Stereo Matching Using Independent Component Analysis

S.H.Jeon
M.S. Student
Sogang univ. Robotics & Viosion Lab
Sogang univ. Shinsu-dong Mapo-gu, Seoul 121-742, Korea
rutus@dreamwiz.com

K. H. Lee
Professor
Sogang univ. Robotics & Viosion Lab
Sogang univ. Shinsu-dong Mapo-gu, Seoul 121-742, Korea
khlee@sogang.ac.kr

Abstract: Signal is composed of the independent components that can describe itself. These components can distinguish itself from any other signals and be extracted by analysis itself. This algorithm is called Independent Component Analysis (ICA) and image signal is considered as linear combination of independent components and features that is the weighted vector of independent component. This algorithm is already used in order to extract the good feature for image classification and very effective In this paper, we'll explain the method of stereo matching using independent component analysis and show the experimental result.

Keywords: Stereo Matching , Digital Terrain Model, Independent Component Analysis (ICA) .

1. Introduction

Fig.1 show the flow chart for stereo matching algorithm using ICA

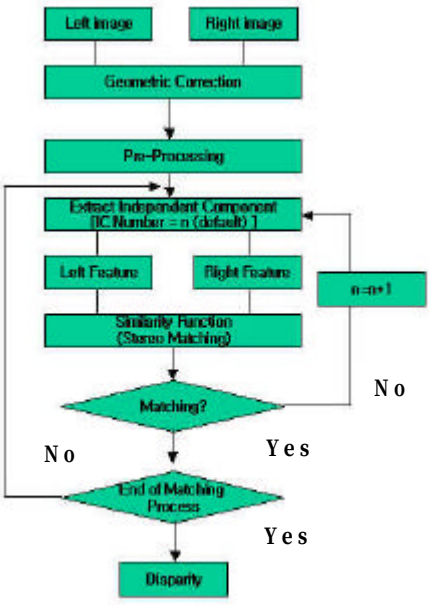


Fig. 1. Flow Chart of Stereo Matching Using ICA

A part of extraction the feature using ICA is added to the previous general matching algorithm. In this algorithm, it is very important to extract the meaningful feature for performing the stereo matching and the process that determine the method of image patch for extraction the feature of image is also important for good performance of stereo matching.

This paper is composed as below. In section 2, we'll introduce the primary theory of ICA and in section 3, the method of extracting the feature for stereo matching using IC filter and in section 4, the algorithm of stereo matching using the feature extracted from stereo image using IC filter. And then experimental result in section 5, Conclusion and Further Study in section 6

2. Independent Component Analysis (ICA)

The ICA algorithm in this paper makes good use of finding meaningful representations for the patched image set. The image data set is formed into the column structure generating the factorial code for input patched image. Typical image decomposition methods (Principle Component Analysis : PCA) are the way to find a good basis image set for representing prototype images. The PCA generally considers the second order linear dependency by adapting uncorrelateness, so that much of information in, which exist high order relationships between pixels can't be extracted.

The Equation of ICA is as below.

$$\tilde{x} = As \qquad (1)$$

$\tilde{x}$: Source Signal (or Image)

A : IC Filter (Basis images) s : Extracted Features

$\tilde{x}$ can be decomposed into IC Filter A and Feature s as eq. (1). The Method of decomposition Source is described in detail at [1]. We'll compare the feature that be extracted from a reference image of the stereo image. to the feature from a correspond image of the stereo images.

3. Extraction the Feature for Stereo Matching at any one point

The method of extraction the feature for stereo

matching at any one point is described as fig. 2.

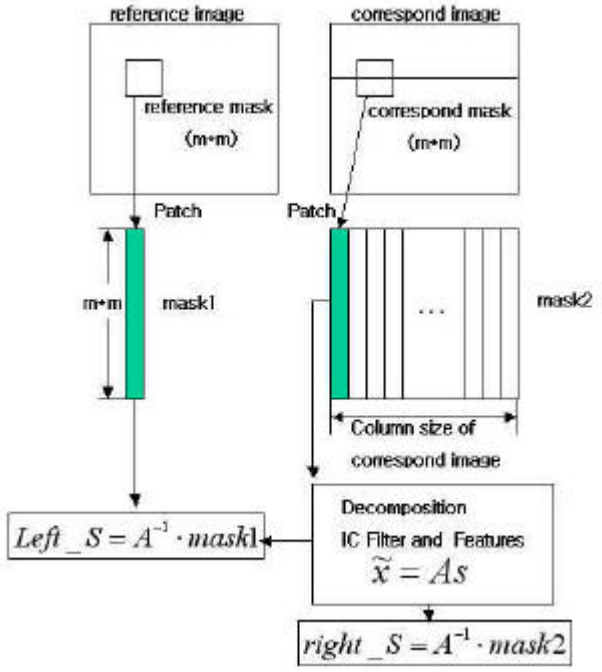


Fig. 2. The method of extraction the feature (m : mask size)

In Fig.2, mask1 is the (m*m) column vector patched of mask of reference image and mask2 is the matrix patched of mask of correspond image. The Dimension of mask2 is (m*m) by (column size of correspond image). After patch the mask image, we must decompose mask2 to IC filter and features of mask2. If we can take the IC filter of mask2, the feature of mask2 can be calculated as eq. (2). [1][3]

$$S = A^{-1} \cdot \tilde{x} = W \cdot \tilde{x} \qquad (2)$$

and then, The column vector mask1 patched from reference image can be considered as linear combination between the IC filter of mask2 and the correspond feature of mask1. the correspond feature of mask1 can also be calculated as eq. (2). In Fig. 2, right_S is the feature of mask1 and left_S is the correspond feature of IC Filter of mask2.

4. Stereo matching using the feature extracted from the stereo images

Above we could extract the feature for stereo matching at any one point. Now, we'll explain the method of stereo matching using the feature extracted from stereo images before. Fig 3. explain the method of stereo matching using extracted feature from stereo images.

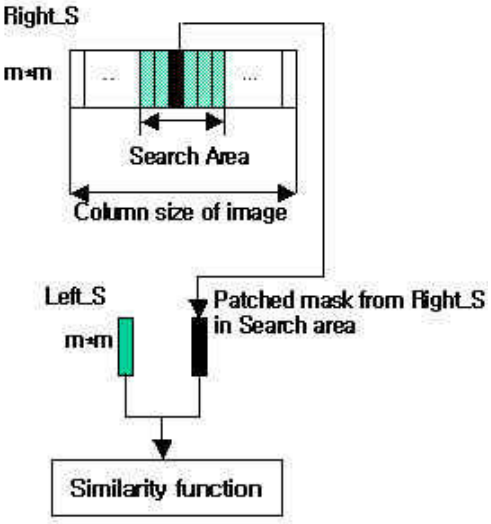


Fig. 3. Stereo Matching Method at any one point.

This stereo matching algorithm will be performed on the assumption that Geometric correction is processed before. If we want to find the corresponding point of any one point of left image, the feature of any one point of left image is compared with patched mask from the feature extracted from right image using any similarity function. We used the normalized cross correlation (NCC) as similarity function. The equation of NCC is described as eq. (3)

$$NCC = \frac{E[AB] - E[A]E[B]}{\sigma_A \sigma_B} \qquad (3)$$

Of course, we can use any other similarity function (e.g Absolute Different function).

5. Experimental Result

We use the Pentagon image and the ALOS simulation image in Akanezaki area. These images are geometric corrected images. Mask size is 17. Threshold value is 0.7 applied both images. Experimental Result show as the disparity map of each images and non post-processing (e.g interpolation or any other processing).

(a) Left Image (b) Right Image

Fig 4. Pentagon Stereo Image (512*512)

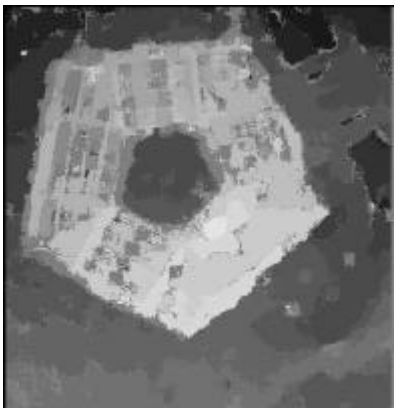
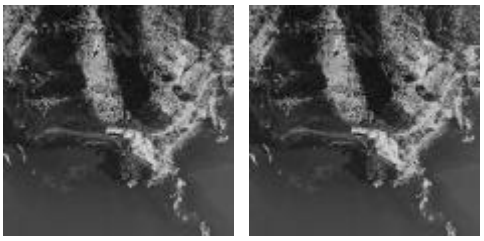


Fig 5. Disparity Map of Pentagon Stereo Image
(mask size=17, threshold=0.7,matching rate=92%)



(a) Left Image (b) Right Image

Fig 6. ALOS simulation image
(Akanezaki area ,300*300)

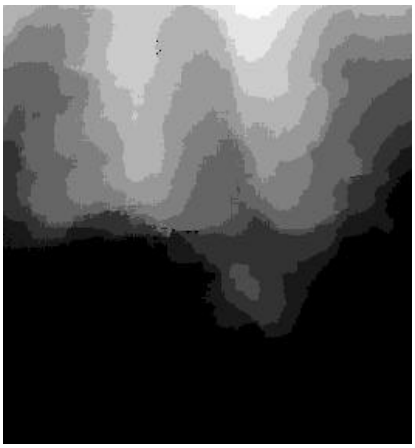


Fig 7. Disparity Map of ALOS Stereo Image
(mask size=17, threshold=0.7,matching rate=94.2%)

6. Conclusion and Further Study.

Experimental result is shown as fig. 5 and fig. 7. These result just display the disparity map of each image after stereo matching and we didn't perform post-processing. In these result ,we can confirm that ICA algorithm can be used for stereo matching. But we didn't analysis the performance from a effective point or accuracy point of view. Further more, this algorithm has two week points. First, Too much Computer resource and time is require to processing this algorithm In Further Study, we'll examine the performance of this algorithm all angles and improve the algorithm that is required less computer source and processing time.

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