Software Modules for Processing 3D Data

Homogenization of point clouds and triangulations

Segmentation of edge curves of geometric elements

Mesh reconstruction / triangulation

Measurement of standard 2D and 3D geometries

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Overview

The use of software modules from specialized suppliers, also called "component ware," is standard today. The components used do not appear in the foreground under their own name; rather, they are integrated as OEM modules into an overall solution. Only in this manner is a company able to rapidly expand its own product portfolio in accordance with market demand, without having to invest significant personnel resources.

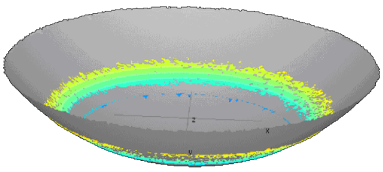


Fig. 1: Fitting of the countersink from the cutting insert in Fig. 2, measurement points color-coded, geometric elements shaded gray

In conjunction with projects in the field of 3D data generation and processing a wide range of versatile 3D software modules are available. The modules realize solutions for special tasks related with the refinement and processing of 3D point clouds in many fields of application such as reverse engineering/CAD or quality assurance.

Areas of application

If only models or design parts are available at the beginning of a manufacturing process chain, these parts must initially be converted into a suitable CAD data format. This reversal of the typical manufacturing process, also referred to as reverse engineering, consists of the recording of the surface topography, typically with an optical 3D measurement system, and the conversion of the generated point cloud into a mathematical model.

This process of surface reconstruction consists of several partial steps, independent of one another. Depending on the characteristics of the point cloud, which in turn depend on the digitalization system and the measurement object itself (shape and optical characteristics), post-processing of the point cloud is first performed. After determining the local point neighborhoods (mesh reconstruction/triangulation), the point cloud is divided into local partial point clouds. These are then approximated by mathematical functions. The descriptions of partial surfaces and curves acquired in this manner and their interrelationships form the CAD data set of the original model or design part.

For a variety of special tasks in quality assurance, a number of additional procedures are used to process 3D point clouds. These include for instance measurement tasks on partial point clouds, the comparison of actual/target values of a point cloud and a 3D data set, or the generation of milling paths directly from a raw point cloud.

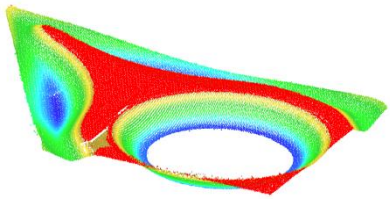
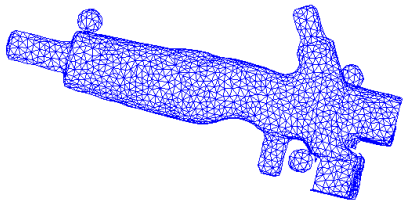
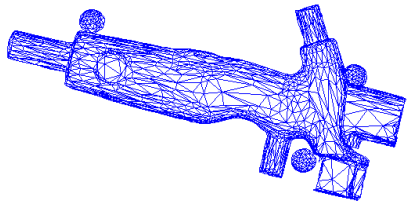


Fig. 2: Cutting insert (40,000 measurement points), automatic segmentation of the plane face, segmented measurement points colored red [1)]

Module for homogenizing point clouds and triangulations

Depending on the measurement system and the measured object (visibility of object parts, different scanning directions, combination of partial measurements, objects that are difficult to scan optically), digitalization often yields highly inhomogeneous point clouds, consisting of individual points that must be interpreted differently on a qualitative basis. Moreover, the point density relative to the subsequent task is often too great, or not adjusted to the surface structure.





Figs. 3 und 4: Uniform and curvature-dependent thinning of a triangulation, injection-molded part (250,000 measurement points, reduced to 2%)

The module realizes various procedures for homogenizing and thinning point clouds or triangulations. The procedures vary in terms of their methodological approach (uniform, curvature-dependent, Figs. 3 and 4), the desired quality and speed of execution, and the manner of dealing with individual points (deletion or merging).

Module for measuring standard 2D and 3D geometries

Due to their cost-effective manufacture, but also for functional reasons, standard 2D and 3D geometries are often used in many industrial settings. Furthermore, their forms of mathematical description are easy to manipulate. A reconstruction of 2D and 3D objects from measurement data first requires correct segmentation of all measurement points belonging to the geometric element in question. The parameters of the desired form of description can then be fitted to the segmented data (Fig. 1).

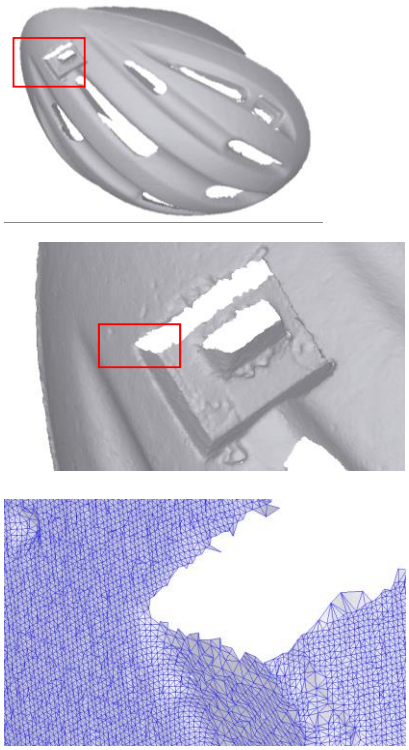
The module provides a variety of measurement procedures, including one for fine segmentation (Fig. 2). All geometric types are supported (lines, circles, ellipses, spheres, cones, cylinders, toroids). In addition to standard measurement procedures, approaches have also been implemented that take into consideration parameters known a priori as well as pre-defined fixed points.

Module for mesh reconstruction (growth procedure)

A 3D scanner records the object surface in the form of unstructured 3D point clouds. For most cases of further processing, however, the reconstructed object surface is required, typically in the form of triangulated data.

If point neighborhoods are known, the further processing of point clouds can often be significantly accelerated. In many cases, this is a prerequisite for any kind of further processing at all. A qualitative assessment of the shape and quality of digitalized objects is only possible with a surface-based representation, including shading, reflections, differentiation between front and rear, and handling of hidden surfaces.

The module implements a speed-optimized growth procedure for triangulating unstructured 3D point clouds. The procedure operates with a high degree of accuracy and speed. Outliers are automatically eliminated.



Figs. 5-7: Triangulation (500,000 measurement points), shaded representation, various resolutions; zoom window is marked in red [1)]

Module for segmenting edge curves of geometric elements

After segmenting digitalized point clouds into standard geometries and free-form surfaces, another task involves determining the inside and outside boundaries of the geometric elements.

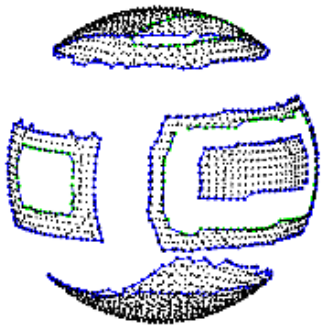


Fig.8: Boundary point segmentation of partial point clouds, standard spherical geometry, outside contours blue, inside contours green

Boundaries result at the transitions between different standard geometries, at the edges of the digitalization area, and at unscanned gaps in the digitalized surface.

The procedures for extracting edge curves have been implemented for the standard 3D geometries of planes, spheres, cones, and cylinders. A separation of inner and outer contours takes place during segmentation. The contour points are sorted according to their position along the boundary curve.

Software features

- Format: Windows - Dynamic Link Library (Dll)
- Generation via VisualC++ IDE (Borland optional)
- Compatible with all Windows operating systems
- Input: 2.5D and 3D point clouds of any size
- All procedures speed-optimized
- Tolerant of outliers and fluctuations in point density

[1)] Point cloud acquisition from fringe projection system at the Fraunhofer Institute of Applied Optics and Precision Engineering IOF in Jena, used with kind permission (http://www.iof.fhg.de)