Highly Accurate Photorealistic Modeling of Cultural Heritage Assets

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Vienna, 17th November 2010
Motivation

- Requirements for Documentation and Visualization are different:

**Documentation Model**
- Geometrically accurate representation of object
- Geometrically rich in detail
- Foundation for
  - Planning
  - Restoration
  - Monitoring
  - etc.

**Visualization**
- Geometrically generalized to support rendering requirements
- Richness in detail through texture
- Foundation for
  - Visual Inspection
  - Marketing
  - Public Relations
  - etc.

What are the requirements to generate multipurpose geometric models?
Motivation

- **Fast data acquisition:**
  - Provided by Laserscanning with > 1 mio points per second

- **Automation in data processing:**
  - Realize efficient workflows
  - Develop automated methods

- **Open new fields of application**
  - Archaeology
  - Cultural heritage
  - Virtual museum
  - etc.

**JUST A VISION?**
Examples

- **Staircase at Schönbrunn Palace:**
  - Restoration Documentation & Change Detection

- **Fountain at Schönbrunn Palace:**
  - Restoration Documentation
  - Visualization

- **Ephesos Terrace House 2**
  - Archaeological Analysis

- **Exhibits**
  - Documentation
  - Visualization
  - Marketing
Restoration of staircase at Schloß Schönbrunn

- **Data acquisition**
  - Campaign 2007 (before restoration): 42 scans à ~ 15 mio points
  - Campaign 2008 (after restoration): 41 scans à ~ 15 mio points
  - Total: 1,300 mio points

- **Processing effort per campaign**
  - **Scanning**: ~ 24 hours  
    *(incl. tachymetric measurement for registration)*
  - **3D-filtering (automated)**: ~ 48 hours (~ 1 hour per scan)  
    *(PC: 8-core, 16 GB RAM, 64 bit-Windows)*
  - **Registration (automated)**: ~ 8 hours
  - **Merging and triangulation**: ~ 8 hours  
    *(incl. ~ 2 hours of interactive work)*
3D-Model

- Model after restoration
  - Point cloud after 3D-filtering and registration: ~ 23 mio points
  - Triangulation model: ~ 11 mio triangles

Triangulation model artificial illumination
3D-Model Analysis

- Differences before vs. after restoration
  - unchanged: $\pm 1\text{ cm}$ (~ accuracy)
  - maximal differences: $\pm 5\text{ cm}$
3D-Model Analysis

- Differences before vs. after restoration
  - unchanged: $\pm 1$ cm (~ accuracy)
  - maximal differences: $\pm 5$ cm
3D-Model Analysis

- Slope of horizontal faces
3D-Model Analysis

- Vertical Structures
**3D-Model**

- **Fountain at Schloß Schönbrunn**
  - 43 scans: ~6 hours
    - sampling distance: ~1.5 to 3 mm (per scan)
    - scanning distance: ~3-6 m
    - object height: ~3.5 m
    - object diameter: ~4.5 m
  - local registration: ~3 hours
Fountain at Schloß Schönbrunn

Horizontal profiles – Animation

Rendering with artificial texture
3D-Model and Rendering

- **Attika Sculpture – Schloß Schönbrunn**

  ![Image](image-url)
  ![Rendering – Animation](rendering-url)
  ![Documentation Model](model-url)
Ephesos – Terrace House 2

- **Data acquisition**
  - Mai/June 2010: 172 scans à ~ 60 mio points (incl. roof construction)
    - 10,000 mio points

- **Processing effort per campaign**
  - Scanning: ~ 7 days (1 person)
    (+ tachymetric measurement for registration)
  - 3D-filtering (automated): ~ 168 hours (~ 1 hour per scan)
    (PC: 8-core, 16 GB RAM, 64 bit-Windows)
  - Registration (automated): ~ 8 hours (single core)
  - Merging (automated): ~ 8 hours
    - 500 mio points (glob. analysis: 125 mio)
  - Triangulation only partially

[in cooperation with ÖAW (Rathmayr, Adenstedt) and TU Wien-E280 (Kalasek), FWF project P 22102]
Ephesos – Terrace House 2

- Vertical Structures
Ephesos – Terrace House 2

- Wall Structures

Point cloud

Triangulation
Ephesos – Terrace House 2

- Wall Projection
Sacred Cup

- Close range scanning
  - Scanning: FaroArm @ ~15 min
  - Images: Canon 20D @ ~15 min
Tutankhamun

- Data acquisition
  - Faro Photon 80
    77 scans @ ~10 hours
    3 mm @ 5 m
  - Canon 20D, 14-18mm
    ~5 hours

Polar image of point cloud (intensity)
Tutankhamun

- Point cloud after filtering

*shaded points*  
*local aspect*
Tutankhamun

- 3D-Models

*automated triangulation*

*patches – animation*
Tutankhamun

- iPhone-App
Conclusions

- 3D-documentation model generation from TLS data allows for automation

- By appropriate generalization and by integrating textures, the same model are appropriate for visualization

- Such multipurpose models opens extensive fields of applications
  - documentation: Distinct objects and whole sites
  - analysis: Change detection, mapping, etc.
  - public relations: From huge projection installation to website and smartphone representation

FROM A VISION TO REALITY
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