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FPI HYPERSPECTRAL FRAME CAMERA CALIBRATION

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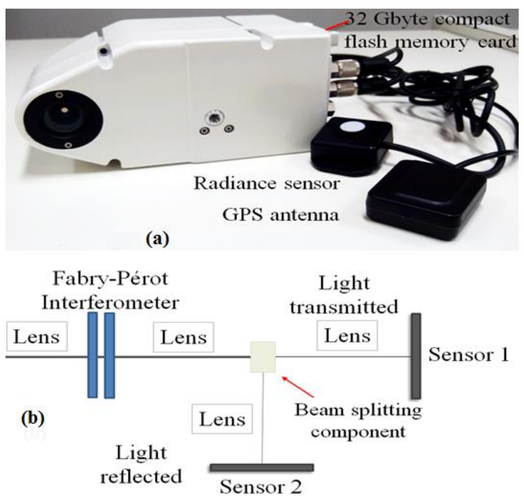
INTRODUCTION

- A hyperspectral camera based on a Fabry-Pérot interferometer was developed by the VTT presenting the advantages of: (1)Rigid rectangular image geometry;(2)Redundancy: an object point can be on many images; (3)Possibility to conduct stereoscopic measurements and multi-angular reflectance measurements and (4) Light weight.
- Only a few studies are available concerning the calibration of hyperspectral systems based on tunable filters.

Objectives: Estimate and assess the IOPs of the FPI camera, considering various spectral bands and applying bundle adjustment with self-calibration + 3D calibration field with signalized coded targets.

FPI HYPERSPECTRAL CAMERA



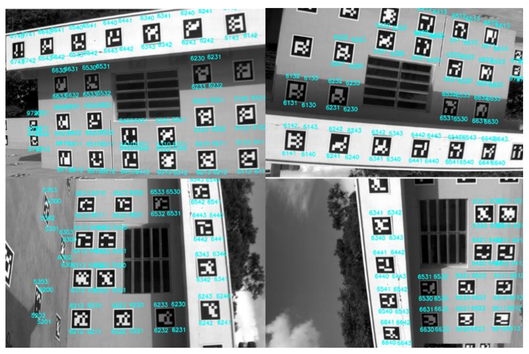
FPI Hyperspectral camera (a) Model 2014. (b) Diagram of the inner optical system.

FPI Camera parameters.

Parameter	FPI2014
Approximate focal length	9 mm
Wavelength detected	500-900 nm
Spectral resolution	10 nm, FWHM
Spectral step	< 1 nm
F-number	~ 2·8
Pixel size (sensor CMV4000)	5·5 × 5·5 µm·
Sensor size	2048 × 2048 pixels
Image size for maximal spectral resolution	1024 × 1024 pixels
Weight	< 700 g
Dimensions	75 x 89·5 x 151·5 mm

METHODOLOGY

- Image acquisition in a 3D terrestrial calibration field (FCT/UNESP);
- Software: CMC (Calibration with Multiple Cameras).



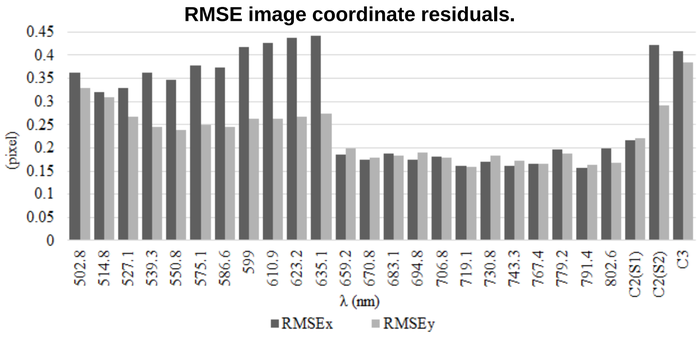
Sample of images acquired in the 3D terrestrial calibration field using the FPI camera.

Experiments description.

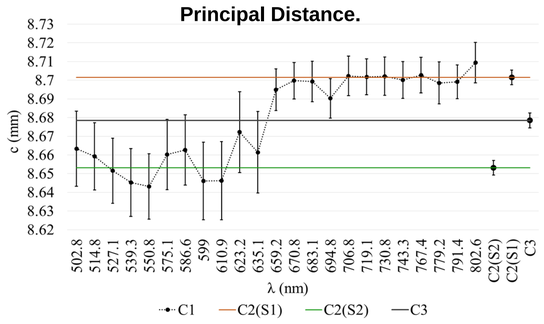
Calib(1)	Images separated by bands. 23 independently calibration trials with 12 images on each.
Calib (2) C2(S1)|C2(S2)	Images separated by sensors, resulting in two resulting sets of IOPs.
Calib (3) C3	All images (276) in a single calibration process with one single set of IOPs.

EXPERIMENTS AND RESULTS

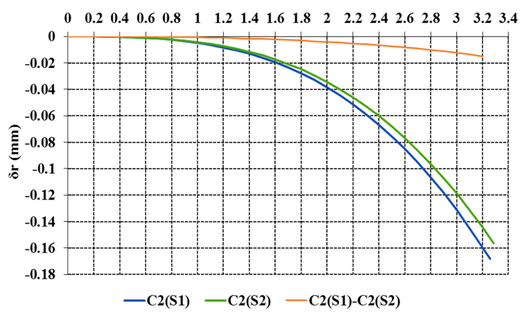
RMSE image coordinate residuals.



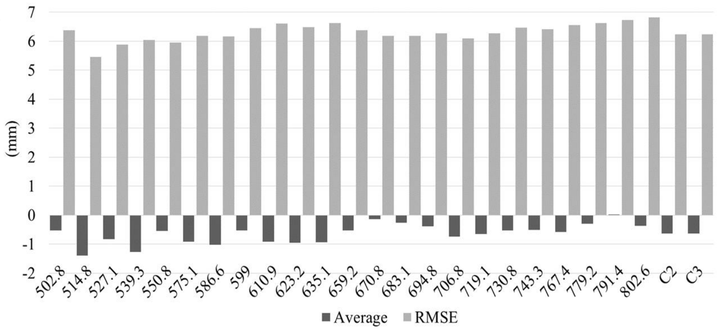
Principal Distance.



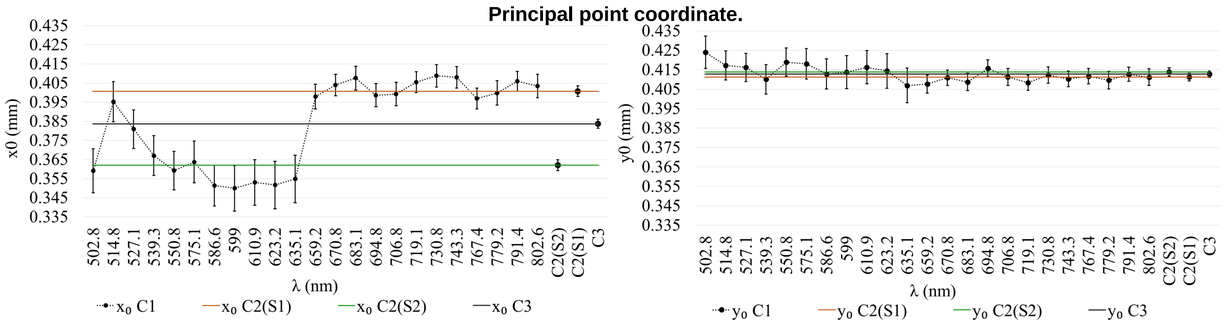
Radial distortion



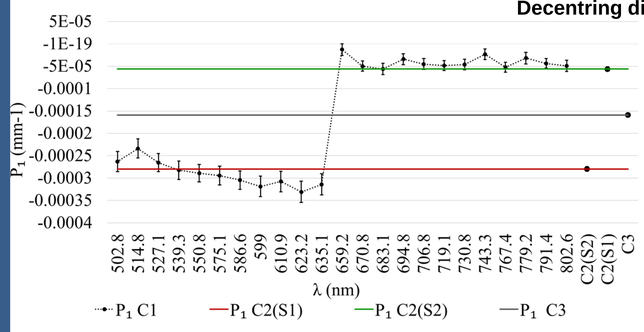
Average and RMSE of the check distances and estimated values.

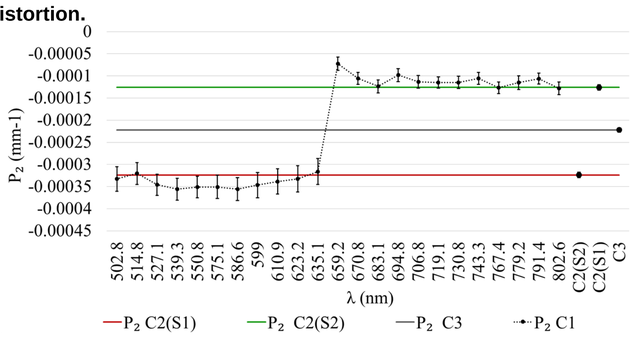


Principal point coordinate.



Decentring distortion.





DISCUSSIONS AND CONCLUSIONS

- FPI camera can be accurately calibrated via self-calibration bundle adjustment and the traditional Conrad-Brown distortion model;
- Within each sensor → no sensitivity variations in the wavelength and the air gap → no significantly impact the IOP values;
- Between the sensors: the differences in the IOPs were found to be significant → it is suitable to determine the IOPs individually for each sensor;
- Depending on the number of bands in the cube, a sample of bands for each sensor could be selected to avoid high levels of correlation in the data when using image observations from all bands simultaneously;
- The quality of the image coordinate measurement differed between the sensors, being less accurate for the sensor optimized for shorter wavelengths (500-636 nm);
- Possible causes: small sensor misalignments, probably occurring during the assembling process, can lead to differences in the IOP of the sensors.

References:

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*3.*Tommaselli et al., 2014. Calibration of panoramic cameras with coded targets and a 3D calibration field. ISPRS, 430(3/W1): 137–142.

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