TECHNICAL NOTE TN2021_3 – FX CAMERA KEYSTONE CORRECTION AND LENSES

Introduction

Keystone is an important parameter to take into account when designing and using a hyperspectral camera. The TN documents the effect of changing the front objective of a FX camera on its keystone.

AIE = AUTOMATIC IMAGE ENHANCEMENT

VNIR = VISIBLE NEAR INFRARED (400 – 1000 NM)

NIR = NEAR INFRARED (900 – 1700 NM)

MWIR = MID WAVE INFRARED (2700 – 5300 NM)

FOV = FIELD OF VIEW

> *The field of view is determined by the angle of view from the lens out to the scene and can be measured horizontally or vertically. Usually expressed in degrees (angle).*

Article

Smile and keystones are two types of optical aberrations which strongly impact the accuracy and the usability of pushbroom hyperspectral cameras. The smile is a spectral distortion and is a property of the solely spectrograph, whereas the keystone is a spatial distortion and is strongly affected by the front objective.

For more detailed information about smile and Keystone, we invite the reader to look at SPECIM TN2022_7_Smile and Keystone.

To limit keystone effects on FX cameras, correction is implemented within the real time AIE algorithm. It reduces the keystone of all FX cameras below 15% of a pixel (see Fig.1)

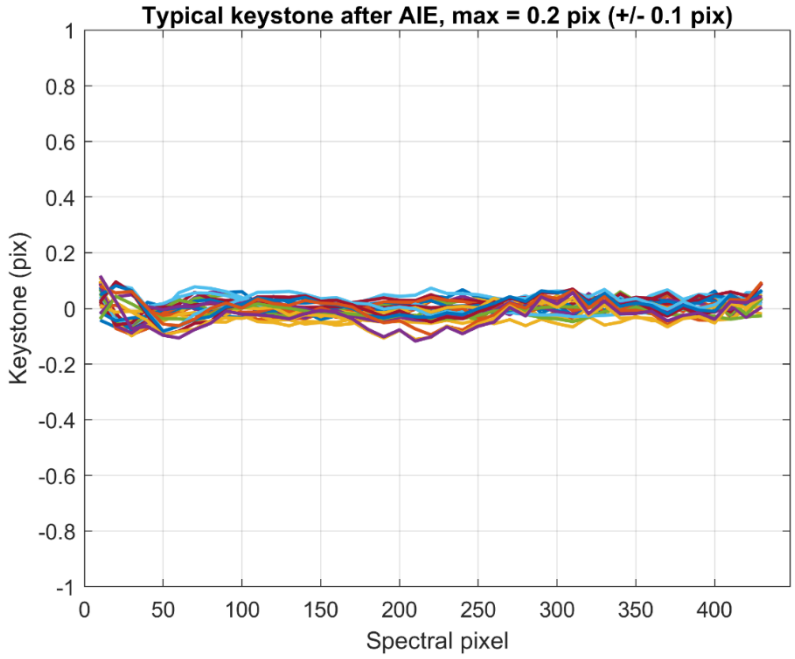

Figure 1: Typical Keystone after AIE correction, here for a FX10 (which contains 448 spectral pixels)

However, since keystone is mostly a property of the camera front objective, the AIE corrective parameters are adjusted and optimized for a single front objective. Changing the front objective may jeopardize the keystone correction of the camera. This TN attends to highlight which lenses could work together from an AIE point of view.

- **Swapping lenses of the same kind**.

Several lenses are available for VNIR, NIR and MWIR FX cameras. Lenses of the same kind have rather similar properties and performances. Swapping within lenses of the same kind would not affect the camera performance.

- **Swapping lenses of different types**

With the FX10(e) (CL or GigE), several lenses are available: 12, 24, 38, 46, 51 and 83 degrees. *

With the FX17(e), available options are 12, 38, 53, 66, 75 and 90 degrees. *

with the FX50, 3 lenses are available: 24, 45 and 60 degrees. *

* Those are the lenses available and sold along with the FX cameras when this TN was written (March 2022). This list of lenses may change over the time. Also, the lenses corresponding to the above mentioned FOV have been tested, so that the induced keystone can still be corrected. Those lenses are recommended to be used with SPECIM FX10(e) and FX17(e) cameras.

Some of the previously mentioned lenses may have AIE keystone corrective parameters which are quite similar. It therefore implied that swapping lenses within those is possible without affecting much the camera performance (keystone wise).

On Table 1, compatibility between lenses is highlighted with colors:

- green for acceptable match (Max keystone ≤ ±50% of a pixel)
- yellow for moderate impact (±50% of a pixel < Max keystone ≤ ±1 pixel)
- orange for significant impact (±1 pixel < Max keystone ≤ ±2 pixels)
- red to be avoided (2 pixel < Max keystone)

Loaded / Lenses	No corr.	83	51	46	38	24	12	Macr
83								
51								
46								
38								
24								
12								
Macr								

FX10(e)

Loaded / Lenses	No corr.	90	75	66	53	38	12
90							
75							
66							
53							
38							
12							

FX17(e)

Loaded / Lenses	No corr.	60	45	24
60				
45				
24				

FX50

Table 1: compatibility between lenses and their related correction.

- **Conclusions:**

- swapping with lenses of the same kind does not affect the AIE correction
- best correction is always achieved for the dedicated lens on which AIE parameters have been tailored.
- the “no correction” is in fact not recommended as it does not provide better results than when a given lens correction parameters are applied.
- For FX50, the user can swap the lens whatever correction is applied.

- **Good to keep in mind:**

  The AIE does not correct only the keystone and the smile, but also the slit tilt and unifies the spectral calibration between cameras of the same spectral range. In the previous tables, “No correction” stands for no keystone correction only.

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Version history

Version	Date	Author	Comments
1.0	Mar 1st 2022	MMA	
2.0	Jun 11th 2024	MMA	Macro VNIR added