Low Latency Video Processing System based on FPGA and DSP

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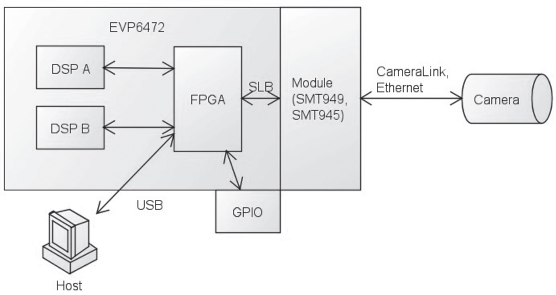
Cameras are widely used in today’s health care. They showed up first in clinics in 1896 with the first clinical x-ray, and have nowadays established their position in the daily business with countless computer tomography devices, video endoscopes and various documentary applications. The number of publications related to “medical imaging” has increased four-fold in the last 30 years.

With diversity comes divergence. The choice of a modern digital camera means, besides sensor and optics, choosing an interface. Firewire (1394), USB 2.0 or 3.0, Gigabit Ethernet or Camera Link are just the available physical connections to a camera, not taking into account the built-on protocols. Having chosen one type of camera in the past, the threshold is raised to go for another type in the future, it would require, amongst others, additional cables, computer interface cards and software.

Materials and Methods

An abstraction layer is provided between the image processing algorithm and the camera access. A Field Programmable Gate Array (FPGA) is capable of reading data from cameras with different interfaces and provides it to two Digital Signal Processors (DSP) for further processing. In addition, three general purpose input/output ports are available; two of them might be used as analogue outputs. This is all combined in an embedded platform.

Two use cases have been defined as guide lines for the development. These are a high-speed low-cost Optical Coherence Tomography (OCT) device and a general purpose Gigabit Ethernet camera.



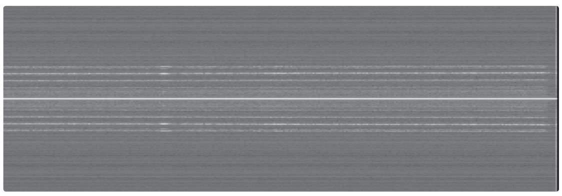
The system overview shows the main components. The FPGA acts as a pivot and manages different interfaces.

Results

Line rates of up to 40.193kAscans/s have been obtained for the OCT device; this is 98.94% of the available internal transmission bandwidth. The latencies vary from 25µs for integration times t_{int} smaller than 40µs to 96µs for t_{int} larger than 80µs. Ethernet frame latencies are 280µs, therefore the quota of frame size and exposure time is much more considerable regarding frame rates.

Discussion

The OCT application, to which this thesis contributed, has well evolved. The results of first tests with the whole system are comparable to the existing devices. Further development should improve the delivery optics and the transmission speed of the processed data to a host computer. The Ethernet camera control is less advanced. The proof of concept for very small frames has been done; but the transmission of larger images breaks down for a yet unknown reason. An architectural decision has to be taken prior to further development.



OCT Bscan of a glass plate with scotch tape layers on top. The three layers are clearly distinguishable.

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