Introduction

Advancements in machine vision have augmented industrial automation and provided a platform to advance imaging-based automatic inspection and analysis applications. This technology, however, comes with its hardware challenges — cameras and their cabling must often fit into cramped spaces while being able to withstand constant strain. This article explains and explores three of the more popular machine vision standards: GigE Vision, USB3 Vision, and CoaXPress. The inherent constraints within these standards affect their implementation, from the lack of vendor diversity with CoaXPress to the limited cable length afforded by USB 3.0..

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GigE Vision Overview

Released by the Automated Imaging Association (AIA) in May 2006, GigE Vision allows for simple interfacing between a GigE Vision compliant device and a network card using standard Category 5 (CAT-5) Ethernet cable. This standard builds on the gigabit Ethernet communication protocol with two custom protocols: GigE Vision Control Protocol (GVCP) and GigE Vision Streaming Protocol (GVSP), which are specifically geared towards machine vision industrial cameras. The GVCP protocol is mainly utilized for camera configuration and connection while the GVSP protocol concerns the transfer of image data. Although the specification's name refers to gigabit Ethernet, it can be used for any speed grade, such as fast Ethernet. GigE Vision leverages the application programming interface (API): Generic Interface for Cameras(GeniCam). This firmware was developed by the European Machine Vision Association (EMVA) with the goal of providing a programming interface for all kinds of cameras and devices, despite vendor diversity. GeniCam also supports the USB3 Vision, CoaXPress, Camera Link HS, and Camera Link vision standards.

GigE Hardware Considerations

Cables and connectors in industrial automation applications are often mounted in and around robotic arms and various machinery in constant motion. The locking clips that come with standard RJ45 connectors are inadequate in these scenarios. They can often become dislodged, or unmated, from constant jostling and vibration. Vendors will often provide screw mounted hardware with the connector head in order to hold the mated connection, thereby limiting the costs of plant downtime. However, connector heads from different vendors may not mate properly due to proprietary designs of the screw interface.

GigE Hardware Considerations (cont)

This will likely be solved with the release of Version 2.1, where the connector design is specified..

USB3 Vision Overview

The USB3 Vision standard is built upon the USB 3.0 (Superspeed USB) specification with custom transport layers defined for the needs of machine vision. The Control Transport Layer and Event Transport Layer transfer asynchronous events from the device to the host PC. This differs from the USB 2.0 half-duplex polled traffic flow, as the receiver can simultaneously transmit data acknowledgements without interrupting the burst of data. Traditional USB 2.0 bus transaction protocols can leave a processor in idle for long periods of time while I/O operations complete, wasting precious bus bandwidth. The USB3 standard draws upon the GeniCam platform to provide a uniform programming interface. The standard also specifies the design of screw-down cable connectors (Micro-B, Standard-A, Standard-B, and Powered-B) to allow for the mating of components across vendors..

USB3 Hardware Considerations

The increased data rate offered by USB3 Vision comes with the caveat of cable length — while GigE vision cable runs can go as long as 100 meters without signal degradation, USB3 vision cables can only go up to 5 meters. If cable length is not an issue, then USB3 would be a natural alternative. While the power that can be sent to peripheral devices from the USB port has improved from 2.5W for USB 2.0 to 4.5 W for USB 3.0, it still may not be enough to power high performance, high resolution cameras. In this case, the camera is often powered with an external GPIO connector — more cabling to worry about in a dynamic environment..

CoaXPress (CXP) Overview

Released by the Japan Industrial Imaging Association (JIIA) in 2013, CoaXPress (CXP) is a high-speed imaging standard for point-to-point, serial communications with camera-to-host speeds (downlink) as high as 6.25 Gbps and host-to-camera speeds as high as 20 Mbps. Similar to the other standards (e.g. 10 GigE, USB 3.1/.2) there is a roadmap to 10 Gbps and 12.5 Gbps throughputs per cable. This protocol leverages commercial off-the-shelf (COTS) coaxial cables with a characteristic impedance of 75 ohms (e.g. RG11, RG6, RG59). These cables often use either BNC or DIN 1.0/2.3 connectors. CXP offers plug-and-play capabilities with built-in mechanisms for automatic link setup..

CXP Hardware Considerations

CXP really only supports point-to-point communications where multi-camera setups are enabled through link aggregation. Multi-destination support will, however, be introduced in the future with CXP v2.0, where a single camera can send data to frame grabbers in multiple PCs. There is not yet much vendor diversity available for CXP chipsets — essentially one CXP-enabled driver/equalizer manufacturer, EcqoLogic. However, MACOM is set to release a chipset that supports CXP v2.0 as soon as it is released. The CXP standard also utilizes IP cores, or FPGAs, for camera or frame grabber development. There are three providers of frame grabber CXP cores: Easii IC, Sensor to Image, and Kaya Instruments. There are also only three manufacturers of CXP cores for cameras: Demand Creation, Kaya Instruments, and Easii IC. The lack of vendor diversity for key components can make integration of this technology less accessible than with USB3 or GigE vision.