

GigabitEthernet

or The Return of Frame Grabbers

The transition from analog to digital camera technology was already forecasted long years ago. But only the availability of cameras based on affordable digital standard interfaces caused a perceptible change. USB2, Firewire and Gigabit-Ethernet as PC standard interfaces competed with different strengths and weaknesses and found their specific markets hereby.



With the use of that kind of interfaces, the frame grabber functionality was shifted into the camera and thus remains invisible as a stand alone component. But hereby cameras require drivers and API/SDK as interface to applications. Digital standard cameras developed from a former analog application focus to demanding applications by the integration of faster sensors. Today's cameras achieve the practical performance limits of their interfaces. Meanwhile successive specifications for higher bandwidths are released for all interface technologies.

Growth

GigabitEthernet meets an above average growth in the range of industrial cameras now. This industrial technology is not only the most established one but also the most predictable one

for future perspectives. Adaptations to requirements in Machine Vision were made, but there are general technological barriers, which prevent GigabitEthernet from a universal usage, compared to other standards like CameraLink. The use of dedicated network interface cards (NIC) eases the integration in lots of applications, but can't offer necessary or even specialized functionality.

Growth Barriers

GigabitEthernet uses a packet-based transfer protocol, which is processed on the host CPU. Each transferred packet releases an interrupt. One packet consists of meta information and payload: the image data. For a better relation between the static meta information and the payload, the packet size can be enhanced to a so called "jumbo packet size".

It lowers the protocol overhead percentage, but increases the latency and the probability of a transmission error. Summarizing, GigabitEthernet can be used as non-deterministic transfer technology with known problems of low protocol efficiency, a probable loss of data packets, a significant load of the host CPU, latencies by driver implementation, and jitters by packet sizes. Besides the load of the host CPU by the interrupt handling of the data transmission, the incoming data packets have to be rebuilt to an image and converted into a suitable image format for the subsequent image processing. In most cases, it is necessary to pre-process the images by certain image enhancements, sensor or shading corrections, and color reconstruction or color space conversion. Only hereafter the images can be sent to the according image processing

software for a content analysis. Problems of that kind are even more evident in multi camera systems. The computer is mainly involved in the administration of data transmission but in the processing of transferred images. The CPU load for the pure image acquisition task can increase to more than 20 % in a four-camera system. However, with the use of a specialized GigabitEthernet frame grabber like the microEnable IV-GigE, the load can decrease again to 2-3 %. The frame grabber works as an interconnected buffer system, which re-builds complete images from data packets. The host computer will process only one interrupt per image afterwards.

Advantage Multiplex

A further advantage is the possibility of a multiplexed image acquisition. GigabitEthernet allows a less expensive setup of a distributed camera infrastructure by use of switches. Many applications integrate numerous cameras, which are infrequently activated at the same time. Four physical camera ports are available for the image acquisition. The frame grabber assigns data packets from the according cameras, reconstructs the images and transfers them to the host PC. That is organized by virtual

With microEnable IV-GigE, Silicon Software offers a PCIe based image acquisition and processing solution



camera ports and DMA channels. In the final completion, microEnable IV-GigE will support up to eight cameras per port. Hereby the board will individually control up to 32 cameras. The limitation of the image acquisition bandwidth will remain at more than 100 Mbytes/sec. per port.

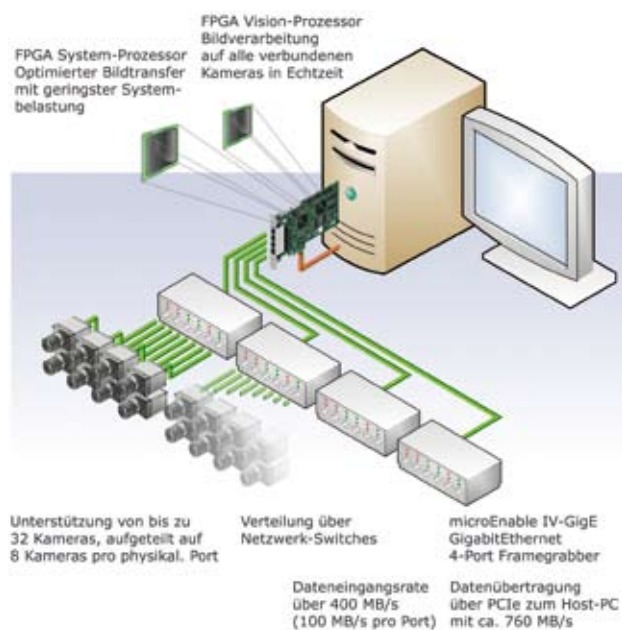
GigE Grabber

The GigabitEthernet frame grabber is identified in the PC system as an image processing component. Hereby the hardware is integrated in a new system with minimal effort and the image processing software can be used immediately. The system's network stack is not replaced and thus problems with existing drivers are prevented. The user receives a SDK, which is

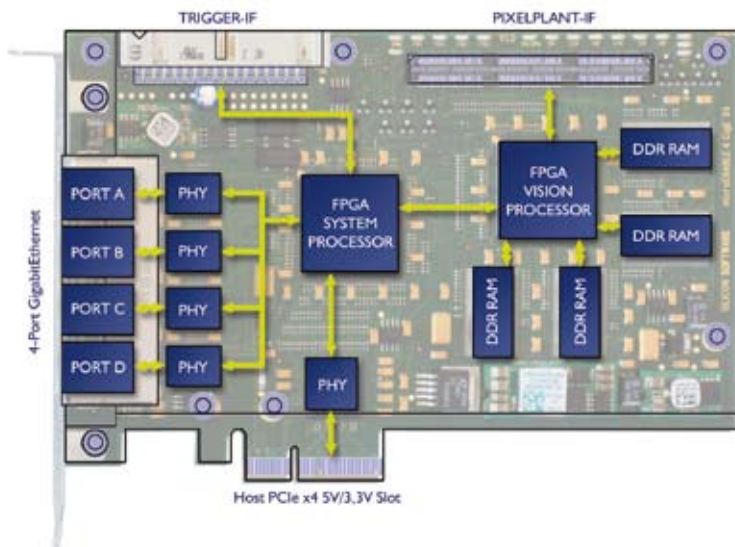
focused on Machine Vision experts by the scope of functions. Moreover the SDK for CameraLink and GigabitEthernet camera systems is approximate. The programmer will continue working with the same mechanism and convenience. Existing applications have to be only marginally adapted to the new camera interface. Moreover a user can choose between the Silicon Software SDK and the Gen<i>Cam programming interface for GigabitEthernet applications.

Real-time Functionality on Top

With microEnable IV-GigE, Silicon Software offers a PCIe based image acquisition and processing solution. The board is equipped with four GigabitEthernet camera ports, 512 Mbytes DDR-RAM on-board and two FPGAs as system processor and vision processor. An additional IO interface allows the control of cameras, external peripherals and general signal sources like encoders and strobes. The board achieves a practical data transfer rate to the host PC of 760 Mbytes/sec by a quad lane PCIe interface (PCIe x4). The input rate per port is limited to 1000 GBit/sec or more than 100 Mbytes/sec in practice by the GigabitEthernet technology. Hereby a total input bandwidth of 400 Mbytes/sec. can be achieved. microEnable IV-GigE is technologically based



Multiplexed image acquisition from cameras with microEnable IV-GigE



Schematic block diagram of microEnable IV-GigE

on the microEnable IV frame grabber series and profits from the advantage of a comprehensive operation system support for Windows and Linux as well as for 32bit and 64bit systems. The GigabitEthernet frame grabber is GigE-Vision and Gen<i>Cam compatible and thereby supports all compatible cameras. microEnable IV-GigE offers the basic functionality of an image acquisition frame grabber and additionally special operation modes and processing functions. The image processing functions can be implemented by the graphical FPGA programming software

VisualApplets and are processed on the vision processor in real-time. The advantage to realize customized image pre-processing on each camera, which is connected to the frame grabber, is an additional benefit, which was formerly reserved exclusively to users of vision processor boards for CameraLink or LVDS. GigabitEthernet is a modern technology, which requires an examination of its weaknesses, but also offers a high potential for new solution approaches.

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