Fast windowing

Fast configuration as solution for fast moving and individual ROIs

The two companies Photonfocus AG and Silicon Software GmbH developed a joint solution to support the acquisition of very fast image sequences with varying system configurations in subsequent frames. On the basis of a fast, high resolution CMOS camera and an intelligent FPGA-framegrabber, regions of interest (ROI´s) can dynamically be defined with respect to size and position; exposure time as well as the sensitivity can be adjusted within each ROI independently. The ultra-high ROI-frequency of 100 KHz in combination with the arbitrary definition of system parameters within each window makes this approach applicable to a broad range of high demanding image processing tasks.

In quality control applications it is often necessary to grab different windows - containing the object(s) to analyze - within the frame at high speed. To make this task even more difficult, usually these regions are subject to varying illumination.
The conventional solution comprises of a relatively high number of low resolution cameras, low-cost multi-channel framegrabbers and standard PC´s. The advantage of such a complex configuration lies in its possibility to individually parametrize the various components; of disadvantage is the high risk of failure due the large number of parts and the problems to control the production process.
Apart from that, tracking, i.e. the acquisition of fast moving objects by means of successive dislocation of (small) ROI´s is another task of industrial image processing.

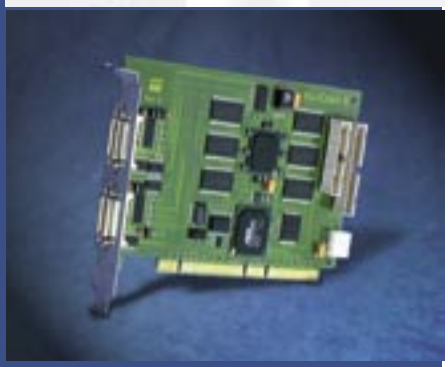

Fig. 1: Components of the systems solution: camera MV-D1024-80CL from Photonfocus, Framegrabber microEnable III from Silicon Software

ROI and CMOS Cameras

Up to now, these requirements could not be solved by using a system of one single camera plus one framegrabber. The limiting factors lie in the conventional CCD-technology and the grabbing tools adapted to it.
CCD image sensors only allow for a very restricted selection of an arbitrary window. It is just by the advent of CMOS sensors and cameras that freely defined ROI´s are possible, without a loss of the pixel transfer rate. Prerequisite for the latter feature is an appropriate architecture of the sensor-read-out electronics, which makes sure that the image date rate is not reduced when applying different system parameters to the multiple ROI´s.

The acquisition of dynamic windows differing in size and position is very demanding for the framegrabbers`(hard- and software-) possibilities in terms of synchronisation and parametrization of the camera.
At present, systems architectures are not yet designed for a rapid communication between camera and framegrabber to define acquisition parameters. The CameraLink™ standard, e.g., allows for a fast transfer of image data from the camera to the grabber, to control the camera, however, a small bandwidth interface analogue to RS-232 is used.

Fast Configuration as a Systems Solution

To overcome this hurdle, Photonfocus AG (Lachen, Switzerland) and Silicon Software GmbH (Mannheim, Germany) jointly developed an appropriate systems solution. Photonfocus specialises in CMOS sensors and cameras for applications requiring fast image data transfer and high dynamics. Silicon Software´s focus lies in the development of reconfigurable framegrabbers on the basis of FPGA processors, supporting image pre-processing tasks. The grabbers run under Microsoft Windows™, but also under real time operating systems like QNX6.x or Linux.
The foundation of the Fast Configuration systems solution were the high-speed camera MV-D1024-80CL comprising a CMOS sensor featuring the LinLog™ technology, in combination with the programmable framegrabber microEnable III with FPGA coprocessor (Fig 1).

Fast Configuration is based on the CameraLink™ standard, since it realises a fast image data transfer. In addition to

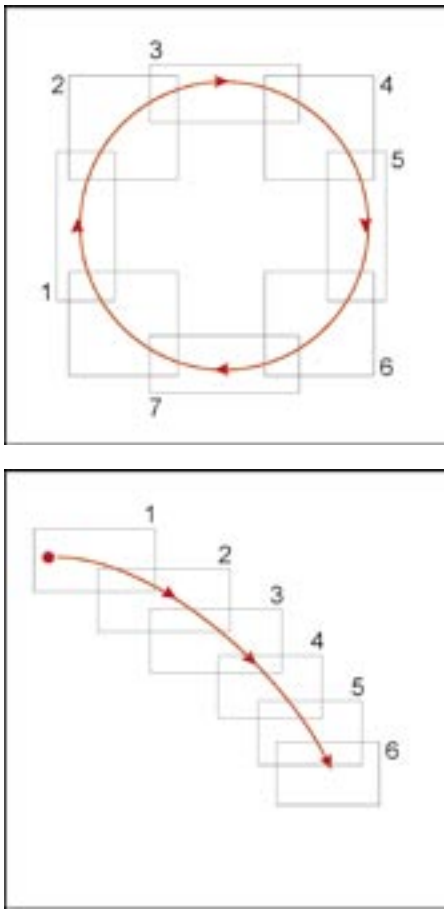

Fig. 2: Arrangement of ROI´s on the sensor to grab a circular path (left), sequence of ROI`s for fast tracking (right)

this standard, a fast communication interface to configure the CMOS camera was implemented.

Hand in Hand

Presently, only CMOS technology gives the possibility to read out arbitrary regions of the image sensor at high rates and to display them with sufficient dynamics. For the implementation of Fast Configuration, the model MV-D1024-80CL was equipped with a high speed interface, especially designed to properly parametrize the camera.
This generalized solution allows for an arbitrary number of ROI´s, also their size and position can freely be defined. Overlap of the windows is possible (Fig. 2).

The systems parameters of each window may be independently defined, and can be modified dynamically from frame to frame: besides the values for exposure, dynamics and frame rate, also the parameter settings for the LinLog™ technology (linear-logarithmic sensitivity) are up to the user.
In this systems configuration, the framegrabber takes the control over the camera. It manages (hardware driven) the parameter settings, the coordinates of the ROI´s and the mapping of frame and window numbers. Given this, it is for example possible to grab a circular path (Fig. 2). Additional image pre-processing operations can either be applied to the full frame or individually to single ROI´s; they are transferred like the parameters for the image properties. It is only the capacity of the FPGA coprocessor which limits the number of different pre-processing algorithms.

Ping-Pong with 100 kHz

The biggest challenge laid in the limited communication speed of the CameraLink™ standard; a higher transfer rate between the components had to be achieved.
Thus, in order to realize a sufficient bandwidth for the information exchange and the control of the camera, the communication speed was increased to 50 Mega-baud (50 Mbit/sec). An average amount of data of 500 bit per parameter set then results in a transfer of 100.000 sets per second. As a result, for example 100 ROI´s with a rate of 1000 frames/sec can be controlled. Since camera as well as framegrabber can cope with this transfer rate, both components are still to 100% compatible with the CameraLink™ standard. The synchronisation is simplified by using one camera and one grabber, but each component of the system can be individually configured.
The camera´s parameter are delivered at the beginning of the image data transfer. Briefly prior to the integration of the new image these parameters are activated for the image acquisition (Fig. 3).

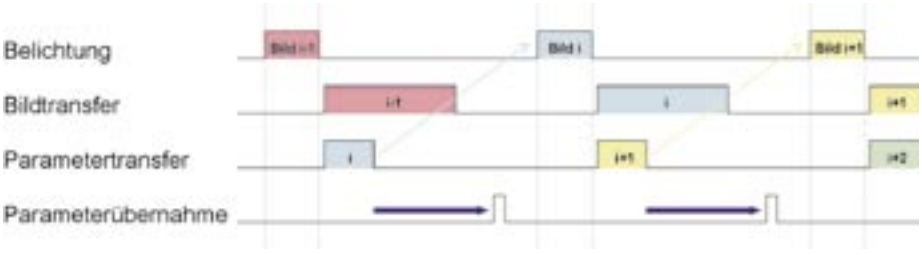

Fig. 3: Parameter transfer for subsequent images (… i-1, i, i+1 …)

A Pilotproject

In the framework of a pilot project of the company TRUMPF, worldwide reknown for its laser technology, independent processes during the laser welding procedure are acquired and analysed. The 1000/sec frame rate and continuously changing exposure- and dynamic- settings make Fast Configuration the ultimate solution for this application.

The components presented are available from Q2/2004 on and are delivered by the manufacturers or their distributors, respectively.

THE AUTHORS

SILICONSOFTWARE

Dr. Klaus-Henning Noffz
Executive manager
SILICON**SOFTWARE** GmbH
Schildkroetstrasse 17
D-68199 Mannheim
Tel.: +49 (0) 621 – 789 507 0
Fax: +49 (0) 621 – 789 507 10
info@silicon-software.de
www.silicon-software.de

photon focus

Dr. Peter Mario Schwider
CTO Photonfocus AG
Bahnhofplatz 10
CH-8853 Lachen
Tel.: +41 (0) 55 451 00 00
Fax: +41 (0) 55 451 00 01
info@photonfocus.com
www.photonfocus.com