Shack-Hartmann wavefront sensor: technical passport

OKO Technologies,

OKO Technologies is the trade name of Flexible Optical BV

Figure 1: *General view of the sensor*

1 Parameters of the wavefront sensor

Parameter	Value
Serial number	FS1540-H300-F18-16.04
Camera model	IDS UI-1540LE-M-GL
Camera type	digital CMOS
Camera interface	USB 2.0
Array geometry	hexagonal
Array pitch	0.3 mm
Array focal distance	18 mm
Clear aperture	≤3.9 mm
Subapertures	127
Maximum tilt, fast mode	0.008 rad
Maximum tilt, slow mode	0.066 rad
Repeatability, RMS	$\lambda/150^*$
Repeatability, PV	$\lambda/20^*$
Acquisition rate	≥25 fps
Processing rate, fast mode	~10 fps**
Recommended Zernike terms	≤44
Wavelength	400...1000 nm
Mechanical dimensions	See Fig. 2

* For $\lambda = 633$ nm.

**Typical, depends on PC configuration.

The repeatability figures can be further improved by averaging over multiple frames. To enable averaging, go to menu "Options ⇒ Camera", press button "Properties" and correct the field "Average over ... frames".
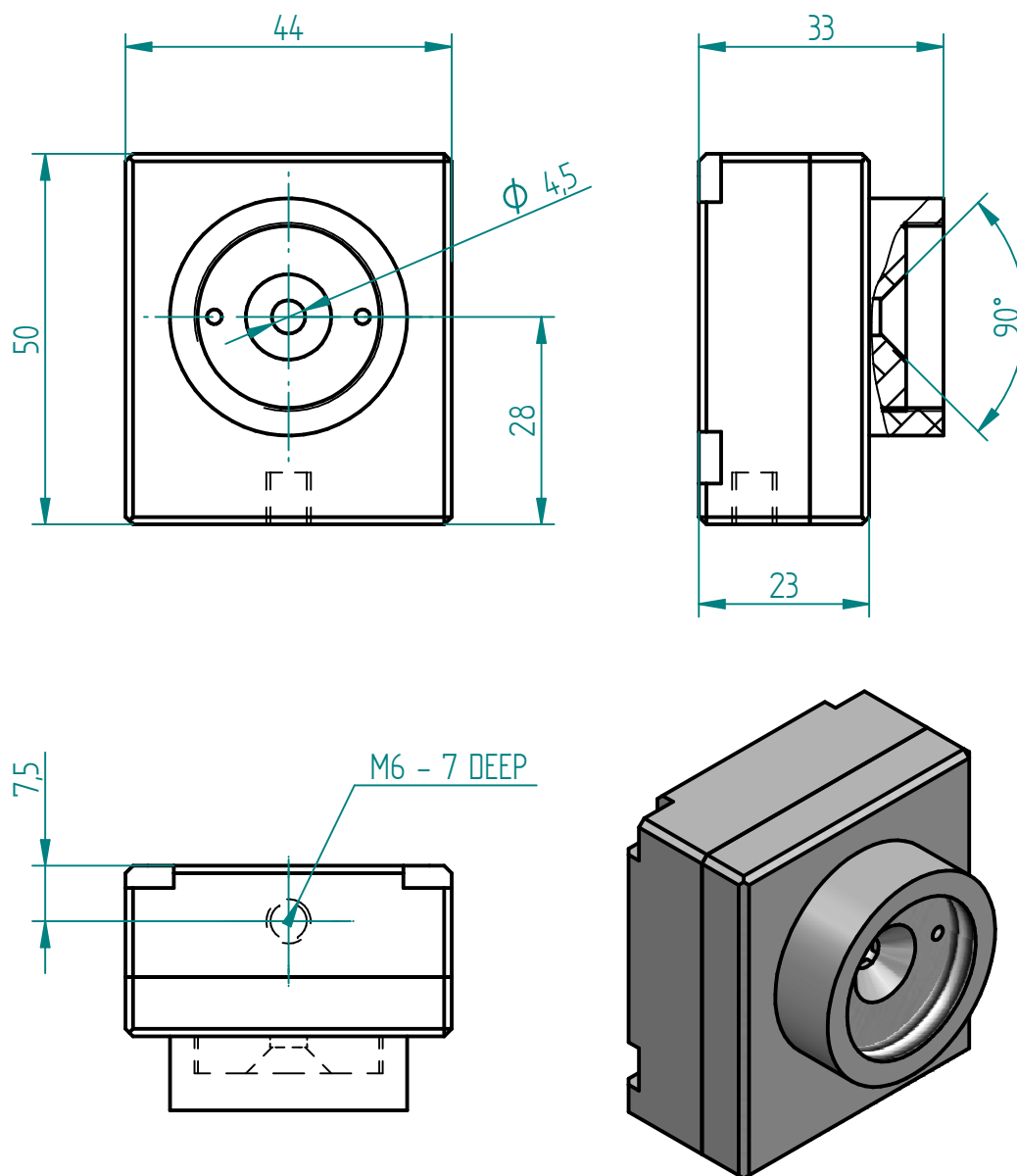
Figure 2: *Dimensions of the sensor*

2 Installation of FrontSurfer software (Windows 2000/XP/Vista/7)

1. Start "setup.exe" from "fsurfer" directory of the installation CD to install FrontSurfer to your computer. Follow further installation instructions.

2. Start "Install.exe" from "keylok" directory of the installation CD to install drivers for the protection dongle. Select the option "USB dongle". Please note that the installation should be completed BEFORE the dongle is connected.

3. Attach the FrontSurfer dongle to a free USB port. The system will recognize the device. Choose for automatic installation of the driver.

4. Under Windows Vista and 7, FrontSurfer should be started in compatibility mode[1] with Windows XP and under administrator access rights. To enable them, right-click on "FrontSurfer" shortcut and locate "Compatibility" property sheet. Enable the options "Run this program in compatibility mode for Windows XP (Service Pack 3)" and "Run this program as an administrator" and press OK to confirm.

5. Now you may start "FrontSurfer" from the Start menu.

3 Interfacing of a wavefront sensor

1. Install uEye camera drivers from "uEye" directory of the installation CD.

2. Connect the wavefront sensor to the computer. The system will recognize the device. Choose for automatic installation of the driver.

3. Start "uEye Cockpit" program and make sure that you can see image from the camera.

4. Configure frame grabber type in FrontSurfer. For this purpose go to the menu "Options ⇒ Camera". In the dialog box "Camera interface" check "Plugin" option. After that, load plugin for the uEye camera by pressing "Load" button and selecting "uEye.dll" file in the FrontSurfer installation directory. Press "OK".

5. Load the wavefront sensor calibration data. For this purpose go to the menu "Options ⇒ Parameters". In the dialog box "Sensor parameters" press "Load" button and load the calibration file "calibration.txt" from the "fsurfer" directory of the CD. Press "OK" to complete. See Fig. 3 for illustration.

6. To increase the processing speed, the sensor can be used with a smaller area of interest (AOI) and/or subsampling mode. To change AOI and subsampling mode, go to menu "Options ⇒ Parameters". In the dialog box "Camera interface" press "Properties" button. In "Area of interest" section, unselect the

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[1]compatibility mode is optional for the latest system and can be omitted

Figure 3: *Sensor parameters window*

option "maximize" and adjust the fields "Left", "Width", "Top" and "Height" to set the desired AOI. You need to reduce dark space at the periphery of the frame, keeping the whole pattern of spots visible. A convenient way to set these parameters is to use the Crop tool of uEye Cockpit (see Fig. 4) to chose the desired AOI, jot down the AOI size and coordinates, and insert their values in the FrontSurfer. In "Sampling mode" drop-down menu, chose the desired sampling mode ("Normal", or "Subsampling x2") (see Fig. 5). Load the proper calibration file for the chosen sampling mode.

4 Microlens array

The wavefront sensor is supplied with a microlens array having hexagonal arrangement of 127 microlenses; the sensor is calibrated. The measured wavefront error of the sensor in the absolute measurement mode, when an ideal hexagonal grid is used as a reference, is shown in Figure 6 (on the left); this error is due to irregularity of the microlens array. It can be partially compensated by extracting the corresponding low-order Zernike terms; the result of extraction is shown in Figure 6 (on the right).
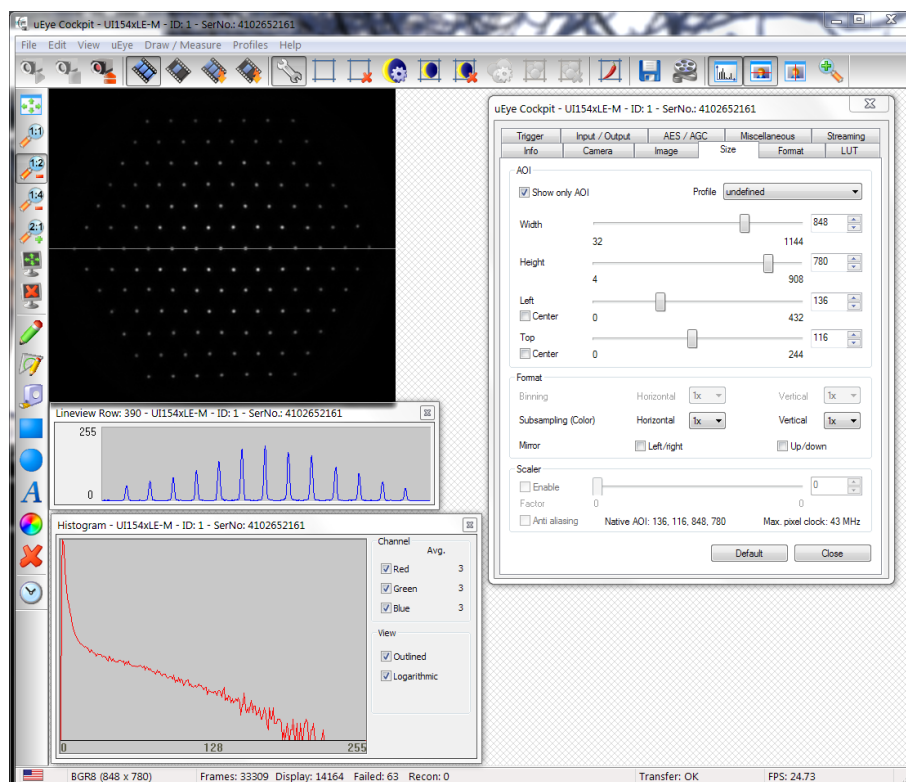
Figure 4: *Reading the AOI values set by the Crop tool of uEye Cockpit (the snapshot was taken wiht 127-lenses hexagonal array).*
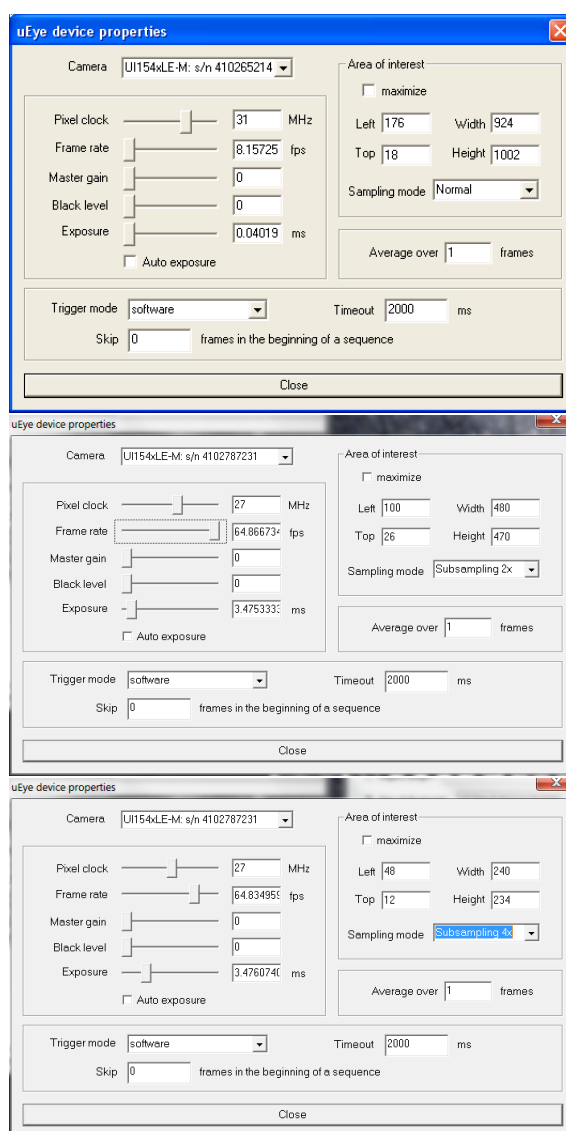
Figure 5: *"uEye" plugin properties; settings for "Normal", "Subsampling x2" and "Subsampling x4" modes (top to bottom).*
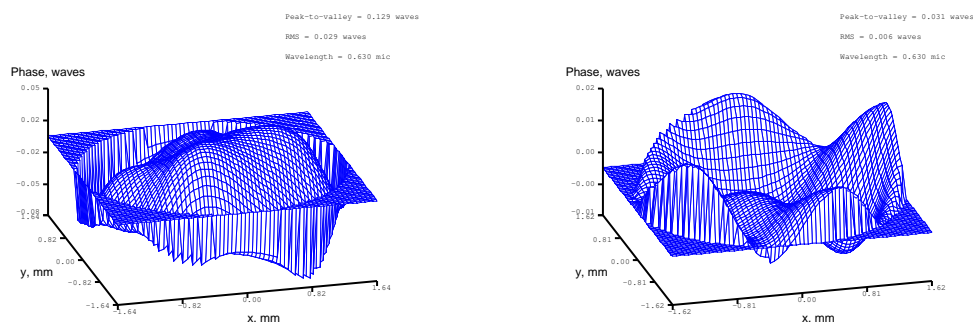

Figure 6: *Wavefront sensor error due to irregularity of the microlens array (left); after extracting the mask aberrations (right); wavelength 0.63 µm.*

5 Using of the absolute and reference measurement modes

- To switch to the absolute measurement mode, go to the menu "Options → Parameters" and change the "Reference grid" setting to "hexagonal". Press "OK".

  If working with an automatically defined aperture, you can extract the errors resulting from irregularity/misalignment of the microlens array, use the menu command "Options → Extract terms" and load the file "extract_terms.txt" from the "fsurfer" directory of the CD. Press "OK" to complete.

- To switch to the reference mode, go to the menu "Options → Parameters" and change the "Reference grid" setting to "get from picture". Press "OK" to complete.

  Please note that in the reference mode extraction of errors is not needed. Use the menu command "Options → Extract terms" and delete all Zernike terms. Press "OK" to complete.

  The sensor is recommended to use in the reference mode.

6 Contact

All questions about the technology, quality and applications of adaptive mirror should be addressed to:
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FS 16.04 for NIST
July 29, 2016