Camera Interfaces

This Tech Tip is designed to re-visit the camera interfaces and transmission standards available for vision systems. Since the last Tech tip on this subject, over four years ago, there have been a number of new developments.

CameraLink

CameraLink is a method of serialising parallel data that made it straightforward for manufacturers of digital cameras and framegrabbers to add a ChannelLink chip to existing LVDS devices to make them CameraLink devices. The CameraLink standard defines three levels of bandwidth:

- Base – which uses a single ChannelLink chip to give 225MB/s over a single cable
- Medium – which uses two chips to make 450MB/s over two cables
- Full – three ChannelLink chips giving upto 675MB/s over two cables

In addition to the image data the cables also carry serial data, CameraLink framegrabbers emulating a serial port on the PC in which they are installed. The cables themselves are somewhat bulky by modern standards and are terminated on both ends by an MDR26 connector. The original standard came out in 2000. In 2007 there were developments to create Mini-CameraLink using an SDR26 connector and also Power over CameraLink (PoCL).

The transmission distance is limited by the nominal 10m cable limit, although it is possible to extend this in some cases. Good quality cables and low pixel clock values can take this further (as far as 18m) but larger increases can be made with CEI's BitMaxx cables that add pre-emphasis and equalisation to give up to 25m for base CameraLink. Much longer distances can be achieved using either a repeater such as the Phrontier CLEVER or a fibre-optic converter such as the Phrontier PHOX, see Figure 1.

Figure 1 – from left to right: CEI BitMaxx extended length CL cables, Phrontier CLEVER CL repeater and Phrontier PHOX CL fibre converter

GigE Vision

The advent of Gigabit Ethernet-based cameras (1000BaseT) and then the GigEVision standard has allowed a revolution in the way machine vision cameras can be used, taking advantage of network topologies and cable lengths. Ethernet allows 90m between links – where a link is a switch, for example. Network topologies allow many cameras into one PC in a way that quickly becomes impractical for a framegrabber-based system. Also it is possible to multi-cast data from a camera, so instead of being a single point to single point connection, one camera can serve data to multiple PCs, see Figure 2. A major advantage to the use of ethernet cameras is the capability to re-send data that is lost in transmission.

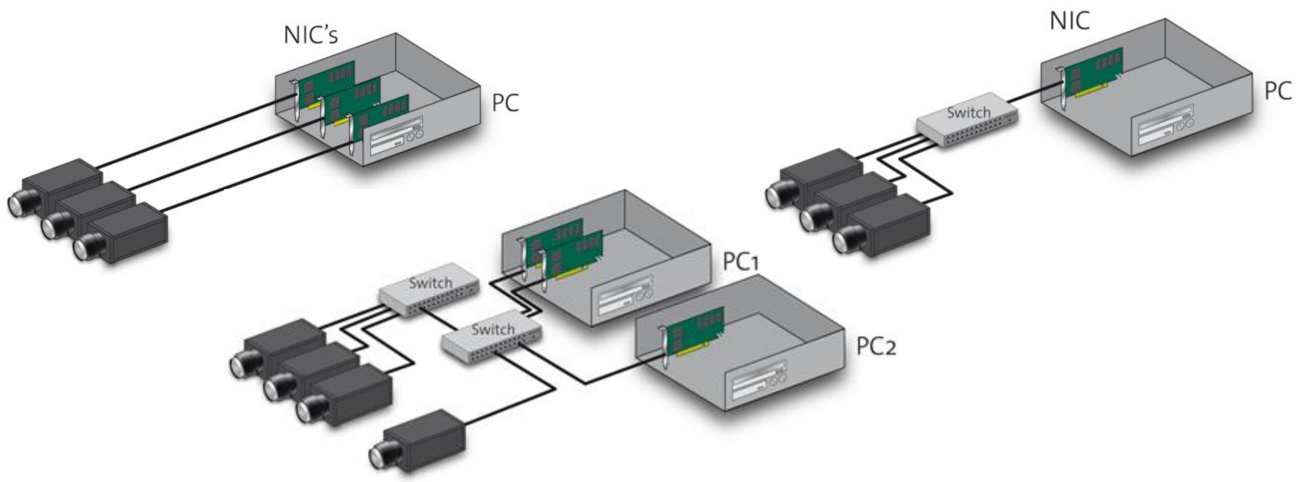

Figure 2 – different network topologies for cameras and PCs. The best arrangement requires consideration of the bandwidth requirements.

The restriction for GigE is bandwidth. The DALSA Genie HM models make full use of GigE, for example 640x480 pixels, 8bits per pixel at around 300frames/second. But with colour, high resolution or multiple cameras it is easy to run out of bandwidth on a single network interface. While 10GigE is beginning to arrive, it is expensive and not yet widespread. However, the concept of Link Aggregation Groups (LAG, also known as teaming) where GigE links are combined into a larger logical link made up of multiple links. The AVT GX range make use of this to allow high resolution and high bit-depth images without sacrificing frame-rate, see Figure 3.

Figure 3 – Teledyne DALSA Genie HM high-speed GigE Vision camera and AVT GX using dual ethernet ports

The GigE Vision standard builds on the Genicam standard, which requires cameras to describe themselves with an xml file. This seemingly simple point means that camera configuration files are no longer needed as the camera can describe its parameters (such as image size, format and so on). It also means that the camera can let a system know its capabilities such as allowable shutter times, gain values etc. The standard describes some standard features but allows for extensions so that any feature can be covered by the standard purely by including it in the camera's xml file.

New Technologies

Although CameraLink is a high-throughput standard, there are still devices that output more data than can be supported by CameraLink Full's 675Mb/s. Some cameras and framegrabbers have used the so-called CameraLink Full 10tap mode to extend the CameraLink standard slightly, for example the Silicon Software microEnable IV AD4-CL grabber with on-board FPGA for processing.

CameraLink HS is close to a specification release and extends the capabilities of CameraLink with more bandwidth, longer and simpler cables. The bandwidth scales between 300Mb/s (between CL Base and Full) and 6Gb/s (around nine times the bandwidth of CameraLink Full). In addition it incorporates Genicam to allow self-describing cameras.

A competitive standard is CoaXpress using coaxial cables to allow 100m cable lengths and upto 6.25Gb/s bandwidth

The advent of USB 3.0 as a consumer interface has also allowed greater bandwidth to be exploited. USB 3.0 is ten times faster than USB 2.0, giving up to 5 Gb/s, can provide more power over the bus but is likely to be highly cable-length dependent.

Figure 4 – Silicon Software microEnable IV AD4-CL framegrabber with user-programmable FPGA with CameraLink Full 10 tap support (left) and IDS uEye CP USB 3.0 cameras (right)

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	Firewire b IEEE1394b	USB2.0	CameraLink	GigE Vision	LAG	CoaXpress	HSLink/ CameralinkHS	USB 3.0
Bandwidth (Mb/s)	800	480	Base: 2040 Med: 4080 Full: 5440	1000	2000	6250 x1 25000 x4	300-6000	4800
Distance (m)	4.5	5	10	90+	90+	100	15-40	3
Camera plug and play	Yes	No	No	Yes	Yes	TBD	Yes	No

Table 1 – comparison of transmission protocols

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