WHITEPAPER

Edge Processing and Smart Devices for Industry 4.0

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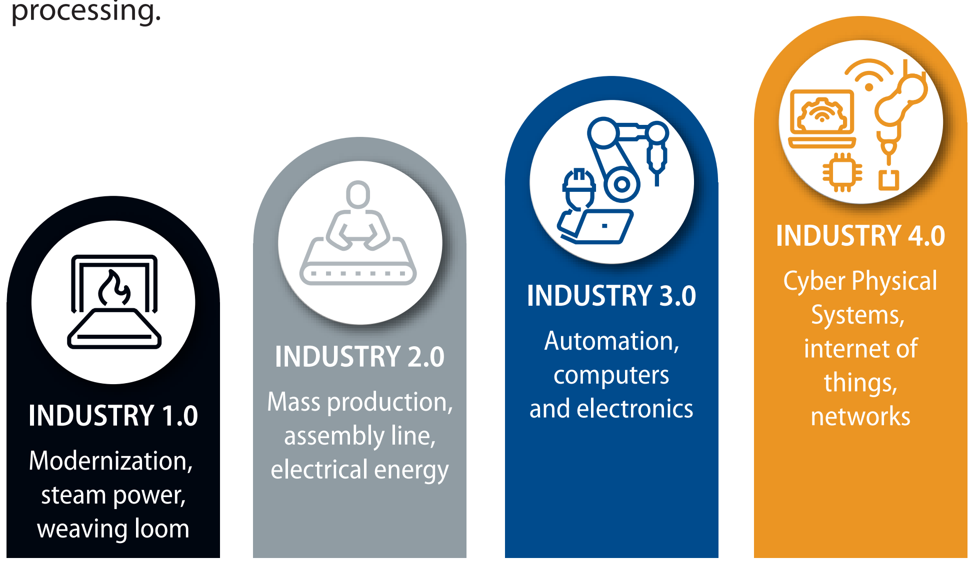
Embedded Vision

For vision inspection and industrial automation markets, advancements in sensor networking and processing capabilities and the introduction of machine learning artificial intelligence (AI) are contributing towards the progression of Internet of Things (IoT). Traditionally, real-time imaging relies on transmitting uncompressed data from a camera or sensor back to a central processor for analysis and decision making. This approach poses challenges for designers, particularly as higher bandwidth sensors create a transmission bottleneck and overburden processing capabilities. In addition, component size, weight, and cost are considerations when working towards the age of IoT.

Industry 4.0 and Internet of Things are one in the same, a term used to describe a variety of physical devices and objects that are interconnected and communicate with each other.

The evolution of smart sensors that perform processing and decision making at the edge of the inspection network have helped overcome these challenges. Smart devices receive and process data, make a decision, then send the data to other devices and local or cloud-based processing.



Edge processing and smart devices are key capabilities enabling the evolution to Industry 4.0

Local decision-making significantly reduces the amount of data required to be transmitted back to a central processor. This reduces bandwidth demands while also reserving centralized processing power for more complex analysis tasks. The compact devices also allow intelligence to be placed at various points within the network. With decision making at the edge, the system is capable of sharing real-time, high-bandwidth data, ultimately developing a more efficient, IoT ready, scalable system.

These devices can take the form of a smart frame grabber that integrates directly into an existing inspection network, or as a compact sensor and embedded processing board that bypasses a traditional camera.

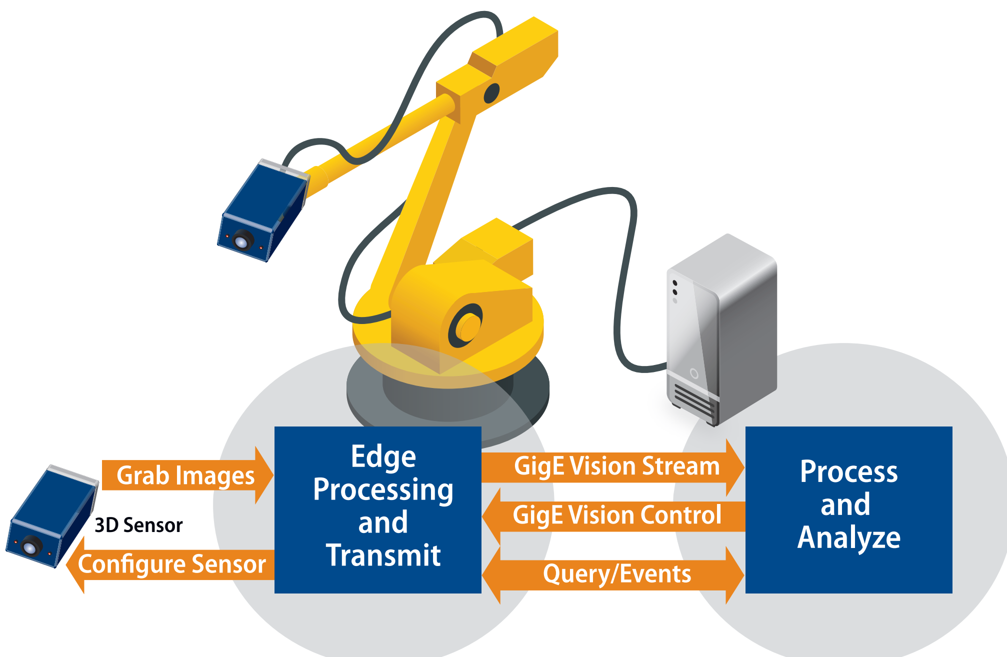
A smart external frame grabber, for example, can be integrated directly into a quality inspection line to receive data from an existing camera and make a decision. This provides an economical approach to implementing edge processing compared with upgrading expensive cameras and processing systems.

Embedded smart devices allow for more sophisticated processing at the sensor level. The key to this has been the introduction of lower cost, compact embedded boards with processing power required for real-time image analysis. Like the smart frame grabber, embedded imaging offers a straightforward path to integrating AI into vision applications. With the ability to share data between multiple smart devices, and with local and cloud-based processing, AI techniques can help train the computer model to identify objects, defects, and flaws while supporting a migration toward self-learning robotics systems.

Another cost efficient approach to incorporating edge processing into a network is through software. Novel software techniques are available that convert any imaging or data sensor into a GigE Vision device, ensuring that each sensor speaks a common language. This enables seamless device-to-device communication across the network and back to local or cloud processing.

In a 3D fringe inspection application, for example, a sensor on a robotic arm is used to identify surface defects and discontinuities during the manufacturing process. These 3D sensors are compact and low power, often part of a mobile inspection system, with no room for additional hardware. With a software approach, these devices can appear as "virtual GigE sensors" to create a seamlessly integrated network. Designers can convert image feeds from these sensors into GigE Vision in order to use traditional machine vision processing for analysis. Looking ahead, there is obvious value in fully integrating the output from all sensors within an application to provide a complete data set for analysis and eventually AI.

Machine learning is an application of artificial intelligence where the machine is learning tasks without rule-based instruction, rather it learns by study of algorithm and pattern recognition.



Software techniques enable the design of "virtual GigE Vision" sensors that can be networked to share data with other devices as well as local and cloud-based processing.

Adding AI Capabilities

While there is considerable interest in AI for vision inspection applications, deployment remains a significant hurdle due to a few key factors. Primarily, new capabilities must fit seamlessly within existing systems where there has been a significant investment in cameras and processing systems. Related to this, there are proven end-user processes that need to be maintained while adding new capabilities. Finally, there is concern that algorithm training is a long, complex, and costly process that requires outside expertise for many companies.

To help overcome these challenges, system designers and end-users can now leverage hardware solutions that provide a more evolutionary approach to AI by working with existing vision standard-compliant imaging sources and providing built-in machine learning capabilities.

With a "plug-in" approach to AI, end-users and integrators can deploy machine learning capabilities without any additional programming knowledge. Instead, images and data are uploaded to "no code" training software on a host PC, which automatically generates AI models that are deployed on the hardware solution in a production environment.

For example, in the pharmaceutical market, machine learning hyperspectral imaging can be used to detect subtle changes in the composition of active ingredients in visually identical pills to screen out-of-specification products. Traditionally, writing an algorithm for this process is labor intensive. With a plug-in approach, images and data are uploaded to "no code" training software on a host PC, which generates a neural network that is deployed onto the hardware platform. For more complex or custom inspection applications, designers can take advantage of the processing flexibility of the platform to train and deploy open source or custom algorithms.

Internet of Things and the Cloud

The cloud and access to a wider data set will play an important role in bringing IoT to the vision market. Traditionally production data has been limited to a facility. There is now an evolution towards cloud-based data analysis, where a wider data set from global facilities can be used to improve inspection processes as part of the first phase of Industry 4.0.

Instead of relying on rules-based programming, vision systems can be trained to make decisions using algorithms extracted from the collected data. With a scalable cloud-based approach to learning from new data sets, processing algorithms can be continually updated and improved to drive efficiency.

Providing this data is a first step towards machine learning, AI, and eventually deep learning for vision applications that leverage a deeper set of information to improve processing and analysis. Ideally, vision systems will have unlimited remote access to real-time data which can be used to continually refine intelligence. Beyond identifying objects, a vision system could program itself to predict and understand patterns, know what its next action should be, and to execute it.

While the concept of shared data is fundamentally new for the vision industry, it is the key to ensuring processes can be continually updated and improved in order to drive efficiencies as part of a machine learning IoT system.

Conclusion

Smart devices and edge processing are considerable assets to vision as it continues to progress towards Industry 4.0. Through these compact, lightweight, lower cost devices, alongside cloud-based processing, machine learning and AI capabilities are becoming more and more prominent in the industrial automation market.

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