Article

3DExpress: easing 3D imaging with graphical assistance

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Current State of Machine Vision

Machine Vision is a well known discipline since as far back as 1950s, being the 60s and 70s the decades where most of the state-of-the-art techniques where developed, although by that time it was better known by "getting numbers out of images", as Don Braggins, an authority in the field, used to say [1].

3D triangulation was already reported in a number of scientific publications, although capable technologies have not been available until very recently, when computer power, FPGA integration densities and GPU evolution have risen, and continues to rise, above threshold levels. Such high data processing power, acquisition and transmission technology has paved the way for applying 3D Machine Vision techniques, including acquisition, calibration, processing and combination with 2D techniques, to production line processes requiring different levels of quality control assessment, automatic manufacturing or parts assembly.

However, because of a number of reasons, the application of 3D Machine Vision systems is still far from being widely spread among automation premises, as compared to 2D Machine Vision counterparts.

3D Machine Vision

Even when 2D algorithms have been widely used since long ago in a multiplicity of systems spread in many automated production lines, certain applications concerning the measuring, checking or assessment of parts with 3D features remain unsolved or involve an increased complexity when they are considered from the 2D point of view.

For example, telecentric lenses can be used to enable cameras in order to accurately measure features in 2D, on planes parallel to the lens plane, but they fail at measuring depths. Alternatively, multiple such optics and cameras can be used to cope with different dimensions.

Normal lenses introduce perspective distortion, making 2D measurement prone

1 Don Braggins passed away in June 2011, after a life dedicated to machine vision development, consultancy and writing.

to errors because of misalignments between the camera and the measurement plane, requiring very complex and tedious calibration processes in order to minimally compensate such errors, still restricting the measurement to a portion of the measuring plane.

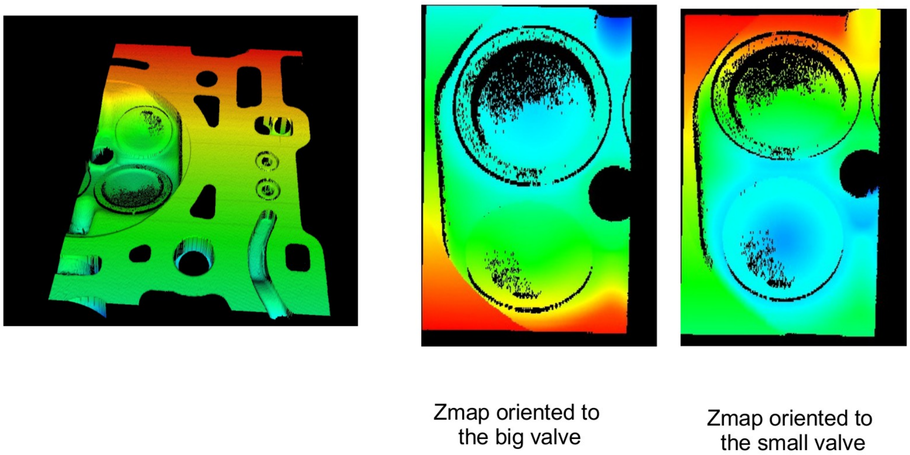

Illustration 1: Engine valves placed in different planes

Definitely, parts such as that shown in Illustration 1, where multiple circle radius must be measured and those are laying on different planes, are extremely difficult, if not impossible, to measure using pure 2D techniques.

However, by means of 3D techniques, such measures are not difficult to accomplish. A good approach would entail defining the regions where the planes are located, rotate the 3D representation of the object to place the planes parallel to the Z plane and generate a Zmap, this is, a two dimensional array representing a projection of a Cloud of Points on the XY plane, with every value of that array representing the Z coordinate at that point (if we take the plane Z = 0 as the floor, we can think of it as the height at that point).

Thanks to the correct placing of the 3D cloud of points, this 2D representations would contain the perfect circumferences with real metric units and, therefore, measuring the radius would be an easy task for any typical 2D analysis tool such as Sherlock.

A Graphic Approach to 3D

In a usual 2D analysis configuration, the system can get pictures from a camera which can be further analyzed. With the Aqsense 3D Express new approach a software entity acting as a “Server” takes pictures from the camera, instead of the 2D system.

Furthermore, a pipeline can be established which graphically sets the 3D data processing sequence, ending with the presentation of the 3D outcome as data understandable, measurable and manageable by the 2D system, and these data are actually delivered as if they came from a normal Frame Grabber (see Illustration 2).

Basically the present approach is based on the selection of inputs and outputs, together with their corresponding configuration. Choosing the inputs to be used consists of selecting the cameras (from a list of available options) and their working modes, as well as the acquisition driver from a list of options too.

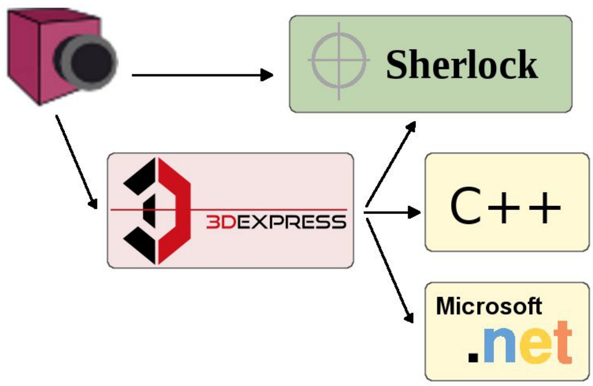

Illustration 2: Sherlock can acquire either from the camera (common setup until now) and from 3DExpress.

The results from 3DExpress (2D pictures after 3D metric processing) can be seen in Sherlock as a usual 2D camera; and a .NET API and C++ API allows getting the processed data types in .NET and C++ programs too.

Once the setup has been finished, right clicking on the selected items several more specific options are presented to fine-tune the pipeline elements according to the user's needs. For example, if true metric coordinates are required instead of only uncalibrated depth information, the metric calibration configuration will provide a GUI to set-up the system calibration and use the metric configuration directly on the acquired data to further provide Cloud of Points or Zmap outputs upon request.

If 2D cameras are used instead of 3D laser triangulation ones, options for configuring the Peak Finder either with the Peak Detector or a state-of-the-art Center of Gravity can be selected.

The 3D power with 2D easiness

However, as seen before, the power of 3D does not consist on obtaining the cloud of points but on its processing. For this purpose, **3DExpress** trusts on an underlying technology based on the powerful and reliable **SAL3D library**.

The combination of this advanced 3D technology with easy step-by-step wizard-like processes gives as a result a tool which enables, **without the need of any programing knowledge**, some of the most useful 3D tasks such as the ones seen on the engine valves example (Illustration 1): detect a laser stripe, calibrate the system to avoid perspective distortion, generate a cloud-of-points (COP) with real metric units, fit a plane on a desired ROI, rotate the COP to meet a desired view or generate a 2D representation containing 3D data (Zmap).

Once the desired 3D representation is obtained, outputs can be set of different types, according to the requirements of further 2D analysis or generic programming languages such as C++ or .Net environments.

Finally, real-time debugging options are provided with on-line configuration and visualization of the data types and values at every stage of the process.

About 3DExpress

3DExpress is a 3D preprocessing software for machine vision applications including graphical assistance for the acquisition, configuration and debugging of 3D laser/LED triangulation systems. Thanks to its easiness to be connected with standard machine vision software, ***3DExpress*** allows 3D analysis with 2D tools.

About AQSENSE

AQSENSE develops and commercializes 3D point cloud acquisition and processing libraries that allow high speed in-line 100% production inspection for the Machine Vision Industry. **AQSENSE**'s customized applications and engineering solutions are supported with training and seminars. Feasibility studies for 3D integration include the evaluation of cameras, lasers and hardware configuration.

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Author:
Josep Forest
Technical Director

AQSENSE S.L.
C/ Pic de Peguera, 15
17003 Girona ,Spain
Phone: +34 972 183 215
info@aqsense.com
www.aqsense.com

Press Contact

Mr. David Sabaté
Marketing communications manager
Phone: +34 972 183 215
dsabate@aqsense.com