Terrestrial laser scanning applied for reverse engineering and monitoring of historical buildings

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Overview

- Laser data processing
  - Pointcloud registration
  - General Spline Definition
  - Interpolation function
- Rehabilitation works and reverse engineering
  - Represent on several projects
- Conclusions
3D Laser scanning technology to acquire spatial data

- 3D model
- Construction drawings
- Orthoimages
- Especially for historical architecture objects without construction records

Laser data processing

- Automated plane detection based Registration
  - Detect planes in the image matrices of the scans (scanner system)
  - Finding identical planes for the registration
  - Calculate the interconnected transformation with reliability and quality values
Plane segmentation
- Detected planes

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Fitting control
- Orientated Scans

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Laser data processing

- Depending on the accuracy requirements the processing work can be accomplish:
  - On the basis of the raw point cloud
  - On the basis of the surface model
Interpolation function

× General Spline Definition

× Searching for a spline function

× Base

\[ g : I \rightarrow \mathbb{R} \]

\[ \delta^m / L_k (u_j) = \delta_{j,k}, \quad j = 1, m \quad (3) \]

\[ \| e_k (t) \| \leq \alpha \exp ( - \beta (t - n_k) ) \quad (1) \]

\[ f = \sum L_j g_j \quad (2) \]

Spline

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FIG Working Week 2008
Stockholm, Sweden 14-19 June 2008
Surface modelling
Find the shape for an accurate model

Rehabilitation works and Reverse Engineering

- Parish hall
- Church ruin Betanien
- New Palace Sanssouci
- Public library of Berlin
Parish hall

- Cottbus
- 15 years unused
- Complete renovation for councillor
- No drawings for inner cylindrical roof
- Now generate data of the actual state for the architectural planning needs

<table>
<thead>
<tr>
<th>Scanning Station</th>
<th>Points [Million]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front</td>
<td>25</td>
</tr>
<tr>
<td>Back</td>
<td>25</td>
</tr>
<tr>
<td>Left</td>
<td>20</td>
</tr>
<tr>
<td>Right</td>
<td>20</td>
</tr>
<tr>
<td>Corner 1</td>
<td>22</td>
</tr>
<tr>
<td>Corner 3</td>
<td>22</td>
</tr>
</tbody>
</table>
Objectives

- Create sections
- Develop a colour model with free hand fotos
- Orthophotos

Church ruin Betanien

- Berlin Weissensee
- Built 1900-1902
- Destroyed WW2
- 65m high
- Obtain actual dimensions and shapes
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- Link point cloud and free hand photo
- Also for historical photos
- Animation

- Line drawings
- Automated sections with step of 50 cm
New Palace in Sanssouci

- Castle, park Sanssouci in Potsdam
- Built between 1763 and 1769

Old anchor construction has to be replaced.

Prefabricated bended beams are to be fitted inside the architraves.
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**Prussian Cultural Heritage**

- Ortho images
  - Roof structure
- Facade
- Brickwork from fundament

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Staatsbibliothek zu Berlin

- Since 1661 (house Unter den Linden since 1914)

- New building of central reading hall will be finished till 2009

Time stamp based data acquisition

- Two epoches are captured

- Volume calculation for the building pit—excavation volume
Conclusion

- Construction drawings based on new reverse engineering techniques
- Different modeling strategies for different accuracy levels
- 3D models for precise volume determination, acoustic calculations and epoch based documentation of the object conditions – preserving evidence

Thank you