AI on the line

In an era of tightening global regulations and rising consumer expectations, the food and beverage industry is increasingly turning to advanced vision inspection technologies. From spotting defects to ensuring compliance, these automated inspection tools are reshaping quality control, enhancing efficiency, reducing waste and boosting safety. *FoodBev* explores how cutting-edge technology is reshaping the industry, one perfectly inspected product at a time.

In the food and beverage industry, traditional quality inspection methods have always relied on human observation – an inherently inconsistent and flawed process. Automated vision inspection systems offer a transformative alternative. By detecting foreign objects, assessing product uniformity and ensuring that only items meeting strict quality criteria reach consumers, these systems significantly enhance operational efficiency and minimise errors.

"As the food industry moves towards more automation, applications are becoming increasingly complex, largely due to the variability in food products," said Anthony Romeo, product manager at US-based vision solutions company Oxipital AI. This complexity stems from the need for automated systems to adapt to the wide range of textures, sizes and ingredients in food, making precise automation a key challenge.

Stephan Pottel, director of strategy at Zebra Technologies, highlighted the rising demand for intelligent automation: "There's a growing need for machine vision and 3D solutions, powered by deep learning, to address more complex food and packaging use cases, along with vision-guided robotics for tasks like inspection, conveyor belt picking and sortation workflows".

Key features of vision inspection

1. Defect detection

Vision inspection systems excel in identifying defects that may go unnoticed by human inspectors. These systems utilise high-resolution cameras and advanced algorithms to detect foreign objects, surface defects, and inconsistencies in size and shape. For example, in the fruit packing industry, vision systems can identify bruised or rotten fruit, ensuring only high-quality products are packaged and shipped.

2. Label verification

These technologies are increasingly used for label verification, ensuring compliance with regulatory standards. Systems can check for correct placement, legibility and adherence to labelling requirements, such as allergen information and expiration dates. Vision is usually deployed for label verification, rather than food surface defects, enhancing compliance and reducing the risk of costly recalls.

3. Product uniformity assessment

Maintaining product uniformity is crucial in the food and beverage sector. Vision inspection systems can assess visual aspects such as size, shape and colour. For instance, a snack manufacturer might use vision inspection to ensure that chips are uniformly shaped and coloured, meeting consumer expectations for quality and appearance.

4. Adaptive manufacturing

Advanced vision systems, particularly those incorporating AI and 3D technology, enable adaptive manufacturing processes. These systems can adjust production parameters in real time based on the visual data they collect. For example, in a bakery, vision systems can monitor the size and shape of pastries as they are produced, allowing adjustments to baking times or temperatures to ensure consistent quality. ▶

A deeper look, empowered to judge

HEUFT *eXaminer*[II] systems combine advanced pulsed X-ray technology with proprietary AI to ensure the precise detection of foreign objects, even in the most challenging cases.

The HEUFT *reflexx*[A.I.] deep learning image processing excels at detecting risks such as glass splinters, stones or wires in complex products like red cabbage or noodles, while simultaneously distinguishing them from harmless irregularities in X-ray images.

This technology not only protects consumers and brands but also prevents food waste caused by the unnecessary rejection of good, uncontaminated products. The effectiveness of the new deep learning algorithm relies on high-quality X-ray images, which are denoised and analysed by the AI. Current HEUFT *eXaminer*[II] systems prevent motion blur during high-speed inspections by emitting short, low-radiation X-ray pulses instead of a continuous beam. These pulses 'freeze' the moment, producing sharper, high-resolution images that are easier for the AI to evaluate.

This intelligent pulsed X-ray technology can be used to inspect filled food jars, tins, cans, pouches, thermoformed trays and unpackaged items. At Drinktec 2025 in Munich (Stand B4 121/321), HEUFT *reflexx*[A.I.] will demonstrate its capability to perform deeper inspections of empty bottles with the new HEUFT *InLine*[II] *IX*. ●
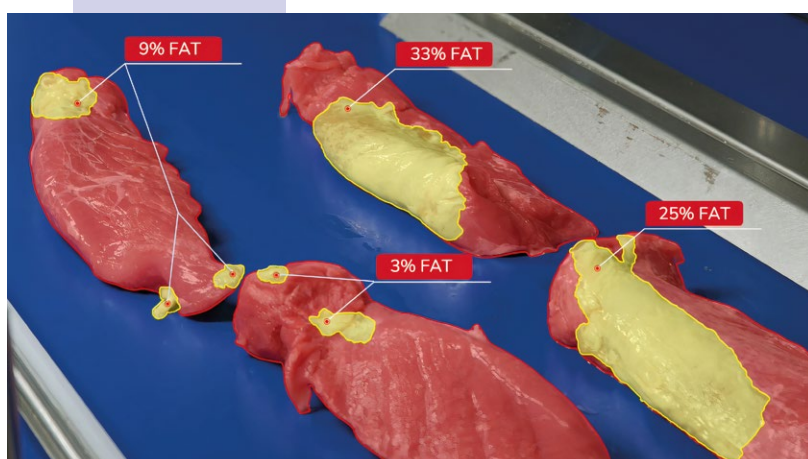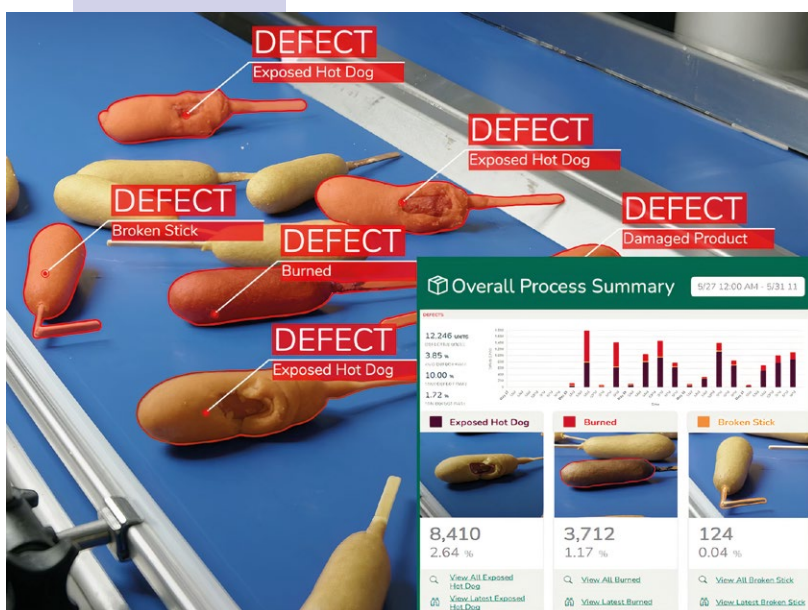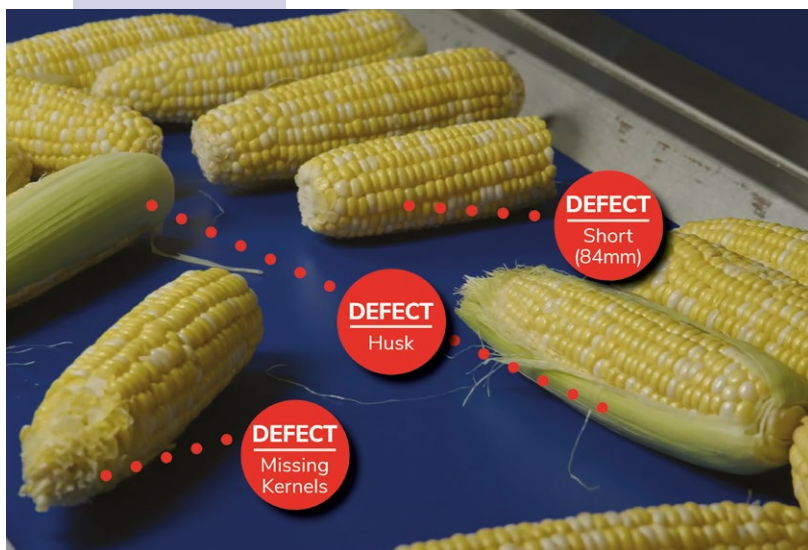
Advancements in AI

Recent advancements in AI, automation and 3D technology have greatly enhanced machine vision systems, increasing accuracy and providing realistic visual sensing capabilities.

3D imaging technologies are being used to assess the shape and size of products, ensuring they meet packaging specifications. For instance, in the seafood industry, 3D scanners can evaluate the dimensions of fish fillets, ensuring they are cut to the correct size before packaging. This not only reduces waste but also ensures consistency in product offerings.

What is more, 3D profile sensors improve depth perception and refine quality control, making them indispensable tools in industrial automation.

Oxipital AI's Romeo highlighted the potential of these technologies: "Removing defects before they reach customers is a key first step where vision inspection technology plays a role, but there's even more data to be leveraged". By preventing defects from the outset, manufacturers can boost yield and reduce waste.

AI-powered vision inspection systems can also facilitate real-time monitoring of production lines, identifying potential issues before they escalate. This capability allows manufacturers to implement predictive maintenance, reducing downtime and improving overall efficiency.

AI and food safety

Consumer safety remains a top priority in the food and beverage industry. AI plays a crucial role in monitoring and analysing processes in real time, helping manufacturers navigate the complexities of compliance with legal requirements and certification pressures from major retailers.

As Zebra Technologies' Pottel explained: "AI is ideal for food and beverage products where classification, segmentation, and object and anomaly detection are essential. It is also enhancing asset and inventory visibility, which is crucial for predicting contamination risks and maintaining high safety standards throughout the supply chain."

"Vision technologies can help check the presentation of food products...offering a quick, repeatable and reliable way to assess the visual aspects of food products like size, shape and colour," added Neil Gruettner, market manager at Mettler-Toledo Product Inspection.

He continued: "Deployment of this type of AI provides context to support rule-based machine

learning and improve human decision-making. It also gives inspection equipment the tools to extract and interpret as much data as possible out of a product, facilitating the evolution and refinement of production processes through the continuous exposure to vast datasets."

AI-enhanced vision systems also guide robots in handling food products, particularly those that are delicate or irregularly shaped. "AI has proved to be a great method for tackling applications with a high frequency of naturally occurring organic variability, such as food," Oxipital AI's Romeo explained, adding that this adaptability ensures gentle and precise handling, particularly important when sorting fresh produce or packaging baked goods.

Fortress Technology uses AI to reduce contamination risks and identify defects. The company's commercial manager, Jodie Curry, told *FoodBev*: "Streamlining processes reduces the risk of contamination and ensures consistent quality. Implementing automated technology and digital tools helps identify inefficiencies and boosts responsiveness."

The role of combination inspection systems

The integration of multiple inspection technologies into single systems is another key trend in this space. These systems integrate various inspection technologies, such as X-ray, checkweighing and vision inspection, to provide a comprehensive assessment of food products. By combining these technologies, manufacturers can ensure higher quality control, better detection of defects and more efficient production lines. This trend allows for more accurate and reliable monitoring, helping to reduce waste, improve safety standards and enhance overall product quality.

For its part, Fortress offers combination systems that enable comprehensive and multi-layered inspection. The company is already leveraging its proprietary data software package, Contact 4.0, across its metal detection, X-ray and checkweighing technologies. Contact 4.0 allows processors to review and collect data, securely monitor and oversee the performance of multiple Fortress metal detectors, checkweighers or combination inspection machines connected to the same network.

Deep learning and quality control

Deep learning is revolutionising visual inspection by enabling machines to learn from data and recognise previously unseen variations of defects. ▶

As Zebra Technologies' Pottel explained: 'Deep learning machine vision excels at complex visual inspections, especially where the range of anomalies, defects and spoilage can vary, as is often the case with food. This technology is vital for automating inspections and ensuring quality.

Deep learning optical character recognition (OCR) also improves packaging inspection by ensuring label quality, regulatory compliance and brand protection. It can verify label presence, confirm allergen accuracy and prevent mislabeling.

"The goal is to strengthen quality control by capturing an image and processing it against set quality control parameters," Mettler-Toledo's Gruettner pointed out.

Vision systems are increasingly deployed for label verification, ensuring compliance with legislative food labelling requirements. The Mettler-Toledo label inspection portfolio features Smart Camera systems (V11, V13, V15) for basic label inspections, including barcodes, alphanumeric text and label quality. For more advanced applications, the PC-based V31 and V33 systems offer a larger field of view, faster throughput and enhanced inspection capabilities.

Oxipital AI uses 3D product scans and synthetic data generation to eliminate the need for hand-labelling images. "All training is done at Oxipital AI, enabling food and beverage customers to deploy AI without needing a team of experts," said Romeo. "Our solutions are designed for immediate impact, requiring no coding, DIY or machine-learning expertise to implement and maintain."

Real-world applications and future prospects

According to Zebra's Global Manufacturing Vision Study, which surveyed leaders across various manufacturing sectors, including food and beverage, 66% of respondents plan to implement machine vision within the next five years, while 54% expect AI to drive growth by 2029. These figures, coupled with the expanding market for vision inspection systems, suggest that the majority of manufacturing leaders are prioritising the integration of these advanced technologies, seeing them as crucial tools for both immediate improvements and long-term growth.

This shift is partly driven by increasingly stringent government regulations, which demand more accurate labelling and packaging. Many companies are already successfully leveraging AI to enhance their operations, particularly in labelling processes.

Despite its clear advantages, the uptake of AI has been slow. The main barrier appears to be cost. While the initial integration can be expensive, AI has demonstrated significant long-term cost savings, making it a worthwhile investment over time.

Zebra's studies have shown that the pressure to maintain quality while managing fewer resources is intensifying for manufacturers. As a result, cost remains a significant consideration when implementing AI solutions.

Fortress recommends consolidating AI systems into a single interface, which helps reduce costs in the long term. Curry told *FoodBev*: "The future of our food supply chain depends on advanced inspection systems that enhance food safety, reduce product waste and require minimal factory floor space".

She continued: "Combination systems offer the benefit of space efficiency, as all sales, services, parts and technical support are handled by one provider. A single interface simplifies training, improves operational safety and drives cost savings through faster installation and reduced training time."

As AI continues to evolve, its role in vision and inspection is set to expand. Advancements in machine learning, sensor technology and robotics will lead to even more sophisticated and efficient inspection systems, raising quality and safety standards for consumers worldwide. ●