Optical 3D Measurement by Laser Triangulation Method

Machine Vision in Online Production Processes: High Requirement on Robustness and Speed

The measurement technology of today has achieved accuracy and processing performance which allows an integration of acquisition and analysis in online production processes. For this purpose non-contact methods are almost solely used with need of high requirement on robustness and speed.

When realizing an optical 3D measurement application by laser triangulation method, the spatial and temporal resolution of the sensor is mainly dependent of the measurement accuracy. The availability of high speed cameras is one of the most important requirements for most of the applications. Machine Vision has reached the limits of its specification for available sensors. Future standards like CoaXPress, Camera Link HS and 10GigE will extend the performance bandwidth significantly and allow new application fields. For the transition period, creativity is needed to offer new speed classes even today.

High Speed Camera: Double Bandwith

For the new camera CMC-4000, VDS Vosskühler (an affiliate of Allied Vision Technology AG since 1.1.2011) has decided for an implementation, which guarantees compatibility to the Machine Vision standard Camera Link, but doubles the bandwidth.

CMC-4000 of is a CMOS high speed camera, which is able to acquire images with a sensor resolution of 2320 pixels width and 1726 pixels height at 386 full frames per second. The image data is transferred by four MDR connectors at double Camera Link Full Configuration with 10 taps each. The camera is especially suited for recording of fast movements by its electronic full frame shutter. The amount of image data of 1,5 GBytes per second has to be acquired, but also processed in real-time for online processes. The camera is connected to two Silicon Software microEnable IV VD4-CL frame grabbers. These are programmable image acquisition boards which fulfill the acquisition tasks and additionally the processing
of the images on the FPGA hardware. The implementation of the "DMA900 technology" enables the frame grabber series to transfer up to 900 MBytes per second via PCIe x4 interface in the RAM of the host PC. The CMC-4000 uses two data channels when it is operating in high speed mode.

Each grabber is responsible for the acquisition of one half of each image. When using triangulation method for 3D measurements, the coordinates from laser profiles are calculated column by column, which is not disadvantageous for a use of two frame grabbers.

**Laser Triangulation for 3D Measurement**

For the 3D measurement application, the sensor width is the maximum horizontal resolution in direction of the laser profile. The setting for the sensor height determines the resolution capacity of profile height, which reflects the depth information of the z-axis. The geometric dependency between the device under test, angle of camera and laser, determines the maximum deflection of the laser beam projection. This projection defines the useful vertical range of the sensor. If the maximum available bandwidth is used, a reduction of the sensor height settings will automatically follow in a potentially higher frame rate, which will increase the sampling resolution in scan direction. For example, the settings of the CMC-4000 with a horizontal resolution of 2320 pixels and a vertical sampling of 128 pixels will result in a scanning performance of about 5200 profiles per second. This temporal resolution determines the horizontal sampling rate together with the speed of the device under test.

**Peak Detector on the frame granner’s internal FPGA**

To determine the best fitting measurement coordinate from the laser line, different methods are implemented on the frame grabber. Compared with simple algorithms like threshold or maximum value method, a center of gravity ("COG") method and the Peak Detector method of the Spanish company Aqsense is used. Both methods
achieve a high accuracy even at difficult lighting conditions and surface of material. The Peak Detector method moreover highlights by a higher robustness and lower noise sensitivity. These concerns to sensor noise, laser diffusion as well as surface dependent noise. Hereby this method is algorithmically more stable in difficult materials such as translucent or reflective surfaces. Even in applications with material of the laser color, the measurement results in detecting and assigning metering points are more accurate. By implementing the Peak Detector on the internal FPGA of the frame grabber, the complete processing of metering point calculation is running in real-time. A highly parallel implementation supports the maximum speed of Full Configuration Camera Link cameras at 850 Mbytes per second. At the same time, a maximum, theoretically accuracy of 1/64 pixel is achieved.

The image of the laser line is processed with a noise filter and a high quality binarisation. The determination of the best fitting coordinate of the measurement point is processed column by column for each image. Reflections and non-relevant areas of the image have to be suppressed. In practice, the Peak Detector algorithm has turned out to be one of the most stable and robust method in various environments and applications. Only 1D images with information about coordinates as combined result of both sensor parts are transferred to the host PC for further processing.

A 3D Obejct's Points of Cloud
A 3D object is finally modeled from points of cloud ("POC") by Aqsense's measurement software environment SAL3D. Although all subsequent calculations are processed on the CPU, the same high-speed timing is required. This is realized by additional modules available for merging objects from different POC, matching objects with CAD data, calculating volume data, slicing coordinate or processing data for integrator's software and more.

A measuring application with CMC-4000 is shown on the Laser World of Photonics from 23.-26. May in Munich at the booth of VDS Vosskühler (Hall B2, Stand 102)

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