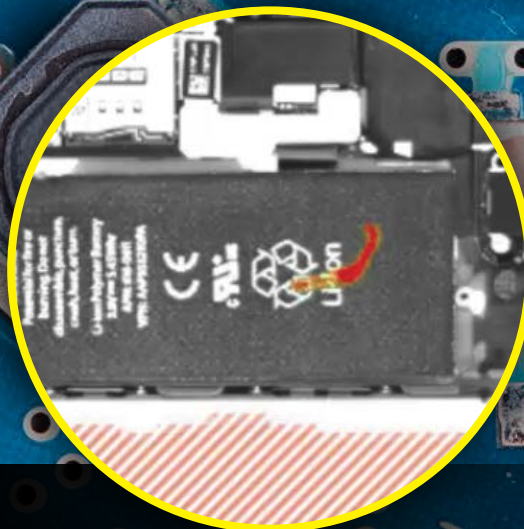
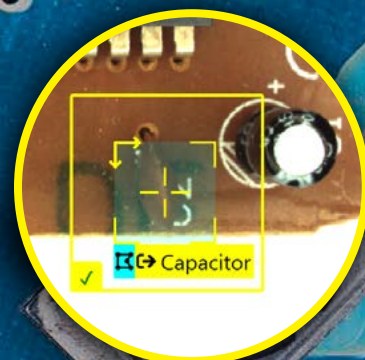
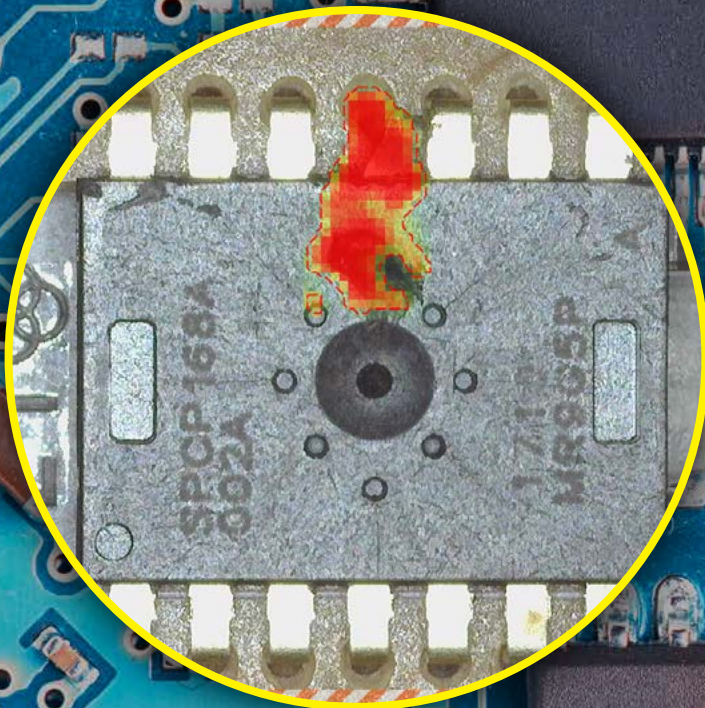




COGNEX DEEP LEARNING

Deep Learning-based Solutions for the Electronics Industry

THE GLOBAL LEADER

IN MACHINE VISION AND INDUSTRIAL BARCODE READING

Cognex®, the leading supplier of machine vision and industrial barcode reading solutions.

With over 2.3 million systems installed in facilities around the world and over thirty nine years of experience, Cognex is focused on industrial machine vision and image-based barcode reading technology. Deployed by the world's top manufacturers, suppliers and machine builders, Cognex products ensure that manufactured items meet the stringent quality requirements of each industry.

Cognex solutions help customers improve manufacturing quality and performance by eliminating defects, verifying assembly and tracking information at every stage of the production process. Smarter automation using Cognex vision and barcode reading systems means fewer production errors, which equates to lower manufacturing costs and higher customer satisfaction. With the widest range of solutions and largest network of global vision experts, Cognex is the best choice to help you **Build Your Vision.™**

**\$726
MILLION**
2019 REVENUE

OVER 39
YEARS IN THE BUSINESS

500+
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GLOBAL OFFICES IN
20+ COUNTRIES

2,300,000+
SYSTEMS SHIPPED



DEEP LEARNING-BASED SOLUTIONS FOR THE ELECTRONICS INDUSTRY

Automating production processes and improving quality are two of the electronics industry's greatest demands. Yet some applications are too complicated, time-consuming, and expensive to program into a rule-based algorithm. Using human inspectors to handle various part types and make judgement-based decisions can also introduce error and slow down production.

Cognex Deep Learning is the first deep learning vision software designed to solve challenging electronics applications requiring part location, cosmetic inspection, classification, and character recognition. Cognex Deep Learning offers human-like inspection capabilities with the speed and robustness of a computerized system, in a field-maintainable unit that makes it easy to train new parts and defect types in the field.

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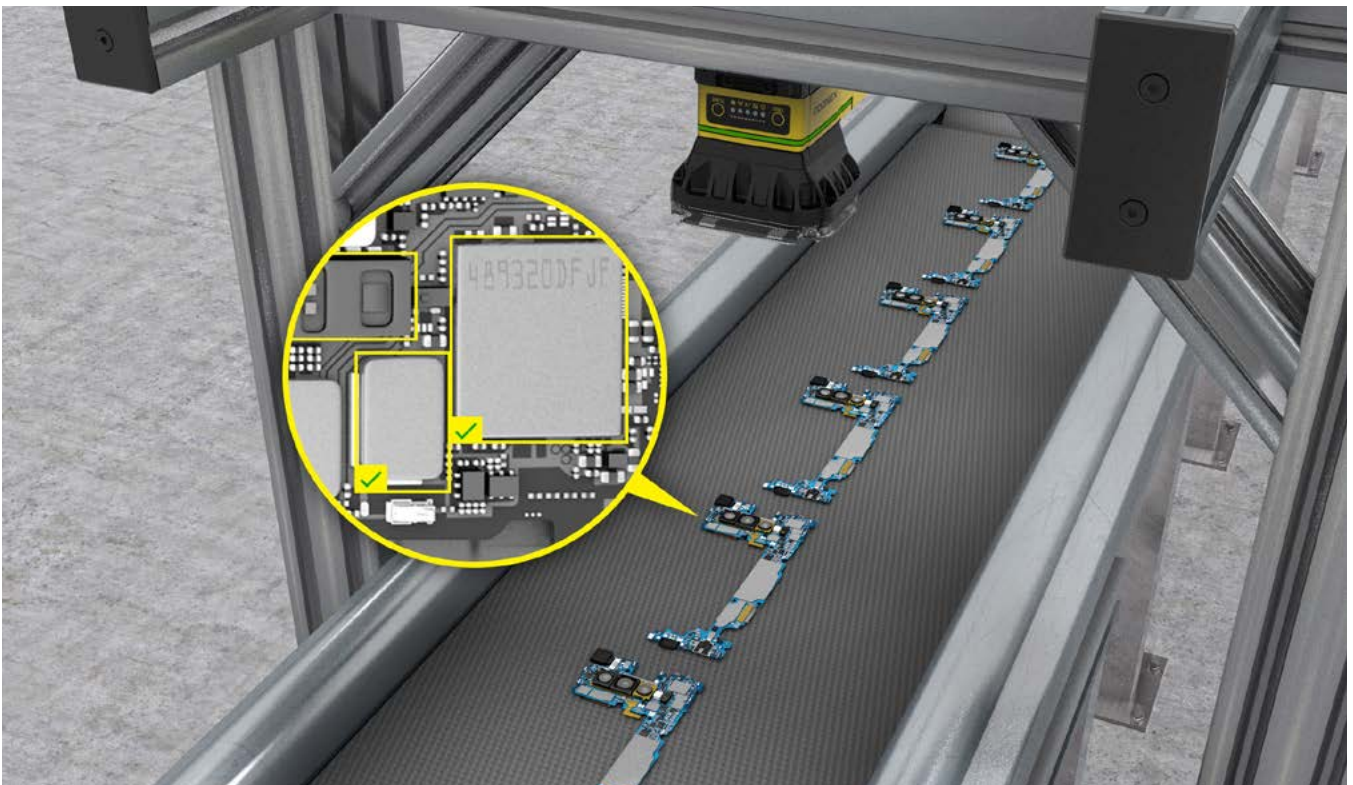
PRINTED CIRCUIT BOARD ASSEMBLY VERIFICATION

CHALLENGE

During final assembly verification, 2D and 3D machine vision systems traditionally inspect PCBs for the presence and correct placement of LEDs, microprocessors, and other surface mount devices. Wrongly positioned or missing components can impact a PCB's performance and lifespan. These errors must be caught before PCBs are assembled into devices or shipped to customers. Yet slight variations in appearance—whether due to subtle lighting contrasts, changes in perspective and orientation, or glare on metallic surfaces—can confuse an automated inspection system. Parts which are close together are difficult for a machine vision system to distinguish as independent components. Programming these inspections into a rule-based algorithm is time-consuming, prone to error, and challenging for a field engineer to maintain. Human inspectors, though capable of identifying these components, cannot meet high-speed processing demands.

SOLUTION

Cognex Deep Learning offers a field-maintainable solution that rivals human inspection to verify the assembly of a PCB. The assembly verification and part location tool learns to identify the components from annotated “good” images, building a reference model of their normal appearance. The tool generalizes the distinguishing features of the components based on their size, shape, and surface features and learns their normal appearance, as well as their general location on the board. During runtime, the tool analyzes all the relevant areas of the board to identify and count components, despite their changing appearance. In this way, the inspection determines whether the components are present or absent and can tell whether the board has been assembled correctly.



SOLDER RESIST INSPECTION

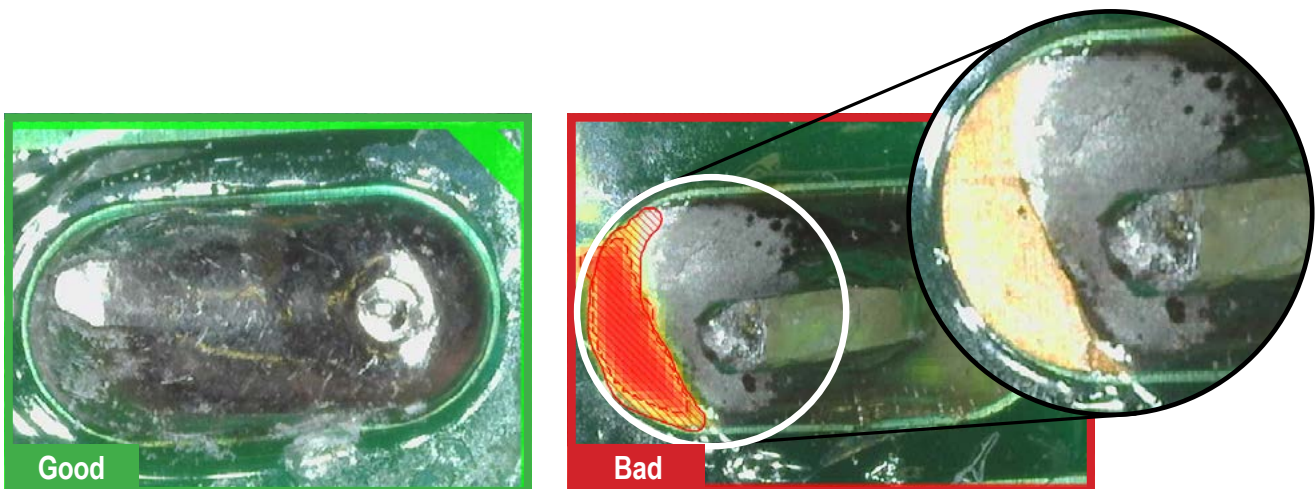
CHALLENGE

For a component like a mouse diode to be mounted without interference to its electrical connection, solder resist must be applied cleanly to a bare board. Even small defects in the solder can cause wiring breakages, shorts, and other electrical problems. These defects vary in size, shape, and appearance due to specular glare. It is difficult to program an automated inspection that tolerates significant part variation under these conditions.

SOLUTION

Cognex Deep Learning quickly identifies the solder resist on a diode when other methods struggle to inspect under the same lighting conditions. The assembly verification and part location tool trains on a set of representative images of solder resist to learn the normal appearance of “good” and “bad” solder. During runtime, the tool fixtures and locates resist on the PCB, despite variations in specular glare. During the second stage of the inspection, the solder resist must be inspected to find any functional anomalies, such as bridging, peaking, or gapping. Using the defect detection tool in supervised mode, the user can train the tool on a representative set of known “good” solders and “bad” solders with labeled defects.

Based on these images, Cognex Deep Learning learns the natural texture of the mouse diode, as well as the normal appearance of its solder. Additional images can be added to the training set during validation testing to reflect additional examples and optimize the model. Various parameters can be adjusted during the training and validation phase to help account for variations in appearance to correctly detect all the diodes with defective solder.



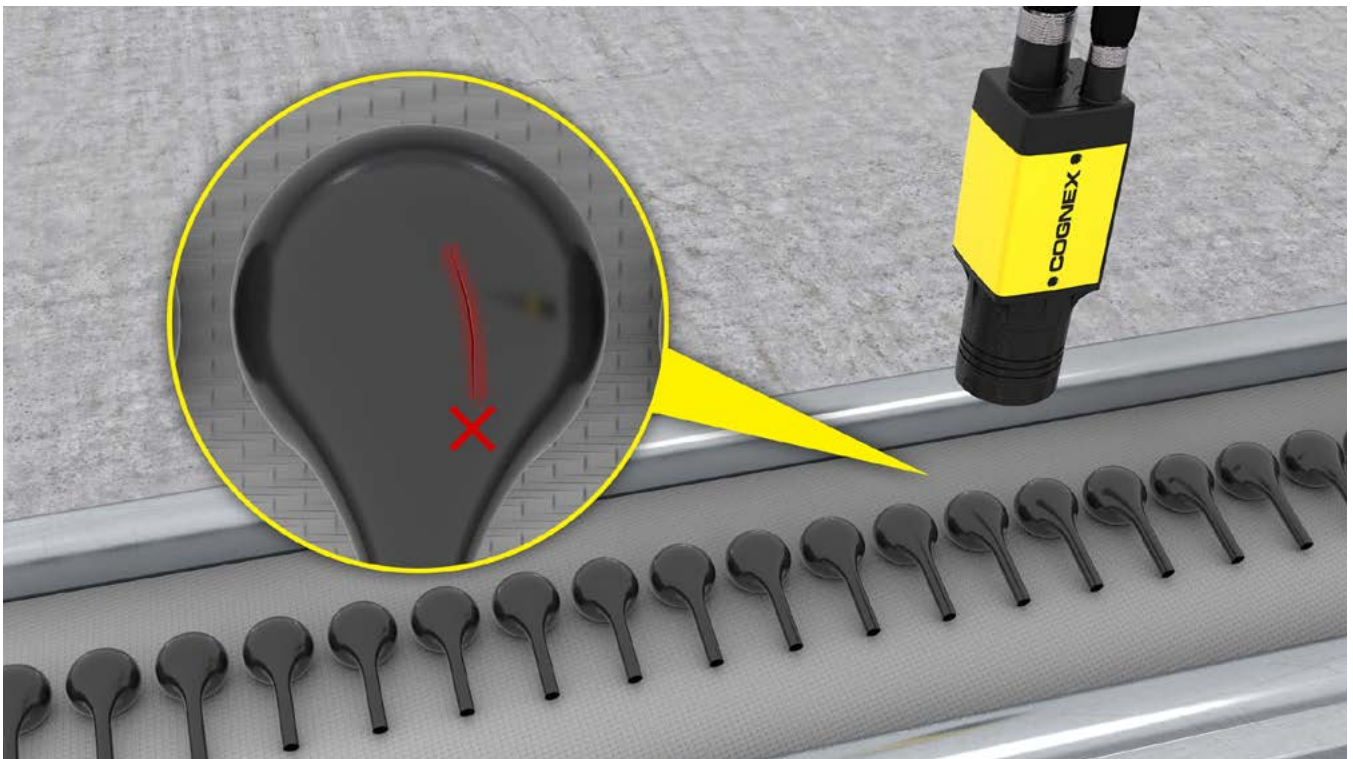
HOUSING COSMETIC INSPECTION

CHALLENGE

Cosmetic inspections can be challenging when parts vary, whether at the component level or at the packaging and housing level. Scratches, dents, and other cosmetic defects may not affect functionality but do affect finished quality and consumer perception. Some cosmetic defects may be obvious cause for rejection, while other minor defects are acceptable. For this reason, manufacturers need to train an inspection system to search for specific defects and differentiate them from minor blemishes. Programming an inspection of this complexity into a rule-based algorithm requires complex defect libraries. Human inspection, though more flexible, is too slow, unreliable, and inconsistent.

SOLUTION

Using the defect detection tool in supervised mode, an engineer can train Cognex Deep Learning to search for specific defects, such as scratches, while tolerating unimportant anomalies and variations. The tool is optimized to work with images that are low-contrast or are poorly captured. For example, the image below illustrates how the defect detection tool analyzes both good and bad images of earbuds. During runtime, the software characterizes images with severe scratches as defective, having learned to recognize and ignore minor cosmetic blemishes.



PRE-ASSEMBLY INSERTION CHECK AND BATTERY MODULE COSMETIC INSPECTION

CHALLENGE

During a pre-assembly insertion check, the contents of a phone are inspected for defects before the cover is assembled. Batteries can be damaged as they are guided onto the housing. Locating and inspecting the battery is difficult due to the confusing, busy background of the phone assembly. Deep learning vision software simplifies the automated detection and characterization of defects on the battery's metal surfaces.

SOLUTION

Cognex Deep Learning allows the manufacturer to check the battery's integrity before the phone undergoes final assembly, and to differentiate between cosmetic and functional anomalies. Using the defect detection tool in supervised mode, an engineer can train the software on "good" images as well as "bad" images with labeled defects. From these images, the tool learns the battery's normal appearance, including natural acceptable variations. Parameters can continually be adjusted during the training phase and validation period until the trained model correctly detects and segments all images with functional anomalies. Once deployed, the defect detection tool identifies and rejects batteries with defects.



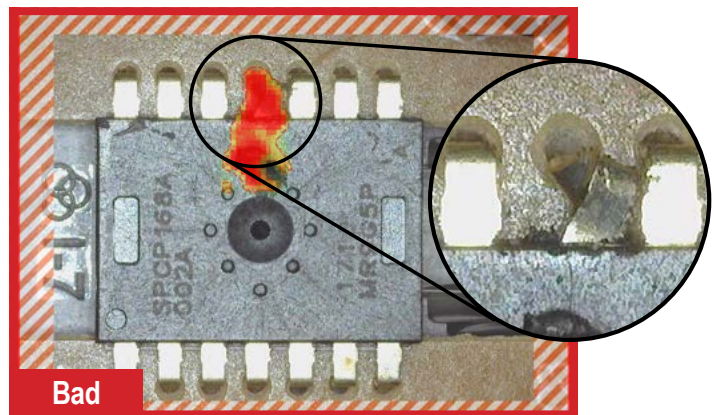
IC LEAD COSMETIC INSPECTION

CHALLENGE

Machine vision is used throughout the semiconductor manufacturing process to rigorously monitor quality and catch defects. Manufacturers must be vigilant for scratched, twisted, bent, or missing pins. A chip has such low tolerances for error that any flaw, even the most superficial, is cause for rejection. With so many potential defect types, it is inefficient to program an inspection into a rule-based algorithm. Deep learning vision software can help limit semiconductor defects and improve yield without the use of extensive defect libraries.

SOLUTION

Explicitly searching for all defects is too complicated and time consuming. Cognex Deep Learning offers a simple solution to identify all anomalous features, even without training on “bad” images. Instead, an engineer uses the defect detection tool to train the software on a sample of “good” images in unsupervised mode. Cognex Deep Learning learns the normal appearance and position of a chip’s leads and pins and characterizes all features that deviate as defective.



CAPACITOR CLASSIFICATION

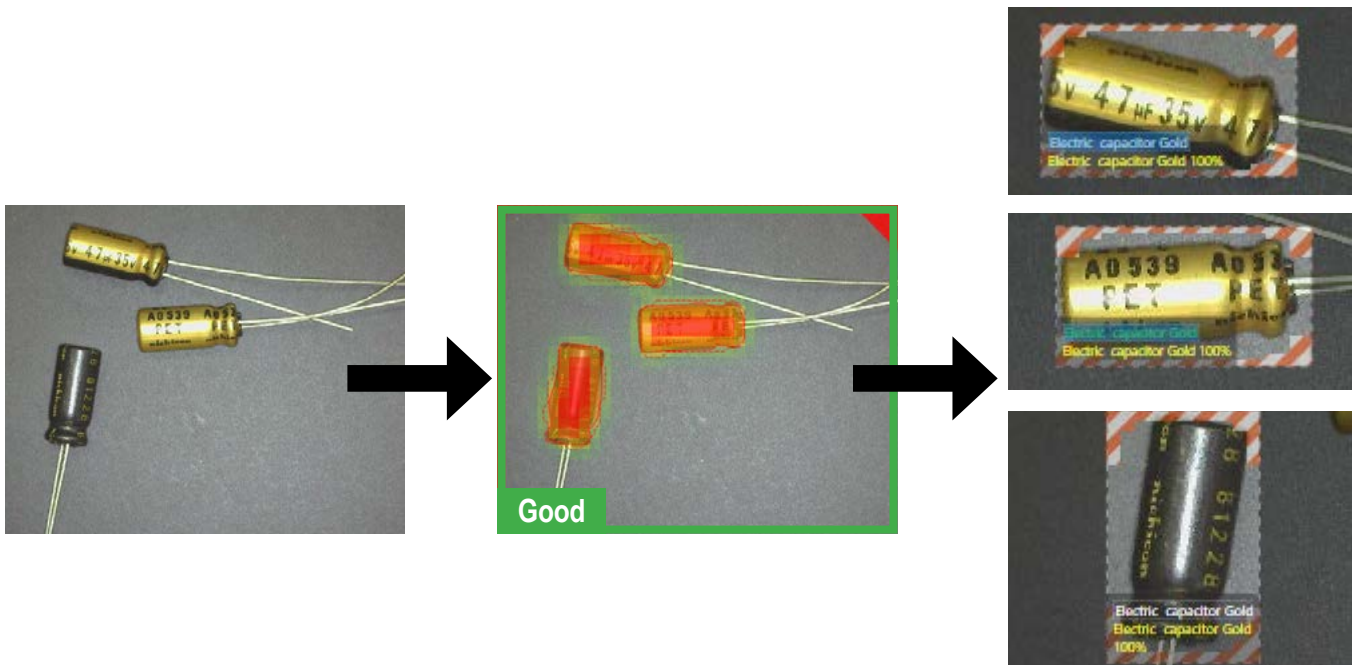
CHALLENGE

Classifying electronic components can be especially challenging when parts fall into multiple classes, each with some visual variation. Capacitors vary in type (ceramic and electric) and also by size and color, depending on their manufacturer and specifications. Even within the same type, there can be confusing variations in pattern. Their cylindrical shape and lighting can add even more complexity. VisionPro ViDi offers a deep learning-based alternative to automate multiple classifications within a single image.

SOLUTION

Using the defect detection tool, an engineer trains the software in supervised mode on a set of annotated images where both gold and electric capacitors are categorized as “good” parts. During runtime, the model extracts and segments all electric and gold capacitors as one type.

In the second part of the inspection, the classification tool learns the attributes of each capacitor, while tolerating variation within the same type. In this way, it can distinguish different electric capacitors by their color and marking, even though they look visually similar. Based on the model developed during training, Cognex Deep Learning accurately classifies and sorts capacitors within a single image during runtime.



USB CONNECTOR INSPECTION

CHALLENGE

Smartphones need a USB connector in order to charge and transfer data. This connector is typically an OEM product and needs to be inspected on all sides before being cleared for installation. The connector consists of power and data contacts, shielding, and some form of mount connector.

These USB connectors can show a wide variety of defects, including burn, short shot, dust, scratch, and shifts, on all sides. Tiny, almost invisible defects on the working end of the connector can have large effects on how well the cable will connect, how tightly it is held, and how easy it is to remove again. Such a connector has to work for the lifetime of the phone.

SOLUTION

Cognex Deep Learning's defect detection tool trains on image data sets that include a wide variety of both functionally significant appearance variations and those of with no functional impact and learns to distinguish them from each other. During the training process, it is possible to ignore acceptable cosmetic abnormalities so that training is focused only on those defects that could impede function, making the process simpler and faster. When deployed on the line, lighting and part presentation are critical to catching as many defects as possible.



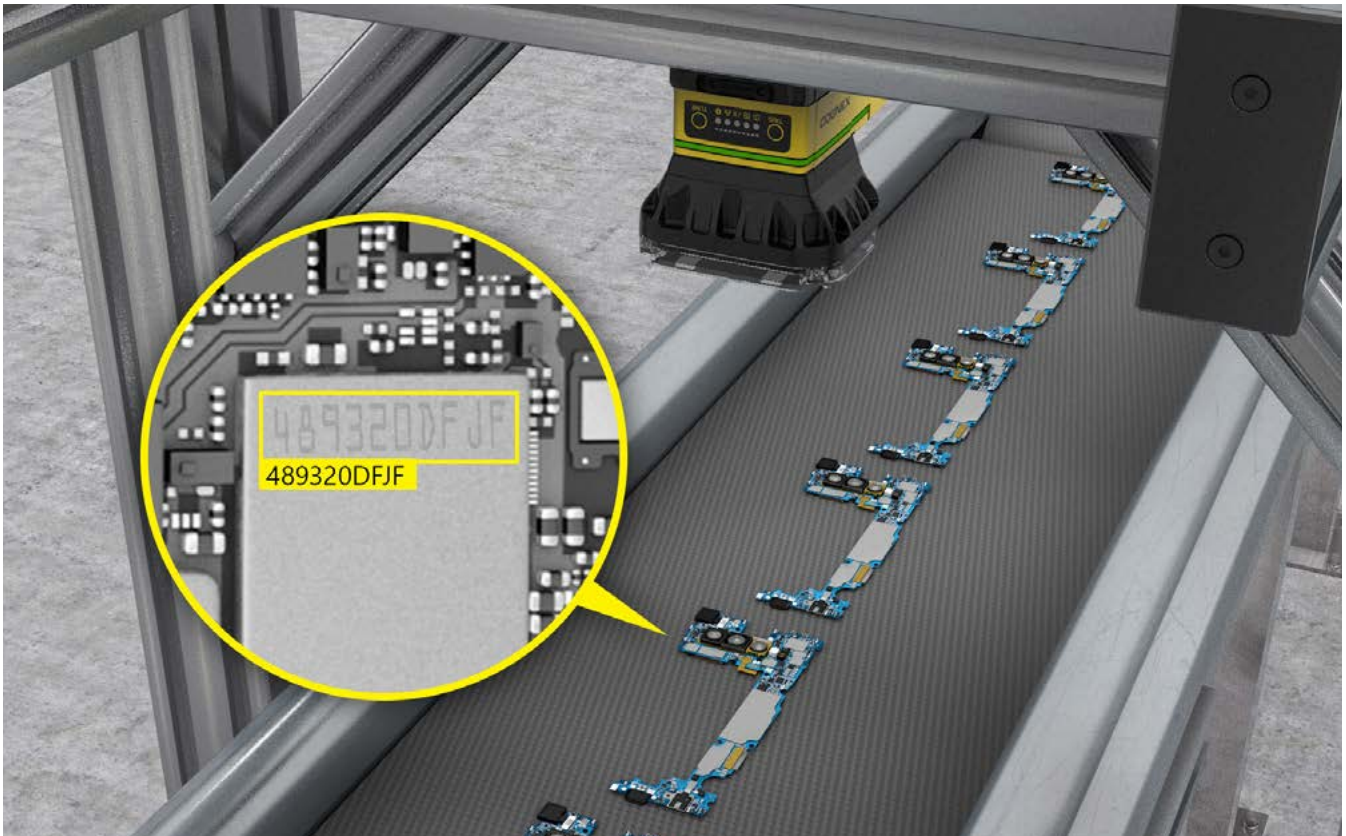
OCR ON ASSEMBLED PCB COMPONENTS

CHALLENGE

Most chips assembled onto a PCB are labeled with a string of alphanumeric characters to track them through production. Specular glare can result in low-contrast images, which make it difficult for a machine vision system to locate and recognize characters. To successfully decode characters on electronic components and modules, an optical character recognition (OCR) system needs to tolerate reflective surfaces as well as deformed, skewed, and poorly etched characters.

SOLUTION

With Cognex Deep Learning, it is easy to read deformed characters, despite image formation challenges. This deep learning-based approach to OCR saves time during training and development by reducing excessive labeling, and successfully reads characters in challenging situations. The software simply requires an engineer to set a region of interest and character size. Once set, the tool's pretrained font library deciphers characters and reads strings without training. In situations where characters are very difficult to read, the software can be retrained directly using characters with variations.



COSMETIC DEFECT ANALYSIS

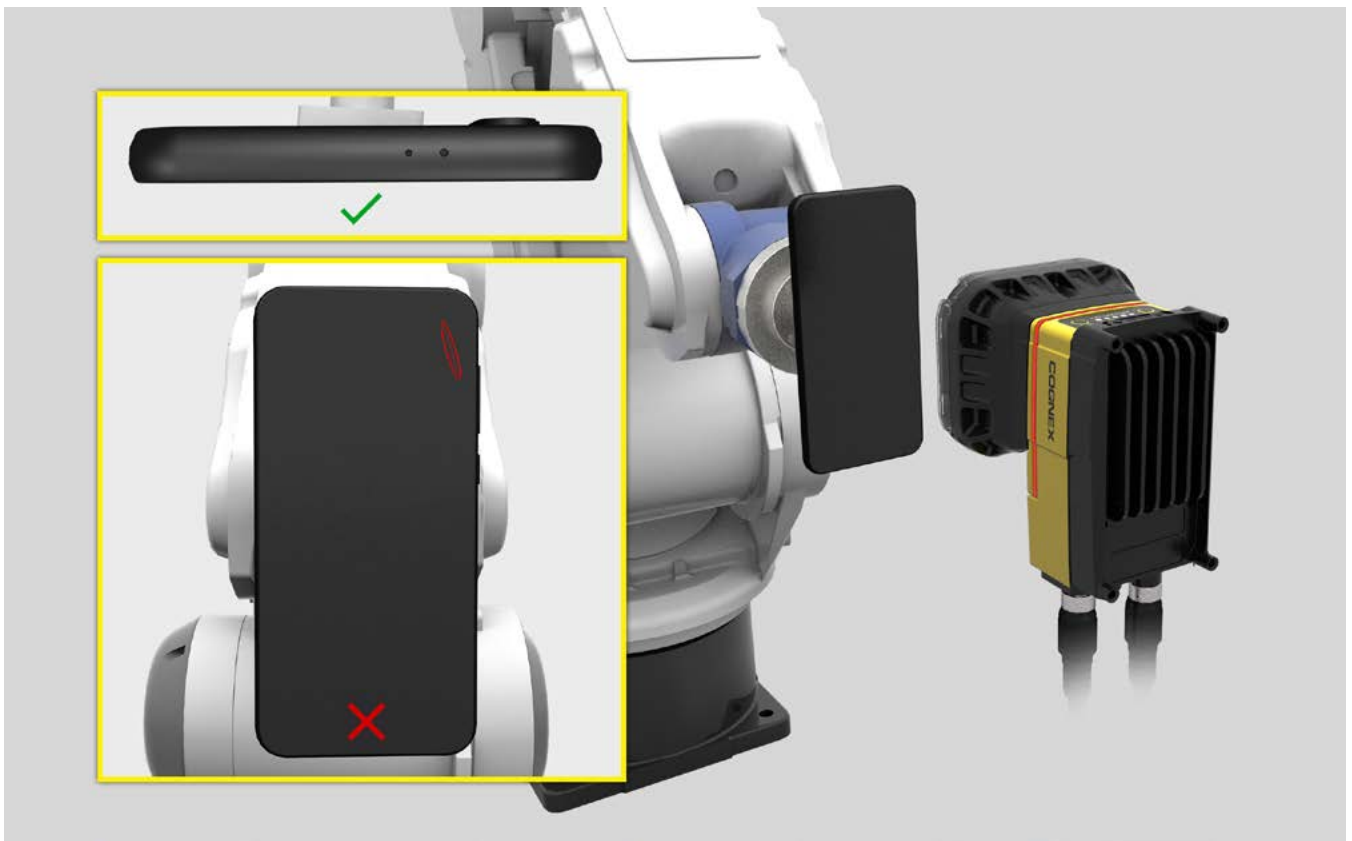
CHALLENGE

After a smartphone is fully assembled but before it proceeds to packaging, it must be inspected for scratches, cracks, chips, dents, misalignment, discoloration, and other defects, which may be in multiple places anywhere on the housing and cover glass. These defects are generally not functional, but negatively affect the appearance of the product.

Traditional rule-based vision applications can be trained on a range of typical defects, such as a scratch in a predefined area, or a crack that tends to appear in a screen corner, but the range of possible defects is extremely large and can appear anywhere on the phone. Even a relatively infrequent defect, such as discoloration of the housing, or dent caused by the impact of a robot arm, needs to be caught before packaging. Given the rate at which phones are produced, human inspection is inconsistent with low efficiency.

SOLUTION

Cognex Deep Learning trains on image sets showing a wide range of unacceptable defects as well as image sets showing cosmetic variations that are within acceptable range and learns to classify them. Parameters can be adjusted during the training phase to ensure that acceptance and rejection criteria meet market requirements for all examples. Leveraging special lighting and proper part presentation combined with Cognex Deep Learning, the trained image analysis tool examines the screen, the band, the back and detects any combination of dents, scratches, and discolorations anywhere on the smartphone. This thorough and accurate inspection ensures that only products without cosmetic defects move on to the packaging step.



MOBILE DEVICE SPEAKER MESH INSPECTION

CHALLENGE

The speaker mesh is a piece of perforated metal that protects a cellphone's acoustic module from dust and damage while minimally affecting the sound.

Meshes must be visually inspected for cracks, scratches, missed perforations, deformation, broken edges, foreign inclusions such as dirt or hair, and damage from the perforation process. This mesh is visible to the end user, and so cosmetic damage must also be detected.

Because meshes are three-dimensional textured parts, they create complex lighting patterns of reflections and highlights. Even a small tilt in the mesh can completely change the pattern. Meanwhile, defects such as contamination or irregular scratches can appear anywhere on the part. This can be on the outer surface, or in the gaps between the wires. These variations make it difficult to program traditional machine vision to handle every possible case.

SOLUTION

To identify speaker mesh defects, Cognex Deep Learning's defect detection tool is trained on a wide selection of speaker meshes to learn the full variation of normal parts, including common lighting variations and the acceptable level of cosmetic defects. As it scans through meshes it analyzes and flags any that are outside of the acceptable range, while minimizing false positives.

Cognex Deep Learning can work in concert with traditional machine vision, which is best for precision alignment tasks and gauging the speaker mesh dimensions. The combination of deep learning plus traditional vision tools far outstrips that of manual inspection, at significantly higher speed. And it does so while maintaining consistency across shifts and production lines.



CAMERA MODULE SURFACE INSPECTION

CHALLENGE

Before the camera module is installed in a mobile device, its surface must be inspected to ensure that there are no foreign materials, scratches, smearing or dust on the lens.

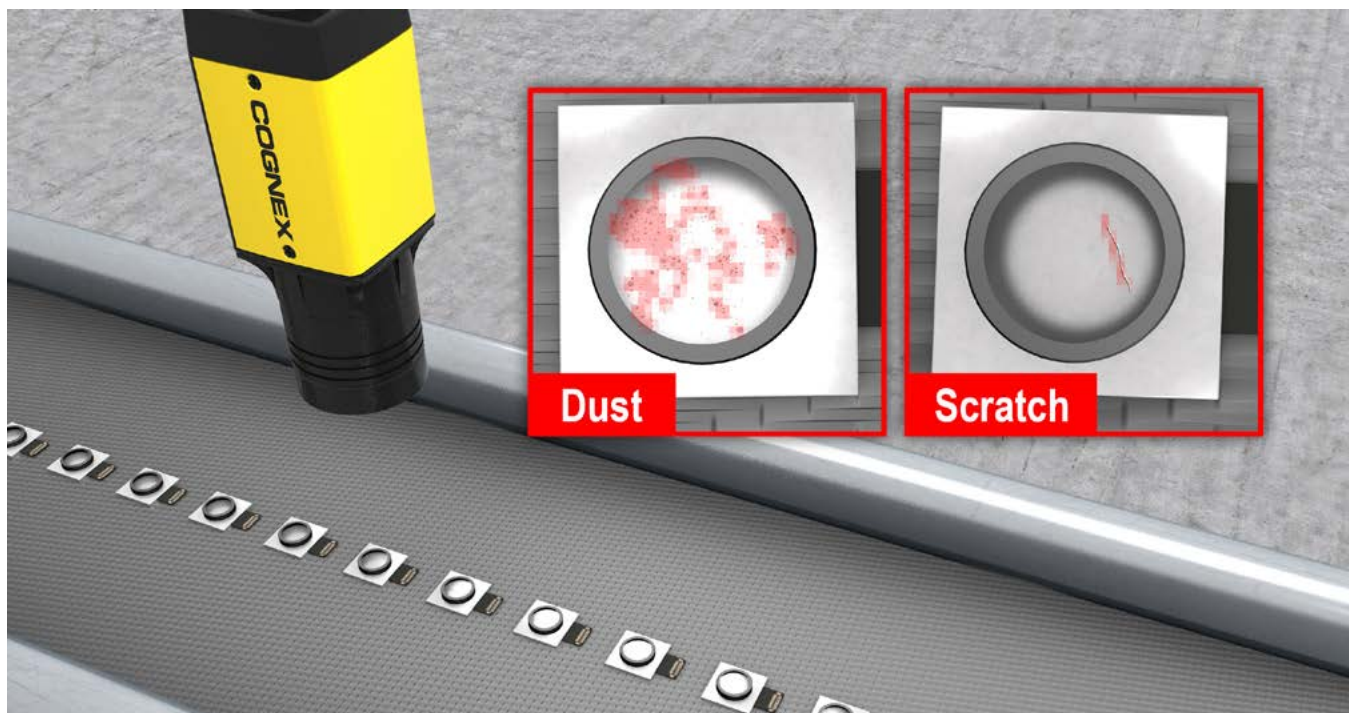
Different defects vary widely in appearance. A smudge from a fingerprint looks quite different from dust particles trapped under the lens coating, and neither looks anything like a scratch on the glass surface. In addition, the lens's reflective surface and refracted images from parts underneath the lens that can appear as unwanted anomalies even though they are actually not. Distinguishing these background anomalies from true defects often requires manual inspection, which is slow, costly, and inconsistent. Yet traditional rule-based machine vision systems cannot be easily programmed to consistently identify such a wide span of defects.

SOLUTION

Cognex Deep Learning's defect detection tool is trained on a wide selection of defect-free lenses to learn the full variation of normal parts. In Unsupervised mode, it then scans through a sequence of lenses and flags any that are outside of the acceptable range, while minimizing false positives.

Lens defects tend to have certain characteristics stemming from specific causes, such as contamination by dust and other particles, smearing from oil or fingerprints, and misalignment of internal components. Users who need to identify the specific type of defect, or precisely measure the defect's size, can use Supervised mode. In this mode, the user trains the system on a combination of good and bad parts, explicitly highlighting the defect regions and labeling them with the type of defect: scratch, stain, contamination, etc.

This knowledge can be used for upstream process control. A certain type of scratch might be caused by a misaligned machine, or a fiber might be deposited due to poor airflow in a manufacturing process. By identifying the root cause of the problem, manufacturers can quickly take corrective action and minimize the creation of more bad parts.



SEALING PIN WELDING INSPECTION

CHALLENGE

Once a battery cell is sealed, it is filled with liquid electrolyte through a small hole in the cap. When filling is complete, the hole is covered by a sealing pin, or cover cap, which is then welded in place to secure it.

The proper placement of the sealing pin has traditionally been confirmed by determining its height with a laser or other 3D displacement sensor. But defects in the weld itself, such as dents, burns, pinholes and breaks, are not easily detected through traditional machine vision due to the variety of possible defects and the reflective background of the battery cap.

SOLUTION

After the weld is complete, Cognex Deep Learning's defect detection tool can identify numerous potential defects on the sealing pin weld. The deep learning application is trained on a wide selection of properly sealed batteries to learn the full variation of normal parts, including the acceptable level of cosmetic defects, lighting highlights and shadows.

Once on the production line, Cognex Deep Learning analyzes and flags any sealing pin welds that are outside of the acceptable range, while minimizing false positives from purely cosmetic defects.

Users can pass the detected defects to Cognex's classification tool. This tool is trained on a range of labelled weld and placement defects so that it can identify them properly. At runtime, the classification data is used to take the corrective action upstream for whatever type of defect is detected.

Depending on customer preferences, the Cognex DSMax, a 3D laser displacement sensor, can easily be integrated into the inspection process without the need for any third-party software. Together Cognex Deep Learning and the DSMax can provide full inspection of the sealing pin and its weld to ensure it is free from defects and welded and placed correctly.



BATTERY TAB CHECK

CHALLENGE

Pouch battery electrodes connect to external circuits with metal tabs. These metallic foil tabs are made from a variety of metals, are thin and soft, and can be easily damaged. Typical defects include scratches, bumps, holes, and dust. Damaged tabs reduce or prevent connectivity, which is why they must be free from defects before being soldered to the electrodes.

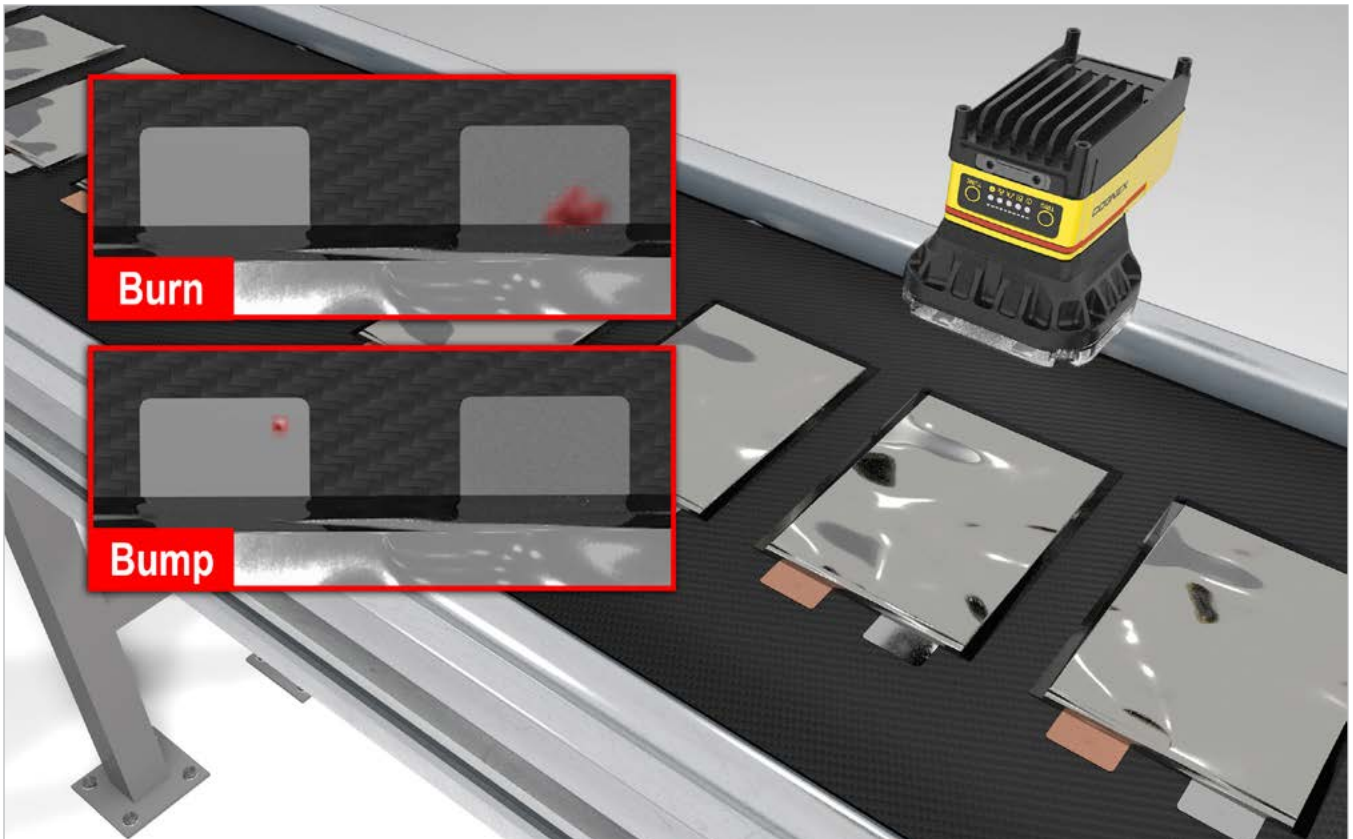
However, improper soldering also leads to defects such as burns, hits, and missing balls. Poor solders lead to reduced or missing connectivity and performance reduction.

SOLUTION

To identify both tab and tab solder defects, Cognex Deep Learning's defect detection tool is trained on a wide selection of undamaged tabs and properly soldered tabs to learn the full variation of normal parts, including the acceptable level of cosmetic defects.

As it scans through the battery tab connections it analyzes and flags any tabs or tab solders that are outside of the acceptable range, while minimizing false positives from purely cosmetic defects. It makes these distinctions despite variations in contrast and background.

Cognex Deep Learning's classification tool can then train on a range of labelled tab and tab solder defects and learn to categorize specific defect types, such as scratches, holes, and bumps on the tab or burn, hit, or missing ball on the solder. These categorized defects can then be used for upstream process control to minimize defects over time.



BUTTON BATTERY INSPECTION

CHALLENGE

Button (or coin) batteries and cylindrical batteries are sealed by welding a cap onto a housing containing electrodes and electrolyte. A low-heat method such as laser or resistive welding is typical used to avoid damage to the battery contents but requires precision to ensure that the cap seal is secured. There is little margin for error. Defects can result in electrolyte leakage and decreased performance.

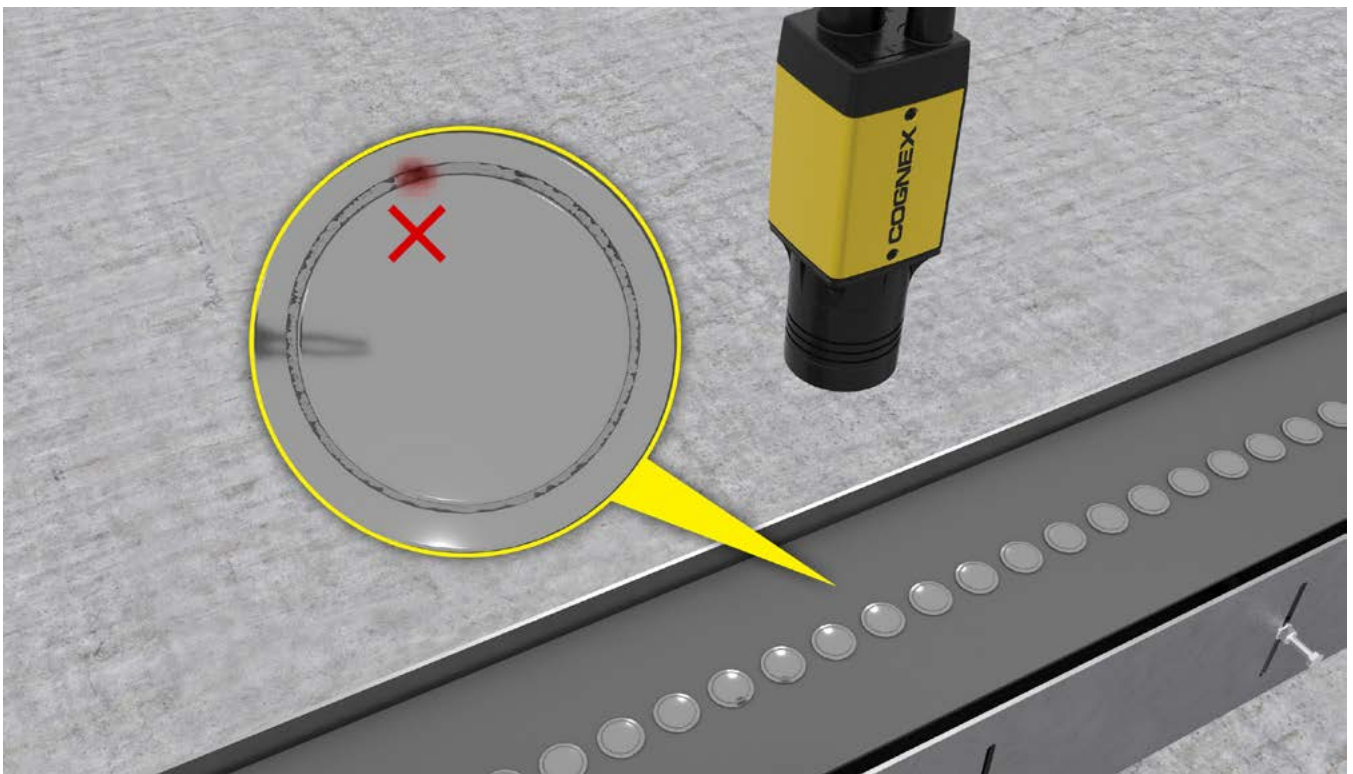
Welding defects can appear anywhere around the perimeter and can vary widely in appearance. Dents, scratches, and other defects can appear anywhere on the body. Both types of defect can be difficult to discern against the reflective surface of the cell. All of this makes it difficult for traditional machine vision to accurately detect the full range of defects.

And because these batteries are produced in high volume, and the defects are small and hard to spot, they present a similar challenge for manual inspection.

SOLUTION

To identify battery weld defects, Cognex Deep Learning's defect detection tool is trained on a wide selection of properly sealed batteries to learn the full variation of normal parts, including the acceptable level of cosmetic defects. As it scans through battery caps it analyzes and flags any welds that are outside of the acceptable range, while minimizing false positives from purely cosmetic defects.

Depending on customer preferences, the Cognex DSMax, a 3D laser displacement sensor, can easily be integrated into the inspection process without the need for any third-party software. Together Cognex Deep Learning and the DSMax can provide full inspection of the sealing pin and its weld to ensure it is free from defects and welded and placed correctly.



SPOT WELD INSPECTION

CHALLENGE

To ensure a firm electrical connection, wires must be spot welded to each other or to terminals. Welding involves melting together two different metals to form a firm connection. It is important that the weld be adequately melted, have a sufficient but not excessive volume, have a good shape, and be positioned properly. Manufacturers tend to have many lines for a wide variety of electronic parts and need to ensure that all connections are secure.

Because spot welds have a high variation and non-uniformity in appearance, including shape, position, color, reflectivity, texture, and surface markings, the inspections can have a high rate of false positives, otherwise known as overkills. Overkills lead to good parts being discarded. Good welds incorrectly marked as defective have to go to manual inspection, which is extremely slow compared to line speeds, and still often results in improperly identified weld defects.

Parts also vary in size, color, and other features from one lot to another. The wide range of variation, and the difficulty of distinguishing good connections from bad ones makes rule-based machine vision impractical.

SOLUTION

Users train Cognex Deep Learning's defect detection tool on a wide selection of properly spot-welded connections to learn the full variation of normal parts. As the tool scans through spot welds it analyzes and flags any that are outside of the acceptable range, while minimizing false positives.

Cognex Deep Learning's classification tool can then train on a range of labelled welding defects and learn to categorize specific defect types, such as a poor shape, blowhole, crack, burn, or surface contamination. These categorized defects can then be used for upstream process control to minimize defects over time.



MLCC INSPECTION

CHALLENGE

A multi-layer ceramic capacitor (MLCC) consists of a block of stacked capacitors with metallized terminals for connection to integrated circuit boards. MLCCs suffer from a variety of possible manufacturing defects, including cracks, blisters, chips, contamination, and voids in the termination coating. These capacitors store significant energy, so failures affect not only the defective MLCC but can damage adjacent components or the integrated circuit board itself.

MLCCs are small and come in large numbers. They can have a variety of subtle defects that vary widely in appearance and location. In addition, they have shiny surfaces that limit the effectiveness of traditional machine vision.

As a result, manual inspection still plays a significant role. An automated optical inspection (AOI) machine inspects all six sides of all capacitors, followed by humans inspecting one side of a statistical sampling of the capacitors. But AOI machines have a high overkill rate, while manual inspection is far too slow for general use. The overall process is expensive, slow, error-prone, and does not produce useful data that could help in process improvement.

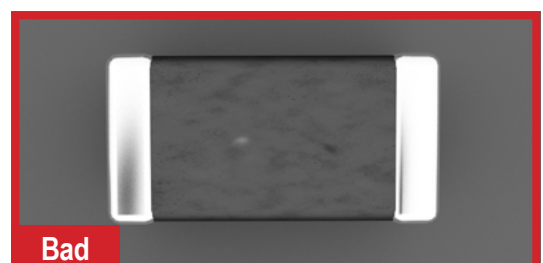
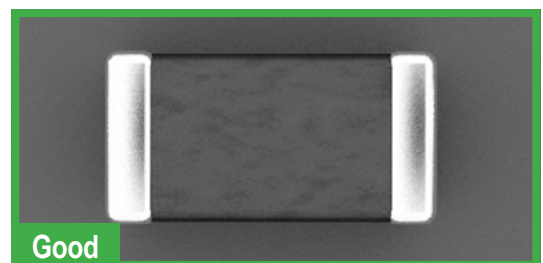
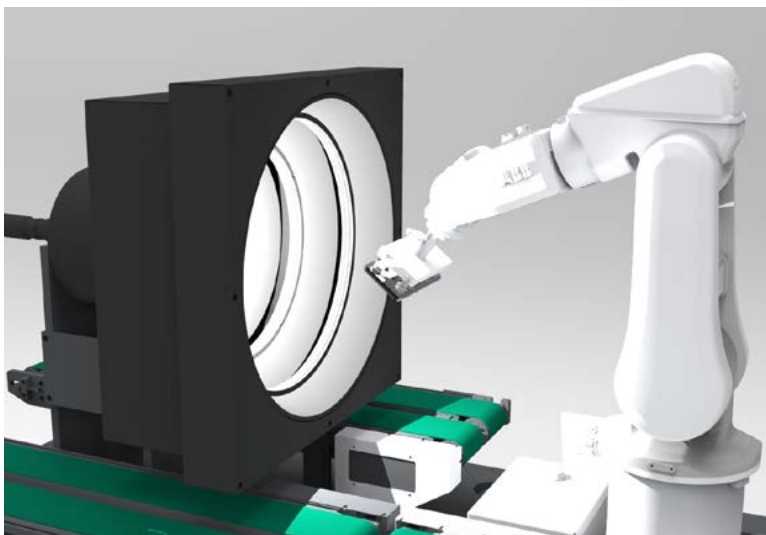
SOLUTION

Cognex has built a cosmetic optical inspection (COI) machine specifically for MLCC inspection, which combines both customized lighting and deep learning vision tools. First, a lighting module customized for MLCC inspection minimizes irrelevant surface variations while revealing otherwise easily missed defects on both the capacitor body and terminals.

After the MLCCs have been inspected by the AOI machine, they are then inspected by the COI machine in order to reduce the amount of false positives and good parts being pulled out of production. This machine delivers better speed, accuracy, and process improvement data when compared to manual inspection.

Cognex Deep Learning's classification tool is trained on labeled images of a wide variety of both defect-free and defective MLCCs. The classification tool learns to categorize the wide range of possible defects, as well as learning the full variation of normal parts. Once trained, it can scan through every MLCC part, and instantly flag any outside of the acceptable range or identify good parts that were previously flagged as defects.

The categorized defects can also be used for upstream process control to minimize part defects over time.



COGNEX DEEP LEARNING SOLUTIONS

Cognex Deep Learning is the first set of deep learning-based vision solutions designed specifically for factory automation. The field-tested, optimized and proven technology is based on state-of-the-art machine learning algorithms.

Rather than following a rule-based approach to solving inspection challenges, like traditional machine vision applications, Cognex's deep learning solutions learn to spot patterns and anomalies from reference image examples. Deep learning automates and scales complex inspection applications that until now still required human inspectors such as defect detection and final assembly verification.

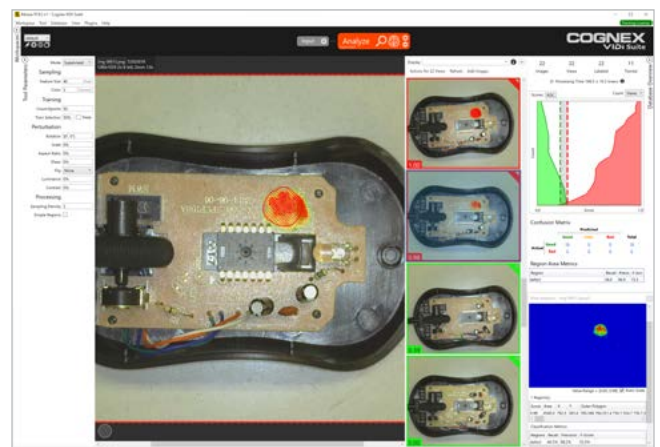


In-Sight ViDi

In-Sight® ViDi deep learning applications are deployed on the In-Sight D900 smart camera without the need for a PC, making deep learning technology accessible to non-programmers. It uses the familiar and easy-to-use In-Sight software platform which simplifies application development and factory integration.

VisionPro Deep Learning

VisionPro Deep Learning software combines a comprehensive machine vision tool library with advanced deep learning tools inside a common development and deployment framework. It simplifies the development of highly variable vision applications and allows engineers to build flexible, highly customized deep learning solutions tailored to their specific needs.



BUILD YOUR VISION

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Cognex machine vision systems are unmatched in their ability to inspect, identify and guide parts. They are easy to deploy and provide reliable, repeatable performance for the most challenging applications.

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3D VISION SYSTEMS

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Cognex industrial barcode readers and mobile terminals with patented algorithms provide the highest read rates for 1D, 2D and DPM codes regardless of the barcode symbology, size, quality, printing method or surface.

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COGNEX

Companies around the world rely on Cognex vision and barcode reading solutions to optimize quality, drive down costs and control traceability.

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