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White Paper

Achieving more effective machine vision interfaces

With what scholars are calling the Fourth Industrial Revolution upon us, the manufacturing industry is steadily moving towards automation, incorporating artificial intelligence into production lines to improve efficiency and better leverage human skill. In this shifting landscape, machine vision has emerged as a key element in driving productivity over a variety of expanding applications.

Whether mounted on mobile or static platforms, machine vision can reduce operator intervention, obtain important quality metrics, identify defective product, scan inventory, identify emergency situations, and carry out many other tasks that promise to reduce downtime and waste while providing quality assurance. But as need for real-time machine intervention increases, the equipment required demands an increase in signal speed and reach.

A variety of new cables and connectors have appeared to meet this need for increased interface capability, offering different options for companies to balance greater reliability with budget constraints during a time of unprecedented labor shortages.

Demand for reliable connections

The unique requirements of each production line call for a variety of different interfaces to achieve optimal performance. Depending on the task, manufacturers might seek out an interface that can carry large amounts of high-resolution data, prioritize the flexibility to carry data from a moving platform (such as a camera mounted on a highly mobile robot arm), aim for reduced delays for machine vision performing real-time tasks, or plan to connect multiple cameras at once.

As operator presence is reduced and production becomes increasingly reliant on machines to identify waste points or downtime events, unreliable machine vision is a risk that factories simply cannot afford to take. Manufacturers seek equipment that is easy to maintain and provide high-quality, reliable performance. Among these requirements, bandwidth and length have always posed the greatest challenge, and cables and connectors that meet those standards can be expensive.

An expanding catalogue of options

Top among the machine vision key interfaces are four main types of connectors: Gigabit Ethernet (GigE) Vision®, Camera Link®, CoaXPress (CXP)® and USB3 Vision®. Each interface has advantages and disadvantages that make it well-suited for specific applications.

Gigabit Ethernet

Gigabit Ethernet (GigE) Vision® stands out for its ease of system integration, with a cable length exceeding 32 feet and a framework compatible with many different networks. Originally created to provide a framework for transmitting video and other control data over gigabit Ethernet networks, it has become an easy way to connect multiple cameras at low cost. However, it can have latency issues due to its reliance on network bandwidth limitations, which can critically affect tasks that require high-speed, real-time precision.

Camera Link

Camera Link was the first interface to be built with the specific application of machine vision. With the ability to transmit high-speed, high-resolution data, it's a favorite for line scan cameras where real-time data with low delay is required—although it comes with difficulties when it comes to price and cable lengths. A lack of reach and flexibility makes it very difficult to apply to mobile platforms, and high data capability significantly raises its price.

CoaXPress

CXP was created to respond to the need for very high-speed, high-resolution cables with extended reach. Its high throughput and multiple-camera support make it excellent for real-time applications, particularly in harsh industrial environments. But its cable length is not quite a match for GigE, and the more complex support equipment required to implement it results in higher overall expenses.

USB3 Vision

USB3 Vision is one of the most popular interfaces available due to its ease of application. With excellent compatibility and ease of system integration, as well as low cost, it allows for multi-camera configurations and high-speed, high-resolution data. These qualities make it an excellent choice for most industrial applications—but its length limitations often pose a barrier. A recent innovation by 3M has made greater length possible, lending new flexibility and connectivity to USB3 Vision applications, which can be easily implemented with the transmission system design methodology described in the second part of this white paper.

Reference: https://www.jai.com/machine-vision-interfaces/

Choosing the correct interface for the application

There are many factors to consider when deciding if an interface is right for a specific application. Vendors can assist in the selection process to determine what interface the network, inventory, and space available on site allow for—and what changes may have to be made to enable higher performance.

Table 1: Interface Choice Factors

	GigE Vision®	USB3 Vision®	Camera Link®	CoaXPress (CXP)®
Bandwidth	115 MB/s	400 MB/s	225MB/s (Base) 680 MB/s (Full)	600 MB/s (CXP6) 1.2GB/s (CXP12)
Cable length	100 m	10 m	8-10 m	10-35 m
Multiple camera connection	Good	Excellent	Fair	Fair
Standard PC architecture	Yes	Yes	No	No
Need additional hardware (Frame Grabber Board)	No	No	Yes	Yes
Realtime triggering	Poor	Fair	Excellent	Excellent
Easiness of system integration	High	High	Low	Low
System cost	Low	Low	High	High

The future of machine vision

With a quickly expanding machine vision market, it's not far-fetched to anticipate a swift increase in the availability of more effective interfaces. Improving factories' ability to manufacture products with less human intervention by increasing the reach of robotic systems and transmitting higher-quality data at greater speeds, will more than likely propel factory automation to new heights. Manufacturers who stay informed of the latest products for use in their applications will witness new industry milestones, adapting and thriving as automation transforms the future of production.

USB3 Vision® transmission system troubleshooting guide

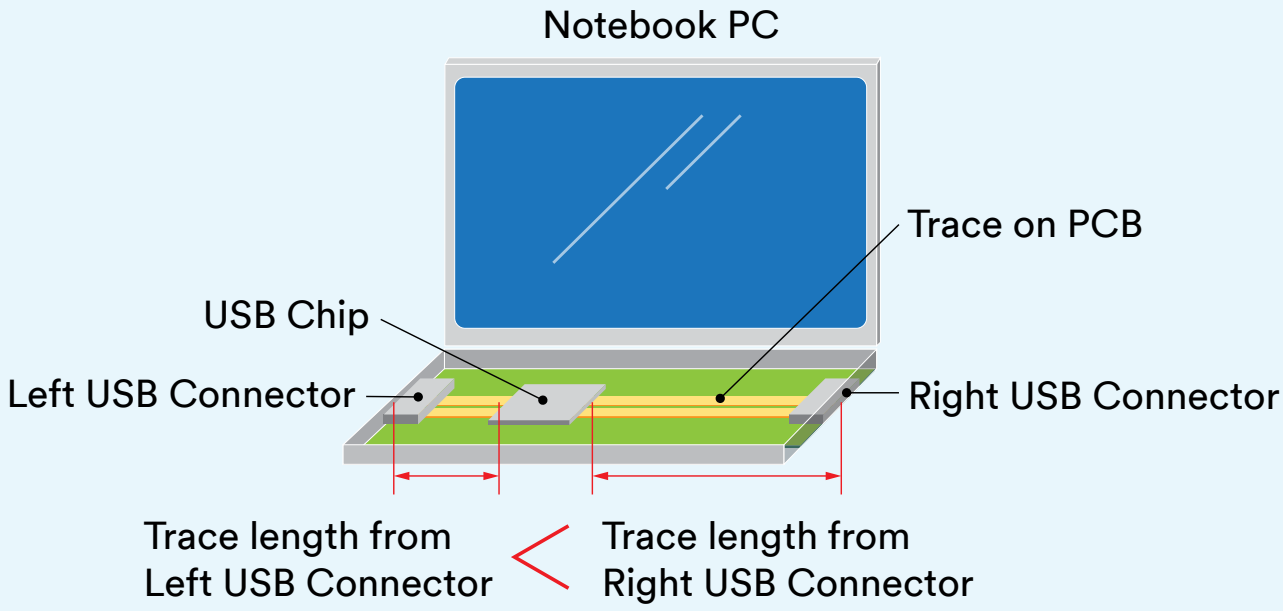
Manufacturers seeking to implement USB3 Vision into production will greatly benefit from the advantages offered by the 3M™ USB3 Vision Industrial Camera Cable Assembly series. Listed below are some common issues faced by USB3 Vision users, which could be avoidable now with help from this next-generation of 3M technology.

Unstable equipment: Most of the instability users experienced with USB3 Vision can be attributed to consumer-level USB accessories, which cannot withstand the rigors of intensive industrial applications. 3M products sidestep these obstacles and provide sturdy, reliable connections.

Inaccurate test runs: Many engineers choose to test equipment for functionality in the office, rather than in the industrial environment where the system will be installed. Cable functionality can change depending on the equipment it is connected to, so make sure to carry out tests in the intended environment to get an accurate picture of interface performance under actual circumstances.

Limited signal: Signal attenuation may limit the communication between the transceiver and receiver devices. In most cases, limited transmission distance means better signal. For example, a 12-meter 3M™ USB3 Vision Industrial Camera Cable Assembly, 1U30A Series with a USB3 Vision camera might work when connected to the USB port on the left side of a laptop, but not when connected to the right side. This is because the trace length from the left connector to the USB chip within the computer is shorter than the trace length from the connector on the right, so the attenuation is worse on the right side, limiting cable functionality.

Inadequate cable length: Cable length can be extended by using computers with high-quality USB chips and compatible cameras. Some cables, such as the 3M™ USB3 Vision Industrial Camera Cable Assembly, 1U30A or 1U30S Series , enable long distance transmission.



3M can assist manufacturers with actionable tips to help them get the most out of their USB3 Vision interface within their site constraints and help them avoid some common technical pitfalls. Achieving greater flexibility in USB3 Vision industrial applications—such as standalone or portable inspection systems, 3D-vision systems on robot arms, and microscopy—can mean the difference between innovation that drives productivity and helps avoid processing bottlenecks.

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