Automatic Guiding of Solar Gregory Telescopes

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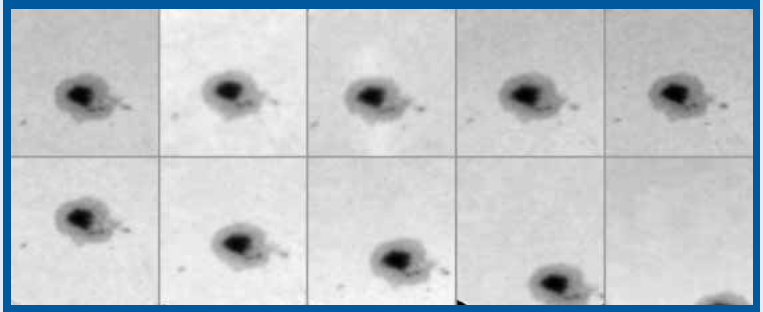
An automatic guiding system of solar Gregory telescopes has been developed in joint cooperation of the Fachhochschule Wiesbaden and the solar observatories at Locarno/Switzerland and on Tenerife. Exact positioning of the solar disc is achieved by means of a two-dimensional intelligent sensor being illuminated by a reduced image of the telescope's primary focus.

This allows to precisely fix (i.e. < 1 arcsec) any location on the solar disc. The observer has at his disposal all relevant functions for a comfortable computer control of the telescope. The software has been developed on a PC largely by means of the graphical language LabVIEW, which is also considered for the development of the GREGOR control software.

Motivation of using a primary image guider



Pointing a sunspot over 2.5 h with (upper sequence) and without primary image guider

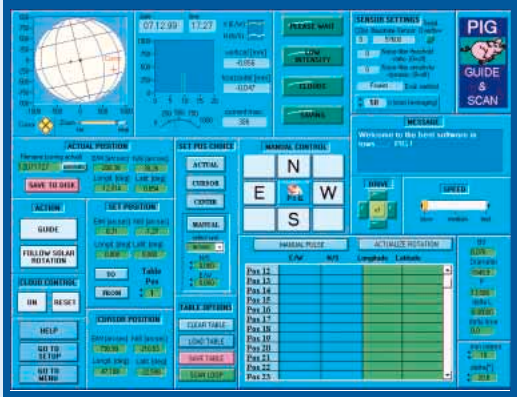
Task of a guider: correcting errors of mechanical guiding, especially due to

- Seasonal progress of the solar declination
- Daily variations of the atmospheric refraction
- Changing flexure of the telescope tubus
- Finite accuracy of the polar axis' orientation

Disadvantages of common guiders fixed on the telescope tubus: Daily variating offset between telescope and guider causes errors of up to 5 % of the solar diameter.

Solution: use of the primary image

Computer Hard- and Software



User interface of the main function GUIDE & SCAN

16-Bit-Microcontroller on the sensor-board ("intelligent" sensor):

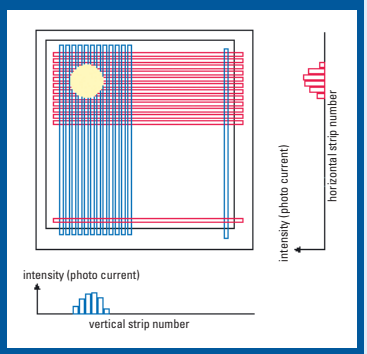
- Reading of strip intensities with an integration over up to 500 single measurements
- Determination of position, maximum intensity, etc., and transmission via RS 232 (57000 baud) to a PC on demand
- Programming language C

Windows PC:

- Multi-functional user interface with main functions SETUP, ADJUST, CALIBRATE, REMOTE, and GUIDE & SCAN [2, 3, 4]
- Possibility of remote control (RS 232 or TCP/IP) by a host system
- Control of the telescope driving motors via digital outputs
- Programming language LabVIEW (80 %) and C++

Optical construction

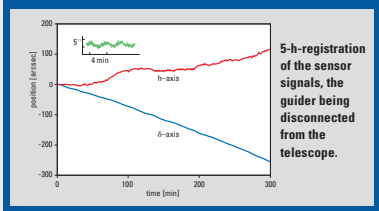
Guider box at the Gregory telescope on Tenerife



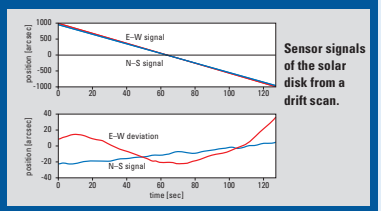
Principle of the position sensor

- Using the part of the solar primary image not required for the 200" field-of-view
- Reducing the image to 6 mm and diminishing the intensity
- Imaging on a two-dimensional position sensor with 64 photo-sensitive strips horizontally and vertically each [1].

Guider Tests at Locarno (Spring 2002)



5-h-registration of the sensor signals, the guider being disconnected from the telescope.



Sensor signals of the solar disk from a drift scan.

5-h-registration of the sensor signals giving the solar position in h and δ without guiding control: δ signal shows north drift of the sun. The enlarged h signal shows the periode of the 4 min (1 degree) revolution of the hour gear wheel: its 2-arcsec-amplitude is very well presented.

If the telescope points to a fixed position on the sky, the earth rotation affects a drift of the solar disc over the sensor in east west direction. The lower panel shows a smooth deviation from the signal expected for the EW and NS direction. The reasons are:
1. very diffuse imaging of the sun on the sensor;
2. the stationary "hole" in the sun picture around the optical axis.

Results:

- Relative locations on the solar disc can be fixed as accurate as about 1 arcsec.
- Absolute positions may be incorrect up to 20 arcsec (limited by the guider optics).

Future aspects:

- While the relative accuracy is sufficient, the absolute accuracy must be improved. This could be done, without change of the hardware, mathematically. Alternately the position sensor could be replaced by an "intelligent" (CCD) camera.
- Particularly, the functionality and surface of the software may serve as a model of comparable future developments. The graphical language LabVIEW is also considered for the development of the GREGOR control software.

Literature

[1] Küveler, G, Wiehr, E. Thomas, D., Harzer, M., Bianda, M.Sütterlin, P., Epple, A., Weisshaar, E.: Automatic Guiding of the Primary Image of Solar Gregory Telescopes. Solar Physics 182, 247-255(1998).

[2] Küveler, G, Wiehr, E., Bianda, M.: Eine sensorgestützte Computersteuerung für Sonnenteleskope. Automatisierungstechnische Praxis atp 42(2000) Heft 7, S. 50-54.

[3] Küveler, G, Wiehr, E., Bianda, M.: Eine Computersteuerung und Nachführ-Automatik für Sonnenteleskope, in: Jamal, R., Jaschinski, H.: Virtuelle Instrumente in der Praxis. Begleitband zum Kongress VIP 2002. Heidelberg Hüthig 2002, S. 47-51.

[4] Web page including the complete manual of the primary image guider: http://r5.mnd.fh-wiesbaden.de/pig/

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