COGNEX DEEP LEARNING

Deep Learning Solutions for Electric Vehicle Manufacturing

COGNEX

THE GLOBAL LEADER

IN MACHINE VISION AND INDUSTRIAL BARCODE READING

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

With over 3 million systems installed in facilities around the world and over forty 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.™**

$811 MILLION
2020 REVENUE

OVER 40
YEARS IN THE BUSINESS

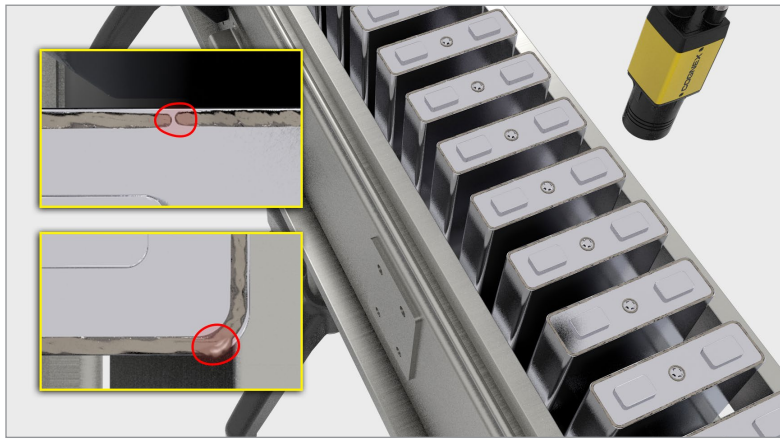
500+
CHANNEL PARTNERS

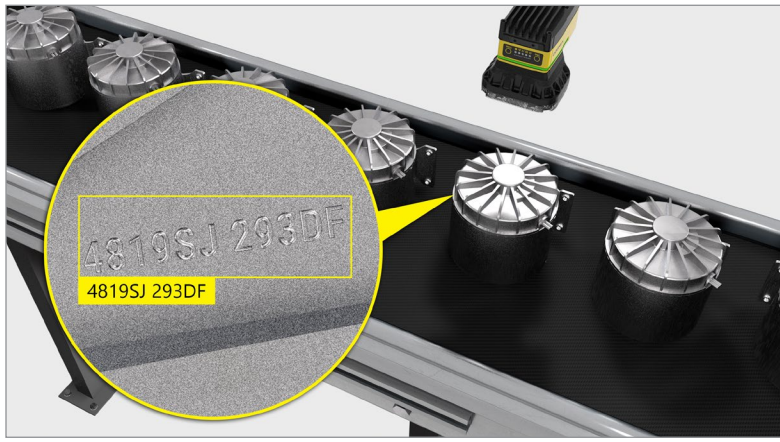
GLOBAL OFFICES IN
20+ COUNTRIES

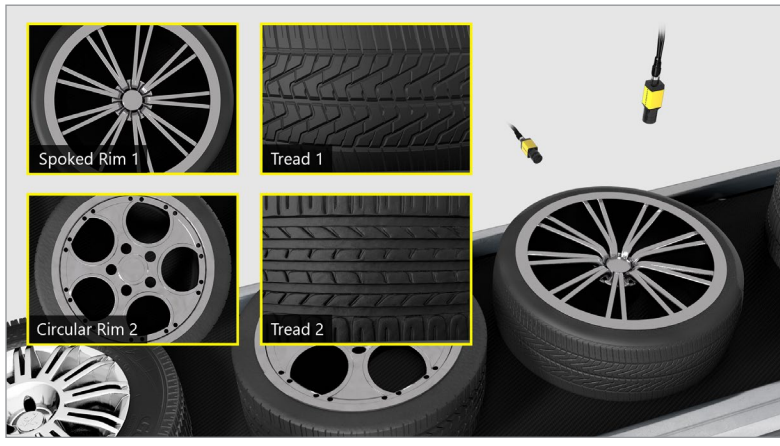
3,000,000+
SYSTEMS SHIPPED

DEEP LEARNING SOLUTIONS
FOR ELECTRIC VEHICLE MANUFACTURING

Cognex Deep Learning is the first set of deep learning vision software and smart cameras designed to solve the most complex and challenging inspections. Combining human-like intelligence with the robustness of machine vision, Cognex Deep Learning is ideal for distorted part location, complex cosmetic inspections, defect detection, assembly verification, classification, and challenging OCR applications. Automate and solve previously hard-to-program inspections in an easy-to-deploy interface.







BATTERY ASSEMBLY

Cap Welding Inspection

Assess low-heat battery cell welds with classification and defect detection tools

PROBLEM

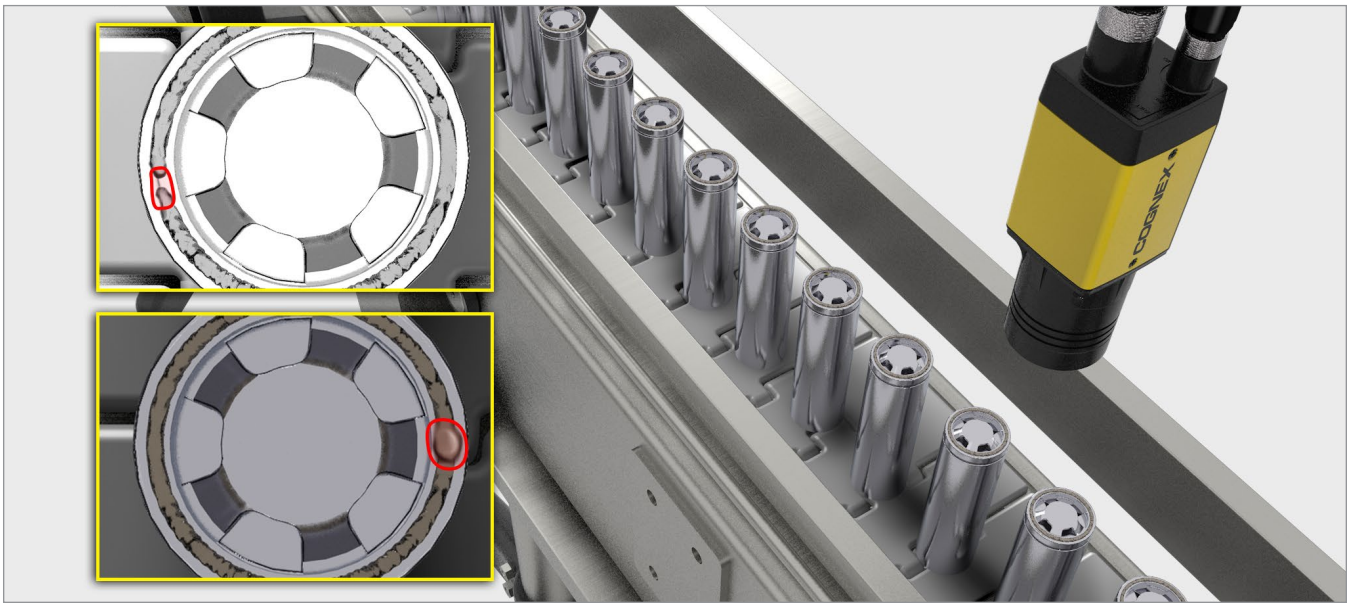
A poorly manufactured battery cell reduces efficiency, creates an uneven load between cells that makes battery management more difficult, and decreases the lifespan of the battery pack as a whole. Errors in cell manufacture are difficult to remedy once they have been combined into modules and packs.

Once the electrodes and separator are packed into the housing of a cylindrical cell and it is filled with electrolyte, the housing is sealed by a cap. To avoid damaging the delicate electrical parts in the housing, a low-heat welding method, typically laser, is required. Such welds must be precise to ensure a secure seal around the cap. The resulting welds must be examined and passed before the cell is used inside a battery module or as a single cell. Any leakage of electrolyte through a flawed weld will lower cell efficiency and could lead to short circuits within the battery.

SOLUTION

Proper assessment of the cap welds is key to the functionality and lifespan of the entire battery. All of these welds can vary significance in appearance, and can show a wide range of defects, but also a wide range of variation that does not affect performance. It is almost impossible to separate cosmetic from functionally significant variations with a traditional vision system because their appearances overlap.

Cognex Deep Learning defect detection and classification tools are trained on a wide range of weld variations. The system then ‘learns’ to accurately classify and distinguish different defect types despite the object and weld variations.



Injection Seal Inspection

Examine battery cell injection seal welds with defect detection and classification tools

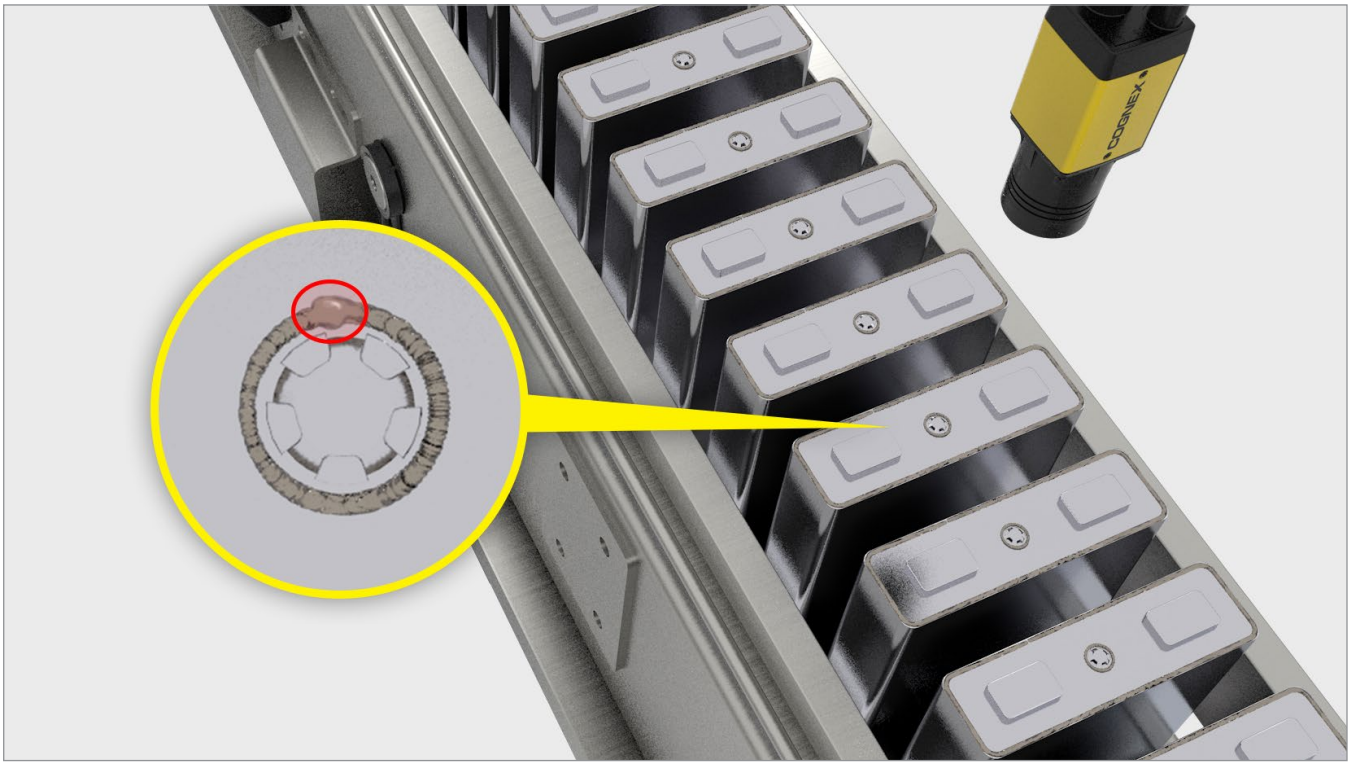
PROBLEM

After a battery cell's top cap has been welded and tested it is filled with the liquid electrolyte that conducts electrons within the battery. When filling is complete, the filling hole is welded closed. Because of the risk of heat damage to the anode, cathode, and electrolyte, this is done with a low-heat laser weld.

Any electrolyte contamination or welding flaws resulting in electrolyte leakage will lower cell efficiency. An electrical test of the filled and sealed cell could reveal the existence of a problem before the cell moves on to be installed in a module, but this method is not completely reliable. Proper assessment of the injection seal welds is key to the functionality and lifespan of the entire battery.

SOLUTION

All of these welds can vary significantly in appearance and can show a wide range of defects. The welds also contain a wide range of acceptable variation that does not affect performance. Cognex Deep Learning's defect detection and classification tools are is trained on a wide range of weld variations and learn to accurately classify and distinguish functional flaws from merely cosmetic ones.



Battery Cell Surface Inspection

Check cell coating quality with defect detection tool

PROBLEM

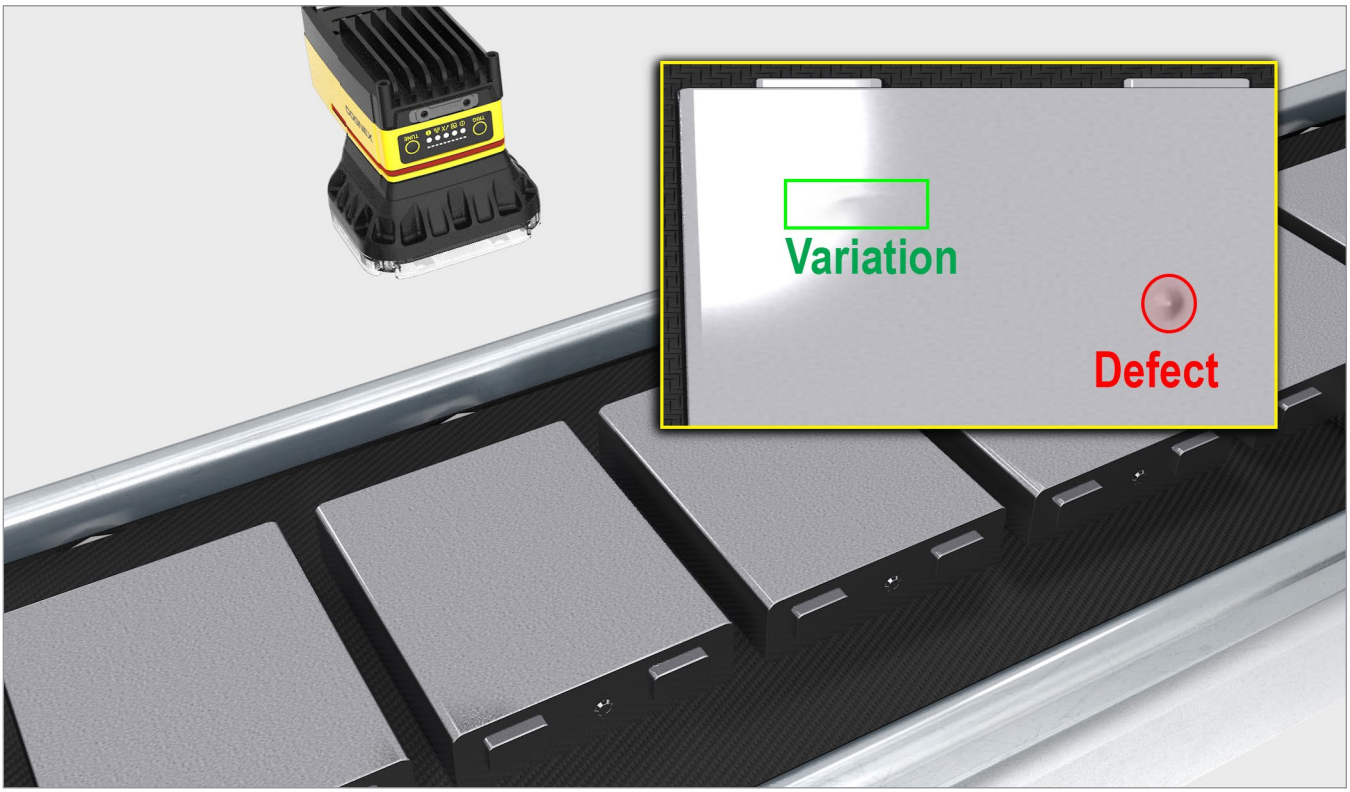
After they are welded, battery cells are wrapped in a durable protective coating. This coating can have flaws, including bubbles and inclusions under the coating, scratches through the coating, and inadequately applied coating. When these cells are packed tightly into a battery module, several factors can lead to an electrical short or overheating: the close proximity of the cells, the charge each cell has to carry, the heat generated by the cells, or inadequate contact with thermal interface material (TIM).

Battery cell coatings can have a variety of minor blemishes that do not compromise function as well as seemingly minor scratches that render them unsafe or unusable. It is important to detect these defects while minimizing rejection of flawed but functional coatings.

SOLUTION

The battery cell surface can be inspected by a more sophisticated machine vision systems such as the In-Sight D900 series, which has deep learning inspection capabilities embedded in the vision system.

Cognex Deep Learning is trained with an image set of both good and defective surfaces. Cognex Deep Learning's defect detection tool learns to identify and pass surfaces within the acceptable range of variation and flags those with unacceptable defects, accounting for natural variations within the image such as light reflection.



Pouch Surface Inspection

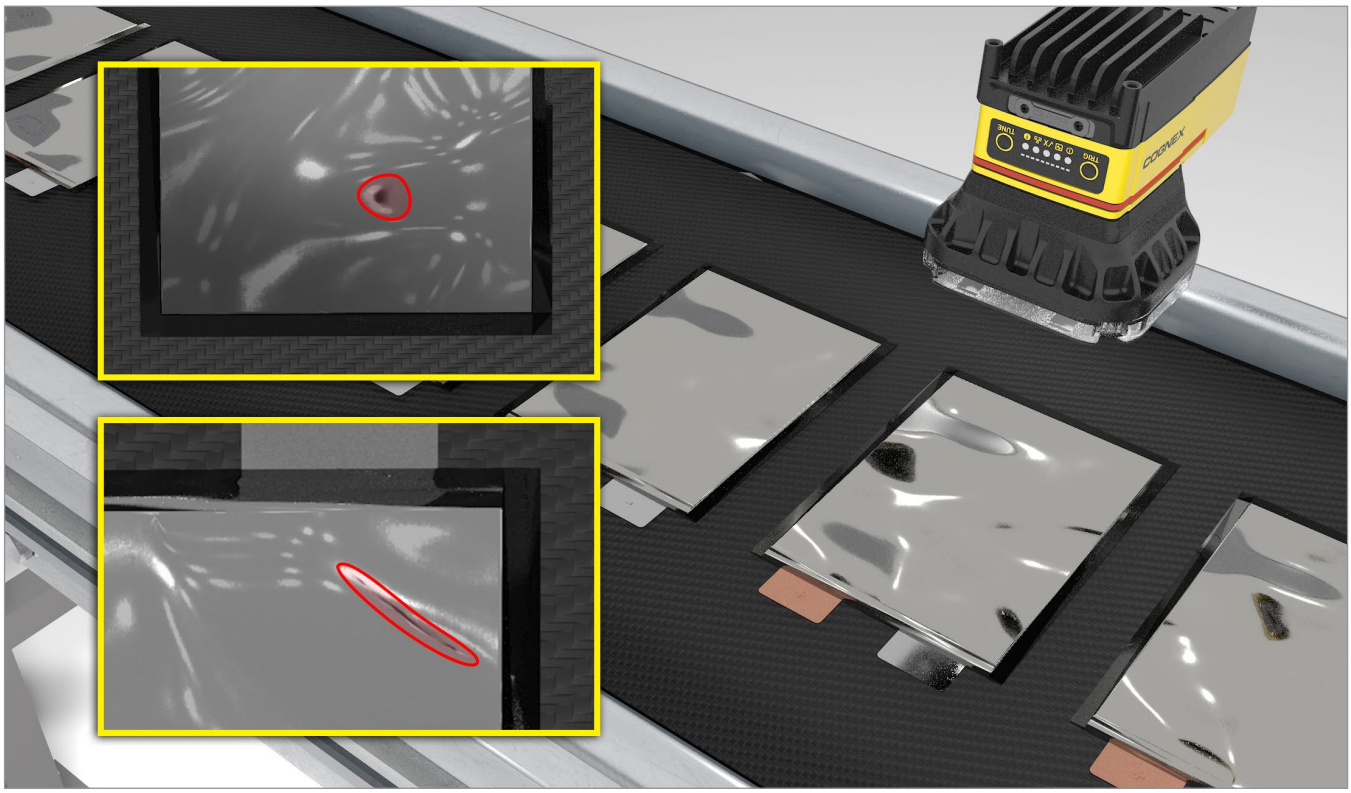
Deep learning tools inspect pouch-style electric vehicle batteries

PROBLEM

A pouch-type battery cell is shaped somewhat irregularly during the degassing process. After jig formation, the cell pouch is pressed to iron out and smooth the surface. It is essential that pouches are even, unwrinkled, and unbent. Cell battery manufacturers employ automated inspection systems between these stages to catch any surface defects. The pouch's complex surface texture creates a noisy and confusing background which can obscure wrinkles, bubbles, and other defects. The visual appearance of one cell pouch can vary drastically from another, making it too complicated and time-consuming to explicitly search for all defects.

SOLUTION

VisionPro Deep Learning uses deep learning-based vision algorithms to identify defects, such as bubbles and wrinkles, by learning from annotated images. The model learns the normal appearance of a pouch's surface, including natural variations that do not constitute defects. All features that deviate from the model's normal appearance are characterized as anomalous. In this way, VisionPro Deep Learning reliably and consistently detects all anomalies without the need for extensive defect libraries.



Side and Top Panel Welding

Assess prismatic battery cell panel welds with deep learning solutions

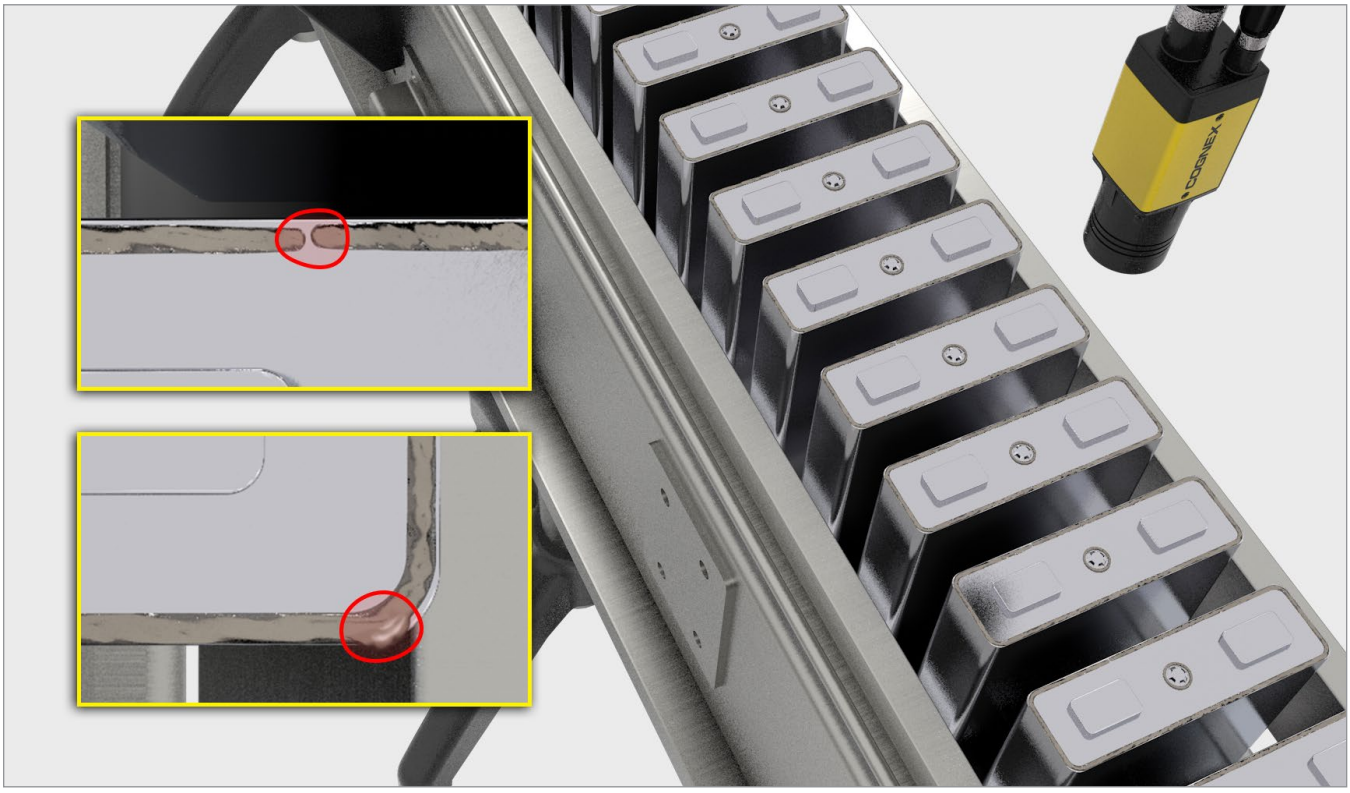
PROBLEM

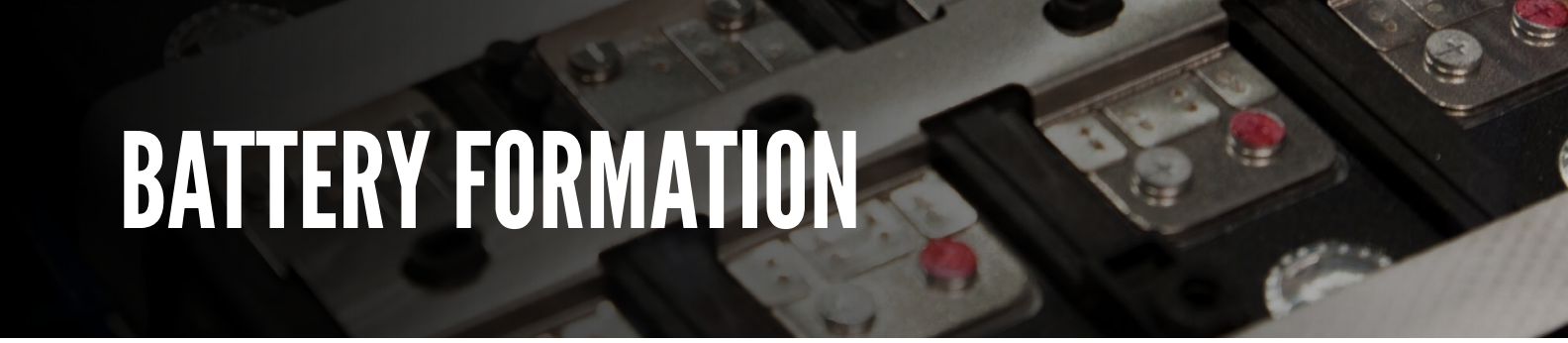
In a prismatic battery cell, a rectangular case is welded around an electrode sheet. Then the top panel is welded on. The lid has to allow for some expansion and contraction of the cell as it heats up and cools down in use. This is a particularly important consideration since the shape of prismatic cells means they can be layered tightly, in a space-efficient matter. The seam welds on both the side panel and the top panel must be inspected for any defects before the battery cell is installed in a module.

SOLUTION

Proper assessment of the seam welds on each cell is key to the functionality and lifespan of the entire battery. All of these welds can vary significantly in appearance. There can be a wide range of defects, but also variations that do not affect performance.

Combining 2D and 3D vision systems with deep learning technology detects many more potential defect types than using just one technology. Cognex Deep Learning's defect detection and classification tools are trained on a wide range of good and defective weld variations and learn to accurately classify and distinguish functional flaws from merely cosmetic ones.





BATTERY FORMATION

Battery Optical Character Recognition

Deep learning OCR tool reads alphanumeric characters on a battery under challenging real-world conditions

PROBLEM

Manufacturers must be able to locate and decode the alphanumeric codes printed on the bottom sides of batteries quickly and accurately. Specular light and glare can make it difficult for a machine vision system to locate and recognize characters, especially if the characters are deformed. An inspection system needs to tolerate these challenges in order to successfully decode characters.

SOLUTION

Cognex Deep Learning's Assembly Verification and OCR tool locates and reads deformed characters, despite image formation challenges. The Assembly Verification tool locates the region of interest (ROI)—in this case, the top of each cylinder battery, which is marked with an alphanumeric code. The OCR tool's pre-trained omni-font capabilities recognize characters even if they are obscured by glare and contrast. To train the software, an engineer defines the region of interest on images which contain a representative set of code characters. During training and validation, a technician re-labels only the missed characters until the software's model correctly identifies all the characters. This deep learning-based approach to OCR saves time during training and development by reducing excessive labeling and ensures accurate reads.

MODULE AND PACK

Thermal Interface Materials (TIM) Inspection

Ensure correct TIM application with deep learning solutions

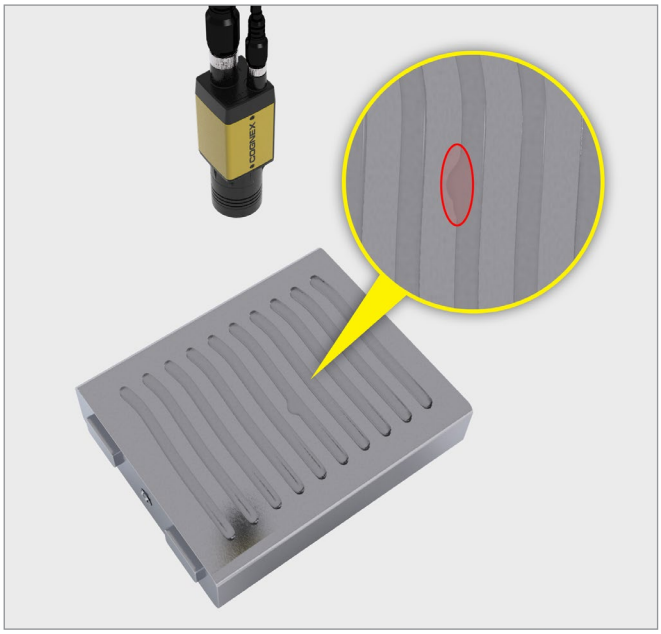
PROBLEM

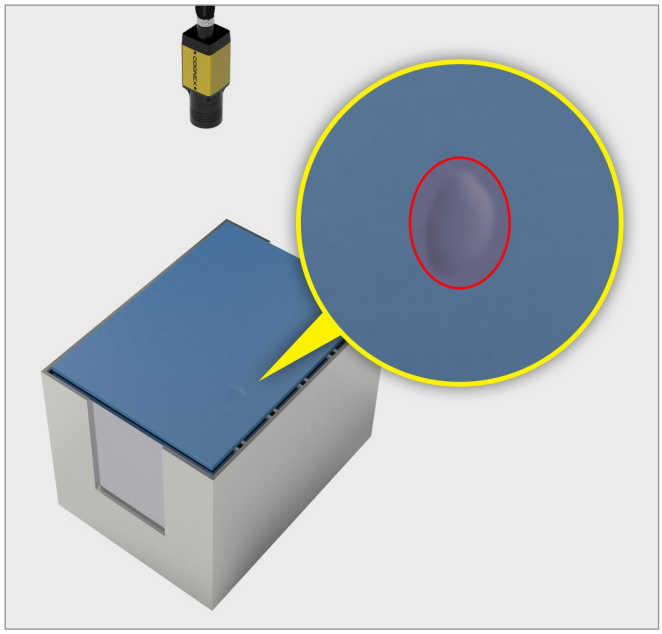
Batteries can generate a lot of heat, which must be removed to prevent battery damage or premature performance decline. Thermal interface materials (TIM) are used to conduct heat away from the battery. Many TIMs simultaneously serve the equally important function of electrical insulation.

TIMs must be applied precisely, with close contact between substrates. A wide range of defects, including air bubbles, poor adhesion, and inclusions, can reduce both thermal conduction and electrical insulation. Visual inspection must identify a wide range of possible flaws in installation and application, often involving materials with poor color contrast. Once the battery assembly moves to the next step, the TIM is permanently concealed and unavailable for further inspection. Errors at this stage can lead to hard-to-diagnose problems down the line.

SOLUTION

While rule-based machine vision can accurately detect anticipated problems with beads, gaps, installation width, and other common features, Cognex Deep Learning learns to detect a significantly wider array of installation problems with every type of TIM. If a battery should later fail, its failure mode can be tied back to a specific stored image of the TIM, and the deep learning training model can be further refined to detect these new errors.





MOTOR

Stator Assembly Weld Inspection

Assess hairpin and leadpin welds with deep learning solutions

PROBLEM

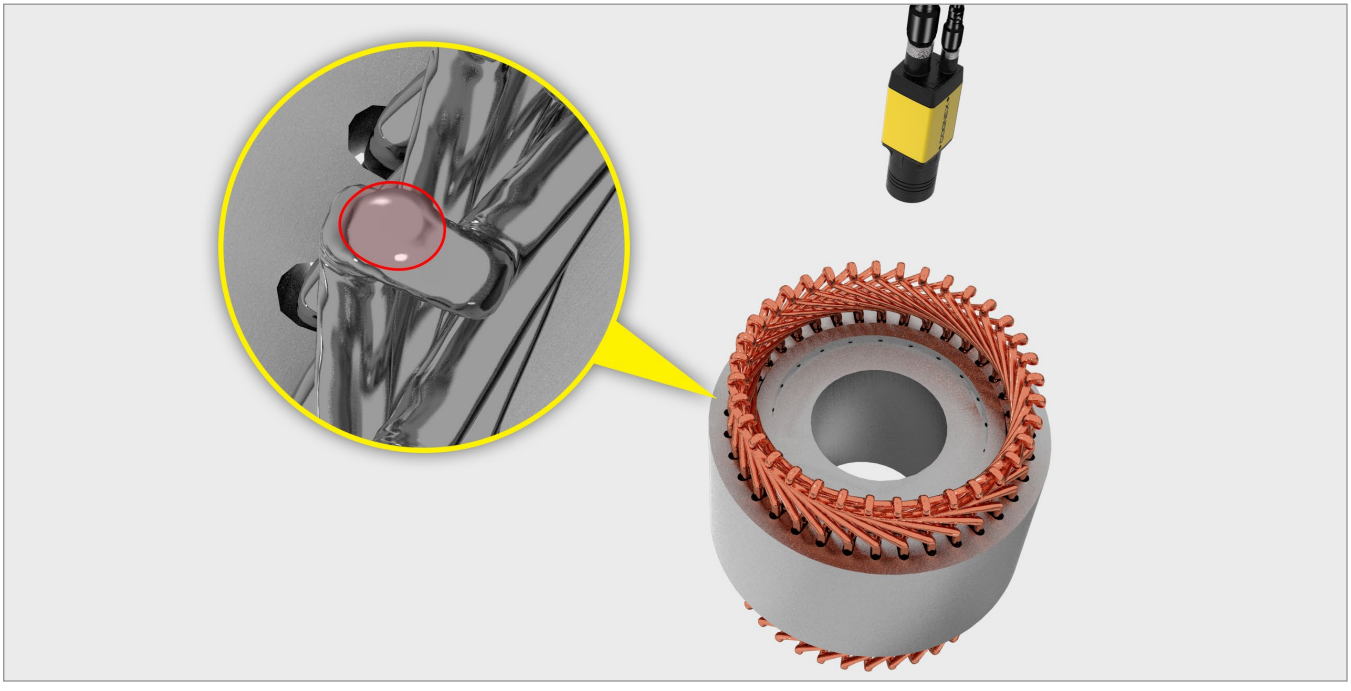
Bar-wound copper pins, called hairpins due to their shape, have replaced wire windings in the stator of many electric motors. They are more rigid than wire so their orientation can be controlled more precisely, leading to higher and more predictable efficiency. Hairpins, or leadpins, are loaded into slots on the stator and welded together to become one single twisted conductor. Welding can introduce inclusions and porosity, increasing electrical resistance as well as reducing mechanical strength. More significant defects can break the circuit and make the entire stator nonfunctional.

Welds have a large amount of variation, both for cosmetic defects that do not affect performance, and for performance-reducing defects that show few overt signs. The weld can have too much or too little volume, be inadequately fused, or show signs of cracking. Hairpin welding inspection must detect all possible defects.

SOLUTION

A range of cameras can be used to image the weld for analysis. Although a 3D camera may be required to measure weld volume, a 2D camera can supply the images for all other defect detection and ensure a proper positioning of the spot welder before the process starts.

Cognex Deep Learning's defect detection and classification tools are trained using a small image set of good welds and a wide variety of defective welds to classify and detect defects.



Optical Character Recognition on Cast

Read challenging codes on motor parts using deep learning-based OCR

PROBLEM

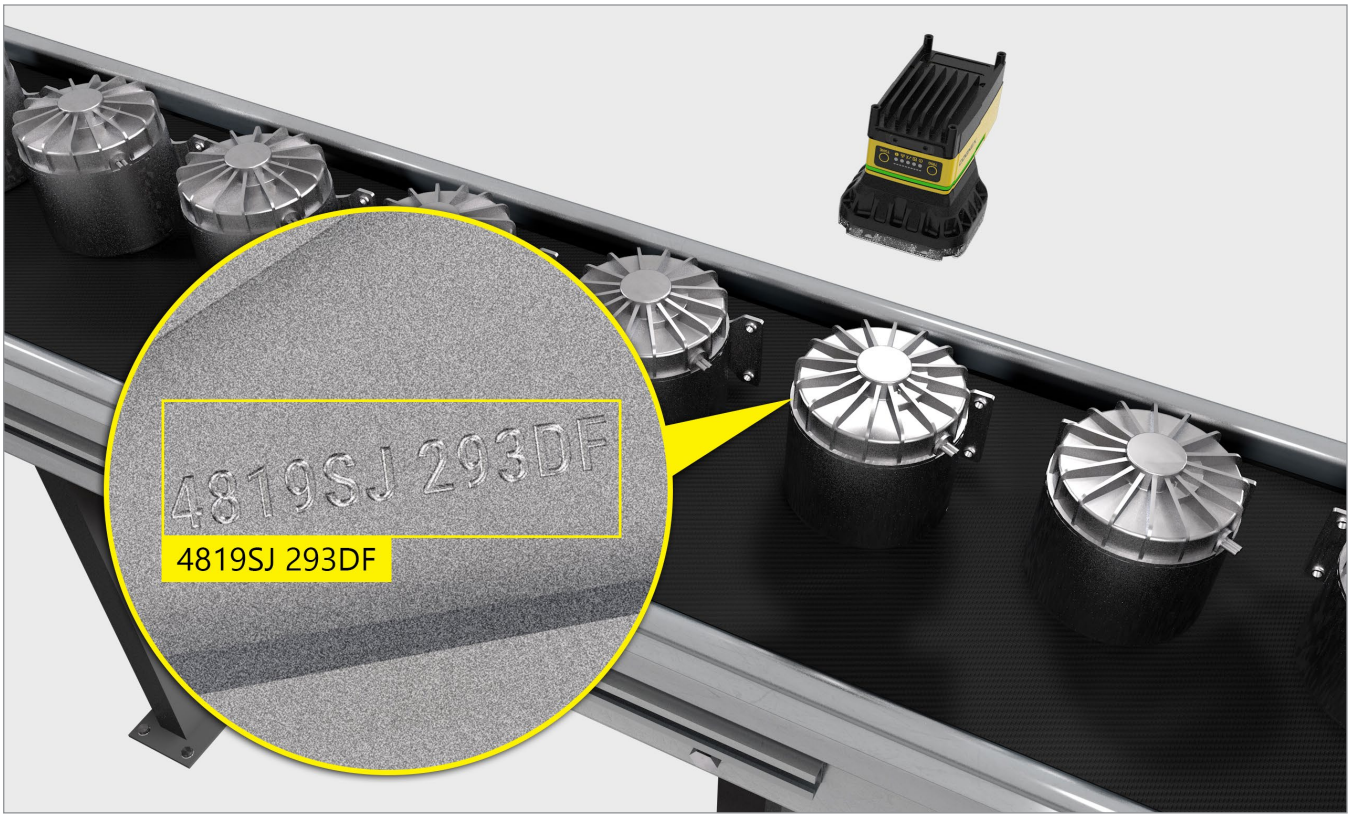
An electric vehicle (EV) motor comes in a die cast housing, typically made of aluminum. Each housing is marked with an identification code, which is generally in raised letters and numbers that are part of the cast housing itself. This lettering, being of the same material as the housing, is of extremely low contrast.

This identification code is essential for traceability at the assembly facility and throughout the supply chain. It is the number to which all other records are tied. Identifying it accurately is very important since any ambiguity stops the line and requires the code to be verified by human inspectors. If this happens multiple times per shift it causes significant delays and increases expense.

SOLUTION

Traditional rule-based OCR tools typically deliver read rates up to 99 percent. For some applications that is adequate, but important applications, such as this one, require read rates to be as close to 100 percent as possible. Any human intervention to manually override the results from a failed OCR read can reduce throughput and lower efficiency.

Cognex Deep Learning's text and character reading functions reliably and accurately deciphers deformed, skewed, damaged, or low-contrast codes. It is trained with an image sets of OCR codes with different angles, lighting, damage, and other variations.



Electric Motor Winding Inspection

Detect electric motor winding errors with deep learning solutions

PROBLEM

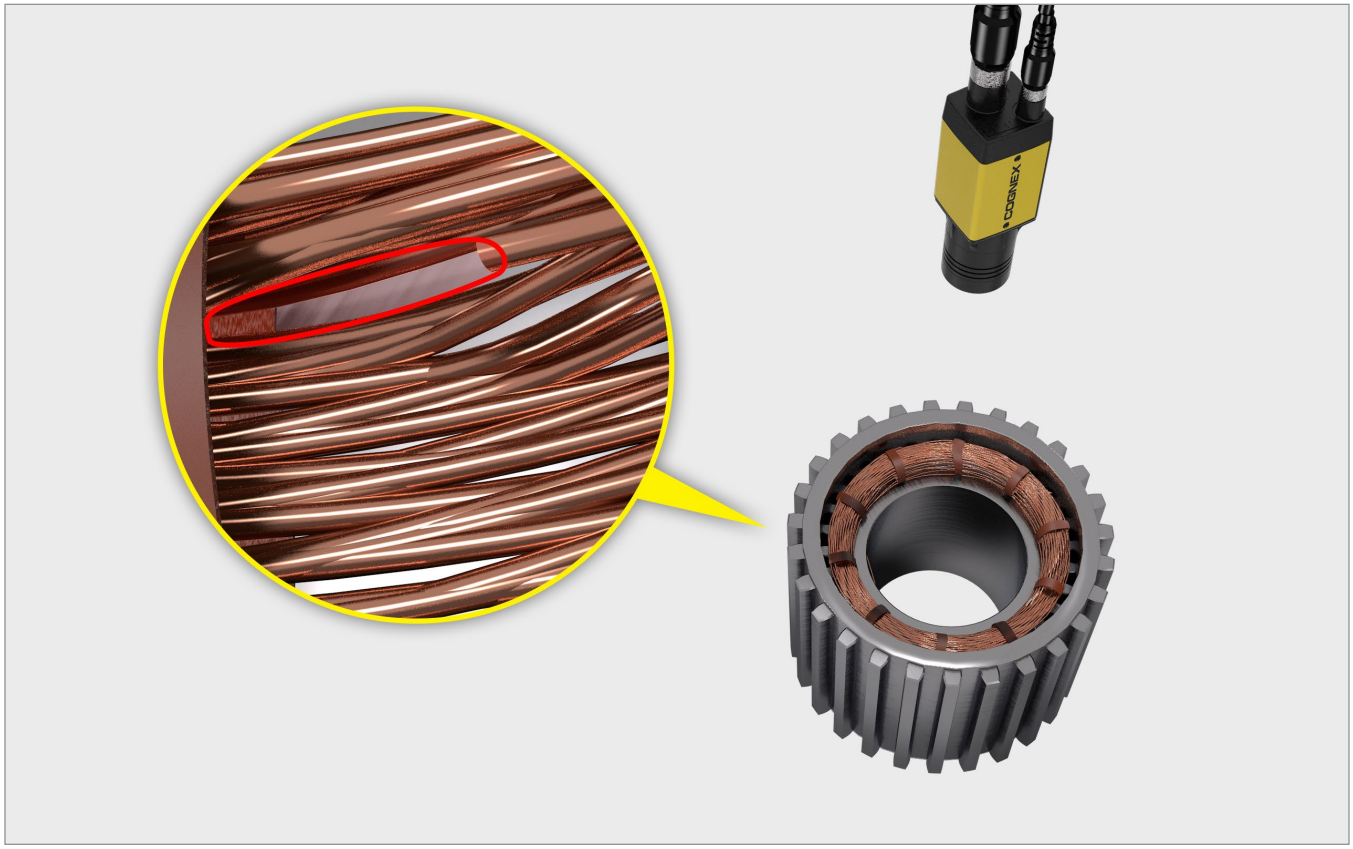
In an electric motor, insulated copper wire is wound around a core to create or receive electromagnetic energy, transferring that energy by induction to another coil. Such coils are also found in converters. These coils are rapidly wound by a machine.

The windings in electric vehicle (EV) motors are extremely dense. Any inaccuracies in how they were wound can have a negative effect on the motor's efficiency. Given the vast number of windings crammed into a narrow space, even small winding errors can be significant, but hard to identify. The winding error may be subtle and can occur anywhere among the many visible wires.

SOLUTION

There is no efficient way to code a rule-based machine vision system to cover all the winding error possibilities anywhere on the coil. Human inspection is also not suited for identifying such subtle errors in a complex image.

Cognex Deep Learning using a color camera accurately verifies that the winding process has been accomplished without error. The defect detection tool learns from a set of training images consisting of error-free windings and labeled images featuring a wide range of overlaps, mispositionings, crossings, and other potential errors in various locations.



POWER ELECTRONICS

Capacitor Soldering Inspection

Detect soldering defects with deep learning solutions

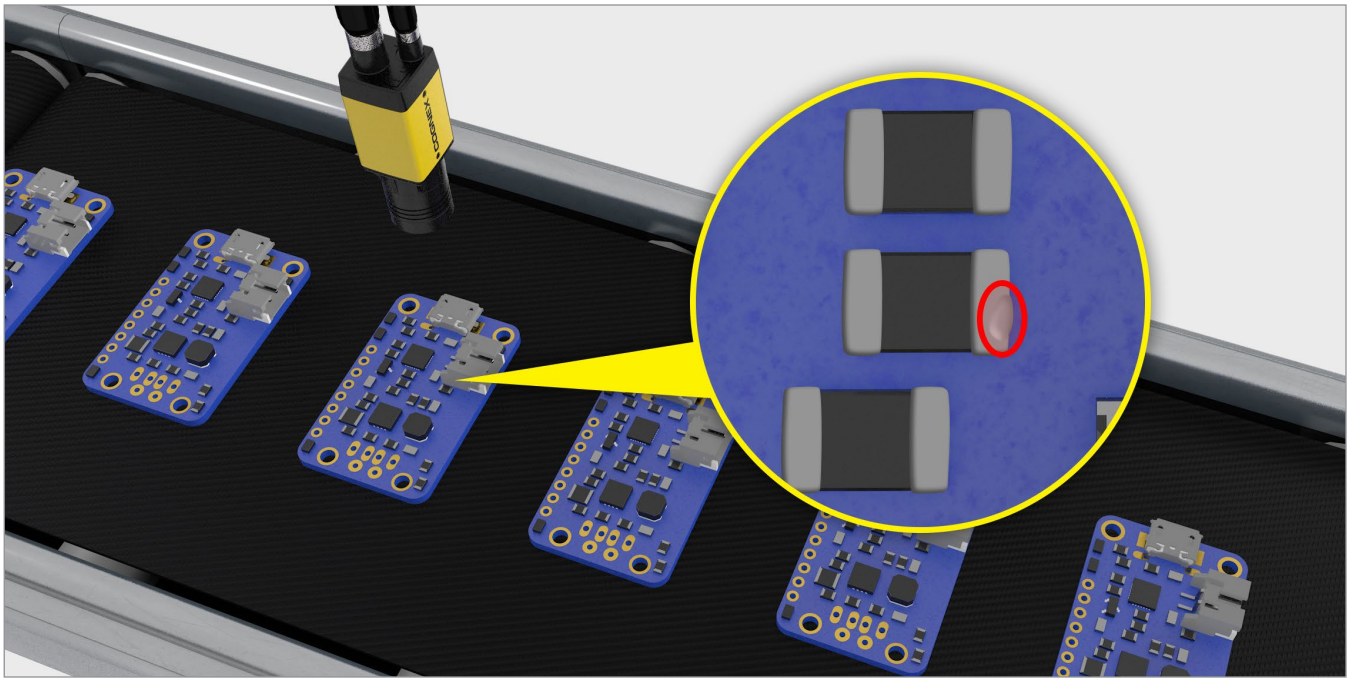
PROBLEM

Capacitors are crucial electronic parts that are soldered into inverters, chargers, and other circuits in electric vehicles (EVs). They may also be interconnected to supercapacitors or ultracapacitors. The low resistance and high current carrying capacity of these soldered electrical connections are essential to EV operation. If a connection to a capacitor is weak and conducts poorly, the vehicle's efficiency will suffer. If a crucial connection breaks completely, it can lead to serious malfunction. If that broken connection is located somewhere like the auxiliary battery, the vehicle might be completely disabled, and require service.

Connections created by soldering can vary significantly in appearance without affecting function, while unacceptable connections can visually resemble functional ones. Given the consequences of connectivity problems, soldered parts with suspected defects must often be pulled and X-rayed to check their connections, with all the expense and delay that entails.

SOLUTION

Cognex Deep Learning's defect detection and classification tools are trained on a wide range of good and defective solder connection variations and learn to accurately classify and distinguish functional flaws from merely cosmetic ones. Using an example-based approach instead of traditional rule-based machine vision allows shortens application development time.



BODY ASSEMBLY

Front and Rear Park Assist Sensor Color Classification

Ensure installation of the correct color of FPA/RPA sensors with deep learning solutions

PROBLEM

Between four to 12 Front or Rear Park Assist (FPA/RPA) ultrasonic sensor assemblies are embedded in both bumper of all new cars. For aesthetic reasons, these sensors are manufactured in a variety of shades to match bumper color. Modern automobile paint can contain a variety of light-scattering particles and metallic flecks, varies slightly in color from one spot to another, and is produced in a range of closely related shades.

Red, green, blue (RGB) or hue, saturation, intensity (HSI) values will change depending on angle and orientation. As a result, picking the correct sensor color from a wide color inventory to precisely match a specific bumper color is a difficult problem. Installation of the incorrect sensor can lead to rejection by the end user. Sensors must be quickly and accurately matched to bumper color so that workers can install the specified model.

SOLUTION

Given all these possible variables and overlaps, rule-based machine vision struggles to make the correct sensor/paint matching decision. Where the colors come close to overlapping, the human eye also interprets color differently from person to person.

Cognex Deep Learning is trained on a range of different images, at different angles and rotations and the classification tool robustly categorizes the paint colors. Then, when making the choice, Cognex Deep Learning examines the image as a whole, properly weighting every variation, reflection, refraction, granularity, and shade within that image to make the best match.

Tire and Wheel Identification

Using deep learning solutions to ensure specified tires and wheels are installed

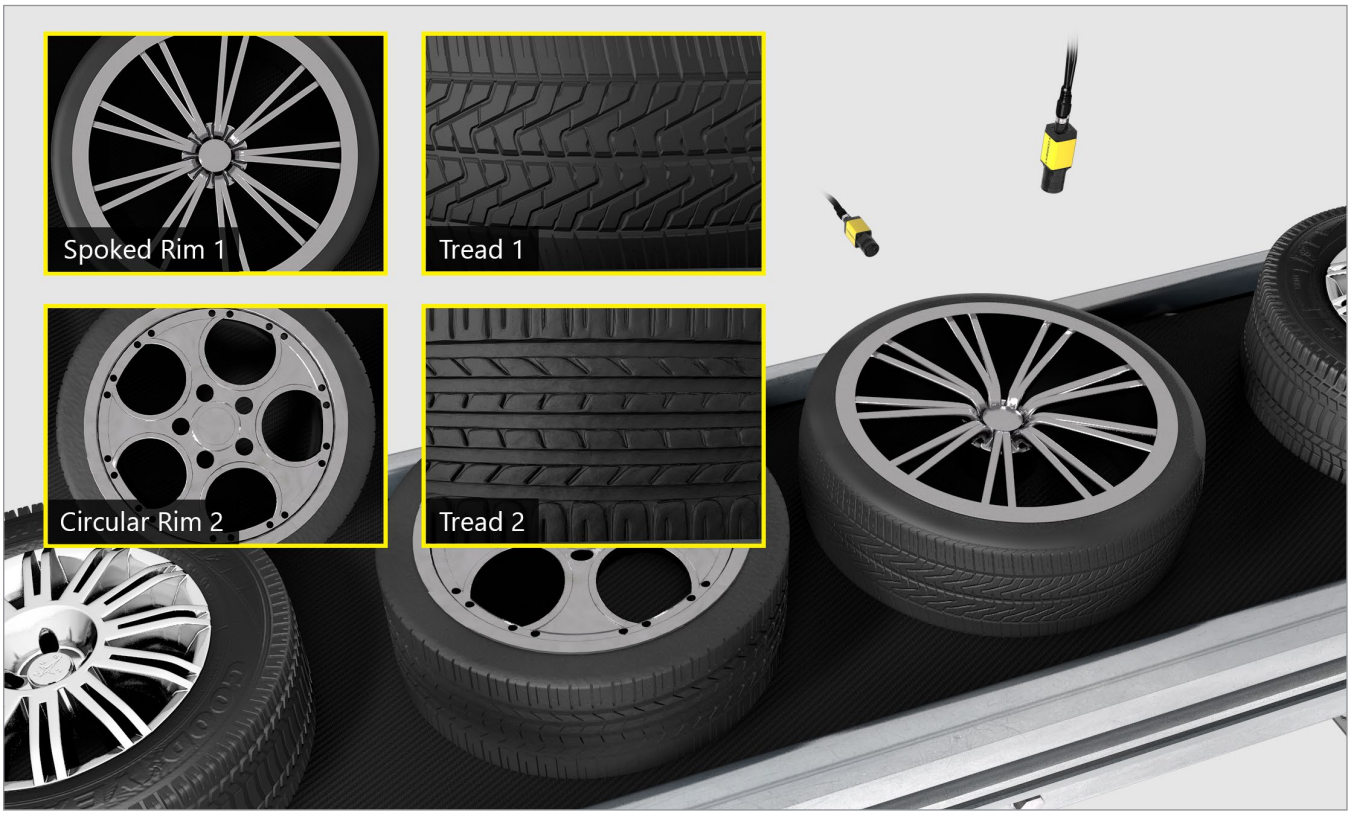
PROBLEM

With the mass customization of automobiles, ensuring that the correct version of a part is selected and installed, rather than a slightly different yet distinct version, can be a difficult task. Wheels and tires are produced in a large variety of models and patterns and are identified by the distinct tread pattern. The tread on modern high-performance tires varies not just from one model to another, but continuously all the way around the tire's circumference. The tire model must be accurately identified despite this variation. Wheels come with rim patterns that can vary only slightly from model to model.

If a supplier inadvertently installs a wheel or tire other than the model specified, it may be rejected by the end user and require corrective action. Tires and wheels must be accurately and quickly classified so that workers can install the specified model.

SOLUTION

Cognex Deep Learning simplifies and automates the identification of a tire from any part of its tread and a wheel from elements of its design. The classification tool learns to identify and sort the different tire tread patterns from a set of training images. It then groups tires and wheels according to their class, ensuring the correct part is selected and installed on the vehicle.



Decoration Panel Inspection

Using deep learning solutions to ensure the correct decorative panels are installed

PROBLEM

Each vehicle on the production line can have different decorative interior paneling depending on the sequence of orders. One popular option for decorative paneling is synthetic wood whose grain varies the same way as that of real wood. Every piece of paneling looks genuinely unique. The appearance of these decorative panels can vary enough in color, pattern and density to make it nearly impossible to reliably use traditional machine vision to ensure the correct decorative panel was installed. These decorative panels must be accurately and quickly classified so that their proper assembly can then be verified.

SOLUTION

Cognex Deep Learning simplifies and automates the identification of any woodgrain trim or carbon-textured pattern pieces prior to installation. It is trained on a set of labeled images containing many examples for each type of decoration panel. Using this data set, Cognex Deep Learning quickly distinguishes even extremely similar woodgrains or other patterns from each other, ensuring that the right type of panel is always installed according to specification.

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.

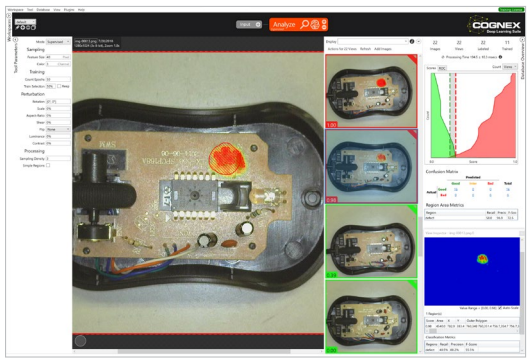
Rather than following a rule-based approach to solving inspection challenges, like traditional machine vision applications, Cognex's deep learning solutions learn to spot patterns and anomalies from reference image examples. Deep learning automates and scales complex inspection applications that until 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

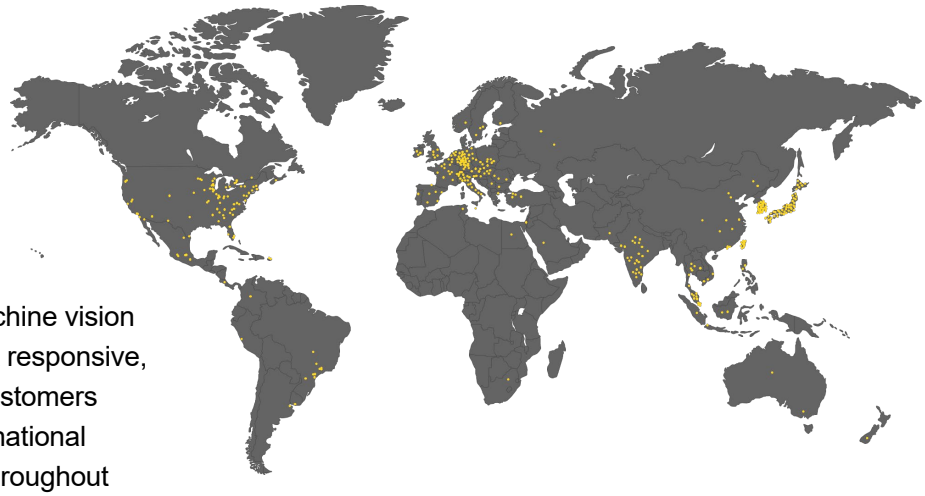
VisionPro Deep Learning software combines a comprehensive machine vision tool library with advanced deep learning tools inside a common development and deployment framework. It simplifies the development of highly variable vision applications and allows engineers to build flexible, highly customized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



COGNEX GLOBAL SERVICES

Customers get more than software when they purchase from Cognex. They get a company focused exclusively on machine vision, with the most comprehensive application experience. Add direct, high-quality worldwide service and support, and it's easy to see why Cognex is the machine vision company that industries rely on.

Technical Support
Product Training
Hardware Programs
Product Lifecycle



When it comes to protecting your machine vision investment, Cognex understands that responsive, expert service is an expectation all customers should have. 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 help you 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.

cognex.com/support/cognex-services

Offices in 20+ countries

500+ Global Partners in 30 Countries

BUILD YOUR VISION

2D VISION SYSTEMS

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.

www.cognex.com/machine-vision

3D VISION SYSTEMS

Cognex In-Sight® laser profilers and 3D vision systems provide ultimate ease of use, power and flexibility to achieve reliable and accurate measurement results for the most challenging 3D applications.

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VISION SOFTWARE

Cognex vision software provides industry leading vision technologies, from traditional machine vision to deep learning-based image analysis, to meet any development needs.

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BARCODE READERS

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.

www.cognex.com/barcodereaders

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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