Toward a Smart 3D Inspection Platform

How smart sensor technology is shaping the smart factory

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As manual inspection methods are increasingly replaced by automated technologies, the reality of Industry 4.0 and the smart factory is beginning to materialize. This brave new world is one of cloud-based software, deep learning and optimization, and smart, networked instrumentation replacing the rudimentary systems born of the industrial revolution.

Higher speed, higher volume throughput requirements in industries worldwide means quality inspection is on the rise, with further integration into automated handling equipment and more adaptability to consumer demand than at any other time in human history.

This new quality control environment is driven by the demand for products with perfect fit and finish, and can only be delivered with intelligent inspection platforms that are easily deployed and maintained by factory engineers.

Challenges to inline inspection

There are a variety of challenges that inline inspection must address in today's automated quality control environment.

Complex measurement algorithms, easy to use setup environments, and increasingly stringent fit and finish expectations all present significant challenges to inspection design. Other trends such as increasing miniaturization in the electronics, pharmaceutical and medical industries demand extremely high resolution to fully digitize parts in 3D and detect target features with a high degree of accuracy and repeatability.

Manufacturing lines are running faster and faster every year, with tact times set at one to two seconds per part, including both acquisition and measurement.

Fig. 1 The modern factory floor

Low yield caused by inadequate inspection methods results in greater rework, rejects, and waste. Assembly processes can fail if out of tolerance parts enter a machine, which leads to increased downtime and system cost.

Ultimately, poor quality parts can lead to product failure in the customer's hands and end up in product recalls, lost revenue and damage to the company's brand.

Smart sensors: the backbone of smarter inspection platforms

Smart sensors are the basic building block of the move toward easier, more cost effective inline inspection. Smart sensors are a fusion of scanning, measurement, and control logic within a single, network-aware device offering rich visualization and an intuitive drag and drop setup experience.

Over the last 25 years, smart sensors were limited to performing 2D measurement and were part of the first wave of smart cameras that simplified the deployment of machine vision for quality control in factories. Now, smart solu-

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At LMI Technologies, 3D inspection is our specialty. We are dedicated to developing easy-to-use solutions that increase productivity and profitability for our customers. LMI leads the automated quality control industry with world-class 3D sensors that power today's smart factories.

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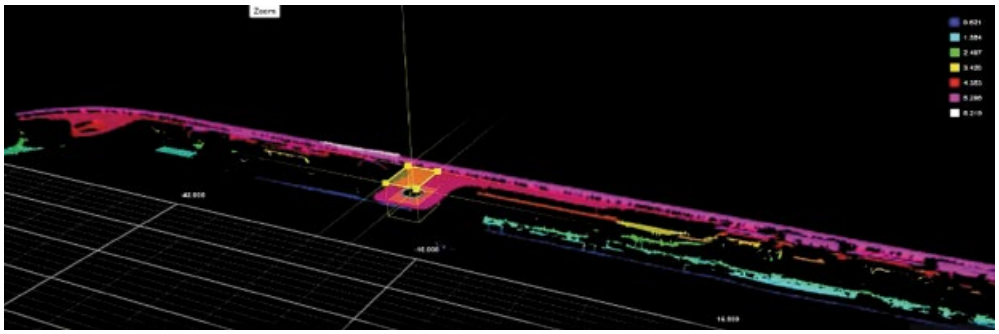

Fig. 2 3D scan of a mobile phone

Fig. 3 Interconnectivity is the key to smart factory

tions have moved beyond 2D by offering the value of 3D laser or structured light scanning and measurement in a single device. Smart 3D sensors measure part features related to shape, such as how two surfaces come together to form a flush fit. With 3D shape now added into the inspection environment, factories can leverage this data to drive greater quality and enable further handling automation.

The introduction of 3D smart sensors is just the beginning of the development of a truly "smart" inspection platform. When done properly, the end result of smart inspection design is a rapid deployment platform that acquires rich data and advanced measurement tools to significantly reduce solution complexity, increase reliability, and shorten setup and inspection cycle times by the people running factories today – the process engineering community.

Interconnectivity is the name of the game

With hundreds of inspection stations in any given factory, interconnectivity is a key ingredient that leads to easier maintenance and standardized analysis and reporting of sensor data.

Smart sensors offering built-in web servers are easily accessed by remote mobile devices and no longer require a dedicated PC with display throughout the factory. With user interfaces designed around a web browser, a standard inspection environment can be delivered offering point-and-click experiences that support rapid configuration, drag and drop measurement tools, dashboard monitoring of inspection results or past history.

Built-in communication protocols further extend a smart sensor's ability to rapidly integrate into a factory process. With built-in support for connecting with PLCs or robots, sensors quickly become a smart add-on to an otherwise blind process to improve every step of a complicated assembly process.

Sensor networks themselves are a key component of building a smart inspection platform where multiple sensors synchronize to scan large parts or the same part from many angles. Scalable inspection systems naturally support this multi-sensor synchronization and perform coordinate transformations to report in factory relevant terms.

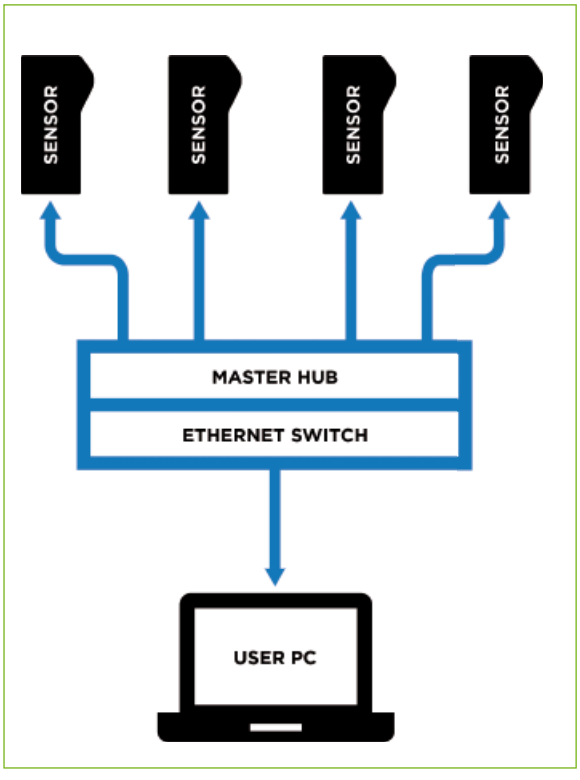

Fig. 4 Network of smart sensors

Data streams produced by networks of smart sensor measurement systems enable the optimization of factory schedules, supply chains, and open the possibility of a dynamic smart factory that customizes products driven by online consumer demand.

It's this interconnectivity that is expected to have the greatest impact on modern manufacturing, with experts estimating that a one percent increase in inefficiency using interconnected devices could result in up to 276 billion US dollars in cost savings for major industries over 15 years in North America alone.

Greater customization autonomy

The smart inspection platform provides toolsets to create both dedicated measurement algorithms running in sensor firmware or customized applications that run on a PC.

Features such as an open source software development kit (SDK) allows users to create network TCP/IP connections, stream sensor data into circular buffers, parse XML settings, and manage multiple threads with ease – with the ability to select any suitable target operating system they require.

In addition, the best sensors today offer the embedded ability to customize actual sensor firmware with proprietary measurement tools. In this case, customers develop their own tools, merge them with the standard sensor firmware and thereby extend sensor capability with custom firmware under their control. Such custom firmware toolsets are supported by sensor emulators that allow modified firmware to run on a PC first to ensure proper behaviour on recorded data without a physical sensor on hand.

The fusion of 3D with 2D

Far from being a dead technology, 2D processing is an essential component to 3D smart sensors. The base functionality in 2D software such as blob segmentation, edge detection, pattern recognition, and barcode processing are underlying components to most inspection solutions. The addition of 3D shape-based measurement with 2D contrast-based measurement creates a powerful set of tools to fully analyze parts and assemblies to ensure perfect fit and finish. The contrast-based images in 2D reveal features that are on the surface of a part such as printed markings while shape-based height maps in 3D reveal features that make up the specific geometry of a part such as step height changes or part curvature.

The fusion of both 3D and 2D scanning for advanced cases where 3D performs the initial feature segmentation and 2D extracts surface information (e.g. barcodes or patterns) represents a key step in the formation of a complete inspection platform. A smart inspection design could support this fusion process by streaming 3D data into a smart 2D sensor where both datasets are transformed into a single coordinate system for final measurement processing.

Other inspection features beyond dimensionality, such as part registration to establish a reference frame from which to lock measurement tools, sectioning to reduce volumes to surfaces to profiles, anchoring methods to track part to part variation or transport vibration and tilt, and track and trace control logic to activate downstream reject or sorting bins for a previous pass / fail decision are all cornerstones of a smart inspection ecosystem.

The smart inspection platform is inevitable

The industrial manufacturing landscape is changing. Processes are increasingly driven by the demands of large volume automated inspection that requires speed, precision, interconnectivity, and rapid deployment.

In response to this challenge, machine vision innovators are working toward a complete, integrated inspection platform built on smart features such as data fusion (mixing 3D and 2D), scalability (handling multiple sensors), extensibility (adding custom measurement or applocation), and acceleration (redirecting performance on a PC). This platform is accessed through easy-to-use web browser-based interfaces using mobile technology allowing connection to network-aware sensors throughout the smart factory floor from process engineers.

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