

TAMING THE COMPLEXITY OF MACHINE VISION AI: HOW THE RIGHT EDGE HARDWARE CAN EASE INTEGRATION



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While traditional machine vision systems that rely on rule-based parameters have served the industry well with the ability to perform specific tasks faster and more accurately than humans, these systems are often constrained when variability, deviations, ambiguity, and unpredictability complicate visual information. They can be thrown off by changes in lighting conditions, perspective, scale, reflections, shadows, occlusion, and even environmental conditions such as dust and debris. Unlike the human eye, which can perceive and adapt to these variations, traditional machine systems can fail to make accurate, meaningful interpretations of visual data without constant reprogramming and parameter modifications.

Industrial automation is now progressing rapidly with Industry 4.0 initiatives aiming to improve quality, efficiency, and productivity across various industries, from manufacturing and assembly to food and beverage, logistics, healthcare, and more. For machine vision systems, that means enhanced data from industrial Internet of Things (IIoT) sensors and innovative high-resolution camera technology that can capture 3D images, infrared wavelengths, and more spectral bands to help overcome issues related to image quality, environmental variability, and real-world complexities. However, artificial intelligence (AI) is the most significant Industry 4.0 technology, taking machine vision systems to the next level by augmenting rule-based parameters with intelligent video analytics.

The Future of Machine Vision is Here

AI uses advanced neural network models that replicate how humans see and make sense of what they see, eliminating the limitations of traditional machine vision systems caused by variations in real-life applications. With AI, a machine vision system can quickly and easily analyze an image to recognize subtle nuances and patterns, compare patterns across an entire data set of images, and retain information from each analysis to continually learn and improve accuracy over time. The surge in AI-powered systems deployed at the edge of manufacturing and assembly lines to process data locally in real time is transforming a wide range of industries.



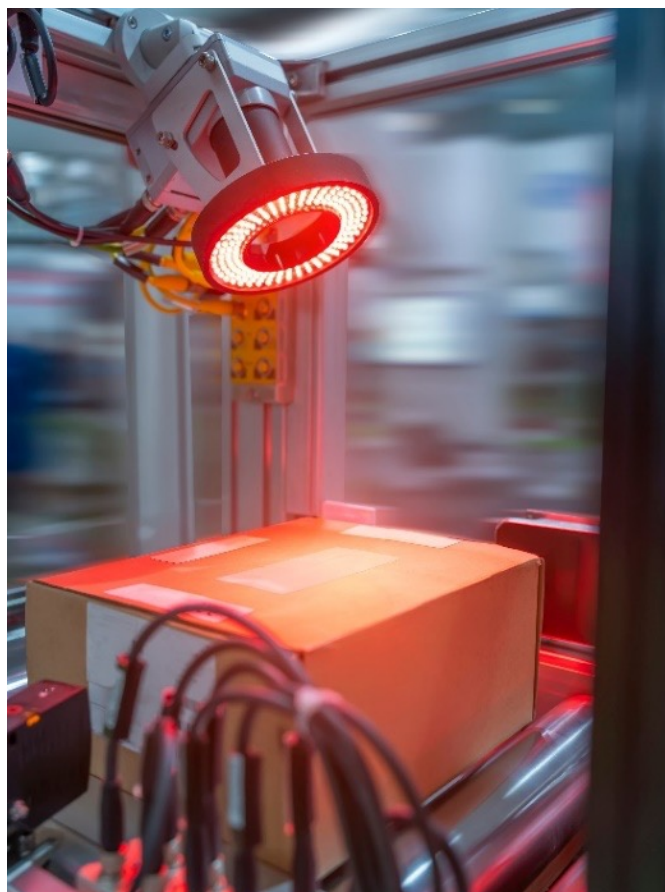
The following are just some examples of how edge AI enhances machine vision systems:

- **Quality Control:** AI meticulously analyzes visual data from cameras on any assembly line for everything from measuring fill levels and ingredients in food and beverage processing to inspecting pills and counting vials to guarantee consumer safety in pharmaceuticals.
- **Defect Inspection:** Across a range of manufacturing and assembly operations, AI detects everything from minor surface imperfections and complex color variations to non-obvious defects that can't be seen with the naked eye. It's ideal for identifying scratches, microcracks, film damage, and structural defects on renewable energy assets like photovoltaic panels.
- **Assembly Verification:** AI confirms proper alignment, arrangement, and quantities of assembly components. This plays a crucial role in the electronics industry by ensuring quality and high-precision positioning of subtle components such as wafers in printed circuit board (PCB) assembly. AI can also classify and count components to route them to the correct assembly line or packaging area.
- **Package and Label Inspection:** AI identifies missing components and damaged and unsealed packaging in warehouse and distribution environments. AI machine vision systems can even leverage pattern-matching capabilities to read,

recognize, and translate bar codes and labels.

This is vital to ensuring product quality, consumer safety, and regulatory compliance in the food and beverage and pharmaceutical industries. The ability to read and verify labels can even optimize inventory management and improve logistics by keeping inaccurate, obscured, or folded shipping labels out of the supply chain.

- **Automation:** AI empowers robots to recognize objects, calculate exact shapes and dimensions, and understand spatial context to identify problems within a system design. This secures the precise placement and orientation of components in 3D space and improves accuracy in sorting and picking.



While machine vision systems dramatically improve productivity and quality control in many industrial, manufacturing, and logistics environments, the integration of AI pushes the capabilities of these systems beyond imagination to supercharge speed, efficiency, and accuracy. Additionally, integrating AI at the edge speeds real-time decision-making and action since there is no need to transmit information across larger networks. Edge AI technology is also smaller in size and weight and offers higher availability, better security, easier scalability, and overall lower costs.



Choosing the Right Hardware at the Edge

While Industry 4.0 and edge AI empower machine vision systems with new capabilities, integrating new technologies into existing manufacturing and assembly lines presents challenges. Today's system integrators face a wider range of increasingly complex components, diverse I/O interfaces, and the need to support both current applications and future AI models that analyze massive data sets and require high-performance computing.

The following are key factors to consider when selecting industrial edge computers for emerging machine vision technologies:

- **Compute power and memory:** Edge computers should have the flexibility to support a wide range of central and graphical processing unit (i.e., CPU/GPU) requirements to meet diverse and future needs, such as the latest 12th/13th generation Intel CPUs with up to 24 cores for efficient processing of larger AI data sets. They also need the latest Double Data Rate (DDR) based memory with extremely high bandwidth for faster access and transfer of stored data to the processor for real-time analysis.
- **Comprehensive I/O support:** A wide variety of interfaces for supporting the latest devices is a key feature to look for in a machine vision edge computer. It should include chipsets with digital interfaces to support high-speed industrial cameras, such as those that meet GigE Vision, USB3 Vision,

Camera Link, and CoaXPress standards. I/O support for audio systems, KVM (i.e., keyboard, video, mouse) devices, serial communications (i.e., RS-232/422/485), displays, and external platforms is also a critical consideration.

- **Secure, high-throughput network connectivity:** Secure, high-bandwidth connections to internal and external industrial networks via multi-gigabit Ethernet LAN ports should be integral to every edge computer. They should also enable the latest 5G wireless connectivity for the growing number of wireless industrial sensors and devices that support remote monitoring and control, mobile robots, autonomous guided vehicles, mobile asset tracking, and emerging technologies like augmented and virtual reality and digital twins.
- **Expansion capabilities:** As AI technology evolves, edge computers should offer flexible expansion options for non-core components, like CPUs and GPUs, and optional extension modules with additional I/O ports. This allows for easily scaling systems to accommodate current and future machine vision technologies, ultimately extending the system's lifespan.
- **Customization options:** Since every machine vision application and environment has unique requirements regarding intended use, connected devices, and configuration, off-the-shelf products may not always fulfill specific needs. System integrators should consider edge computers backed by design and integration services to meet

precise project specifications. These services can customize solutions to accommodate unique hardware and software requirements.

- **Intelligent PoE device management:** Edge computers should ensure safe power supply to internal components through DC input power while providing seamless intelligent power management, such as the ability to manage and monitor power consumption per port for remote power distribution technologies like USB and power over Ethernet (PoE) that power connected devices (e.g., cameras, lights, sensors, etc.).
- **Environmental protection:** Edge computers deployed near assembly lines must be robust and designed to withstand the harsh realities of industrial and manufacturing environments, including exposure to shock, vibration, extreme temperatures, humidity, electromagnetic interference, dust, and debris.
- **Industry Compliance:** For added assurance, any industrial edge hardware should comply with the latest performance and safety standards applicable to electronic equipment intended for use in industrial environments.

Scaling Up Machine Vision with Axiomtek

To meet the demands of AI-enhanced machine vision applications, Axiomtek has designed the IPC962A. Like all Axiomtek products, the IPC962A is built with strict quality

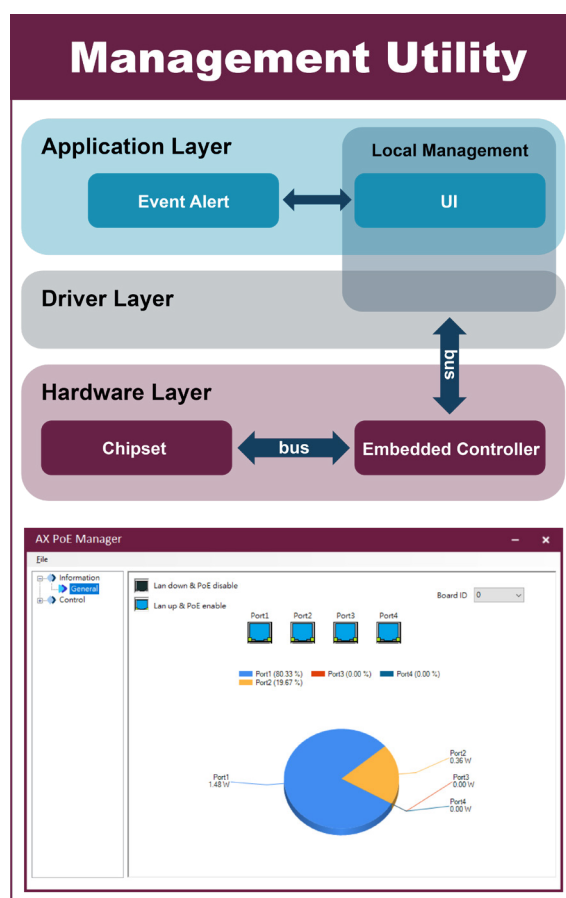
standards to withstand harsh industrial environments. It is certified to EN 61000-6-4 and EN 61000-6-2 for electromagnetic compatibility and offers a wide operating temperature range of -20°C to 60°C (-4°F to 140°F) and heavy-duty cold-rolled steel construction.



The IPC962A offers:

- **Next-gen performance:** Latest 13th/12th gen Intel® Core™ processors with Intel® Q670E/H610E chipsets and dual DDR5 4800/4000 SO-DIMM slots for up to 64GB of RAM and options for AI accelerator modules to handle intensive AI workloads.
- **Advanced connectivity:** Latest high-throughput wireless, USB 3.0, and Ethernet connectivity, including support for 5G wireless.
- **Multiple display options:** DisplayPort, HDMI, and DVI-D ports for advanced 3D, infrared, and hyperspectral machine vision cameras with resolutions up to 4096 X 2160.
- **Flexible I/Os:** Ports for USB devices, audio, serial communication, external displays, robotics, industrial computers, and more.

- **Intelligent PoE Device management:** 4-pin terminal blocks for 18 to 36 VDC input power, ignition control, remote LED, etc. Axiomtek PoE manager for PoE control and monitoring provides the ultimate intelligent power management, including physical layer connectivity, communication layer protocol, middleware API, and high-level software management.



Built for Today — and Tomorrow

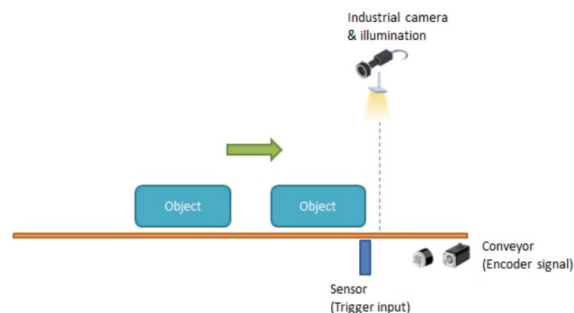
Backed by superior design flexibility and modularization, the IPC962A offers superior expansion capabilities for easy scaling of machine vision systems. The IPC962A's front-facing I/O extension

accepts a variety of I/O modules for additional device connectivity — from LAN, USB, and serial ports to external displays, robots, and other external industrial devices and computers. The IPC962A also features two high-speed PCIe slots for high-performance parallel CPU and GPU AI accelerators like Nvidia T600/T1000 and Intel ARC Pro A50 GPUs that support AI deep-learning inference and training models, allowing integrators to quickly and easily adapt to new diverse edge AI and Industry 4.0 technologies that bring machine vision systems to the next level — whenever they are ready.

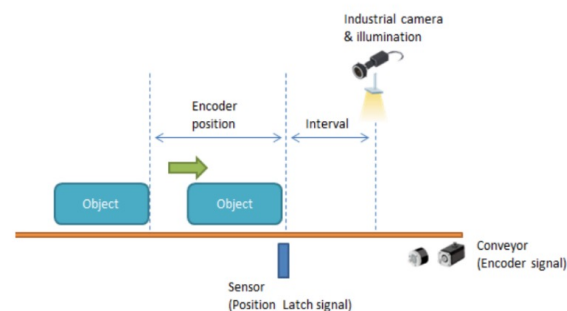
The IPC962A also features a PCIe slot for additional capabilities. For example, the IPC962A can accept Axiomtek's AX92320 4-port PCI Express GigE Frame Grabber Card to support four independent 30-Watt PoE-compliant Ethernet ports for powering and connecting GigE Vision cameras. It also supports IEEE 1588 (precise time protocol), enabling synchronization with multi-camera acquisition.

The IPC962A also accepts Axiomtek's AX92350 Real-Time Vision I/O Card with incremental quadrature encoder input and de-bounce filters for integrating and controlling multiple I/Os in real-time, enabling accurate interaction between lighting, cameras, actuators, and sensor devices. Axiomtek's lighting control module offers multiple lighting control modes and an adjustable delay/duration time function, allowing users to set the delay time that the system waits before it sends a trigger output and define the duration to adjust pulse width for the LED output. When paired

with the highly modular IPC962A, the AX92350 Real-Time Vision I/O Card and lighting control module deliver microsecond-scale control and lighting control to meet timing sequence requirements and ensure high-quality image output, as shown in the diagram below for two real-world scenarios.



Scenario 1: When an optical sensor or encoder detects objects on the production line, trigger signals notify the system to prompt a camera to capture images. The vision platform analyzes the objects in the images. If a defect is detected, a pneumatic actuator or robotic arm can remove the affected object.



Scenario 2: In this application, the system needs to record the encoder positions for camera trigger. The Axiomtek hardware is specifically designed to store encoder positions. When the sensor produces an external latch input signal, the encoder position value will be recorded

to the latch register. Users can acquire position data by calling API and setting the value to the first-in/first-out (FIFO) buffer. Further, trigger-out will output the FIFO data, which adds up both latch and interval values.

[Click Here](#) for detailed technical information regarding the integration of advanced vision I/O modules for machine vision applications featuring real-time trigger and lighting control.

Ensuring Seamless Integration

Axiomtek is committed to helping manufacturers across a wide range of industries facilitate diverse machine vision applications and seamlessly integrate emerging AI technologies via the following services:

- Our Design Services Team of experienced engineers with best-in-class service and domain know-how can customize solutions from board to system level with fully integrated deployment through a combination of hardware and software that meets the demands of AI and machine vision applications.

- Our Key Account Management service offers proactive, comprehensive support to guide customers through every stage with precision and care — from individualized program management, project requirements, planning, and ordering through delivery and ongoing post-project support.
- Through our expanding partner ecosystem, Axiomtek collaborates with software partners to provide API utility, driver support, and embedded operating systems. We work with hardware partners, ensuring advanced peripheral devices that are verified to be compatible, compliant, and reliable.
- Our DigiHub of resources and software development kits helps machine vision integrators easily build and implement customized AI training and inference deep learning models. Our AI-ready software development toolkits are based on Intel® Edge Insight for deploying AI without coding and the open-source OpenVINO.



Advancing Next-Gen Machine Vision Applications

As machine vision systems evolve to deliver next-level speed, efficiency, and accuracy with the integration of advanced camera, 5G, IIoT, and AI technologies, Axiomtek is truly at the forefront of innovating machine vision computer solutions that take advantage of these new and exciting capabilities. From AI-embedded systems to comprehensive I/O support and seamless software integration, Axiomtek delivers high-performance, industrial-grade machine vision computers in a range of customized configurations to help customers across a variety of markets achieve operational improvements, increased productivity, performance boosts, and efficiency gains across their manufacturing and assembly lines.

As new Industry 4.0-enabled technologies continue to advance, so does Axiomtek. We constantly stay

on top of new technologies and collaborate with our partner ecosystem to develop advanced and highly reliable industrial computer solutions that support new functions for real-world applications. And it's all backed by U.S.-based expert design and integration services that let system integrators quickly and cost-effectively deploy advanced machine vision systems — from traditional to edge AI — that perfectly meet their needs today and tomorrow.

Visit us.axiomtek.com for more information, and **contact Axiomtek today to get started building the ideal machine vision solution for your application.**

Additional Resources:

[IPC962A Datasheet](#)

[Real-Time Trigger I/O and Lighting Control](#)

[Frame Grabber & Vision I/O Cards](#)

