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Multi-camera vision for flawless wheels

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Multi-camera vision for flawless wheels

Camera-based quality control with AI and multi-shading

An automated inspection cell combines 17 cameras, neural networks and rule-based machine vision. Sequential dome lighting and multi-shading reveal even the smallest surface and geometric defects on aluminium wheels within a cycle time of less than 6.2 seconds.



Aluminium wheels must meet particularly demanding quality requirements. They must satisfy stringent safety standards while also pleasing the eye with a perfect, flawless design. In the past, individual smart cameras were generally used locally and independently along the production line to inspect specific features. Before a wheel reached the OEM's line, it would usually also pass through six manual 100% inspections. As people detect only up to 70% of defects, however, defective wheels still passed quality control.

Cretec's QBIC Wheels inspection solution has changed this process. At the end of a value chain involving many manufacturing and finishing operations, wheels from 14 to 26 inches are now inspected for numerous quality features and the results documented. Only completely defect-free products with documented quality assurance reach the customer.

The wheel inspection process

A gripper lifts the wheel from the conveyor and moves it precisely into the inspection positions, including rotation. Several patented features in the QBIC inspection cell enable highly reliable checks of numerous criteria using new image acquisition methods with strong detection capabilities. Wheels enter the cell on the conveyor, and the machine vision system's 17 cameras detect defects that can easily escape the human eye. Geometric features on both sides of the wheel are also checked, while the coating is inspected for quality features such as

Key points at a glance

An automated cell inspects 14- to 26-inch aluminium wheels using 17 cameras, AI and rule-based machine vision. Segmented dome lighting and multi-shading reveal minute surface and geometric defects. The front and rear are inspected in an average of 5.88 seconds. Results and image data are documented, while modular components allow flexible integration into production lines.

The QBIC Wheels system inspects wheels in less than 6.2 seconds, enabled in part by the combination of a 1,000 mm diameter dome light and 17 cameras.

thickness, colour, gloss and other characteristics.

A high-performance PC in the cell runs several neural networks and machine vision software based on the latest version of HALCON. Compressed images, together with all relevant inspection features, are backed up on the PC and additionally in the user's IT system. A large touchscreen provides a clear, detailed view of the quality assurance processes. The PC also controls the entire inspection cell.

After extensive inspection of the front and rear, the wheel is returned to the conveyor within the required cycle time of less than 6.2 seconds; the value achieved in practice is 5.88 seconds.

In-house dome lighting with a 1 m diameter

Many inspection features can only be detected reliably if the lighting provides the required capabilities across a very broad range. Diffuse, highly uniform illumination from all directions is suitable for reliable inspection of uneven metallic surfaces with curved and glossy areas. It avoids harsh shadows and interfering reflections.

Dome lighting provides these conditions. As no suitable light with the diameter required for wheel inspection was available on the market, Alexander Trebing, Cretec's Managing Director, designed an appropriate dome light and had it manufactured. Its 1,000 mm diameter allows large components to be illuminated effectively. This previously unique lighting solution is already being used successfully to read DOT codes at tyre fitters.

Instead of the four segments previously common on the market, the light uses 16 segments, providing substantially better detection capabilities. The LED rows are selected to suit the camera acquiring the image and are flashed sequentially during camera exposure. The lighting can be pulsed at up to 100 A. The methods known as shape from shading and photometric stereo allow a 3D height model to be calculated from greyscale images captured under different lighting directions. Cretec extends these capabilities by combining 17 cameras with precise exposure control via flash controllers to create a multi-shading image. Image acquisition takes 60 ms. The cameras transfer data to the computer over fibre-optic connections at rates of up to 100GigE.

This enables vision systems to detect a very wide range of fine defects in metal, cast, rubber and plastic parts: for example, tiny scratches and cracks, dents and pores on smooth and reflective surfaces, and the separation of structures from textures.

High-precision results with AI

The central top-view camera has a resolution of 65 MP. At the measurement plane, this corresponds to a pixel size of 90 µm. Measurement also uses subpixel information, achieving accuracy below 0.09 mm and repeatability better than 0.09 mm.

Sixteen angled-view cameras, each with 12 MP, are distributed evenly around the dome. An additional side-view line-scan camera scans the wheel's drop centre from the outside at 4k resolution.

The dome's LED lighting is switched sequentially so that each camera can acquire several images from its viewing angle. The images are then additionally combined using a multi-shading method. This allows very fine surface defects to be detected and displayed with a clear sense of depth. LED pattern projectors can further improve defect detection, for example by highlighting defects in highly reflective clear coats.

AI training follows an intuitive workflow through a clear graphical user interface using all camera images, whether top or side views. During neural network development, the operator is guided step by step through training on defective regions. These regions are classified only at the end of the process. AI classification therefore focuses exclusively on the relevant areas. According to Cretec, evaluation with this method is considerably easier to understand, more stable and more robust than processing everything together in a single network.

The multifunctional QBIC philosophy

The consistently modular architecture of the QBIC cell concept enabled a space-saving, standalone solution integrated to meet the requirements. The QBIC system proved its value during the feasibility study by simplifying many demanding machine vision requirements and approaches. This allowed the solution to be adopted almost unchanged. Modules with extensive capabilities in robotics, control, data analysis and communication are integrated directly into the autonomous system.

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