EXPERIMENTAL ASSESSMENT OF SIMULTANEOUS IN-SITU HELIOSTATS CALIBRATION METHODOLOGY HELIOCONTROL AT THEMIS FACILITY

Gregor Bern
Fraunhofer Institute for Solar Energy Systems ISE
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www.ise.fraunhofer.de
Introduction
Closed Loop Heliostat Control / In-Situ Calibration

- Pointing uncertainties: $0.6 \text{ mrad} < \text{RMS}_{\text{point}} < 3 \text{ mrad}$
- Recalibration is necessary to feed heliostat error / drift models
- Closed loop tracking can allow for relaxed requirements and reduce heliostat costs
- Measurement at the receiver promises little error propagation
- In-situ measurement needs to work at high flux from thousands of heliostats
- HelioControl method
LINEOUT

- Introduction

- In Brief: The HelioControl Method

- Measurements at Themis

- Reflectance Correction Model

- Conclusion
In Brief - The HelioControl-Method
The Principle of Evaluation

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The Principle of Evaluation

In Brief - The HelioControl-Method

The Principle of Integration
In Brief - The HelioControl-Method
The Periodic Movement

- Parameters
  - Drive Acceleration
  - Maximum speed
  - Amplitude of high speed

- At Themis:
  - Periodic movement of focal spot implemented
  - Frequencies between 0.04 – 0.23 Hz
  - 4 Heliostats equipped
    - 0.04 Hz; 0.1 Hz, 0.16 Hz, 0.23 Hz
Measurement at Themis
Aiming at Large Flux Target

Uncertainty B12:
ca ±33 mm

Uncertainty E07:
ca ±45 mm
Measurement at Themis
Large Flux Target Results
Measurement at Themis
Large Flux Target Results
Measurement at Themis
Large Flux Target Results

Uncertainty: ca ±33 mm
Deviation B12: 13 mm

Uncertainty: ca ±45 mm
Deviation E07: 10 mm
Measurement at Themis
Aiming at Small Cavity Receiver

- Exp. I: 5 static, 4 moving
- Exp. II: 12 static, 4 moving
- Distance between two reference positions

Reference Distance 320 mm ± 51 mm
Measurement at Themis
Aiming at Small Cavity Receiver
Measurement at Themis
Aiming at Small Cavity Receiver
Measurement at Themis
Aiming at Small Cavity Receiver
Measurement at Themis
Reflectance Correction Model

Original amplitude signal  Correction model  Corrected amplitude signal

Vertical image coordinates in pixels
0 127 255 392 511
0 127 255 392 511

Horizontal image coordinates in pixels
0 127 255 392 511
0 127 255 392 511

1.0
0.8
0.6
0.4
0.2
0.0
Measurement at Themis
Aiming at Small Cavity Receiver
Measurement at Themis Cavity Receiver Results

Measured Distance (I) 340 mm

Measured Distance (II) 357 mm
Measurement at Themis
Cavity Receiver Results

→ Deviation towards *reference distance* of 20 mm and 37 mm respectively
→ Corresponding to 0.2 and 0.38 mrad for the present heliostat position
Conclusion

- HelioControl successfully integrated with heliostat field control
- Scheme of periodic movement with different frequencies implemented
- Method can precisely extract and find aim points
- At special receivers with high variances in reflectance a correction model can be generated and applied
- Deviations of aim point measurement well below reference uncertainty

Outlook:

- Measurement campaign with thorough statistical evaluation necessary for representative uncertainty assessment
- Test in commercial scale power plant during operation
Thank you for the attention

Fraunhofer Institute for Solar Energy Systems ISE

Gregor Bern, gregor.bern@ise.fraunhofer.de
Moritz Bitterling, Peter Schöttl,
Alain Ferriere, Yann Volut,
Anna Heimsath and Peter Nitz
www.ise.fraunhofer.de

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