Enabling Smart Manufacturing:

Axiomtek's Machine Vision Solutions

Industry 4.0—a global manufacturing movement also known as the Fourth Industrial Revolution—is reshaping the landscape of today's manufacturing world like never before. Aiming to optimize operation, increase production yields and drive costs down, Industry 4.0 is characterized not only by the progression towards full automation, but also by the continued digitization of production processes. Through the Industrial Internet of Things (IIoT), intelligent elements like sensors, controllers and communication interfaces create a cyber-physical ecosystem that turns smart factories into reality, with a multitude of digitally interconnected devices and machines being able to communicate and exchange information in a fast and coordinated way. Vast amounts of data generated by factory floor equipment become accessible via the cloud and computer networks for backend diagnosis and analysis. Driven by the rise of fast-evolving technologies behind Industry 4.0, such as cloud computing and deep learning, all manufacturing assets will learn from their environments to improve performance, reduce wasted resources, and ultimately hit maximum productivity.

Machine vision plays a critical role in this Industry 4.0 revolution because it allows manufacturing facilities to generate a tremendous volume of image data during production operation, based on which manufacturers can make timely adjustments to streamline and optimize procedures. The ultimate goal is to help manufacturing industries achieve substantial increase in efficiency and accuracy.

Basics of Machine Vision

Machine Vision Performs Repetitive Tasks Faster, More Accurately, and with Greater Reliability

Machine vision is a technology that utilizes sensors, industrial cameras, I/O control hardware and vision software algorithms to extract information from captured images, providing imaging-based inspection analysis and visual guidance for production line operations. As a crucial part of factory automation, the technology is widely implemented in automated product inspection to enhance quality control, as well as in assembly process to guide robots and adjust machinery behavior. Machine vision gives manufacturing equipment the ability to see and identify objects just like the human eye—yet with far greater speed and precision. Systems incorporating machine vision are able to examine massive numbers of parts within seconds and deliver consistently reliable and accurate inspection results despite long hours of repetitive operations. Aided by high resolution cameras and sophisticated optics, machine vision systems can also distinguish subtle differences too tiny to be discerned by human inspectors.

How Machine Vision Works

A typical example is how a machine vision system inspects products flowing down a production line in front of a camera:

1. Once the sensor detects the presence of a product, it signals the vision system to trigger the LED lighting to highlight the product and activate the camera to capture the product image.
2. The system's digitizing device such as a frame grabber card takes the image data provided by the camera and translates it into digital format to be processed and manipulated by vision software.
3. Vision software processes the digital image and analyzes it against a set of predefined criteria to identify defects and flawed parts.
4. If a product meets the criteria, it will pass inspection and proceed to the next step. If not, the vision system will send a fail signal to the machine actuator, triggering a reject mechanism to remove the product from the line and sort it out for further inspection.

Key Components of a Machine Vision System

Industrial camera. The industrial camera captures the image of the object to be inspected. Some smart cameras have their individual built-in processing units to extract information directly from captured images.

Light sources. To facilitate accurate image acquisition, different types of LED lighting can be configured to project light on targets in a number of specific ways.

Sensors. Sensors and encoders serve to trigger a machine vision system's reaction. They can track the position of an object moving down a conveyor belt, producing a feedback signal as they detect the incoming object. The system will use this information to initiate an image capture at the exact moment when the object comes into the camera's field of view.

Vision system controller & I/O hardware. The vision controller uses digital I/O (digital input and output) to coordinate all system components, ensuring seamless interaction between sensors, lighting, cameras and other devices during the course of a machine vision task. By integrating vision I/O interface, the controller can execute a series of trigger actions involving sensor/encoder input reading, LED lighting control, and camera activation to achieve quality image acquisition in real time. Controllers driven by high-performance processors can also accelerate image analysis when used in conjunction with vision software.

Camera communication interface. To ensure fast and accurate image feed from cameras at all times, the vision system requires a reliable camera communication interface that allows cameras to quickly send captured images back to the vision system for further processing. Power over Ethernet (PoE), for instance, is a mainstream networking interface and a great way to simplify vision system design. The PoE technology lets Ethernet cables supply electrical power to connected cameras over an existing data connection, meaning no extra power cabling is required to power up cameras. Gigabit Ethernet, an extension to the Ethernet standard, also offers high-speed transmission at 1 Gbps to enable instant access to visual data.

Image processing software. The vision system's analytical software processes captured images to extract required information. The software highlights image features and performs defect detection, measurement and advanced analytics using pattern matching techniques and image processing algorithms. The findings will determine a product pass/fail and will be used for operational corrections, machine performance forecast, calibration, maintenance and other decision-making references.

How Machine Vision Benefits Production Lines

Reduces defects and lowers error rates. Unlike human vision, which requires rest and is susceptible to errors resulting from eye strain, fatigue or distraction, vision equipment can perform inspection tasks at higher speed and with greater precision. Defective parts can be screened out before entering the market to ensure quality product output.

Minimizes part damage. Adopting a vision system helps reduce the chances of parts being damaged or contaminated by physical contact during an inspection process, reducing the need for part replacements, preventing rework, and minimizing downtime.

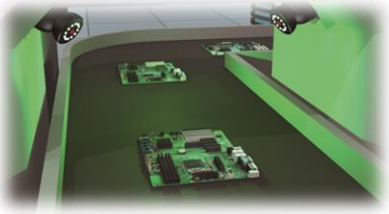
Boosts efficiency and productivity. Machine vision systems can work for a much longer period than human operators to significantly increase production capacity. Moreover, machine vision helps direct machinery's operation to improve its performance and operating precision, and is capable of delivering visual feedback on product or equipment conditions as irregularities occur, so corrective actions or calibrations can be carried out right away to maintain normal production. Machine vision is also used for barcode decoding or symbol recognition to help track and identify parts for better inventory control.

Industrial Machine Vision Applications

Some of the most common applications of machine vision include:

Flaw Detection

Machine vision systems are broadly implemented in industrial visual inspection to automate quality control procedure. Utilizing part locating or pattern matching software, the machine vision system can compare predefined patterns to the actual products to immediately catch defects, flawed parts, and other abnormities, making sure every product leaving a production line meets all quality criteria.

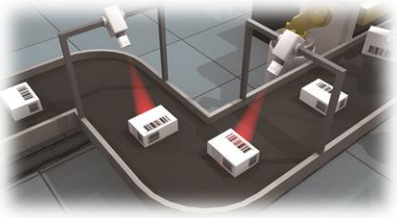


Counting

Machine vision can be used to count the number of products, or the number of required components on a part, as in the case of PCB (printed circuit board) inspection, to verify that the part was manufactured correctly without anything missing.

Part Measurement

After the image of a part is captured, the vision software measures the details of the image, such as distances between selected points, to help determine whether the part is acceptable based on its dimensional specifications or tolerances. Machine vision can also be trained to evaluate the color, position or orientation of a part to reduce manufacturing faults and to ensure proper assembly.



Identification & Sorting

Machine vision systems are employed extensively for barcode and print verification in stock management. They read 1D/2D barcodes or identify symbols via OCR (optical character recognition) technology to verify and sort products on a production line. They can also recognize and classify items by color, shape, or size.

Robotic Guidance

As the eye of an industrial robot, machine vision manipulates the robot's motions and provides positioning feedback through the use of cameras and sensors mounted on the robotic arm, instructing the robot to pick and place targeted objects moving down a conveyor belt, or guiding the robot through a part alignment operation in automated product assembly.

Axiomtek's Machine Vision Solutions for Smart Factory Automation

Axiomtek, an enthusiastic Industry 4.0 advocate as well as a global leader in innovative technologies for factory automation, is launching a series of industrial-grade system controllers and I/O hardware solutions to streamline the development of a variety of machine vision applications, aiming to help manufacturers make the best of their vision platforms and to transform their conventional plants into fully automated smart factories quickly, economically, and with the least deployment and maintenance efforts.

Machine Vision Controller – IPS960-511-PoE

The IPS960-511-PoE is a highly integrated vision controller built expressly for machine vision applications. Featuring an industrial-grade IP40 rugged design, excellent computing performance, flexible expansion capacity, as well as real-time vision I/O control and camera communication interfaces, the machine vision controller provides a total solution that addresses the needs across various machine vision platforms and automatic inspection cases.

Powered by the 7th/6th Gen Intel® Core™ i7/i5/i3 & Celeron® LGA1151 socket-type processor with the Intel® H110 chipset, the IPS960-511-PoE vision controller delivers remarkable computing performance for fast vision processing and analysis. It also comes with fully modularized design for maximum expandability and scalability, supporting two DDR4-2133 un-buffered SO-DIMMs up to 32GB, two swappable 2.5" SATA HDDs/SSDs, one I/O module slot, plus one full-size PCI Express Mini Card with USB interface.

Successful execution of automated visual inspection requires fast, accurate, and reliable communication and coordination among all vision devices. To satisfy this demand, the IPS960-511-PoE vision controller integrates the following key techniques:

Integrated real-time vision I/O. Real-time I/O guarantees instant machine control and response. With its CPLD (complex programmable logic device) architecture, the IPS960-511-PoE is able to perform encoder input, camera trigger, LED lighting control and other vision I/O tasks. The controller also allows users to set timing with microsecond-scale control, making the system a highly efficient digital I/O platform to harness all machine vision peripherals in real time.

Dimming control. The IPS960-511-PoE supports lighting dimming control through the use of pulse width modulation (PWM) and constant current, to help identify object characteristics for different inspection types.

Camera interfaces. The IPS960-511-PoE has a complete set of Gigabit Power over Ethernet (PoE) ports and USB 3.0 ports for connecting industrial cameras. The Gigabit PoE ports enable Ethernet transmission at 1 Gbps to achieve high-speed image acquisition performance, meanwhile sending power to cameras using the same Ethernet cable that transmits data. The remote smart on/off function of the PoE ports enabled by power management also provides monitoring and control for various devices.

SDK with rich Library & API. By incorporating Axiomtek's software development kit (SDK), the IPS960-511-PoE provides rich library and API resources for system designers to develop applications specific to their vision I/O configuration needs, achieving desired hardware-software integration and collaboration.

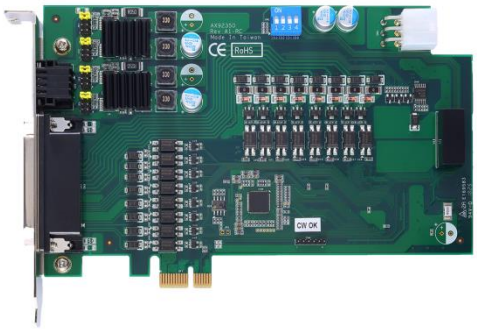
IPS960-511-PoE

Intelligent Machine Vision Controller

- LGA1151 socket 7th/6th Gen Intel® Core™ i7/i5/i3 & Celeron® processors (up to 3.4 GHz)
- Intel® H110 chipset
- Integrated real-time vision I/O
- Supports camera interfaces (GigE with PoE, USB 3.0)
- Built-in LED lighting control
- Supports two DDR4-2133 un-buffered SO-DIMMs for up to 32GB of system memory.
- Supports two swappable 2.5" SATA HDDs/SSDs
- 24V DC power input
- -10°C to +55°C operating temperature range

Real-Time Vision I/O Card – AX92350

Axiomtek's AX92350 is a PCI Express x1 vision I/O card that integrates a full range of isolated I/O interfaces and real-time controls essential to machine vision applications, including trigger input, LED lighting controller, camera trigger, as well as an encoder input function suited for automated conveyor inspection. To adapt to operation in severe industrial environments, the AX92350 vision I/O card provides an auto measurement function for rugged machine vision applications, and has been fortified to withstand a wide temperature range from 0°C to 60°C. The vision I/O card can also fit in the PCI Express slot of any multi-channel vision control systems to simplify deployment and maintenance of your machine vision platform.



AX92350

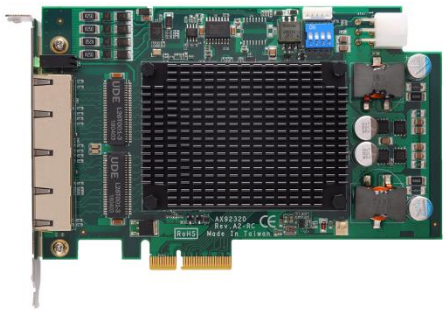
Real-Time Vision I/O Card

- PCI Express x1 compliant
- Integrated vision I/O:
  - 4-CH trigger input
  - 4-CH or 8-CH trigger output
  - 4-CH LED lighting control
  - 1-CH quadrature encoder input
  - 8-CH isolated DI; 8-CH isolated DO
  - 1-CH auto measurement function
- 0°C to +60°C wide operating temperature range

4-port PCI Express GigE Frame Grabber Card – AX92320

Axiomtek's AX92320 is a PCI Express x4 GigE frame grabber card that combines Power over Ethernet (PoE) technology and Gigabit Ethernet (GigE) camera interfaces to deliver high-speed image acquisition via an Ethernet link. The frame grabber has four independent Gigabit IEEE 802.3at compliant Ethernet ports. Each port supports up to 1000 Mbps bandwidth and is able to supply maximum 30 watts of power at 54 VDC to connected PoE-compatible devices, such as machine vision cameras. This Ethernet based frame grabber also features IEEE 1588 (precise time protocol) for synchronization with multi-camera acquisitions and supports jumbo frames up to 9.5KB, allowing cameras to stream large volumes of images back to the vision system.

With its IEEE 1588 and PoE functions, the frame grabber card can utilize a single Ethernet connection to power the camera, feed images and synchronize data, presenting an ideal option to simplify any system design for automated optical inspection (AOI), factory automation, PC-based surveillance systems and other vision-related applications.



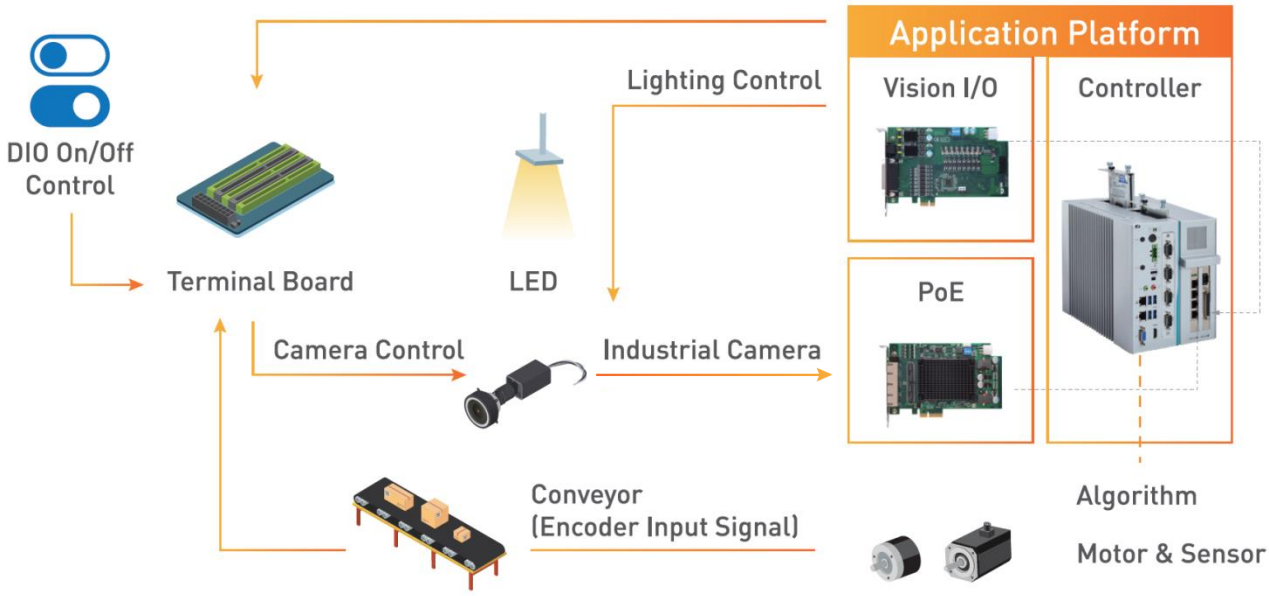
AX92320

4-port PCI Express GigE Frame Grabber Card

- PCI Express x4 compliant
- Four independent Gigabit Ethernet (GbE) LANs
- Supports 9.5KB Jumbo Frame and IEEE 1588
- Compliant with IEEE 802.3at to deliver 30W at 54 VDC per port
- Up to 20/120W PoE power from PCIe bus/6-pin ATX power connector
- PoE power management software
- Supports LAN port smart on/off
- 0°C to +60°C wide operating temperature range

Axiomtek's Machine Vision System Architecture

The figure below illustrates how Axiomtek's vision solutions facilitate the vision inspection system in a conveyor belt scenario:



1. The IPS960-511-PoE vision controller uses its vision I/O functions to manipulate the vision DIO (digital input/output) mechanism:
   a. The inspection sensor or motor encoder sends a trigger input signal to notify the controller of an incoming product that is passing through.
   b. The vision controller flashes the LED lighting and triggers the industrial camera to capture the image of the product.

2. The vision controller's GigE frame grabber converts the captured image into formatted data packets to be fed into system, so that the system can carry out real-time monitoring and analysis of the product.

3. The IPS960-511-PoE vision controller processes and analyzes the image using available vision software and algorithms.

4. Based on the image processing results, the vision system determines the object's pass/fail status and takes responsive action to either let the object pass or eject it from the line.

About Axiomtek Co., Ltd.

As one of the world's leading designers and manufacturers of PC-based industrial computer products, Axiomtek specializes in data acquisitions and control systems of rich diversity and modularization. With the upmost enthusiasm in serving their customers, Axiomtek has mirrored PC evolutions in various industries by shifting its focus toward the design and manufacture of PC-based industrial automation solutions, standing as a trustworthy long-term provider of industrial computers.

Established in 1990, Axiomtek has partnered with more than 60 distributors globally, offering more than 400 products through product lines of Industrial PCs (IPCs), Single Board Computers (SBCs), System on Modules (SoMs), Fanless and Rugged Embedded Systems (eBOX and rBOX), Intelligent Transportation Systems (tBOX and UST), Industrial IoT Gateway, Touch Panel Computers (TPCs), Medical Panel Computers (MPCs), Digital Signage Solutions (DSSs) and Network Appliances (NAs).

Axiomtek is a Member of the Intel IoT® Solutions Alliance. A global ecosystem of more than 800 industry leaders, the Alliance offers its Members unique access to Intel technology, expertise, and go-to-market support—accelerating deployment of best-in-class solutions.