Infrared and Visible Spectrum Camera Calibration

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I. Introduction

Video sensors fusion requires variety of calibrations and adjustment procedures. Those procedures may include a) time synchronization b) color/intensity adjustment for visible spectrum (VS) cameras c) temperature adjustment for infrared (IR) cameras and d) calculation of intrinsic and extrinsic parameters of the cameras. This paper handle the intrinsic and extrinsic parameter calculation form VS and IR cameras pair, awe call this process as "cameras calibration".

For calibrating a VS cameras, a planar patterns with known size of square control points (chessboard) is a popular calibration approach, and it's implementation could be found in OpenCV library and Matlab toolbox[1].

However, when the calibration must be done between VS and Long Wave Infrared (LWIR) cameras this approach will not work properly. The LWIR cameras can only distinguish between temperature difference and will not be able to sense a printed chessboard pattern on the paper. Therefore, the calibration pattern in this case must contain intensity and temperature disparity in the control point locations.

In [2] direct constant light illuminate is used with printed chessboard patter, the black area of the pattern observe the heat from the light more then white area and it can be seen in LWIR cameras image (see figure (1.a)). Yasuda [3] presents a calibration pattern with heat source on it, however creating such pattern with high accuracy is a complicated task.

In this paper we present "holes-board" pattern that will be describe (in the next section) and compare the accuracy of camera calibration by using chessboard and holes-board patterns.

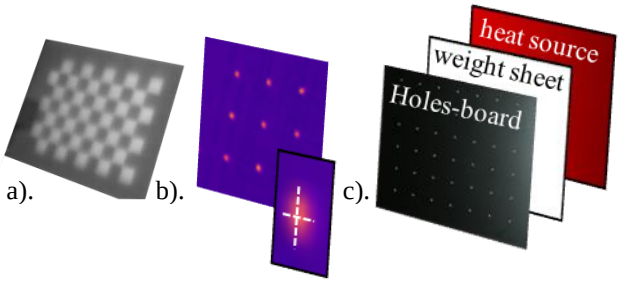

Figure 1: a). Chessboard image by LWIR camera using constant illumination. b). Image of holes-board by LWIR and the resoult of ellipce center location analysis of one hole. c).Holes-board with white sheet and heat source object constalation

II. Holes-board Calibration Pattern

Nowadays, a board with small circular holes that are placed with high precision as shown in figure (1.c) can be easily acquired. The centers of holes represent the control point in the calibration pattern. By placing a white sheet of paper behind the black colored holes-board makes the holes visible for VS camera. At the same time, by putting an object with high temperature to the holes-board behind it the holes location will be seen by LWIR camera as well. (see figure (1.c))

In addition, for increasing the accuracy for the calibration and for speed-up the procedure we introduce automatic extraction of holes centers in the image function based on ellipse fitting [4] (see figure (1.b)). The detected center of the ellipse is not the projected center of the circle due to perspective distortion. However, as the radius of the hole are small this error can be ignored.

III. Evaluation

In this section we describe evaluation procedure and the results of VS and IR cameras calibration accuracy by using two types of calibration board patterns: 1) chessboard and 2) holes-board. We calibrated Grasshopper VS camera from PointGrey with 640x480 resolution and LWIR camera A325 from FLIR with 320x240 resolution. Matlab toolbox [1] was used as basic calibration framework in our experiment. For the holes-board pattern, similar to the original corner detection function in the toolbox, we implemented ellipse center detection function. Intrinsic and extrinsic parameters of both cameras was calculated simultaneously. Both cameras were attached to rigid surface and there rotation and translation parameters were calculated with ±0.05deg and ±0.05mm correspondingly.

We compared the accuracy of the calibration by error estimation of the toolbox, and by rotation and translation parameters error of the cameras in with to ground truth.

	VS camera error (pixel)	IR camera error (pixel)	Translation error (mm)	Rotation Error (deg)
Chess.	*0.163*	*0.853*	2.46	0.25
Holes.	*0.162*	*0.597*	2.46	0.24

Table 1: Presents calibration errors in intrinsic parameters of VS and IR camera in pixels and extrinsic parterres error in mm/deg. for chessboard and holes-board patterns.

The results in the table 1 indicates that the use of holes-board pattern, for visible and infrared spectrums cameras calibrations, increase calibrations accuracy.

References

[1] Camera Calibration Toolbox for Matlab. http://www.vision.caltech.edu/bouguetj/calib_doc/index.htm

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[4] Fitzgibbon A., "Direct least square fitting of ellipses", *PAMI*, vol. 21(5), 1999.