Geometrical Approximation and Segmentation of Laser Scanning Point Clouds

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Outlines

- Introduction
- Segmentation of the point clouds
- Surface approximation
- Feature lines detection and extraction
- Examples
- Conclusions

Scanning Systems - Hardware

Scanning technology

Main fields of usage :

- Terrestrial Laser scanning - 25 up to 100 m
  - Geo referenceing – identical points – tacheometry
- Airborne Laser scanning – hundreds of meters
  - Geo referencing – identical points, GPS,INS

Very quick and efficient technology
Automated data acquisition

- This huge amount of data can not be processed manually
- Forcing the automated data processing

Surface and Feature Line Extraction

Two methods for the feature lines extraction:

- Automatic extraction of sharp edges based on robust curvature analysis of the whole point cloud. This is the high end solution but needs very powerful hardware
- Interactive extraction of sharp edges and/or smooth edges (semi-automatic method).

Focus – second method

Automatic extraction of feature lines

- Once the neighbors of each point p_i of the point cloud within the search radius R have been determined, best fit planes E_i in each point depending only on the neighbors of p_i can be computed.
- the best fit plane E_i can be interpreted as being a local approximation of the surface near the point p_i. The normal vector of the plane E_i can then be interpreted as an approximation of the normal surface vector of the measured part. (sliding planes)

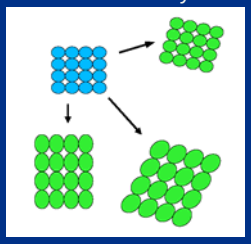
Fitting Planes and feature lines

Fitting planes to point data is a well-known problem and is normally solved using least-squares methods

Once the normal vectors n_i for the relevant points within the search radius R have been computed, point curvature values will be determined by applying a formula which gives an approximation of the average curvature of the surface of the part.

Adjacency Preserving

- the orientation of the normal vectors of the neighbored points must be homogenous and in depend on the reference system.



The semi automatic strategy

Important! the segmentation leads to so called functional patches

- Fitting of free form Surfaces - NURBS
- Comparison between the point cloud and the fitted geometry (Measuring against CAD)

Segment based computation of feature lines

special attention for producing results of high quality in means of accuracy to the measured point cloud and smoothness of the resulting feature lines.

- A theoretical edge line (NURBS representation), which specifies the position of the intersection curve of the extended surfaces, adjacent to the segments to construct.
- Of course the input for the method consists of the measured point cloud only

Surface Approximation

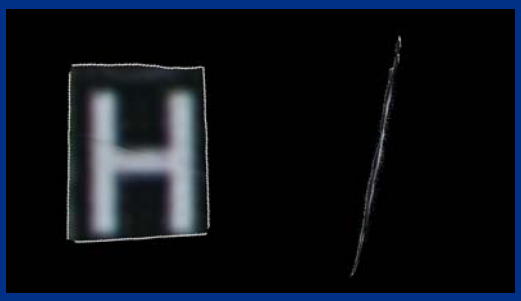
Computation of the Theoretical Edge Line

- The "used" boundary line is defined by the restriction of the segment

follows

- the segment end points in a section are computed
- the computation of the theoretical edge point will be done, simply by intersection of the tangents of the curve in the extracted segment end points.
- 2D intersection of the tangent can be used, because the fitting curve and consequently the tangents are expected to be located within the cross sectioning plane.

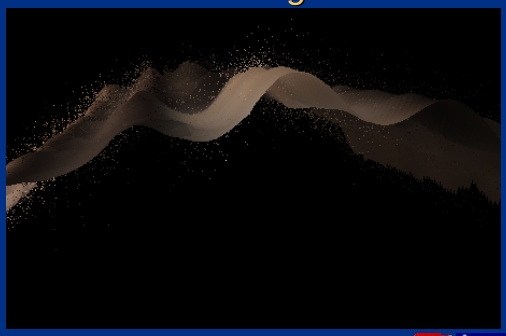
Plane / Surface Approximation



Automated Multiple Spline Fitting for Curvature Analysis of Cross Section Points

- the resulting spline curve should be accurate respectively to the cross section points, means the distances of the points to the fit curve need to be checked and should be rather small.
- On the other hand, if the resulting spline curve would follow the cross section points too closely, oscillations appear in the spline curve, if the scan data would be noisy (and it always is). The amount of oscillations of the spline curve normally will increase, if the distance to the points should decrease
- oscillating spline curves can be used for curvature analysis only with great difficulties.
- necessary to separate the errors by sources, spline optimization

Noise in the Single Shoots



Measurement Noise – against approximation Oscillations

- Physical differences from the theoretical (CAD) surface
- Accuracy of the used laser scanner

preconditions

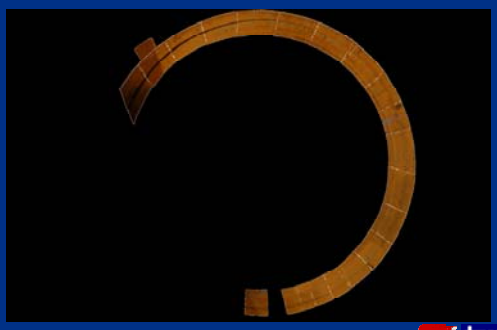
- No big errors in the laser source
- No temperature drift
- The scanner is frequently calibrated and checked

- Gauss – normal distribution of errors, very high redundancy
- Adjustment methods

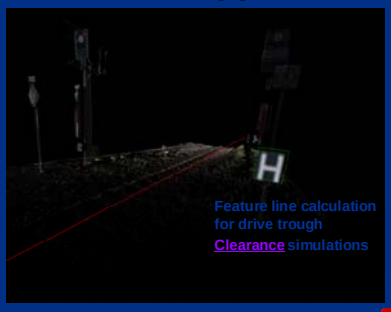
Curvature Analysis

Segmentation

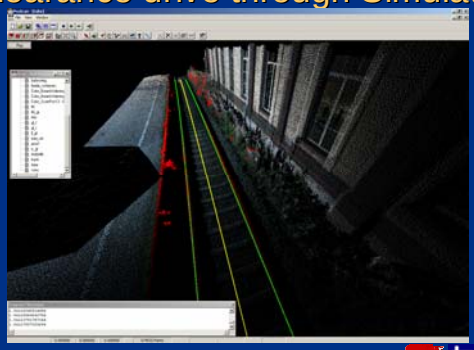
Calculated RGB Patches



Adjustment Algorithm – Contour Finder



Clearance drive through Simulation



Airborne Laser Scanning

Animation

Conclusions

- The calculation of surfaces and feature lines using adjustment methods with respect a‘priory and resulting accuracy with quality improvement
- The Automatic feature line detection is an important tool for engineering applications.
- With the described algorithms the workflow for computing of segmented surfaces in 3D scanner data will be continuously automated.
- The method can handle even dense huge point clouds in real time

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