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What Is AI Vision Inspection?

Quality Control from Production to Shipment



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ABSTRACT

From production to shipment: turning visible defects into controlled decisions.

Being able to make a product does not mean it is ready to ship to the customer. A missing assembly component, a scratch on the surface, the wrong label or a different product mixed into the packaging can turn into a serious quality problem at the customer's site, even while production counts look correct.

AI-based image processing is a technology that examines camera images with artificial intelligence and image analysis methods to evaluate whether a product meets its defined visual acceptance criteria. Its value does not come from simply marking defects on a screen. The real benefit comes from catching the defect in time, separating the suspect product, recording the decision and preventing a nonconforming product from moving on to the next operation or to the customer.

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Introduction

Manufacturers should consider this technology both during production and after it. Where to place an inspection should be decided based on where the defect originates, the risk of escape, the cost of downstream operations and customer expectations. Rather than putting a camera at every station, the goal is to put the right inspection at the right operation.

1. What is the difference between image processing, machine vision and AI?

Image processing covers operations such as filtering an image, finding edges, taking measurements and extracting features. Machine vision combines these methods with cameras, lenses, lighting, triggering and automation to perform an industrial task. AI supports this setup with models that learn from examples, especially for products whose appearance varies.

Table 1

Approach	Suitable tasks	What to watch for
Rule-based image processing	Presence of a hole in a fixed position, a distinct edge, barcode reading	Changes in position and lighting can affect the rules
Supervised AI model	Recognizing labeled defects such as scratches, flash and missing assembly	Requires correctly labeled, highly representative data
Anomaly detection	Finding deviations from the accepted product appearance	May also flag acceptable natural variation as anomalies
Combined solution	AI for surface inspection, rules for code and dimension verification	All checks must be tied to a single product identity

Not every inspection needs AI. For a fixed, easily defined feature, a classical method may be simpler. AI is especially useful for products with variable texture and appearance; however, it does not remove the need for good images, correct acceptance criteria and validation. ¹²

2. How does the system work?

The basic flow of an industrial vision inspection is as follows:

- 1. The product and recipe are identified.** The work order, product variant, mold cavity or serial number is determined.
- 2. The image is captured.** A sensor or machine signal triggers the camera at the right moment. The required surfaces are imaged under suitable lighting.

3. **Image validity is checked.** Is the product missing, is the image blurry, is the camera's view blocked? An invalid image is not automatically treated as a pass.
4. **The checks are applied.** Models and rules evaluate features such as defects, assembly, codes, color or position.
5. **A decision is made.** Conforming, nonconforming and undecided products are routed onto separate paths.
6. **The physical action is verified.** A sensor or another suitable check confirms that the part ordered to be rejected actually moved into the quarantine area.
7. **Records and release are managed.** The inspection result, the product identity and, where needed, the image are linked to the MES/quality system. Rules for moving to the next operation are enforced.

Detecting a defect and keeping the defective product under control are two separate conditions for success. Even a very good model cannot compensate for a mechanism that diverts the wrong part or lets a rejected part slip back into the accepted flow.

This control logic manages product quality. Machine safety, emergency stops and personnel protection must be provided separately through proper safety design.

3. Where is it used, and what can be inspected?

Table 2

Area	Example visual checks	Limitation or complementary check
Plastic injection molding	Short shots, visible flash, burn marks, foreign material, insert presence	Internal voids and mechanical strength may require additional testing
Metal and machining	Visible surface scratches, tool marks, hole presence, orientation and contour	Internal cracks require suitable non-destructive testing
Rubber and seals	Contour, cuts, deformation, surface defects, missing areas	Visual conformance is not a guarantee of sealing
Assembly	Presence of clips, screws and seals; part orientation; wrong variant	A visible screw does not prove correct tightening torque
Electronics	Component presence, orientation, markings and assembly appearance	Hidden connections and functionality require other tests
Packaging	Product count, lid presence, label position, visible packaging damage	The contents of a closed box cannot always be verified by an external camera
Labeling and marking	Code reading, text verification, matching product to label	The code that is read must be compared against the work order and customer rules
Dimensional inspection	Edges, diameters, distances and profiles with a suitable optical setup	Calibration, fixtures and measurement uncertainty must be evaluated

This table is not a guarantee of feasibility. The same defect may be visible on a matte surface but hidden on a glossy or patterned one. A single camera cannot see the back of the product or enclosed internal surfaces. The inspection list should therefore be finalized through an optical and mechanical evaluation with real parts. ¹³

OCR, code reading and verification are not the same thing

OCR tries to read the text in an image. A barcode reader decodes the content of a code. What the business usually needs, however, is to **verify that the information read matches the right product, order, lot and customer**. A label printed flawlessly on the wrong product cannot be caught with a readability check alone. The rule, the data source and the product identity must be designed together.

4. Think about lighting and part presentation before the camera

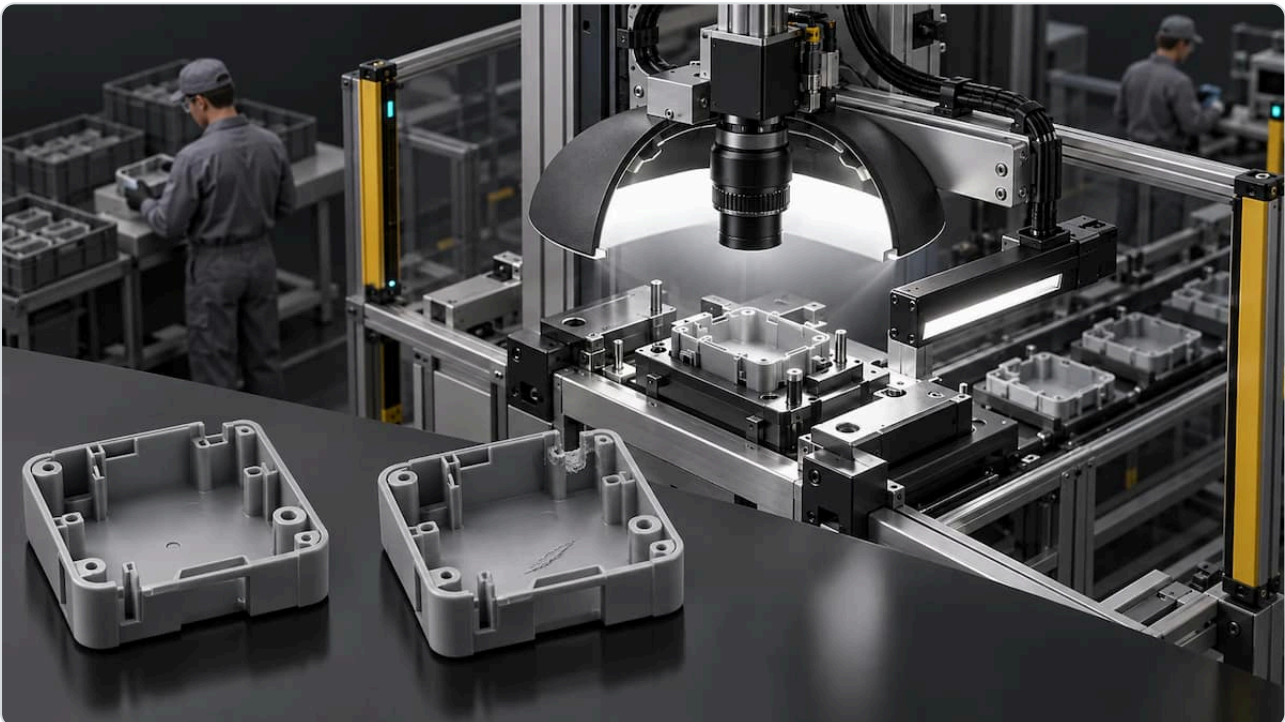


Figure 1. Whether the same defect is visible depends on the illumination, viewing angle, lens and positioning of the part.

The first question in a vision inspection project should not be "How many megapixels should our camera have?" First, determine which defect needs to be made visible, on which surface and under which conditions.

Backlighting sharpens the contour; it does not have the same effect for examining surface texture. Dark-field illumination can highlight scratches and edges. Diffuse lighting can help reduce harsh reflections on glossy surfaces. The choice should be tested on the actual material. ³

For moving products, exposure time, motion blur and trigger timing matter. Higher camera resolution alone does not mean reliable detection of smaller defects. Field of view, lens, contrast and optical resolution are evaluated together.

The fixture is also part of the system. If the part sits at a different angle each time, the camera may learn position variation instead of defects. A dirty lens, aging lights or an operator placing parts differently can also change performance. Maintenance and reference-part checks should be included in the operating plan.

5. Why is in-process inspection valuable?

Inspecting close to the operation where the defect occurs can reduce unnecessary cost in downstream operations. A simple example is separating a short-shot part early, instead of letting it travel from injection molding all the way through painting, assembly and packaging.

In-process inspection should not be used only for sorting. When defect records are linked to the machine, mold cavity, product, shift and process conditions, they can guide improvement. A shortfall that keeps occurring in a specific mold cavity is more useful information than a single rate for the entire shift.

However, two data points that change together do not automatically establish cause and effect. Seeing a rise in defects at the same time as a temperature change does not justify an automatic process adjustment without verification. The first step is a reliable alert and review record that the operator and process engineer can use.

6. What is a quality wall, and how is AI used there?

In this guide, a quality wall means an additional inspection and segregation point set up to keep non-conforming product from passing to the next process or to the customer. It may be set up temporarily after a customer complaint, or it may become a permanent control for specific risks. If the customer's specific requirements contain different definitions and approval rules, those take precedence.



Figure 2. At a quality wall, conforming, nonconforming and undecided outcomes must be managed physically. The colors only support the illustration; they do not replace identity and authorization controls on the shop floor.

AI can standardize repetitive visual checks, flag suspicious areas and create inspection records. People can then focus on borderline decisions, new defects, management of acceptance criteria and root cause work.

In a well-designed quality wall, the answers to these questions are clear:

- Which defects are being looked for, and which samples are accepted?
- Which products and which production time window are within the scope of the inspection?
- How is an uninspected part prevented from mixing with accepted product?
- Where is rejected product physically held?
- Who resolves an undecided result, and against which reference?
- Which inspections does reworked product go through again?
- What evidence and approval are required to remove the quality wall?

A quality wall should not become a final stop that accepts defective production as an ongoing condition. Sorting data should be turned into actions that reduce the source of the defect.

7. How should a final inspection work center be set up?

Final inspection is the work center where a product's readiness for shipment is evaluated after the defined production and assembly operations. Here, image processing can address visible surface defects, assembly status, variant and label matching together.



Figure 3. Multiple images increase coverage of visible surfaces. Cameras do not, on their own, take over function, torque or leak tests.

When a product is scanned, the work center should select the correct inspection recipe and should not release the product until all required images and test results are complete. If the bottom surface or an internal pocket is critical, a suitable fixture, product rotation, an additional camera or a different inspection method may be needed.

The inspection cycle time is not just the model's computation time. Loading, positioning, preparing the lighting, image capture, computation, communication, diverting and unloading are evaluated together. In addition to the average cycle, the upper limit of delays and peak production conditions should also be tested.

Risk continues after final inspection as well. A product can be scratched during packing, placed in the wrong box or skip inspection after rework. That is why the final inspection approval must be linked to the packing and shipment identity.

8. How much can we bring under control?

Two concepts need to be separated: **inspection coverage** and **detection performance**.

Inspection coverage describes which products, surfaces, defect types and production conditions are inspected. Detection performance shows what share of nonconformities within that coverage are caught and how often conforming products are falsely rejected.

"We inspect every part" does not mean "we catch every defect." Likewise, a high score from an AI model cannot be read directly as the probability that the product is defect-free. Thresholds are decision rules validated in the field.

At the start of the project, an inspection definition should be prepared for each defect:

Table 3

Definition	Example content
Defect and acceptance limit	Scratch on a specific surface; accept/reject references
Inspected area	Outer surface of the top cover; bottom surface out of scope
Visibility condition	Defined lighting, position and surface cleanliness
Product variants	Color, material, variant and mold cavities
Production conditions	Line speed, vibration, temperature and ambient light range
Error targets	Acceptable escape and false reject limits by defect type
Undecided-result policy	Re-imaging, manual review or hold
Next action	Diverting, line hold, review and authorized release

Feasibility limits should be stated clearly for small defects, low contrast or surfaces outside the field of view. A success percentage based on a few samples that do not represent the production environment is not sufficient for a purchasing decision. ⁴⁵

9. Do not measure success by accuracy alone

The numbers below are purely illustrative; they are not a performance claim for any product or installed system. Consider 10,000 parts whose true status has been determined by independent evaluation:

Table 4

True status	System said nonconforming	System said conforming	Total
Nonconforming product	95	5	100
Conforming product	99	9,801	9,900
Total	194	9,806	10,000

In this example, overall accuracy is **98.96%**: $(95 + 9,801) / 10,000$. But the critical information from the customer's perspective is that **5 nonconforming products were accepted as conforming**.

- Rate of catching nonconforming product: $95 / 100 = 95\%$.
- Miss rate among truly nonconforming products: $5 / 100 = 5\%$.
- False reject rate among truly conforming products: $99 / 9,900 = 1\%$.
- Share of rejected parts that are truly nonconforming: $95 / 194 \approx 48.97\%$.
- Escaped nonconformities relative to total parts inspected: $5 / 10,000 \times 1,000,000 = 500 \text{ ppm}$.

This ppm belongs to the inspection point in the example; it cannot be called a customer ppm value without knowing the downstream inspections and quarantine. The 99 conforming parts that were falsely rejected should not automatically be counted as scrap either; they can be sent into a defined re-review process.

Performance should be examined not only in total but also **by defect class and product variant**. A system that catches large missing features well may be missing small scratches. The share of products actually imaged, missed triggers, undecided results and physical diverting success should also be tracked.

10. How are labor savings created?



Figure 4. As repetitive visual checks are automated, human effort can be redirected toward evaluating suspect decisions and improving the process.

In manual inspection, the person picks up the part, turns it, examines specific surfaces, makes a decision and records it. When automation takes over part of this work, the same quality workload can be covered with fewer direct inspection hours. But loading, packing, re-review, maintenance and shift coverage continue.

Let's work through an example workload calculation. In a hypothetical plant, four people in each of two shifts work eight hours a day on this inspection task. The baseline workload is $4 \times 2 \times 8 = \mathbf{64 \text{ person-hours/day}}$.

In the new setup, two people per shift across two shifts handle direct loading and inspection supervision: **32 person-hours/day**. Add eight hours of suspect-part review and four hours of cleaning, changeover and maintenance workload per day. The total is **44 person-hours/day**.

Table 5

Item		Before	After
Direct inspection / supervision and handling		64	32
Additional review	Included in baseline workload		8
Cleaning, changeover and maintenance allowance for the new setup	Included in baseline workload		4
Total person-hours/day		64	44

Under these assumptions, the workload falls by **20 person-hours/day**, or **31.25%**. On an eight-hour day, this equals 2.5 people's worth of daily labor. It does not mean 2.5 people will be removed from headcount. Work distribution, break coverage, shifts, occupational safety and the remaining tasks determine actual staffing needs.

The gain may come in the form of reduced overtime, handling growing production without adding inspection staff, or freeing the team for root cause work. If the payroll budget does not change, a capacity gain should not be presented as a cash saving.

11. How is quality protected until the product reaches the customer?

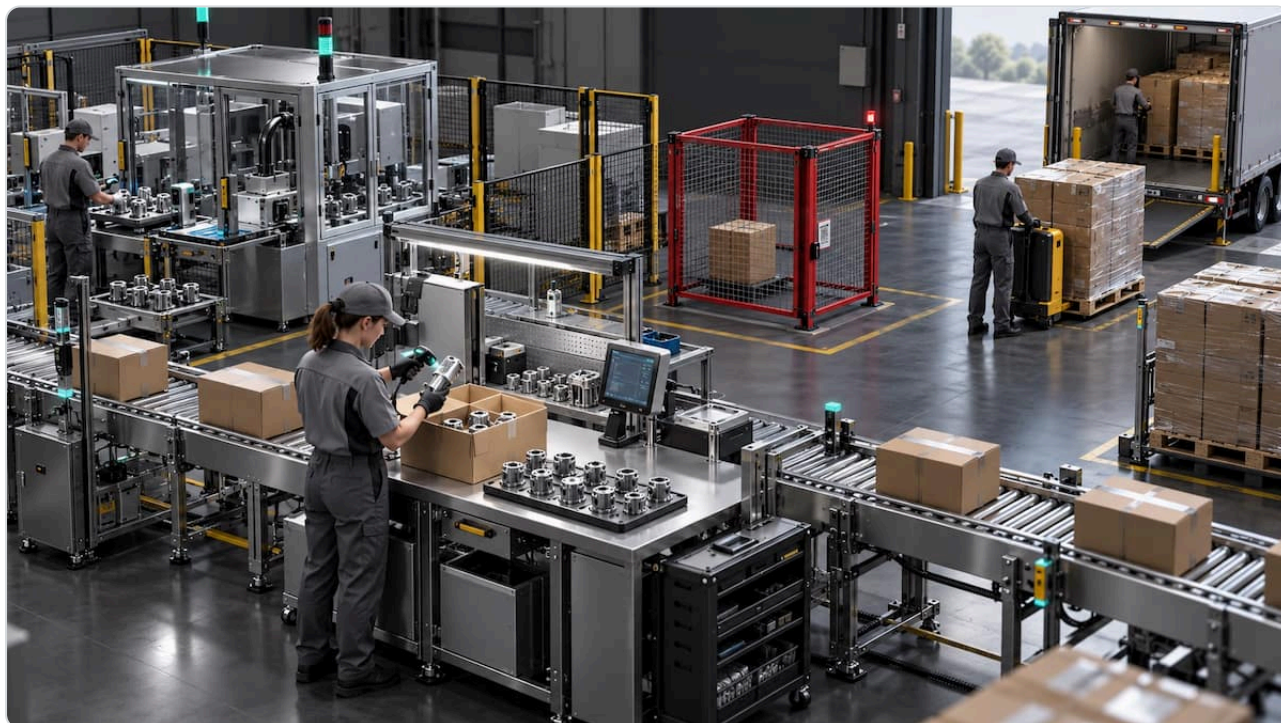


Figure 5. When product approval is matched to the box and shipment record, the inspection result becomes part of traceability that extends to the customer.

Confidence in a shipment depends on matching the inspection result to the physical product that is shipped. That is why a part that passed final inspection must be prevented from mixing with another product, and uninspected reworked product must be prevented from returning to the same box.

The recommended record structure links the product identity, work order, lot, station, time, inspection recipe, model version, decision and release history. The retention period and scope for images are determined by defect risk, customer requirements, data volume and access needs. Keeping every image indefinitely is not an automatic requirement.

When a box is closed, the part-to-box relationship, quantity and variant match can be verified. If serial numbers are not used, lot- and carrier-based tracking can be set up; however, it must be clearly understood that the resulting traceability is not at the part level.

Product in quarantine should be released only by an authorized decision; after rework, the previous approval should be invalidated and the required inspections repeated. If an image or result record is missing, whether that counts as a pass must be defined. For critical inspections, holding a product with no result and routing it to authorized review is a fundamental design option.

A camera cannot prevent every damage that may occur during transport after approval. Packaging adequacy, transport conditions and customer acceptance processes are managed separately. On the other hand, accurate records help narrow down the affected product group and speed up the investigation when a complaint comes in.

12. Why do training data and model management matter?

Good data does not simply mean lots of photos. Natural color variation, different mold cavities, products at the acceptance limit and real defects must be labeled correctly. If the quality team cannot agree on the acceptance limit, it is also hard to expect consistent decisions from the model.

Training, tuning/validation and independent test data should be kept separate. If images of the same part taken from different angles end up in both the training and test sets, the system can appear better than it really is. The split should be made by physical part and, where needed, by lot, date or production condition.

Anomaly models trained only on conforming products can be useful; however, they do not guarantee that every previously unseen defect will be caught. The risk of falsely rejecting acceptable variation should also be measured. ²

Every model update should be recorded and evaluated on a fixed comparison set and on data representing new conditions. Rather than letting the model learn on its own in the field and silently change the acceptance criteria, version changes should preferably go through authorized review and approval. There should be a plan for rolling back to the previous approved version.

13. What benefits should the investment be evaluated against?

An image processing investment makes sense when labor hours, customer escapes, rework, scrap, inspection capacity and traceability are evaluated together. Care should be taken not to count the same benefit twice under two different headings.

Table 6

Potential benefit	How is it verified?
Less repetitive inspection labor	Actual person-hours and remaining tasks before/after the pilot
Earlier defect detection	Nonconforming product escaping to the next operation and additional processing avoided
More consistent decisions	Comparison against an independent reference by shift, product and defect
Fewer false rejects	Re-review workload and unnecessary segregation of conforming product
Increased inspection capacity	Cycle time including loading, and availability, at actual line speed
Faster investigations	Access to lot/serial records and complaint investigation time
Process improvement	Verified reduction in recurring defects

The total cost calculation should cover, in addition to cameras, lenses and lighting, the fixture, mechanical diverting, sensors, PLC, safety arrangements, computers, licenses, data preparation, integration, training and commissioning. Maintenance, spare parts, revalidation, storage and product changes during the operating period should also be budgeted.

If the annual net realizable benefit is positive, the simple payback period can be calculated by dividing the initial investment by this benefit. The financial evaluation should use the company's own costs and financing conditions. There is no single payback period that applies to every business.

14. How do you start a project, and who should be on the team?

To start, choose a station where the cost of defects or the inspection workload is significant and the product family can be clearly defined. Rather than covering the entire factory at once, solving a single real problem with measurable acceptance criteria provides a more manageable start.

The team should include people responsible for quality, production/process, automation, maintenance and IT/MES. The quality team owns the acceptance decision; production defines the actual flow of the line; automation builds the physical action and timing; maintenance ensures sustainability; and the IT/MES team manages the identity, data and access structure. End-user operators should also take part in the trials.

An example pilot plan includes the phases of scope and defect catalog, optical trials, data preparation, offline evaluation, shadow mode on the shop floor and controlled rollout. For a limited-scope pilot, **6–10 weeks** can be used purely as a planning assumption; available defect data, mechanical fabrication

and customer approval can change the duration significantly. This is not a delivery commitment.

What should the pre-purchase acceptance specification include?

- Product families, surfaces, defect classes and acceptance limits.
- Test parts labeled against an independent reference, and sample adequacy.
- Miss, false reject and undecided-result limits by defect.
- Verification of cycle time at actual speed, changeover and physical diverting.
- The state in which product will be held if a camera, light or network fails.
- Records of unauthorized bypasses, recipe changes and manual releases.
- Model versioning, backup, maintenance and revalidation conditions.
- Operator training, support scope and data usage rights.

Seeing no misses in a trial does not prove that the real-world probability of a miss is zero. The number of test samples and how well they represent actual production are as important as the result. Industrial AI should be evaluated within the system where it will be used and together with the related risks. ⁴

15. How does it work together with MES and OEE?

MES provides production context by linking the inspection result to the work order, product, machine and lot. The vision system, in turn, generates observations and decisions at a specific inspection point. When the two are combined, you can investigate not only "how many defects are there?" but also "under which conditions do they recur?"

Data definitions must also be consistent in relation to **OEE**. Not every product the camera routes to review should immediately be counted as scrap. First-pass result, re-review, rework and final conformance should be recorded separately. Otherwise, the quality rate may be calculated incorrectly or the same part may be counted more than once.

Linking defect photos to production data can make improvement opportunities visible by mold cavity, variant or operation. Its value lies less in the data piling up on a screen and more in turning it into actions that have an owner and closure criteria.

16. The OETECH approach: connecting the vision decision to the production flow

At OETECH, we draw on our experience in production data, automation and MES to treat vision inspection together with work orders, stations, product identity and quality records. The starting point is clarifying which defect the business wants to bring under control, and at which point.

In this approach, how the product is presented, which physical action the decision turns into, how rejected product is held and how approved product is linked to shipment matter as much as camera selection. No commitment to a success rate or labor savings should be made before technical feasibility and acceptance criteria are verified with real parts.

The goal is to build an inspection setup that the production team can trust, that can be maintained and whose results can be tracked.

Sources and reading notes

The practical recommendations on this page are general engineering guidance. The labor calculation and the performance table are hypothetical teaching examples; they are not customer results, product guarantees or market averages. The primary sources below were used for the core concepts; they do not constitute a recommendation to purchase any specific brand.

1. [Cognex — Deep Learning for Vision: image, labeling and training requirements](#)
2. [Cognex — Unsupervised Mode: training and evaluation](#)
3. [Basler — Illumination: industrial lighting methods](#)
4. [NIST — Industrial Artificial Intelligence Management and Metrology](#)
5. [Scientific Reports — Evaluation of different defect-inspection setups for injection molding parts based on deep learning](#)

Sources accessed: October 18, 2026.

Appendix A — Frequently asked questions

A.1 Can AI image processing find every defect?

No. Visibility, defect size, contrast, viewing angle and model scope set the limits. Features that cannot be inspected visually must be covered by other tests.

A.2 Does imaging every part mean one hundred percent quality?

No. One hundred percent part inspection is a statement about coverage. Defect detection performance, missed triggers and physical diverting are verified separately.

A.3 Will we no longer need any quality personnel?

The repetitive visual workload may decrease. Acceptance criteria, suspect decisions, product changes, audits and root cause work continue. Actual staffing needs are determined by reviewing all tasks together.

A.4 Are a quality wall and final inspection the same thing?

Not always. A quality wall can be an additional sorting point to contain a specific risk. Final inspection evaluates fitness for shipment at the end of the defined operations. Both functions can also be designed into the same station.

A.5 If we have in-process inspection, why might we still need final inspection?

New defects or mix-ups can occur in later assembly, handling and packing operations. The need for a final inspection is determined by the remaining risk and customer requirements.

A.6 If we have final inspection, do we need cameras in production too?

Early detection can reduce unnecessary processing of defective products and prevent the same defect from being produced for a long time. Which point makes economic and technical sense is evaluated separately.

A.7 Can we use our existing security cameras?

They can be used for some observation tasks; however, they may not provide the lens, triggering, lighting, resolution and speed needed for product defect inspection. Using an existing camera should be tested with real defect samples.

A.8 Can a single camera inspect all surfaces?

Surfaces outside the field of view or hidden behind one another cannot be seen. Product rotation, an additional camera or a different inspection technique may be needed.

A.9 Is a 3D camera always better?

No. It can be useful for depth and height measurement; for surface color or print inspection, a suitable 2D setup may be the more direct solution. The choice depends on the feature to be inspected.

A.10 Can we get started if we have only a few defect samples?

You can start with optical trials and data collection. Anomaly models may also be an option. However, few samples make it difficult to reliably prove defect detection performance; this limitation should be kept transparent.

A.11 Will the model recognize new products on its own?

It must be verified that a new variant is within scope. It should not be assumed that the existing model will reliably evaluate a new material, color or geometry.

A.12 Can the system run without an internet connection?

With a suitable architecture, image analysis can run on a local device. How records will be buffered and how shipment approval will be managed when the MES connection is lost are designed separately. Sending every product to an online service is not mandatory.

A.13 What happens to the product when the system is undecided?

Depending on a predefined rule, it is re-imaged, set aside for manual review or held. Uncertainty should never be silently converted into a pass.

A.14 Are falsely rejected products sent straight to scrap?

Not necessarily. They can be re-reviewed according to the quality procedure. The authority to re-accept or scrap, the records and the physical flow must be defined.

A.15 Can AI tell whether a screw is tightened correctly or a part is leak-tight?

Visual indicators can be checked; however, they do not replace a direct torque or leak measurement. The result from the relevant test equipment can be added to the product record.

A.16 How do we handle products that are scratched or packed incorrectly after the camera?

If needed, a packing inspection and identity matching are added. The flow after inspection, the carriers and the packaging method should also be part of the quality plan.

A.17 Can we promise that no defective product will ever reach the customer?

No such guarantee can be given based on a single AI station. A defined scope, validated performance, process control and shipping discipline work together to reduce the risk.

A.18 What should our first step be?

Pick one of the most costly or most frequently recurring inspection problems. Prepare accept/reject samples, line speed, product variants and the current workload. The first goal should be a feasibility and benefit assessment that can be measured under real conditions.



ABOUT THE AUTHOR

Ender Öztürk works on enterprise solutions at OETECH Solutions, focusing on bringing manufacturing execution systems, industrial data and AI applications to the shop floor.

ABOUT OETECH

Founded in 2013 and based in Bursa, OETECH Solutions develops software and hardware for production management, industrial data collection and automation. With IoE+ MES Cloud, HR+ Cloud PDKS and SoSo Inventory, it carries production data from the shop floor to decisions.

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