OXIPITAL AI

How AI and 3D Imaging Have Transformed Pizza Manufacturing

WHITE PAPER

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Machine vision continues to expand and diversify as new end markets, from autonomous vehicles to automated assembly, discover its benefits. However, the technology will remain closely tied to its origins in industrial automation, particularly in inspection applications.

Fueled by enduring demand for quality assurance, package inspection, assembly verification, and sorting and grading operations, inspection remains the dominant task for machine vision technology. According to research firm Interact Analysis, inspection applications accounted for more than 40% of vision revenue in 2022 and will represent nearly 42% of the market ($3.9 billion) in 2028.

This is partly the result of secular trends. For example, automated inspection is a natural extension of a broader trend toward automating industrial processes as human inspectors become just as difficult to find, train, and retain as other manufacturing workers.

Perhaps more importantly, machine vision offers additional inspection capabilities that humans simply cannot match — particularly in applications that involve high-speed or high-volume production, absolute consistency in quality assurance, and/or the need to spot defects that are impossible for humans to see.

In the highly regulated food and beverage industry, for example, cameras operating beyond the visible range can detect spoilage in agricultural products before it is visible to the eye. They can also determine the presence of defects, hard-to-spot allergens, and other contaminants before products make their way into the hands of consumers. Product recalls are costly in terms of dollars and time and can put brand reputation at risk. So automated inspection offers significant benefits to quality, consumer safety, and brand equity — even beyond the benefits.

A third factor is helping to further cement inspection as the bread-and-butter application for machine vision:

Advancements in both 3D imaging and artificial intelligence (AI) are — together and separately —

- introducing powerful new capabilities for detecting defects
- verifying correct assembly
- sorting and grading similar but not identical objects

Ensuring the correct amount and proper distribution of pizza toppings, for example, is an application made possible through the use of machine vision and AI technologies.

Importantly, as these technologies become more sophisticated, they are counterintuitively becoming easier for nontechnical users to adopt and implement. Nevertheless, it is still helpful to have a deeper understanding of both AI and 3D imaging with respect to how their benefits to automated inspection converge and multiply.

3D Vision: Past, Present, and Future

Conventional 2D imaging is a suitable and cost-effective solution for most machine vision applications in inspection and beyond. However, by capturing length, width, and height data, 3D imaging offers unique benefits for inspecting complex or reflective surfaces, or when illumination or image contrast is limited. It introduces new inspection capabilities for measuring volume, flatness, gaps, and angles. 3D imaging is also instrumental in applications beyond inspection, such as dimensioning packages for logistics or to help vision-guided robot systems find and pick up randomly arrayed objects.

Several 3D imaging technologies can gather spatial data from a scene and arrange it into a high-fidelity point cloud for analysis.

Stereoscopic systems position two cameras slightly apart and combine their image data to reconstruct a 3D space based on the disparities between each camera's images. Stereoscopic systems can gather 3D information from complex environments with varying textures. They are well-suited for inspection applications that require precise depth measurements across a wide field of view.

Structured light systems project an illuminated pattern, such as a matrix of lines or dots, onto a scene, which is imaged by a camera. Computers analyze distortions in the illuminated pattern and then map the shape of the surface or object. Structured light systems offer highly accurate surface information, making them useful for inspecting very small features or complex shapes.

Like structured light systems, time-of-flight (ToF) sensors also project light onto a scene. But rather than measuring deformations in a pattern, ToF sensors instead clock the time it takes for a pulse of light to reflect back to the camera. Each camera pixel provides direct depth information based on the travel time of each pulse to reveal high-fidelity 3D spatial information. ToF technology delivers low-latency depth measurements with a single camera, making it suitable for inspecting high-speed applications or processes in real-time.

3D systems often offer megapixel resolution or above, submillimeter depth precision, and capture speeds supporting real-time inspection of moving objects or dynamic scenes. As vendors test the limits of 3D imaging's traditional specifications, they are also exploring what other benefits the technology can provide.

RGB-D depth cameras are one example. They combine color information from red, green, and blue (RGB) channels with depth (D) information to create images that provide a deeper understanding of a scene's spatial features. A stereoscopic or ToF sensor provides depth data, which is merged pixel to pixel with RGB data to deliver both in a single frame.

As 3D component and system technology evolves, it will likely support more inspection applications.

But it could also drive stronger demand for automated inspection itself. Multiple end markets will benefit from this trend, most notably automotive manufacturing, where 3D inspection solutions are already used extensively for absence/presence checking, assembly verification, and final inspection.

Use of 3D imaging technology is also rapidly growing in the food and beverage sector, where it is used for quality inspection, volume measurement, defect detection and packaging operations.

In pizza manufacturing, for example, 3D imaging technology can perform surface inspection of frozen pizzas on a conveyor line to ensure there are no defects or contaminants present, among other applications.

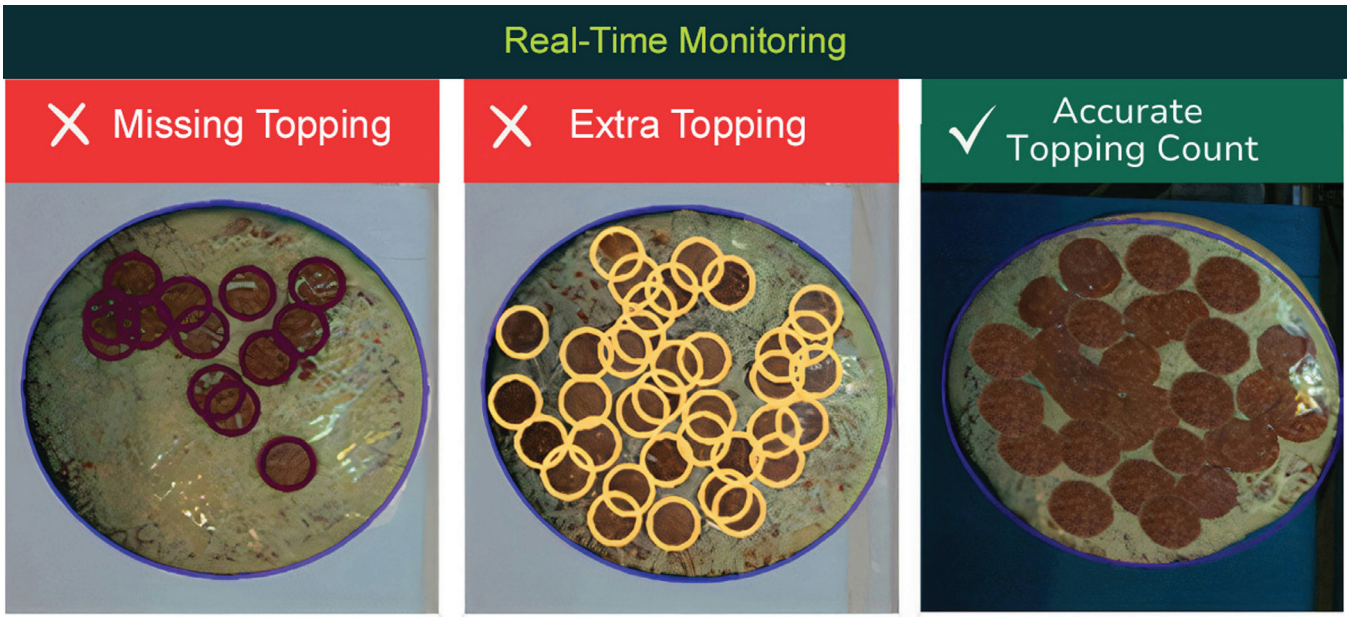
AI Propels Pizza Production

Between the pull of end market demand and the push of technological advances, the momentum behind 3D imaging is already substantial, and growing. And AI and deep learning are lending further impetus to 3D inspection by introducing potentially transformative new capabilities.

Deep learning, a subset of AI, uses artificial neural networks to learn from data. Rather than following preprogrammed rules such as conventional machine vision algorithms, AI's neural networks are trained on large datasets to gradually learn how to recognize patterns, features, and anomalies independently. Applied to 3D vision systems, deep learning extends inspection capabilities beyond rule-based inspection methods by enabling detection of more complex defects, patterns, and anomalies in 3D data. This leads to more accurate and thorough quality control with increased efficiency, especially in scenarios with high variability or intricate geometries.

AI and 3D imaging together bring significant improvements to several aspects of pizza manufacturing:

Detecting pizza surface irregularities and defects: Pizzas traveling on a conveyor must be inspected to ensure that no incorrect toppings, contaminants, or foreign materials have made their way onto the pizza surface. Machine learning or deep learning algorithms inspect pizzas the same way humans do, by identifying and classifying detects, and can dramatically improve the sensitivity and accuracy of surface defect detection by recognizing overall patterns of normalcy to then single out deviations. Additionally, AI's ability to learn from past data about what distinguishes an acceptable surface feature from a flaw can lead to higher precision in defect detection.



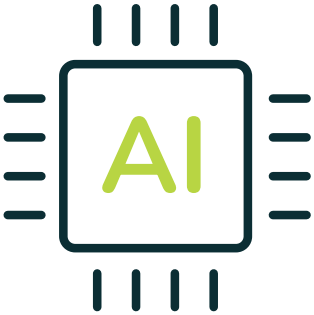
Automatically monitor product characteristics and quality parameters in real-time.

Topping inspection and verification: Frozen pizza manufacturers offer many varieties of pizza. These companies must ensure that the toppings are evenly distributed with the correct amount of each — whether it's pepperoni, pepper, or onion — or else face the risk of customer dissatisfaction.

Automation systems that leverage AI can train the model on acceptable images of different types of pizza; the AI can then verify pizza type and ensure that each topping is evenly distributed and that the right amount was dispensed onto the pizza.

Pizza measurement: Frozen pizza manufacturers must ensure that all pizzas are consistent, which requires imaging in the X, Y, and Z coordinates. 3D imaging technologies such as 3D RGB-D cameras can measure a pizza's size, shape, and height to ensure that it will fit correctly into its packaging while enhancing overall product consistency.

Adaptive inspection for new pizza types: When frozen pizza manufacturers want to introduce new pizza varieties, AI helps eliminate the need to make drastic changes to existing processes. Instead, a model is trained with acceptable images of the new type of pizza, and the AI-enabled vision system will recognize the new variety. This process helps reduce downtime while maintaining the manufacturing line's agility and efficiency.



AI Without Complexity

By improving defect or contaminant inspection, enhancing topping inspection and verification, enabling pizza measurement, and enabling adaptive inspection for new pizza types, AI is helping 3D inspection systems deliver higher precision and flexibility for pizza manufacturers. The biggest hindrance to their adoption may be perceptions of the complexity associated with training and implementing such sophisticated technology. Such perceptions made vision engineers and end users slow to integrate deep learning solutions at first, despite widespread recognition of the technology's potential benefits.

Yet, paradoxically, as AI and deep learning tools have become more sophisticated, they have also become simpler to use. Oxipital's AI solution, for example, is designed specifically to deploy and configure quickly with a minimum of operator expertise. Its sophisticated yet easy-to-use software interface eliminates the complexity of deploying AI for machine vision.

With pretrained object models and a set of no-code application builder tools, the system is ready to go out of the box.

For one frozen pizza manufacturer, deploying Oxipital AI's technology means saving more than $5,000 a month while providing customers a consistent, high-quality product.

Amid ongoing labor shortages and increasingly demanding inspection applications, manufacturers of all types can turn to 3D inspection technology to address their needs. To do so, companies can task a systems integrator with taking a greenfield approach by specifying components and designing and integrating a system. Alternatively, they can opt to have the integrator deploy a turnkey applications-specific system, such as Oxipital's AI solution, into an existing 3D imaging system. The potential result is faster deployments and reduced costs. Connect with Oxipital today to schedule a demonstration of how our AI technology can transform your frozen pizza manufacturing processes.

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