The 12th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI 2015)
October 28 ∼ 30, 2015 / KINTEX, Goyang city, Korea

# Geometrical Calibration of Multispectral Calibration

Namil Kim, Yukyung Choi, Soonmin Hwang, Kibaek Park, Jae Shin Yoon and In So Kweon

KAIST, Korea

E-mail: {nikim, ykchoi, smhwang, kbpark, jsyoon}@rcv.kaist.ac.kr, iskweon77@kaist.ac.kr

***Abstract -*** In this paper, we introduce a novel calibration pattern board for visible and thermal camera calibration. Our pattern board is easy to make, handy to move and efficient to heat. Also, it preserves a uniform thermal radiance for a long time. Proposed method can be employed in single- and multi- spectral camera system, and also used in the splitter or stereo camera system. As a result, our method shows a good performance comparing with previous works, and we also shows that the calibrated system is enough to use in ADAS systems.

***Keywords -*** Camera Calibration, Pattern Board, Visible and Thermal Camera.

## 1. Introduction

The advantages of thermal cameras make them superior or complementary to conventional visible cameras. For example, thermal cameras are more robust to illumination changes and to temperature variations. Therefore, multi-camera setups involving thermal and other-spectral cameras have been a promising platform for many research and industrial applications. For the synergy of combinations, an accurate and efficient multispectral calibration procedure is important. Such calibration requires a pattern board for compatible multiple camera systems. Therefore, we are to provide an accurate but a convenient camera calibration pattern for both single- and multi-spectral cameras.

## 2. Preliminary

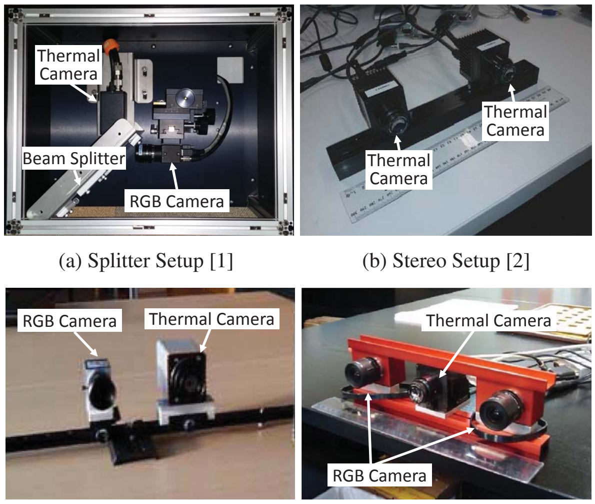
### 2.1 Multi-Camera setups

Although this paper deals with the multi-spectral calibration, the related multi-camera setup deserves some attention. As shown in Fig.1, the most popular setups are a beam splitter and stereo setup. These setups have been demonstrated to be highly effective and convenient for the fusion of visible and thermal cameras. All setups were proposed to capture images in the road traffic environment.

The beam splitter is more effective to calibrate multi-spectral cameras. Without additional preparation, it can easily find to visible and thermal correspondences. However, the stereo setup could struggle to get the reliable calibration point due to the baseline and different properties of both cameras. Despite of demerits, it is clearly easy and convenient to setup rather than a splitter.

### 2.2 Pattern Board

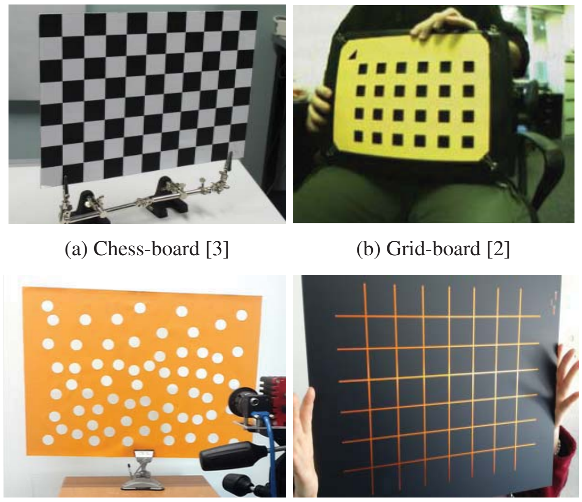
A regular printed chessboard in Fig. 2.(a) is the most popular pattern for the task of calibrating visible cameras. The calibration points are easily located in a visible-spectral image, while they cannot be reliably located in a thermal-spectral image. This is because the printed pattern generally maintains near-uniform temperature with low contrast in the thermal camera.




(a) Splitter Setup [1] (b) Stereo Setup [2]

(c) Stereo Setup [3] (d) Stereo Setup [2]

Fig. 1 Multi-Camera setups with visible and thermal cameras.



(a) Chess-board [3] (b) Grid-board [2]

(c) Circle-board [4] (d) Line-board (Ours)

Fig. 2 Pattern boards for camera calibration.

Recently, several chessboards have been introduced for enabling the use of thermal camera calibration with heating the pattern. Mouats *et al.* [2] proposed a pattern consisting of a grid of regular squares cut out of a thin material, which is opaque in the thermal-spectrum. When used, the pattern is held in front of a different thermal radiance object. However, this method often gets the crisp corners and it is vulnerable for flatness of pattern-board

978-1-4673-7971-7/15/$31.00 ©2015 IEEE

to result in inaccurate calibration.

An alternative approach involves piercing circle-shaped holes onto metal board. Jung *et al.* [4] first proposed this pattern for the use of time-of-flight (ToF) camera, and Hwang *et al.* [1] employed the pattern to calibrate the visible and thermal calibration. Unlike conventional corner points, it uses the center point of each hole. However, centers can be easily distorted by the thickness of pattern in lateral views, and it is hard to maintain an even temperature on all surfaces.

## 3. Proposed Approach

We are considered in following aspects to manufacture the new pattern.

(1) Accurate and effective for multispectral calibration

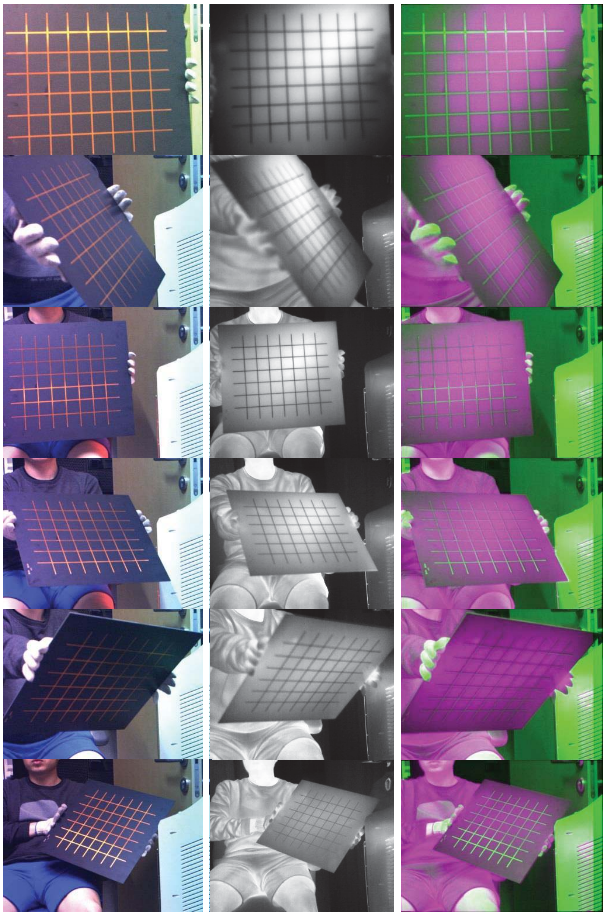
(2) Compatibility with conventional algorithms

(3) Uniform thermal radiance for a long period

(4) General field of view/resolution of thermal camera

The proposed calibration pattern consists of a line based grid of regularly sized squares pattern. The thin cooper line is milled onto a printed circuit board (PCB) with 2 *mm* wide and spaced with 40 *mm* separation, and a six/seven intersections along the shorter/longer axis.

Our line-grid pattern is more robust to maintaining a high contrast in thermal image, because the copper-line has a good conductivity to keep a uniform thermal distribution. As the proposed pattern has the same geometric relations to the conventional chess board, it can use many existing algorithms to calibrate thermal cameras.



(a) Visible images (b) Thermal images (c) Fused images

Fig. 3 Examples of calibration results. Re-projection error is 0.73 pixels (V) and 0.78 pixels (T).

## 4. Experiment

We used two multispectral cameras to evaluate and verify our approach for calibrating cameras and multi-camera setups. For the experiments, the pattern was heated up with a hairdryer, spending only a few seconds. As shown in Fig.3, it can be clearly seen lines in single-(a),(b) and combined-spectral images (c). Without additional optimization, the re-projection errors are measured in 0.73 (visible) and 0.78 (thermal) respectively. Fig 4 shows one of our applications [1], [5]. With accurate multispectral calibration, we can make completely aligned visible and thermal images and improve performance for pedestrian detection.

Fig. 4 Case Study: Pedestrian Detection.

## 5. Conclusion

We have presented a newly line-based grid pattern board for the calibration of visible and thermal cameras. The pattern board can be easily manufactured without extra equipment, such as metal or other light sources. Experiments showed that our approach can obtain accurate calibration parameters. We expect our pattern board to be extended and helpful in the development of many vision applications.

## References


[1] S. Hwang et al., Multispectral Pedestrian Detection: Benchmark Dataset and Baseline, CVPR, 2015.

[2] T. Mouats et al., Multispectral Stereo Odometry, TITS, 2015.

[3] S. Vidas et al., A Mask-Based Approach for the Geometric Calibration of Thermal-Infrared Cameras, TIM, 2012.

[4] J. Jung et al., Time-of-Flight Sensor Calibration for a Color and Depth Camera Pair, TPAMI, 2015.

[5] Y. Choi et al., All-Day Visual Place Recognition: Benchmark Dataset and Baseline, CVPRW, 2015.