ASIA-PACIFIC SOLAR RESEARCH CONFERENCE

Heliostat Tracking Sensors for Concentrating Solar Thermal

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Accurate tracking of heliostats is important for achieving high efficiencies from concentrating solar thermal power systems. We present the modelling and experimental results of optical and orientation sensors developed for improving the commissioning and operation of heliostats.

Introduction

A range of heliostat technologies are being developed as part of the Australian Solar Thermal Research Initiative (ASTRI) (Coventry et al., 2016). One concept is that of a ‘Drop-in’ heliostat, designed for rapid deployment and autonomous operation, as a means of driving cost reduction by simplifying heliostat installation and calibration. As part of this, techniques for relaxing installation tolerances and reducing installation time and costs, while maintaining heliostat tracking accuracy are being developed.

Heliostats require in the order of 1 milliradian tracking accuracy in two dimensions to ensure alignment of the sun’s image on the central receiver. The initial calibration can take months due to the large number of heliostats (Schell, 2011). Periodic calibration is also necessary to compensate for changes in components (Hogan et al., 2014), for example, movement of foundations. To overcome these limitations, orientation sensors and closed-loop optical tracking are being investigated.

Tracking systems

Experiments were conducted using a modified commercial heliostat with a 6.3 m^2 reflector (uncoated, for safety reasons), as shown in Figure 1. As part of the ‘Drop-in’ concept, the heliostat uses a concrete-free, non-displacement foundation.

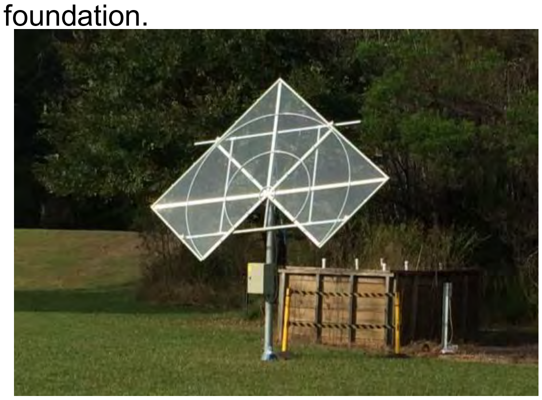

Figure 1. Drop-in heliostat testbed

The orientation of the reflector is a 45° rotated square, with the lower quadrant vacant, to form a chevron shape. The unique geometry is part of a cost-reduction investigation into higher-density field packing. The vacant quadrant allows for convenient mounting of the camera used in the optical tracking.

A low-cost nine-axis accelerometer, magnetometer and gyroscope sensor board was mounted on the rear of the heliostat reflector to directly determine the coarse orientation. Accurate time of day was obtained from a GPS sensor and sun position calculations were used to close the tracking loop (Blanco-Muriel et al., 2001).

To further improve tracking, a closed-loop optical system is being developed and tested. The optical tracking uses an array of retroreflectors mounted on a target. These provide a strong return signal from the heliostat nearest the camera only, allowing for real-time closed-loop control of multiple heliostats simultaneously.

Figure 2. Retroreflector mounted on tower

The system uses a small computer with a camera mounted near the heliostat. The camera images the retroreflectors mounted on a tower located approximately 60 m from the heliostat. One of the retroreflector signals is shown in centre of Figure 2. The resulting image from the retroreflectors allows accurate determination of the heliostat orientation. The camera uses these images to adjust the heliostat tracking, forming a closed-loop control system. Modelling indicates that the system performs well in a full scale CST system.

Summary

Optical and orientation sensors have been developed and implemented on a heliostat system, demonstrating the potential for closed-loop tracking as a way of reducing initial calibration times and improving operational tracking accuracy.

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