How to use Machine Vision for Manufacturing 4.0

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INTRODUCTION

As Manufacturing 4.0 puts greater emphasis on quality and efficiency across supply chains, manufacturers are under the gun to make more effective and timely use of their data.

Many plants have already risen to this challenge by adopting digital platforms for centralized data collection, management and analysis. They understand that it's not enough to just collect data. The goal must be to make the data usable, to empower people on the plant floor to take quick and appropriate action to maintain quality and yield, and to create an accessible archive with which quality engineers can experiment to drive continuous improvement.

Machine vision images and data are a valuable part of this equation – provided they are brought into the fold and correlated with all other relevant production data for each part coming off the line. This data is often trapped in silos across the plant floor, with images stored in formats that make them difficult to access and analyze.

In the effort to do more with data overall, vision, oddly enough, often gets left out of the picture.

In this e-book, we explore how and why machine vision images and data should be integrated with the rest of your process and test data. This is not about monitoring camera performance, but rather, managing the performance of the station that is using machine vision inspection, to drive the profitability and competiveness of your plant.

What you will get out of this e-book

What is data when it comes to vision?:

How to use your machine vision data for much more than pass/fail and have real impact on quality down the line.

PART 1 →

Find test limits faster for speedy setup and runoff:

How vision data can be used to create a repeatable and systematic process for launching and calibrating new vision stations, fast.

PART 2 →

Monitor station performance for quality and yield:

Gain practical and actionable insight with modern reporting tools and dashboards that are user-friendly and cost-effective.

PART 3 →

Trace defect source to root cause:

How correlating vision images and data with information gathered from other stations helps you pinpoint root cause faster than ever before.

PART 4 →

Working smarter, not harder:

How to use your part data to maximize its utility for real-time visibility and insight to address the needs of the hour on the production line.

PART 5 →

The right toolset:

What data management and analysis tools and capabilities do you need?

PART 6 →

The Sciemetric and CTS advantage:

How data management solutions from partners Sciemetric and CTS contribute to the Manufacturing 4.0-driven factory.

PART 7 →

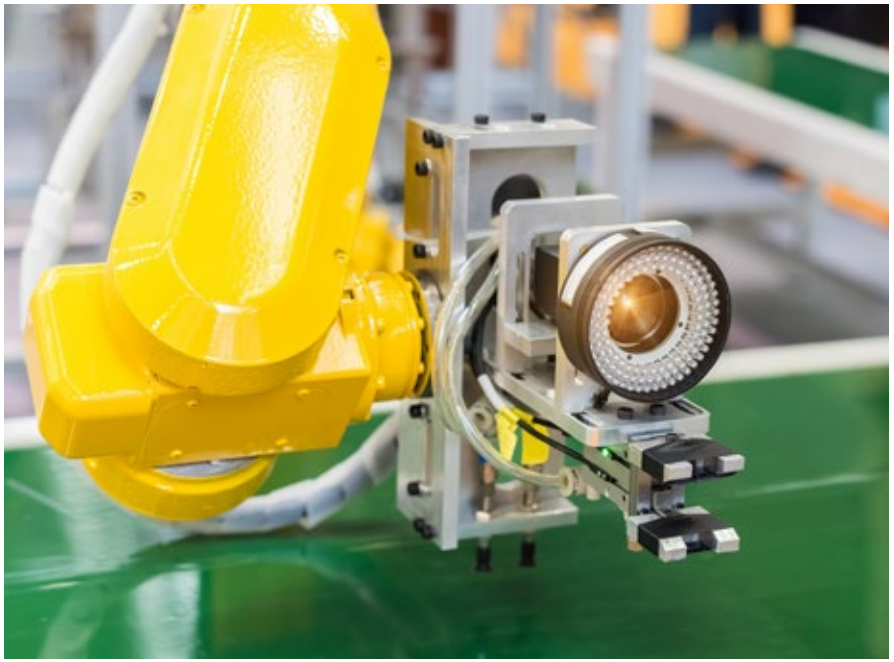
PART 1

What is data when it comes to vision?

Machine vision images are commonly used for basic pass/fail determination during the process cycle. Related data collection is often restricted to camera performance. Pass/fail results, after serving their immediate purpose, are often discarded. If they are kept, they reside on local PCs and servers – silos across the plant that lack digital connectivity.

This pass/fail data, as well as additional process data that can collected and correlated with those machine vision images, can be used to do so much more. They can be used to spot anomalies early before they lead to failures or quickly trace root cause when quality problems crop up downstream.

Machine vision images and data must therefore be considered part of a collective whole, along with the scalars and digital process signatures generated by each cycle of a process or test on the line, and the datasets generated by other plant systems – manufacturing resource planning, enterprise resource planning, overall equipment effectiveness, manufacturing execution, statistical process control systems and operational historians.



Raising the bar for Manufacturing 4.0

Anything that happened upstream can have a bearing on a problem that arises downstream. The more data you collect, the greater insight you have into what has happened to a part at every stage of production, from raw materials to final product.

This ensures that, when quality issues arise, tracing root cause won't be a nightmare.

Implementing such a system won't be either. Today's data management and analytics platforms can deploy quickly and generate a rapid return on investment. They have the flexibility to ingest data from disparate sources (including systems from competing vendors).

This eliminates silos and standardizes reporting models with off-the-shelf tools. Machine vision data can be organized in a schema that mimics your production line. You no longer must walk from station to station with a pocketful of flash drives to retrieve the data you need.

All this allows your plant to elevate the return on its existing technology investments and achieve the kind of quality and performance metrics that define Manufacturing 4.0.

Winning the War on Bubbles

Machine vision is commonly used for monitoring dispense operations, to measure bead width, location, etc. With today's data management and analytics tools, machine vision images and data from dispense operations can be consolidated with all the rest of your production data.

This allows you to:

- Integrate scalar data and images, including image overlay information, from multiple cameras, traceable to a part serial number
- Capture images and data for systems with limited or no storage capability at the camera level
- Consolidate data from vision systems from different vendors
- Retrieve, review and analyze image and scalar data, fast
- Scale from a single station to all inspection systems on the plant floor
- Gain the insight to spot quality issues that can escape visual detection alone, such as trapped air and microbubbles

PART 2

Find test limits faster for speedy setup and runoff

Machine vision is complex. The old mainstay of follow your gut and tweak it till you get it right wastes time and often leaves you without the data trail you need to make consistent and effective improvements elsewhere. But by using your data, setting up an inspection application to monitor quality on the production line can be much faster, more accurate and repeatable.

Use data to set objective limits … fast

If limits are changed at the vision station, these are tracked in feature trend reports. Limits can be reviewed by model/serial number. Specific limit changes can be time-stamped for a clear picture of their impact on production and which parts were built to the new limits.

Once the ideal limit settings are established, they can then be applied to like or parallel stations elsewhere in the plant or at another plant altogether.

This allows you to quickly launch and dial-in new vision stations. Bottlenecks can be identified immediately, and their root causes diagnosed and eliminated systematically. New control limits can be verified and easily adjusted. Indicators from the new line can be matched against existing ones to give a strong indication of conformance.

Analyze the impact of new settings

Determining accurate limits for a visual inspection system can require many steps: setting up initial limits, running known good and bad parts, analyzing the results, tweaking the limits, running more parts, tweaking the limits further, running more parts again and on and on. It's a tedious process that takes time and takes over your production line while being executed.

With vision part of your data repository, you can fine-tune your processes in a virtual testbed. Simply use your historic vision data and other process data to play "what if?" by running simulations to quickly evaluate the impact of new limit settings.

See the pass/fail results instantaneously so you can quickly narrow in on the boundary between good and bad parts and precisely determine new limits to effectively catch defects. Do all this from your desk in minutes instead of disrupting production equipment for hours.

Use this same what-if analysis to mine for suspected defects if you find that your existing limits did let bad parts slip through. In this way, you can contain contaminated work-in-progress before it ships and selectively recall faulty products by serial number. Respond faster to a quality issue and accurately triage the problem to limit the scope of a recall.

PART 3

Monitor station performance for quality and yield

With machine vision images and their related datasets integrated with all other relevant production data into a consolidated birth history record for each part, you can easily correlate the data trail between hundreds, thousands and tens of thousands of parts. The same analysis can be done for the production or test cycles of a specific station. This gives you big data insight that's useful in many ways.

Gain manufacturing insight by monitoring station performance

Quickly highlight stations that are falling behind in part count or in first time yield. Today's reporting tools and dashboards can review, compare and correlate hundreds, even thousands, of records at a time by visualizing histograms and time-based trends for select feature sets, upper and lower specification limits, and upper and lower control limits. View statistics for groups of parts to distinguish passes from fails and to spot the anomalies or trends that warrant deeper investigation.

This can be particularly useful for parallel station comparisons, and to launch, calibrate and set limits for machine vision stations faster. Innovations in one plant can be reliably applied to other plants, providing a repeated increase in yield.

We worked with one customer that could launch new lines around the world an average of four times faster, for estimated average savings of US$4 million per plant, using its data in this way.

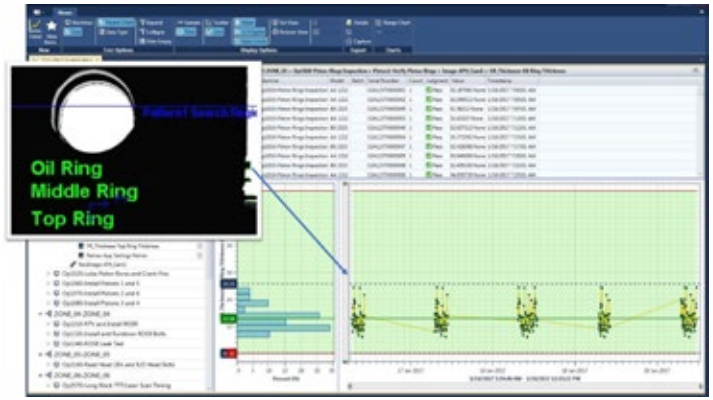


Figure 1. Trend of data generated from camera images showing statistical histogram, statistical limits and upper and lower specification limits.

Use your data for continuous improvement

With this level of insight, you won't suffer the consequences of the same problem occurring twice. Once the root cause of a production or quality issue has been identified, the comparable process, test or machine on other lines or at other plants can be adjusted before they can suffer the same problem.

This is particularly valuable for large manufacturers that may be launching lines with 50, 100 or even 500 machines strung together, where one weak link will hold up the entire line. In addition, you can track time-of-day or product variances by model.

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PART 4

Trace defect source to root cause

When quality issues do arise, you may find yourself faced with customers who want answers, production lines that are sitting idle, and the prospect of a costly recall. You need all the relevant data at your fingertips to quickly trace root cause and address the problem, and that includes vision.

How?

Take a part surface on a which a material is being dispensed. The surface of the part under visual inspection can be broken into regions, each with a corresponding feature node. This makes it possible to collect and index for easy analysis different types of data from each region of the part, such as scalar values derived from the images and digital process signatures. This segmented data can then be used to create different reporting visuals, such as histograms of the machine vision-generated measurements for each part and time-based trends of when measurements were taken.

Analyze image-based profiles

This image-based profile (a.k.a. digital process signature) data can then be used to adjust and fine-tune processes such as dispense systems or robots, and to track failures. Bead location and width, for example, can be tracked with a regional waveform. Histograms can track the time-based minimums, maximums and averages for each region of the part.

With all this data centralized, it can be accessed from anywhere in the organization.

Say a quality engineer is having a problem with a robotic dispensing station on their line in Shenzen. A colleague in Detroit can cross-reference the data from comparable stations that are running at spec. In this way, they can determine what tweaks need to be made to the control limits of that dispensing station in China to address the issue.

Look beyond the vision station

A typical production line contains various assembly steps, intermixed with testing stops where the assembly process is verified. This includes functional testers, vision systems for error proofing and so forth. The ability to look at the data generated by all the assembly steps and all test systems, including vision, in a single place provides the operator with a complete "picture" of exactly what happened in the assembly process, as opposed to looking only at numeric information, which may not give the full picture.

This makes it much quicker and easier to trace root cause of a failed part.

Take, for example, the failure of a seal in a joint. If all that part's related data is collected into a single birth history record, you can take a comprehensive look at the joint's leak test results, fastening data, dispense data, real-time video image and real-time video bead data to quickly identify and address the issue, as well as determine if any other parts are risk of the same failure.

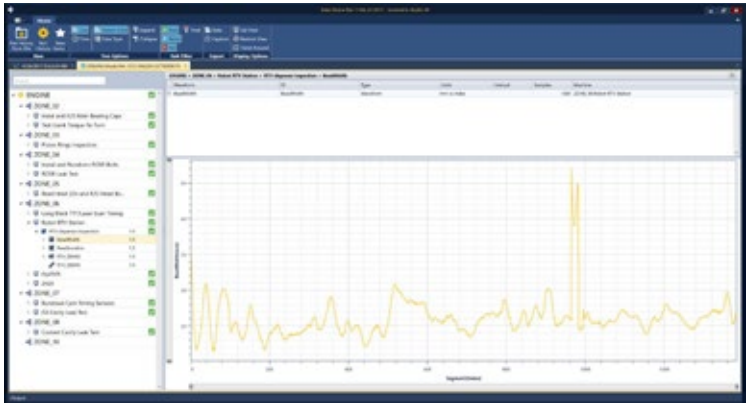

Figure 2. View statistical data on your image-derived scalar data. Analyze the image-based profile (or waveform) data to chart trends and adjust processes, such as dispense systems or robotic stations. In this image, the consistency and accuracy of bead location and width during dispensing operations is being analyzed and trended.

Find issues before they become problems

We discussed playing "what if?" in Part 2. Use this same approach to mine for suspected defects. In this way, you can contain contaminated work-in-progress before it ships and selectively recall faulty products by serial number. Respond faster to a quality issue and accurately triage the problem to limit the scope of a recall, both in terms of cost and PR impact.

But this of course requires that you have collected all the production data related to the part, from every process and test station on the line that touched it, into that single birth history record.

Visualize the problem and fix it

For example, an automaker used machine vision to inspect transmission assembly. Recently, a quality issue cropped up with a component that had been installed with the wrong alignment. This particular step in the assembly process wasn't even being directly monitored with the machine vision system, but in the process of documenting another production step, the image also captured this component after its installation. Once transmission assembly was complete, this component, and any error with its installation, was no longer visible.

When the quality issue was caught downstream and the faulty transmissions torn down to find the fault, quality engineers were able to call on that vision data. They had a visual history they could use, a repository of vision images they could analyze and correlate by serial number with other production data, to quickly identify which transmissions bore the fault and find them before they ended up in a vehicle. Faulty units were identified and quarantined with surgical precision, to avoid a costly recall that would have otherwise affected thousands of perfectly good units.

This is the power that comes of having machine vision seamlessly integrated with all the rest of a line's production data.

Figure 3. In this image, we present a trend graph of the width of a temperature vulcanizing (RTV) bead that shows a sudden variance in bead width outside of spec.

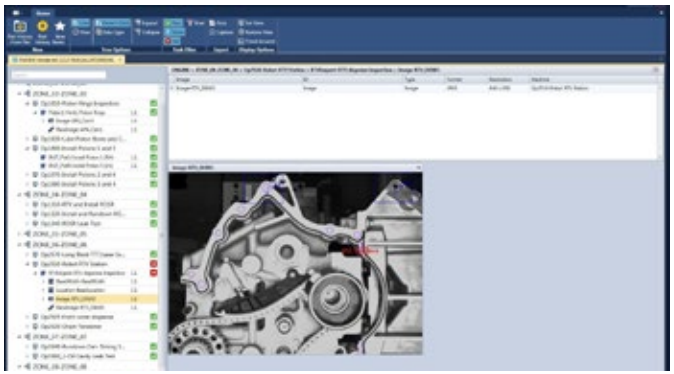

Figure 4. Collect and organize all relevant image data. The surface of the part of the image data under visual inspection is broken into regions, each with a corresponding feature node. This makes it possible to collect and index for easy analysis different types of data from each region of the part, such as scalar values derived from the images and the digital process signatures. This data can then be used to create different reporting visuals, such as histograms of the machine vision-generated measurements for each part and time-based trends of when measurements were taken.

PART 5

Working smarter, not harder

Sometimes, the greatest value of consolidating and visualizing all this data isn't the impact it has within your plant. It's the stamp of quality you can demonstrate to your external stakeholders and how fast you can respond to a problem.

Image and image data that reside in a central database and can be recalled by a part's serial number makes it easy to provide evidence that the part was built to specification and that manufacturing and test processes were under control. Images of the product as shipped can also be used to verify the status of what left the plant.

Maybe you're a supplier to a major OEM that demands some assurance you are not the weak link in its supply chain. If a quality issue does arise, you need the means to trace the birth history of a part, quickly, to find the root cause and take corrective action to ensure it never happens again.

Speed matters

The longer it takes to trace and address root cause, the more it will cost you, in terms of lost production, flawed production, warranty claims and a tarnished reputation in the marketplace. You don't have time to waste wandering the plant floor with a pocket full of flash drives in search of vision data.

How well you respond to a quality issue is defined by how fast you can respond. Not only will having all the relevant production data collected and correlated in one place allow you to take the right action quickly, it will ease the burden on your team.

Data that is accessible prevents traceability from becoming a full-time job. More focus can be put on proactive efforts that drive continuous improvement and catch problems before they negatively impact production.

PART 6

The right toolset:

Don't leave vision out of your Manufacturing 4.0 data strategy

Manufacturing 4.0 isn't just theory, it has become practice. Many plants are already using centralized data collection, management and analysis tools for other datasets generated by processes and test stations on the line.

Bringing machine vision images and data into this fold is the next logical step. The data stuck over there in that silo can help you make tangible improvements in quality and yield. For plants that are looking at a system for centralized data collection, management and analysis for the first time, it only makes sense to get it right from the start and ensure machine vision isn't a forgotten part of the equation.

The good news is that the cost and complexity of this kind of investment continues to fall. Manufacturers have at their disposal affordable tools that allow them to harness the true power of all their data, and that includes vision. Doing so will give you even greater insight into production processes and tests, to achieve higher standards of quality and efficiency and troubleshoot problems faster when warranty claims come through the door.

This is fundamental to creating a modern plant capable of competing on an even footing in a Manufacturing 4.0 marketplace.

PART 7

The Sciemetric and CTS advantage:

What do Sciemetric and CTS bring to the table when it comes to data management?

In November 2017, Sciemetric and CTS became partners in the Product Integrity Division of the TASI Group of Companies to provide the global manufacturing automation marketplace with the broadest portfolio of leak testers in the industry and the right Industry 4.0 tools to make immediate, practical use of the data these test produce.

Sciemetric pioneered process signature analysis in the 1990s with a major North American automaker to find a better alternative to the end-of-line hot test for engines. Today, waveforms can be captured from every process and testing station up and down a manufacturing line using our technology for data management, analysis and visualization. Together with CTS, we are bringing that technology to both companies' customers, to show them how process signature analysis can be applied to tackle the complexities not only of leak testing, but of any in-process test on the production line, using our QualityWorX suite of data management and manufacturing analytics software.

QualityWorX Vision was brought to the market in May 2017 specifically to help manufacturers organize, store, access and analyze terabytes of images and image data from machine vision systems so they can use this data for more than just basic traceability.

As more and more manufacturers learn about the potential of Manufacturing 4.0 technologies to reveal greater insight into their production challenges, CTS and Sciemetric are the right partners to help them with data-driven solutions for the connected factory.

Contact us to learn more about the Sciemetric and CTS advantage.

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