Terrestrial Laser Scanning
Investigations and Applications for High Precision Scanning

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Contents

- Short introduction to laser scanning
- Investigation of laser scanners
  - Trunnion axis error
  - Distance measurement system
- Application of terrestrial laser scanners
  - Chapel of „Neubrück“ (cultural heritage)
  - „Muehlebach“ – Tunnel (high precision scanning)
- Conclusion

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Short introduction to laser scanning (1)

Concept of Zoller+Froehlich laser scanner (Imager 5003)

- Laser beam is deflected by a fast rotating mirror
- 360° scan is possible (full view scan)
- "Panorama Scanner" (opposite: "Camera Scanner")
- Result is a 3D point cloud

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Laser scanner “Imager 5003” (2)

Phase distance measurement system

- First laser scanner with the principle of the phase measurement system
- Carrier wave (λ = 780 nm)
- Signals are simultaneously bi-modulated with a sinusoidal signal on a coarse and a fine frequency:
  - 2 coarse frequencies to determine ambiguities
  - Up to 25.2 m (λ ∼ 54 m): Measurement mode "close"
  - Up to 53.5 m (λ ∼ 108 m): Measurement mode "far"
  - 1 fine frequency (λ ∼ 6.7 m) for accurate measurements

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Trunnion axis error (1)

Instrumental error

- Laser scanner used as a geodetic instrument like a total station

Experimental setup

- Leica Nivel 20 was fixed on the scanner
- Scanner was rotated around the vertical axis
- Measuring the inclination in two orthogonal directions at each position
- Deriving the trunnion axis error (r) from the multivariate values (x, y, z)

\[
x = \frac{1}{2} (\Delta x + \Delta y)
\]

\[
y = \frac{1}{2} (\Delta x - \Delta y)
\]

\[
z = z_{\text{current}} - z_{\text{average}}
\]

\[
r = \sqrt{x^2 + y^2 + z^2}
\]

- trunnion axis error of position i
Modeling the trunnion axis error as a harmonic oscillation

Fourier Transformation shows the parameters:
- Amplitude, phase angle, frequency and trend (the trend corresponds to the vertical axis error)
- Frequency with highest amplitude represents trunnion axis error

Three data series were measured with a shifted start angle of 60°

Results:
- Vertical axis error approximately constant
- Amplitudes are constant
- Phase angles are constant
- Influence in a distance of 60 m: approximately 1 cm

Assumption: Influence of the "unbalanced system" causes deformation of the tripod

For verifying this assumption the investigation was repeated.

The scanner was mounted on a solidly built table (granite table).

Results of new investigations:
- Trunnion axis error only reproducible (until now) if this "unbalanced" scanner is mounted on a stable "surrounding"
Chapel “Neubrück” (1)

Cultural heritage

- Location
  “Vispertal”, Valais – Switzerland
- Problems
  - Difficult area around the chapel (road, railway, river)
  - Limited choice of viewpoints

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Terrestrial Laser Scanning – Investigations and Applications 13 / 18

Chapel “Neubrück” (2)

Scanning principle and results

- 5 view points: 4 sides and the interior
- Minimum number of 3 control points in each scan
- Separate scans of chapel and spheres from each viewpoint
- Resolution of the scans: middle (chapel) & super high (spheres)
- Registering the scans by using control points
- Creating a 3D-Model including texture mapping

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Terrestrial Laser Scanning – Investigations and Applications 14 / 18

“Muehlebach” – Tunnel (1)

High precision scanning

- Location
  “Muehletal”, Valais – Switzerland
- Problems
  - Linear object: small angles between tunnel surface and laser beams
  - View points close to each other (max. 10m)

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Terrestrial Laser Scanning – Investigations and Applications 15 / 18

“Muehlebach” – Tunnel (2)

Scanning principle and results

- For each viewpoint 360° scan of the tunnel (resolution “middle”) and fine scan of the spheres (resolution “super high”)
- Registration of scans by using control points

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Terrestrial Laser Scanning – Investigations and Applications 16 / 18

Conclusion

- Laser scanning is a promising technology
- For high precision applications the accuracy and the behavior of the instrument have to be investigated (such as instrumental and methodological errors, distance accuracy,...)
- Planning the view points and control points is important for a successful project
- Scanning takes not as much time as the traditional technologies (except photogrammetry)
- Results are high detailed scans with huge point clouds and a lot of information
- “Post processing” work (creating a 3D-Model) can be quite intensive (ratio between scanning and modeling extends up to 1:10)

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Terrestrial Laser Scanning – Investigations and Applications 17 / 18

Thank you for your attention

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FIG Working Week

Athens, 22 – 27 May 2004

Athens, 26 May 2004

Terrestrial Laser Scanning – Investigations and Applications 18 / 18
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