Electro-optics and Infrared Image Registration using Gaussian Pyramids

Hyeok-Gi Gwon, Ik-Hyun Lee, and Tae-Sun Choi

School of Mechatronics, Gwangju Institute of Science and Technology (GIST),
123 Cheomdan Gwagiro, Buk-Gu, Gwangju, 500-712, Republic of Korea
{regret66,ihlee,tschoi}@gist.ac.kr
http://sipl.gist.ac.kr

Abstract. Image registration is a spatial alignment of two or more images and essential technology in image fusion, surveillance. Unlike the electro-optics (EO) sensor, infrared (IR) sensor absorbs the radiation energy. The relation between IR and EO image of pixel intensity is sometimes similar or often reverse. To overcome this complicated problem, we propose block-based processing incorporating corner detector and descriptor. This method also uses the Gaussian pyramids to register EO/IR image. The proposed method provides more accurate registration results.

Keywords: Image registration, Gaussian pyramids, Feature extraction

1 Introduction

In particular, image registration is considerably important technique in remote sensing, image fusion system, and surveillance. Image registration is a spatial alignment of the same area acquired from same or different times, views and sensors (reference and sensed image). Electro-optics (EU) image is acquired by using reflection and radiation of visible rays, whereas infrared (IR) image is use to absorb the radiation of energy and temperature information. Generally, single-modal registration is commonly used for many applications with visible range sensors during day and in indoor environments. In multi-modal case, infrared sensors were used in special medical imaging or and night vision. In surveillance system and remote sensing, infrared sensors provide more information than EU sensors in condition of poor lighting, smoke, fog, and cloudy weather. According to the different characteristics, using the both EU/IR sensors are more effective and each compensative. EU sensors are better than IR sensor during the day, while IR sensors provide more information in the dark. The drawback of using two sensors at same time is hard to extract corresponding features due to the complicated pixel intensity relation. It has sometimes similar intensity, while often reverse. Moreover, the contrast of IR image is less than EU image.
In the literature [7], feature-based methods is recommended to use in remote sensing which has lots of information, whereas area-based methods are employed

in medical images which contain less detail. The general drawback of the feature-based methods is difficulty to extract more distinctive features and its high computational complexity. To overcome these problems, first we apply Harris corner [3] detector instead of scale-invariant feature transform (SIFT) [4, 1,6] detector for more distinctive features and fast processing time. Second, we use block-based processing for reducing computational time. Finally, we apply the use of Gaussian pyramids to register EU/IR image.

2 Proposed method

Extracted features using IR image are comparatively smaller than EU image due to the low contrast. Non-block processing has high computational complexity due the high dimension of descriptor and large image size. To overcome these problems, we propose Gaussian pyramids with block-based processing to register accurately and efficiently. The proposed approach is as follows:

– Gaussian pyramids [2]: The first step of proposed method is to down-sample the original image using Gaussian pyramids.

$$I' = C * I \qquad (1)$$

where C is Gaussian low-pass filter and $*$ is the convolution operator. Down-sampled image $I'_{2\downarrow}$ is as follow:
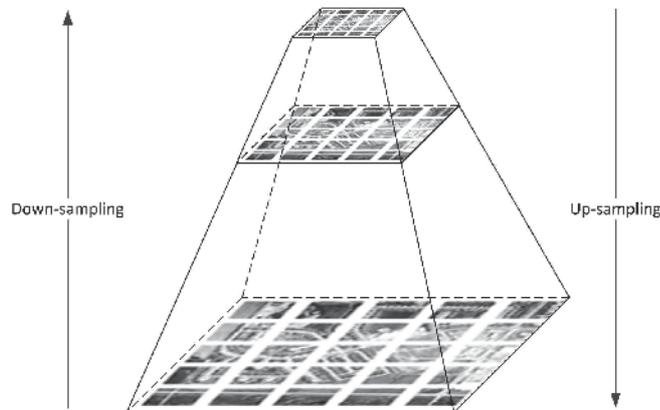
$$I'_{2\downarrow}[n] = I'[2n] \qquad (2)$$

Fig. 1. Gaussian pyramids via down-sampling and up-sampling.

Figure 1 shows Gaussian pyramids. Down-sampled image can be extracted features more efficiently due to the small image size and low computational cost.

– 1/2 scaled registration: registration processed using down-sampled IR image and EO image.
– IR-to-1/2 scaled IR warping: original IR image is warped by using the previous registered IR image with the up-sampling by a factor 2. Up-sampling is as follow:

$$I'_{2\uparrow}[n] = I'[n/2] \tag{3}$$

– Final registration: feature extraction and matching are processed using warped IR image and EO image via block processing. Then, IR image is transformed using the estimated transformation model.

3 Experiment results

3.1 Data sets

Three sample data are used to evaluate proposed method. The range of IR images is 3μm to 6μm, and its size is 1000 × 1000. EO image has also same dimension. In addition, image contains geometric distortion and terrain relief.

3.2 Detector comparison

Difference between SIFT and Harris detector is detected feature type. SIFT extracts blob and Region, whereas Harris detects corner. Feature detector should extract corresponding features both EO/IR images, but SIFT is not appropriate detector due to the lack of blob similarity between EO/IR images. Corner detector can extract features, even low relation of pixel intensity between EO/IR images.
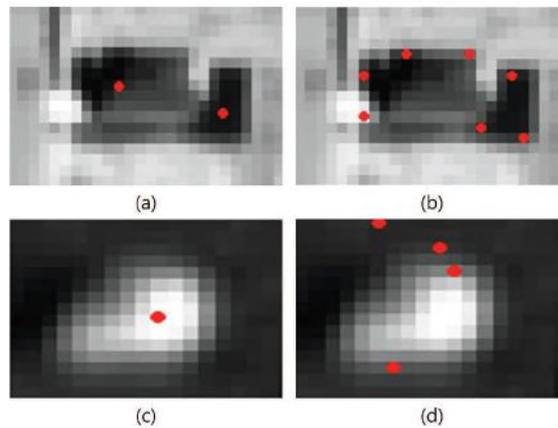
Fig. 2. Features comparison of EO (first row) and IR (second row) images using (a), (c) SIFT and (b), (d) Harris corner detector.

Figure 2 shows the extracted features using SIFT, Harris corner. From the figure, we can observe that Harris corner detection provides more distinctive features than SIFT.

3.3 Performance comparison

The criterion of recall is calculated by using the ratio of the number of correct matching points to the number of corresponding feature feature points, in which a higher value indicates better accuracy. 1-precision is the number of false matching points relative to the total number of matching points. Its smaller values represent higher accuracy. More detailed description is found in [5].

Table 1. Performance comparison of original SIFT and proposed block-based Gaussian pyramids (BGP).

Items	Sample 1		Sample 2		Sample 3	
	SIFT	BGP	SIFT	BGP	SIFT	BGP
Corresponding points	189	1,368	198	745	185	1174
Correct matching points	2	362	7	286	1	285
Recall	0.0105	0.2646	0.0353	0.3838	0.00540	0.2427
1-*precision*	0.9894	0.7353	0.9696	0.6161	0.9945	0.7572

Table 1 compares accuracy in terms of recall and 1-precision. From the table, proposed method provides more accurate registration results, which are higher recall and lower 1-precision value.

3.4 Visual comparison

Figure 3 is in color (Red: registered IR image, Green: EU image, Blue: EU image). The output images of the proposed method shown in Fig. 3 second row. From the figure, we can observe proposed methods registered accurately.

4 Conclusions

The block-based Gaussian pyramids is proposed in this paper for multi-modal EU/IR image registration. Due to the different characteristics of two sensors, original SIFT fails to register accurately, whereas proposed method is able to extract more distinctive features and accurate results, with respect to recall, 1-precision, and visual comparison.
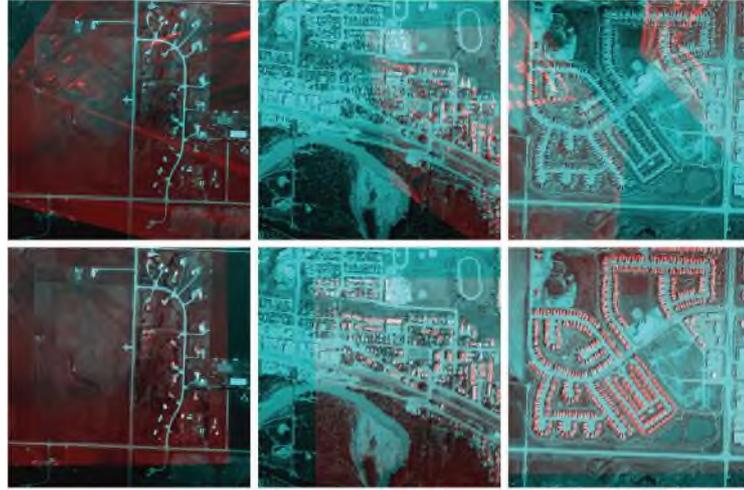
Fig. 3. Samples of warped RGB images: origianl SIFT (first row), proposed method (second row).

References

1. Brown, M., Lowe, D.: Automatic panoramic image stitching using invariant features. International Journal of Computer Vision 74(1), 59–73 (2007)
2. Burt, P., Adelson, E.: The laplacian pyramid as a compact image code. Communications, IEEE Transactions on 31(4), 532–540 (1983)
3. Harris, C., Stephens, M.: A combined corner and edge detector. In: Alvey vision conference. vol. 15, p. 50. Manchester, UK (1988)
4. Lowe, D.: Object recognition from local scale-invariant features. In: Computer Vision, 1999. The Proceedings of the Seventh IEEE International Conference on. vol. 2, pp. 1150–1157. Ieee (1999)
5. Mikolajczyk, K., Schmid, C.: A performance evaluation of local descriptors. Pattern Analysis and Machine Intelligence, IEEE Transactions on 27(10), 1615–1630 (2005)
6. Song, Z., Li, S., George, T.: Remote sensing image registration approach based on a retrofitted sift algorithm and lissajous-curve trajectories. Optics Express 18(2), 513–522 (2010)
7. Zitova, B., Flusser, J.: Image registration methods: a survey. Image and vision computing 21(11), 977–1000 (2003)