MULTI-CAMERA VISION SYSTEM WITH COAXPRESS

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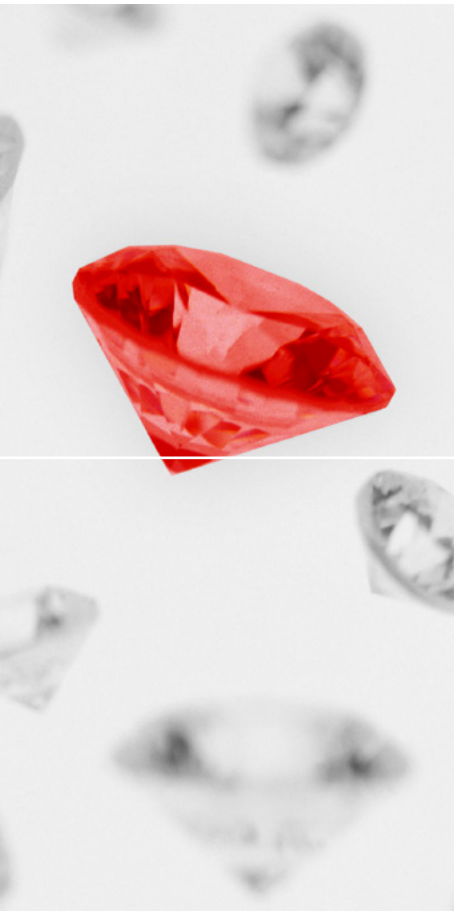
EXECUTIVE SUMMARY

A multiple camera (multi-camera) based vision system can provide a bigger field of view, faster throughput, greater detailed inspection or more measurement information, and possibly all combined for metrology and inspection equipment.

Faster throughput requirements can be satisfied with a single high-speed camera or the larger field of view (FOV) needs are met with a single ultra high-resolution (i.e. 25 Megapixels) camera depending on the system implementation. In certain circumstances, the necessary performance enhancements can be more efficiently achieved through a multiple camera vision system.

In this paper, we will explore some of the possibilities and compare the use of multiple CoaXPress cameras to those based on other interface standards, such as GigE Vision and USB3 Vision.



CoaXPress is a digital interface standard that allows the transmission of data from a device, for example a camera, to a host such as a frame grabber in a PC, at a high speed of up to 6.25Gbps over a single coax cable. CoaXPress (CXP) is an ideal interface for linking together data from several cameras since CoaXPress has the ability to carry many channels of image data and meta-data, which makes the interface easily scalable.

Because multiple cameras can be linked via a single frame grabber and long, low cost coaxial cables and with absolute synchronization, an accurate system can be created. For example, four (4) 8 Megapixel cameras at 16 fps each can be combined on a single frame grabber with a single cable per camera with power also over the cable greatly reducing the system complexity.

CoaXPress as an interface for multiple camera solutions in machine vision provides system builders the highest throughput improvement options. In addition, greater flexibility is available as different non-similar cameras with varying speeds can be connected with the same PC/frame grabber architecture without any constraints in cable lengths and with low cabling costs.

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MULTI-CAMERA VISION SYSTEM ARCHITECTURE CONFIGURATIONS

There are many application and system configuration possibilities with multi-camera systems. Perhaps you already use multiple cameras in your system, and you are looking for ways to make it better, faster, and cheaper. Or, perhaps you had not yet thought of what advantages a multiple camera system could offer. Here we provide a few ideas from our experience to get you thinking of the possibilities.

Get views from different angles for increased accuracy

For many different applications, accuracy can be increased when multiple angles of an object are obtained simultaneous. For example, with automated optical inspection (AOI) systems of PCB assemblies, multiple cameras give the ability to get a top view and a side view at the same moment. CoaXPress was developed with triggering in mind from the beginning. With multiple cameras on CoaXPress there is triggering on 4 channels at the same time. The cameras behave as a complete set with exact synchronization and control. The data gathered from the different video cameras occurs at precisely same moment. Because 10-bit data can be transferred at high speeds, there are also options for zooming in for more thorough analysis.

Increase throughput and field of view

Because of the precise triggering capabilities, multiple lower speed cameras can be used and act as one very high-speed camera to increase throughput. Or as another way (instead of using a higher resolution camera) to increase the field of view (FOV), depending on the system configuration and requirements. For example, if you are currently using a single camera at 60 fps, you can add a second camera to the system. The two cameras are focused on the same target, triggered at exactly the same time, with parallel processing to get 120 fps or increased FOV or both. Combining these cameras over CoaXPress can be a cost effective way to increase system performance as only one frame grabber is still required and the other critical system components stay the same, such as the lenses.

Combine inspection and metrology or alignment and measurement - mix CCD and CMOS cameras

Because different speed cameras or even CCD and CMOS cameras can be combined into one CoaXPress frame grabber, there are many different options to simplify the imaging system. For instance, you can mix 2 CCD cameras and 2 CMOS cameras, which may allow you to combine the inspection and measurement cameras. Or, you could combine a low-resolution camera for alignment and then say an Adimec QUARTZ Q-4A180/CXP-dual for measurement, etc. There are many options…

Moving measurement head

When the camera is mobile with respect to frame grabber (i.e. moving measurement head), long, flexible cables are advantageous. Often these systems use multiple cameras to capture more information with minimized stage motion. With CoaXPress, robotics cables can be used and the cabling is not space consuming. Because power to the camera can also be provided over the coax cable, the camera is connected to the PC and nothing else so no ground loops are required.

Multiple Lower Speed Cameras

Even if you are not using high-speed cameras, but you have multiple cameras, all of the data rates combined can be very high. CoaXPress allows for this to be done cost-effectively. As an added benefit because CoaXPress is scalable, there is room to grow should you want to move to higher performance cameras in the future.

UNLOADING THE COMPUTER RESOURCES WITH COAXPRESS

Minimal computer resources are required by multi-camera vision systems with CoaXPress, for example 4 4-megapixel cameras can run at 70 frames per second with less than 5% CPU load. Here are the details on how CoaXPress works and the different available options.

CoaXPress Background

CoaXPress was designed in the beginning of 2007 to overcome all of the limitations of Camera Link. The interface has many advantages in terms of bandwidth, infrastructure cost, ease of implementation, and scalability. With CoaXPress digital video, control, GPIO, triggering and power can be managed with just a single, flexible and cost- effective cable.

CoaXPress is a point-to-point serial interface connecting a camera to a frame grabber. The physical medium between the camera and the host is one (or more) 75 Ohm coaxial cables. Its use of coaxial cable enables automatic equalization of cable losses, which allows it to operate over greater distances. Thus, a fundamental benefit of CoaXPress is its ability to provide higher performance over longer distances than any other current or emerging standard.

As stated, the standard's use of coaxial as its connectivity medium offers many advantages over other media (e.g. twisted pair), in addition to inherent performance capabilities (CoaXPress offers up to 6.25 Gpbs over a single cable and is scalable to an unlimited number of cables). Coaxial cables are already in use in many legacy systems, including analog cameras that need to be upgraded to high-resolution digital cameras. There are hundreds of different coaxial cables to choose from, depending on the application: standard RG59/RG6 type, thin and flexible cable for moving cameras, higher quality cables for extra length or a noisy environment, etc.

In addition to cost-effectiveness, coaxial cables can be very long (CoaXPress supports transmission of up to 130 meters). Also, field installation of BNC connectors is easy

and efficient. Coaxial cables don't have skew problems that are common with cables that use differential and/or multiple wires.

Power over cable is another important consideration for systems developers. CoaXPress enables power-over-cable capable of most systems' needs (13W per cable), eliminating the need for separate power supplies.

Because GenICam™ (abbreviated for Generic Interface for Cameras) is part of the CoaXPress standard, the specific interface technology is decoupled from the user application programming interface (API). This allows for standard software development independent of the specific physical layer of the interface and the camera.

This standard also includes real-time trigger support, making it well suited for timing critical applications like fast area scan and line scan. CoaXPress opened up new applications for machine vision cameras, such as those over a slip ring or easy upgrades from large analog based systems, such as with intelligent traffic systems.

Version Description

There are several versions of CoaXPress to meet different needs. Table 1 below describes the different versions.

CoaXPress Version	Camera Link equivalant	Total Bit rate (Gbps)	Maximum cable length (meters)
CXP-1		1.25	up to 212
CXP-2		2.5	up to 185
CXP-3	Base	3.125	up to 169
CXP-6	Full	6.25	up to 102
CXP-3 Dual	Full	6.25	up to 169
CXP-6 Dual		12.5	up to 68
CXP-6 Quad		25	up to 68
CXP-6 N cables		N * 6.25	up to 68

Table 1. CoaXPress Versions

INTERFACE STANDARD COMPARISON

WHEN TO USE COAXPRESS FOR A MULTI-CAMERA VISION SYSTEM

GigE Vision and USB3 Vision are based on internet protocol standards and are networked interfaces. For multiple cameras on a network, each camera is addressable (through an IP address or an other unique identifier). While that may make these interface standards seem ideal for multiple camera machine vision systems, there are situations when CoaXPress has advantages. Camera Link is not ideal for multiple camera systems, but it is also compared in some cases as it has a long history of successful application in machine vision systems. All of the available interface standards are beneficial for particular system or application requirements, but here we are talking specifically about multiple camera systems. Some considerations when selecting and interface for a multi-camera system:

Consideration 1: need full bandwidth?

CoaXPress can transport the highest bit depth per pixel at high speed and long distances. Multiple camera systems over CoaXPress are scalable and have 25 Gbps of bandwidth available and not just the 6.125 Gbps per cable. This supports a wide variety of combinations of high-speed cameras, such as two 4 -Megapixel cameras at 180 fps each among many others.

GigE Vision and USB3 Vision are based on consumer standards where multiple devices share a connection. For example if there are 4 cameras in a system, the cameras share the interface so they either share the available bandwidth or only one uses the connection at a time. Multiple camera systems over Camera Link are limited to a total of 6 Gbps per frame grabber.

Consideration 2: limited cable space/need long cable length?

CoaXPress connectors are small (especially compared to Camera Link) and the cables are flexible. Available power on the cable further reduces the number of cables required.

Both CoaXPress and GigE Vision allow for longer cable lengths (40 meters and greater) compared to 5 meters and 10 meters for USB3 Vision and Camera Link, respectively. For

systems in a clean room, the longer cable lengths can enable the PC (and the dust from the fan) to be in a separate space. Or, for traffic cameras to be over the road with the main processing system at the side of the road or even further. For both of these applications, the precise triggering and greater bandwidth make CoaXPress a better fit. For multiple assembly lines, perhaps GigE Vision is preferable for connecting multiple cameras over long cable lengths.

Consideration 3: need to combine cameras with different speeds or image sensor technology?

As we discussed, multiple camera systems can involve combining cameras that perform different tasks in the system. This may be best achieved by using cameras of different speeds or utilizing different image sensor technology, such as one CCD camera and one CMOS camera. With CoaXPress, once the data gets to the frame grabber, the image sensor technology does not matter, different speeds are fine. This is not possible on GigE Vision or USB3 Vision.

Consideration 4: require tight timing/synchronizing?

Point-to-point interfaces, such as CoaXPress and Camera Link, are inherently deterministic and therefor the timing is guaranteed.

GigE Vision has unpredictable latency, as it is not a real-time protocol. There are some workarounds to triggering, but it is not as stable.

With both GigE Vision and USB3 Vision (non-deterministic) there can be a collision of data or dropping of packets- requiring resend. When adding nodes and sharing bandwidth, this potential for lost data increases.

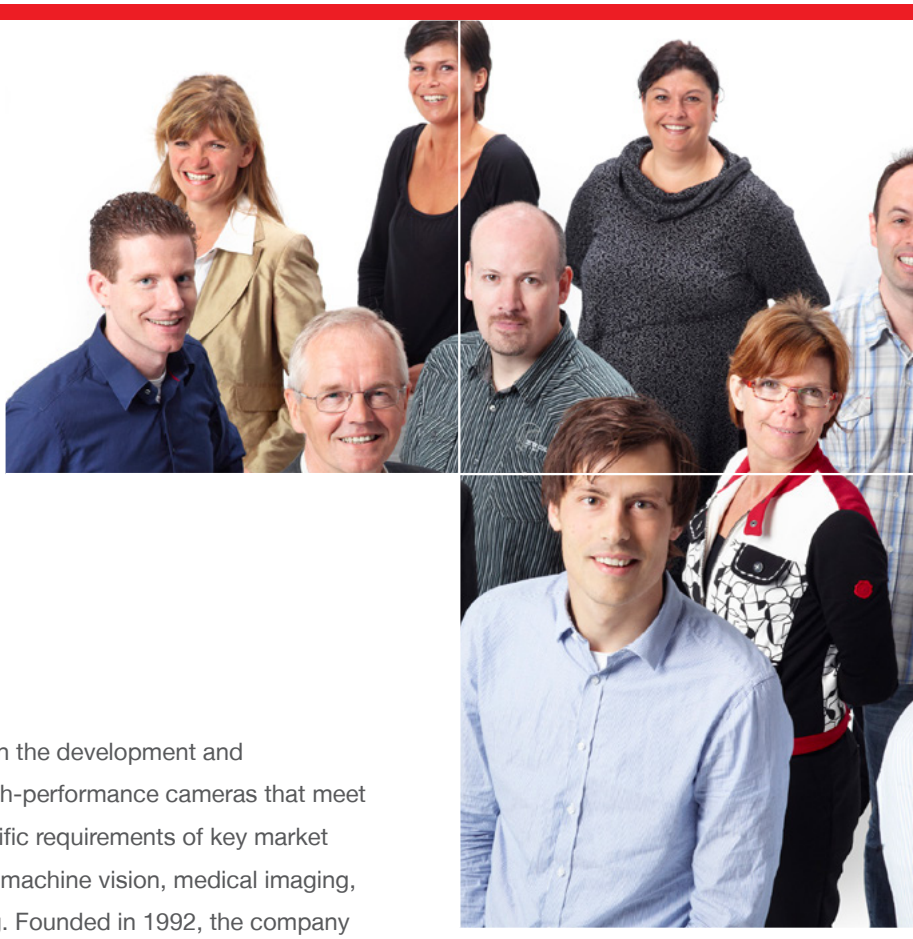
Consideration 5: want to simplify the system? Upgrading from analog?

Neither USB3 Vision no GigE Vision require a frame grabber so these appear to simplify the system design. This may be true with single camera, low-speed systems, but when multiple cameras are used, the load on the PC increases dramatically. A standard PC cannot be used in the case of USB3 Vision, and a network card is required for GigE vision, negating the cost and complexity savings.

CONCLUSION

If you have determined that a multi-camera vision system would increase the performance of your overall instrument, then CoaXPress may be the best interface to use if you have at least one of the following situations:

- You need to utilize the full bandwidth of the cameras
- You have limited cable space
- You need long cable lengths
- You want to combine cameras of different speeds
- You want to combine cameras with different image sensor technologies (CCD and CMOS)
- You have strict timing/synchronization requirements
- You want to upgrade from analog
- You want a system that does not overload the PC



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Adimec specializes in the development and manufacturing of high-performance cameras that meet the application-specific requirements of key market segments, including machine vision, medical imaging, and outdoor imaging. Founded in 1992, the company partners with major OEMs around the world to facilitate the creation of industry-leading cameras.

The unique Adimec True Accurate Imaging® technology provides new levels of precision and accuracy to vision systems. Its diverse line of camera products meet a wide range of performance, size, cost, interface and application requirements. Adimec has offices around the world focused on creating customer value and satisfaction through local, personalized support.

Need more inspiration? Contact us www.adimec.com

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