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Engineering Geodesy

Quality Control of Robotics made Timber Plates

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From the Wisdom of the Ages to the Challenges of the Modern World

FIG Working Week 2015, Sofia, Bulgaria

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Overview

- Motivation
- Project description
- Measuring Process
- Quality Control and Analysis of Results
- Deformation Analysis
- Conclusion and Outlook

Motivation

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- Wood is renewable, cheap and environmental friendly
- New developments in design and fabrication
- Industrial robotics could be used
- Simulation processes are develop well
- → But which accuracy is reachable with industrial robotics and wood?

Project: *Robotics fabrications in Timber Construction*

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- Innovations in computational design, simulation, timber fabrication and quality control
- Goal: Development of a lightweight timber construction
- 7 freedom degrees robotics from KUKA Roboter GmbH
- Natural model: sand dollar
- Result: Prototype at the horticultural show Landesgartenschau 2014
- Properties of the Prototype:
  - Beech plywood
  - 243 plates with 50 mm thickness
  - 7600 finger joints
  - 125 m² ground floor
  - 12 m³ of timber used

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Measuring Process – Laser Tracker

- API Radian with IntelliProbe 360™
- specialty: two kinds of distance measurements
  - Interferometric measurement
  - Absolute measurement
- Self-developed edge adapter
- Reachable accuracy with SMR:
  - ± 50 µm for 3D points in a distance of 10 m
- Reachable accuracy (given by producer) with IProbe:
  - ± 126 µm for 3D points (2σ) in a distance of 7 m
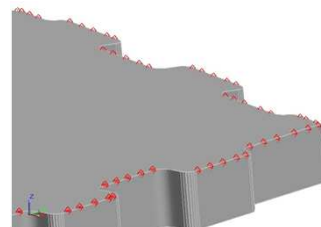- Reachable accuracy with edge adapter:
  - 0,106 mm for 2D

Source: apisensor.com

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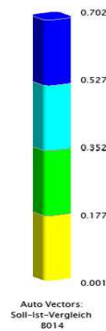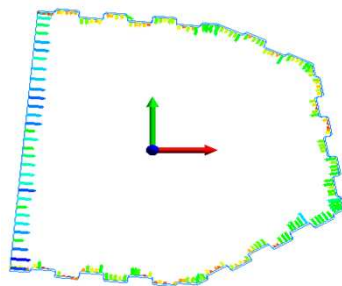
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Measuring Process

- 24 plates of 243 plates were quality controlled
- Used software: Spatial Analyzer from New River Kinematic

1) Alignment of the tracker to plate
  - Spherically Mounted Reflector is used for alignment

2) Measuring the edge points
  - Edge adapter with IProbe is used
  - Ten points per finger joint
  - Discrete point measuring

3) Fine alignment
  - 6 parameter transformation
  - Iterative algorithm for minimizing the standard deviation

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Deformation Analysis

- 4 plates are measure 3 times:
    1. After fabrication
    2. Before transport (2 weeks later)
    3. On building site
- Significance test:
    - Test statistic: $y = \dfrac{|\bar{d}_{epoch1} - \bar{d}_{epoch3}|}{\sqrt{s^2_{FM_{epoch1}} + s^2_{FM_{epoch3}}}}$
    - Quantile: $y_{1-\frac{\alpha}{2}} = 1.96$
    - Null hypothesis: $E(y) = 0, y \sim N(0,1)$
    - Null hypothesis accepted: $y \leq y_{1-\frac{\alpha}{2}}$
    - Example plate 1: at all 52 edges the null hypothesis is accepted

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Conclusion

- Reachable fabrication accuracy: 0.4 mm
- Only 4% of significant deviations
- No problems while setting up the prototype
- No significant deformations during six week bearing
- In different epochs, different points were measured →Local deformations are not detected

Outlook

- Investigation of movements of the prototype
- Investigate the changes of the plates
- Develop a method to detect local deformations

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Questions?

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