LANDING AI

Redefining Quality Control with **AI-powered Visual Inspection** for Manufacturing

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Introduction

The evolving industrial world

Emerging technology — from the introduction of assembly lines to the Internet of Things — has always defined manufacturing.

With the creation of computers and early automation came traditional machine vision, in which machines analyze photos of parts and components for defects based on a set of human-defined rules. While it reduces human error, traditional machine vision lacks the capacity to solve for pain points like complex defects and changing environments.

Today, more sophisticated artificial intelligence (AI), including machine learning (ML) and deep learning (DL), allows manufacturers to use AI-powered visual inspection to enhance quality and reduce costs. But even now, only **5% of manufacturing companies** have a clearly defined strategy for implementing AI.

Companies need strategies to overcome challenges in visual inspection, which still relies heavily on human inspectors or inflexible rules-based machine vision. The cost of sending defective pieces to customers — both in reputation and in recalls — isn't sustainable in a competitive global environment.

The right AI platforms offer tools that can enhance quality control and cut costs — after users tackle key obstacles.

From proof of concept (PoC) to production

Manufacturing companies can successfully create a proof of concept (PoC) of a visual inspection system in a few weeks or even a few days. But getting to a deployable solution ready for production and then scaling it threatens to bring manufacturers to a standstill.

Arriving at a PoC — which generally takes the form of offline tests run under highly controlled conditions — is a major milestone, but developers are still a long way from successful deployment. At this point, manufacturers only have less than 10% of the software needed for the first deployment, and the first deployment is a small fraction of the software needed to scale to multiple production lines. Teams need to carefully plan, prepare and execute each step of AI deployment.

Too often, companies fail to scale solutions beyond an initial project or two. This is particularly pervasive in manufacturing due to the complex and unique nature of each project. In conventional detection built on rigid rules, **you'll need to invest massive amounts of time and money to adapt thousands of lines of code to account for small details and variables.**

Manufacturers must overcome a uniquely complex set of obstacles to deploy and scale AI visual inspection systems, causing many projects to delay or fail.

5% of manufacturing companies have a clearly defined strategy for implementing AI.

Obstacle 1:

Small Data

In an industry focused on preventing defects, it's difficult to implement AI to capture actionable insights from a small dataset because defects happen a fraction of a percent of the time. Unlike consumer web companies like Google and Amazon that can apply data from billions of users to train powerful AI models, collecting massive training sets in manufacturing is often not feasible.

58% of research respondents report the most significant barrier to deployment of AI solutions was a lack of data resources. Manufacturers may have **100, 10 or even fewer images of a particular defect they want to detect.** For example, in automotive manufacturing, where Lean Six Sigma practices are nearly universal, most OEMs and tier-one suppliers strive for fewer than three to four defects per million parts. Tools designed to work for big data can't function with this small amount of data.

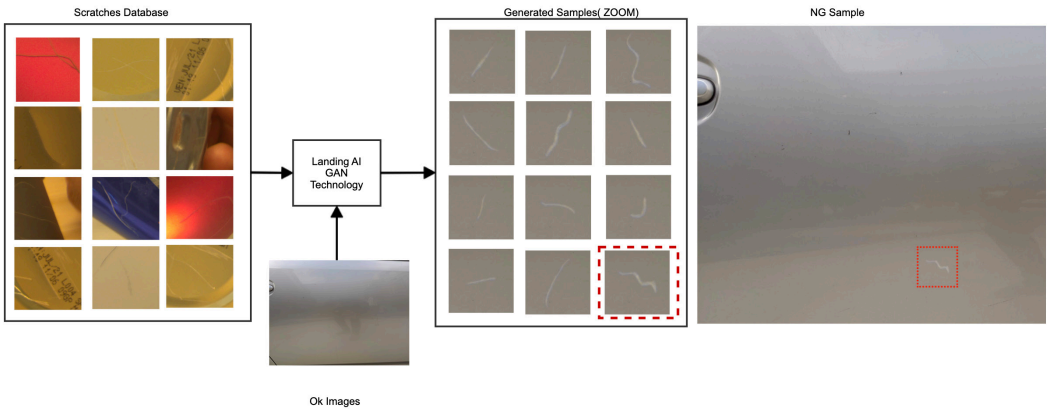
When there are only a few examples of a problem, AI models are difficult to train. This prevents companies from scaling or solving for natural variance in environments.

Solution

Manufacturers need a portfolio of techniques to overcome the small data challenge, including synthetic data generation, transfer learning and self-supervised learning. In synthetic data generation, a GAN Data Generation tool reviews images deemed "OK" by inspectors and synthesizes images of defects. A small dataset of images of a rare defect can therefore be amplified into a much larger dataset to train an AI model.

GAN data generation is a cutting-edge AI technology, but it's not a panacea for the small data problem. Instead, manufacturers need the ability to integrate a host of tools, ranging from transfer learning to self-supervised learning, to approach a specific problem. As the system accumulates more data/product knowledge over time, its algorithms become more accurate, reducing the error rate. **A Landing AI study showed that by using these tools, a scratch detection model can use 13x less data to achieve the same performance as a standard model.**

But simply supplying data to an algorithm won't eradicate errors unless manufacturers also have an unbiased method for defining ambiguous defects.



These images show Landing AI's synthetically generated surface scratch data. These scratches were transferred from a scratch database and then layered on a clean metal surface

Obstacle 2:

Ambiguous Defect Requirements

Identifying a defect can be subjective, and it's common for two inspectors to disagree on qualifications. One inspector may consider a scratch to be problematic, while another thinks the same scratch is small enough to be ignored. When even experts are in disagreement, how can we expect AI trained by humans to perform?

There's a high rate of error between inspectors: Many studies set error rates for manual inspections between 20% and 30%, meaning as few as 70% of defects are caught by human inspectors.

Unlike big data settings like the software industry, where users can average the responses of millions of inspectors, a manufacturing setting may take the average of a judgement call from two or three experts and it is ineffective. Often, manufacturers opt for using automation such as traditional machine vision to compensate for the shortcomings of human inspection, but this comes with its own tradeoffs. Given its low accuracy, traditional machine vision forces users to permit high overkill rates (the percent of products marked defective that are actually acceptable) to prevent escape (the number of bad parts that aren't caught).

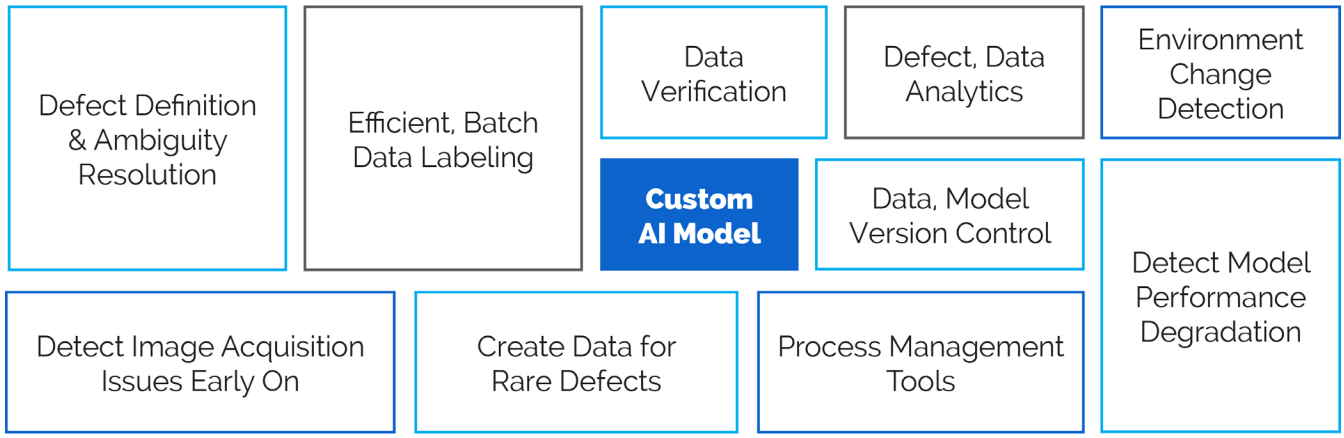
The **rate of overkill or false positives could be as high as 40%** for many manufacturers, which forces inspectors to physically inspect rejected parts on the manufacturing line.

Solution

Manufacturers need practical, objective tools that systematically help human inspectors identify clear defect definitions, manualize defects and decrease their ambiguity. Factories that continue to rely on human inspectors often defer to paper manuals or "defect books." In the modern era, an **AI platform should support a digital version of the defect book** that can be updated in real time to adapt to shorter product cycles and frequent changes.

Further, the digital defect book should automatically flag ambiguities and labeling inconsistencies. For example, inconsistent labels of discolorations may signal that the definition of discoloration is unclear and must be corrected.

By helping domain experts clarify and express what should be deemed "OK" to the AI system, inspectors can focus on delivering solutions while AI systems deliver significantly more accurate results.



In addition to a custom-build AI model, to deploy AI inspection systems, manufacturers need a long list of custom capabilities and tools.

Obstacle 3:

Changing Environments and Requirements

Manufacturing doesn't operate in a vacuum, but many traditional vision models address visual inspection as if it does. When changes in the external or internal environment occur, performance of AI systems degrades. Suppose an AI system is inspecting smartphones for scratches. The system must be able to respond to changes including: seasonal changes causing lighting levels in the factory to shift; scratches that were previously silver in color, but a new manufacturing process causes darker tinted scratches to appear; or a stained camera lens that causes the images to suddenly blur.

Manufacturers also regularly change requirements that alter product appearance, often after an inspection team has labeled data according to the original requirements. For example, a factory may previously have considered 1 mm scratches acceptable, but new requirements now only accept scratches under 0.8 mm.

Solution

Manufacturers need to ensure changes to products or environments do not harm inspection operations or quality. **To do so, an AI visual inspection platform needs to perform a few key tasks:**

In the past, hard coding a traditional machine vision system to cope with these types of unpredictable changes was either impossible or else required thousands of lines of code. Intelligent AI systems are more forgiving and flexible in changing environments, and a robust AI platform can simplify the process of overcoming these key challenges.

Key Tasks

1. **Keep track of slowly changing operating metrics,** so operators are alerted if performance changes.
2. **Collect data continuously,** and then systematically organize data to ensure accessibility for human auditing and AI retraining.
3. **Enable easy ("one-click") retraining,** so an operator can easily trigger the AI systems to relearn based on the newest data and make sure it performs according to new specifications.
4. **Validate new models before redeployment** to reduce the chance of failure during scaling.
5. **Detect any abrupt changes,** and alert the appropriate teams — for example, if a camera is suddenly knocked askew and a part of the product is no longer visible.

Obstacle 4:

Compounding Complexities

For visual inspection to reach its full potential, manufacturers need to be able to deploy their solutions across many factories and projects. Without scaling, manufacturers encounter prohibitive costs by maintaining small deployments unique to each task.

But scaling introduces the problem of compounding complexities — when trying to apply an already-complex AI project across many stations, assembly lines and factories, complexities build on each other. For example, a manufacturing company may decide to implement AI-powered visual inspection solutions across 100 factories to inspect hundreds of products, and each could have 100 potential defects. **This can easily result in thousands of unique AI software models, each of which is trained on 10-1000 images of a particular defect.**

No team has bandwidth to continuously update software models to align with new protocols and definitions, let alone continuously track changes at this magnitude.

Solution

A software platform helps companies scale up, allowing each piece of data and each software component to be systematically developed, deployed, tracked, maintained and monitored. Platforms eliminate the need for a plant operator to run between dozens of production lines to spot problems, enabling operators to aggregate statistics.

This benefits workers from the top of the chain down to those on the frontline. **It would enable the head of manufacturing for a large multinational firm to simply look at an overview of all the deployments around the world from their desk.**

It also allows appropriate teams to drill down into specifics at the factory, product, line or even defect level. For example, a quality engineer must be able to see if a particular defect is becoming a common pattern across plants, then take appropriate corrective actions.

Landing AI's platform enables customers to create, deploy, manage and scale industrial AI solutions. The platform is able to reduce the overall AI project development time by up to 67% and speed up the labeling process by as much as 50%.

67% faster project development with as much as 50% shorter labeling process.

Conclusion

Modernizing manufacturing means accelerating efficiency through the implementation of new tools without undermining the importance of human employees. Creating AI-powered models that accurately detect defects empowers workers by giving them more time to solve the root causes of defects. Here, workers add more value, while companies save costs and boost efficiency.

The benefits of investing in AI: Deep learning-based machine vision techniques in smart manufacturing will see a CAGR of 20% between 2017 and 2023, with a revenue that will reach $34 billion by 2023.

While an end-to-end AI platform that enables better quality control may sound like a dream come true, don't implement AI for the sake of keeping up with the masses. Speeding up digital transformation without completing the necessary research and preparation often results in failed projects.

AI isn't right for every instance; conventional machine vision is still the best option in cases like gauging and precision, while AI excels at cosmetic inspections, part location and assembly verification. **A custom end-to-end platform is the best solution for implementing AI-powered visual inspection projects.** It solves for all issues presented, enables acceleration and scale, and provides a continuous learning infrastructure. Manufacturers need tools like a digital defect book, data labeling tool and data generation software that can work in harmony.

When manufacturers answer critical questions and correctly adopt the right tools , AI makes workers and factories more effective and powerful.

20% predicted CAGR in deep learning-based machine vision techniques in smart manufacturing between 2017 and 2023

LANDING AI

Landing AI is an industrial AI company that provides enterprise transformation programs and solutions with a focus on computer vision. By providing an end-to-end AI platform, Landing AI enables customers to create, deploy and scale AI-powered industrial computer vision applications such as defect detection faster and with higher accuracy. The mission of Landing AI is to empower companies to jumpstart AI adoption, propel teams toward success and create practical business value today. Founded by Dr. Andrew Ng, co-founder of Coursera, and founding lead of Google Brain, the team at Landing AI is uniquely positioned to help companies across the globe successfully move their AI projects from proof of concept to full-scale production.

Additional information is available at: **www.landing.ai**