Hyperspectral imaging data correction and standardization, mobile applications
HSI – data correction and standardization, mobile applications

HSI area scan sensors

xicSpec HSI cameras
HSI – data correction and standardization, mobile applications

HSI sensor types from imec (used in XIMEA cameras)

filter layouts

line scan

Snapshot Mosaic

‘wedge’ design
100 bands: ~ 600 – 975 nm
150 bands: ~ 470 – 900 nm (new)

‘per-pixel’ design
4x4: ~ 470 – 630 nm
5x5: ~ 600 – 975 nm
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23.03.2016 XIMEA GmbH, Jürgen Hillmann
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RAW image interpretation (calibration files)

Active area

Sensor width (2048 Px)

Sensor height (1088 Px)

Active area width

Active area height

Snapshot mosaic 5X5-NIR, 675-975nm

Start 1. 5X5 pattern

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XIMEA GmbH, Jürgen Hillmann
RAW image interpretation / snapshot mosaic

2 leaves on a stone

Snapshot mosaic 5X5-NIR, 675-975nm

Single 5X5 pattern, wavelength peaks [nm]

<table>
<thead>
<tr>
<th>900</th>
<th>909</th>
<th>892</th>
<th>882</th>
<th>683</th>
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<tr>
<td>861</td>
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<td>852</td>
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Spectrum (Raw-values)

675 nm

975 nm
The spatial resolution in case of a snapshot mosaic sensor is about
- SM 5X5: $\leq 409 \times 216$ px
- SM 4X4: $\leq 512 \times 272$ px
By Interpolation / demosaicing the native resolution of the active region can be calculated:
Sensor or object has to be moved. The spectral info for one position has to be collected:
When using standard VIS-NIR lenses, a significant “vignetting” may occur:

The “vignetting” has also an impact on the spectral curves:

- upper left corner
- upper right corner
- center
- lower left corner
- lower right corner

It is recommended to implement a white image / fixed pattern image correction for each band.
A significant “vignetting” may occur, depending on the lens and angle of the light:

It is recommended to implement a white image / fixed pattern image correction for each band.
The response curves have crosstalks with neighbors. Several curves have two peak wavelength (can be eliminated with long or short pass filters).
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Position of the crosstalks are at the peak wavelength of neighbors.
This effect can be corrected by a correction matrix.
Some response curves have two peak wavelength (cannot be eliminated with long or short pass filters).
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The position of the second harmonic (peak wavelength) is not the peak wavelength of another band. This effect can be corrected by a correction matrix.
Data correction steps

simplified

HSI – data correction and standardization, mobile applications

1. Camera
2. RAW image
3. De-vignetting / fixed pattern correction, de-noising
4. De-vignetting / fixed pattern correction
5. Spectral correction
6. Corrected HSI cube

- Use calibration data:
  - Active area, offsets
  - Wavelength positions

Options:
- Interpolation
- Stitching

Snapshot mosaic: Line scan
The standard EMVA 1288 is to be expanded in order to describe hyperspectral imaging cameras. The first meeting took place on 03/03/2016 at Imec (Leuven, Belgium).
Mobile applications

For the operation of cameras a computer is needed to:

- control the camera(s)
- grab images
- data compression if needed
- send and store data
- process and analyze the data

For hyperspectral imaging the computer has to be powerful.
Mobile applications

XIMEA is developing a very compact (HSI) imaging and recording unit for mobile applications, e.g. installable in payload compartment of drones with

- massively parallel computational resources onboard
- storage on fast SD (UHS-II SDHC/SDXC) or M.2 PCIe x 4 SSD (1000-1200 MB/s)
- integrated IMU 9-axis
- interface to a drone control unit
- interface to connect GPS / wireless connection

This system is able to handle several cameras at once, e.g.

- 1 or 2 HSI cameras (looking downwards)
- visible light sensor (looking downwards)
- additional HSI-camera or spectrometer for ambient light measurement
Mobile applications

The system is designed to (e.g.)

- create the corrected hyperspectral imaging cube for the connected xiSpec cameras in realtime
- match spectral signatures against pre-learned signatures
- perform a data self clustering / principal component analysis (PCA)
- check whether differences against expected results occurs
- perform a multi-pass flight (other directions, different flight altitude for detailed data)
- optional data reduction (store only not expected info, e.g. possible plant diseases for a detailed postprocessing)
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HW block diagram and interfaces

- HSI-A
  - LVDS->MIPI
  - MIPI[0...3]
- HSI-B
  - LVDS->MIPI
  - MIPI[4...7]
- VIS-A
  - LVDS->MIPI
  - MIPI[8...11]

Interfaces:
- I2C, SPI
- IMU
- USB3
- Ethernet
- CPU / GPU unit
- Carrier/Expansion board
- GPIO, SYNC
- UART UAV
- SD-A / M.2 SSD
- SD-B / M.2 SSD
- PWR
Thank you for your attention