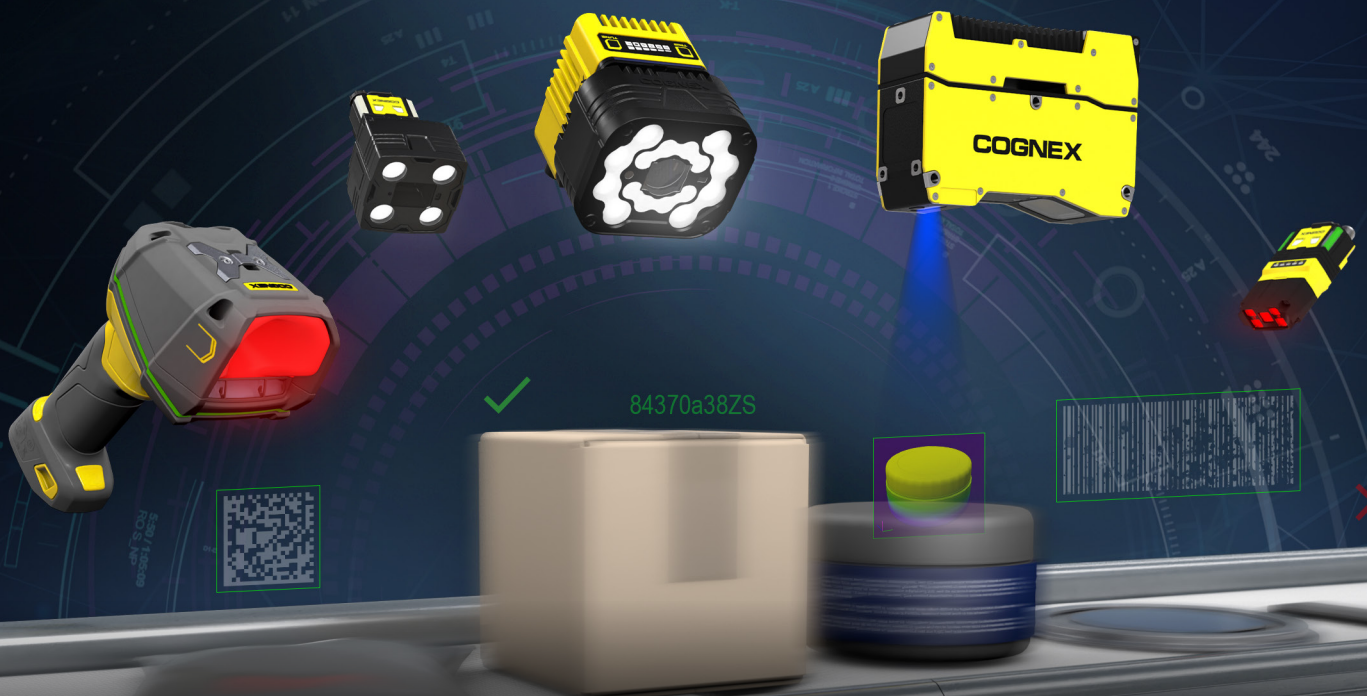
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