Take away

Mobile image processing with USB2

When Firewire and USB2 image processing systems came onto the market for the first time, there have been questions about their efficiency in „machine vision“ applications. The wish to get easily configurable systems with well-known interfaces along with the promise of reasonably priced components rapidly increases the attraction of these solutions. Which general ability have these solutions which are offered as a „low cost“ variant or as an alternative positioned below CameraLink?

Fig. 1: Integration plate microUSB2

Fig. 2: Mobile frame grabber microUSB2 CAMextension

Just like Firewire, USB2 isn‘t a generic development of the industrial image processing. The main feature is obviously that it is digitally, reasonably priced and mostly available in every computer. It is the „give away“ of the mainboard manufacturers which promises an immediate use in a wide range of applications.

USB2 is specified at a maximum data transfer rate of 480 Mbit/sec. or 60 Mbyte/ sec. This transfer rate is already sufficient in most applications with megapixel cameras and moderate frame rates or in applications with arrays of low-resolution cameras. However in practice, there are frequently problems when applications shall be ported to Firewire or USB2.

Behind the mirrors - the technology

For data transmission over USB2 two different modes were officially specified, bulk transfer and isochronous transfer. These transfer modes differ strongly with respect to their implementation of data integrity, sustained bandwidth, latency and therefore by their potential applications.

Bulk transfer was designed for high security in the data transmission. It contains a flow control which generally allows to interrupt the data transmission. A data transmitter can be stopped if the acquisition is too fast for the data receiver. Data packets aren‘t lost by appropriate data control and by an eventual subsequent new request of the packets. As a disadvantage, data packets may not arrive „in time” if a data delay occurs. In terms of performance, this mode is suitable if only an average transfer rate must be achieved.

Contrary, the isochronous transfer cannot be stopped. His architecture is very simple and efficient, doesn‘t need a cache memory and is optimized to very short latencies. In case of a possible data loss it always prefers the current data packet as the most significant one. The isochronous data transfer is well suited for very high and constant data rates.

This mode is implemented in every USB2 chip besides the bulk transfer, but is, however, hardly used. The reason lies in a necessary error correction for most peripheral devices.

The standard drivers generally consist of three driver levels: a port driver, a USB driver and a manufacturer specific driver. This driver model consumes computing time for the data transfer and therefore loads the CPU with data control tasks. In consequence, there is an increasing danger to lose data packets if the CPU cannot process the data. Nevertheless, these driver properties are taken into account by manufacturers for compatibility reasons to common operating systems and peripherals.

In general there are similar problems with external interfaces, whether it is Firewire, USB2 or also Gigabit Ethernet, concerning peripherals. At higher transfer rates the CPU load rises strongly, additional processing of data is restricted and short latencies can’t be guaranteed.

Back to start again !

Basis of the microUSB2 frame grabber from Silicon Software for machine vision applications was the development of a high speed driver featuring isochronous data transfer. At the present, a

complete support of all transfer settings exists only in the Intel chip sets ICH4 and ICH5 which are integrated in current mainboards. In the meantime, further manufacturers also have engaged themselves on this standard. A special high performance controller which also supports this data transfer mode was used for microUSB2. This combination guarantees a data transfer of 48 Mbyte/sec.

Besides the transfer rate, the actual CPU load is an important characteristics, eventually limiting additional image processing and analysis. By reducing a three-levelled driver model to a single-levelled one, the driver overhead was substantially lowered. Only the manufacturer dependent driver is used as a link between the operating system and the hardware.

The usage of the DMA channels relieve even more resources, since they are applied by the Silicon Software driver for hardware-driven data transfer. Unlike CPU peak loads of approx. 85% at 24 Mbyte/sec., when using drivers of a standard operating system, the load of the CPU approx. 2-3 % despite transfer performance of 48 Mbyte/sec. In our one-level approach!

The relief was further increased by the integration of a FPGA image processor, which takes over additional image preprocessing tasks. Thus, the USB2 frame grabber can also be used for advanced machine vision applications such as a Bayer pattern interpolation for the colour representation or colour space conversion, combined with colour correction. These calculations are performed in real time at full data transfer rate.

But it is only by the provision of a working environment for the image processing user, e.g. configuration software, SDK libraries, support of all formats, resolutions and a professional memory management, that a product is applicable in machine vision.

All-in-one

The company Photonfocus AG has integrated the USB2 interface into its camera series. For its realisation the hard- and software solution was licensed from Silicon Software. The complete integration plate microUSB2 was shrinked to camera size. Hereby, Photonfocus achieved complete compatibility with the external USB2 frame grabber module. Besides the standard processes of image acquisition and conversion, the camera is able to load and use preprocessing algorithms, e.g. a Bayer pattern interpolation or customized adaptions. The custom-designed programming is loaded directly into the FPGA of the camera via the USB2 connection, is immediately operational and works in realtime. By this preprocessing feature, the Photonfocus USB2 camera series turn to intelligent cameras.

Fig. 3: Photonfocus Kamera with USB2 interface

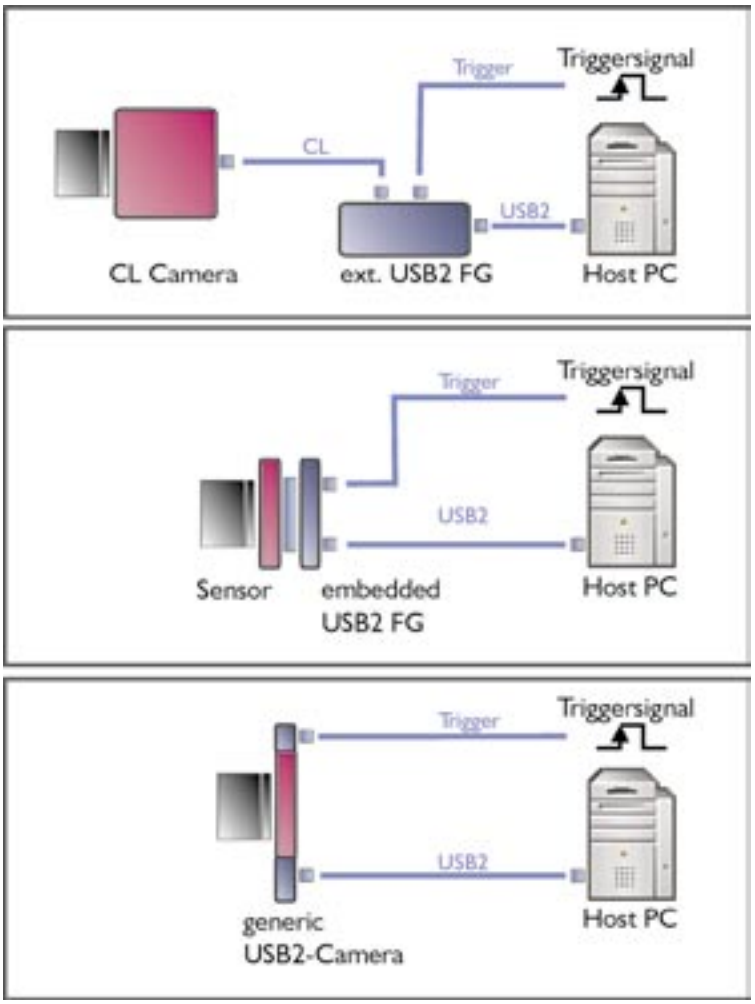

Fig. 4: System and camera integration of an USB2 interface

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