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Stereo Matching with Gaussian Correlation Approach

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Abstract

Constructing photorealistic 3D models of object or scene from images is still a very difficult task in 3D image modeling research area. Matching problem is a challenging task in various application fields of computer vision such as recognition, identification, motion analysis, 3D structure reconstruction and so on. A robust method is represented for matching of the most interesting image points (feature points) among the multiple images. a detection algorithm of the corresponding corner points of an object is developed based on the Gaussian correlation based on the singular value decomposition approach. All of the corresponding image pairs between two images are computed by the transformation matrix. And then depth of the images are computed by Stereo Approach. Given its tremendous performance /complexity figure, the method is particularly suitable for research purposes where an off the shelf but reliable feature correspondence is needed.

Index Terms: Feature Extraction, Image Matching, Stereoscopy, Gaussian correlation.

Introduction

In the last two decades, a tremendous amount of research has been done in the area of reconstructing three-dimensional objects from two-dimensional camera images. One major challenge of the reconstruction problem is to find feature correspondences, that is, to locate the projections of the same three-dimensional geometrical or textural feature on two or more images. Classical approaches to reconstruction focus on estimating structure either from stereo image pairs or from monocular image sequences. Limitations in both of these approaches have motivated a growing interest in computing structure from stereo image sequences; however, most existing techniques in this area assume that feature correspondences are established in a previous step, or that they use domain specific assumptions that are inappropriate in other applications.

The problem of feature correspondence across two or more images is well known to be of crucial importance for many images analysis tasks. Recently, there has been a boost of interest in the correspondence estimation problem due to the development of the Fundamental Matrix theory [3] and its tremendous practical implications in the analysis of uncalibrated stereo pairs and image sequences. If the fundamental matrix is known, reliable

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Volume 1, Issue 7, October 2014

and fast feature correspondence can be obtained in general situations. However, in order for the fundamental matrix to be computed one needs a good initial set of feature correspondences. [1]

There are two approaches for solving the feature correspondence problem. In the first one, features are detected in one image and then correspondences for each of them are sought for in the second image, generally via multi-scale techniques. In the second approach, which the present work addresses, features are detected independently in both images and then matched up usually by relaxation. Incidentally, recent state-of-the-art work on the fundamental matrix estimation [2, 3] follows this latter avenue for achieving initial correspondences.

This paper presents a new simple method for achieving feature correspondence across a pair of images by Gaussian correlation based on the singular value decomposition approach. This paper is organized as follows. In the next section we study the previous work of feature point matching approaches. Then, the preprocessing steps for feature point matching for the proposed method is described in section 3. Section 4 presents the proposed matching approach for image pair. The experimental result of our system is expressed in section 5. Finally, section 6 provides some concluding remarks and future directions of research.

Related Work

Due to its inherent combinatorial complexity and ill-posedness, feature correspondence is one of the hardest low-level image analysis tasks. The problem can be stated as finding pairs of features in two (or more) perspective views of a scene such that each pair correspond to the same scene point.

Throughout the 1980s, sparse stereo matching algorithms have been an active field of research. With improved performance of dense algorithms in recent years, interest in sparse methods decreased and nowadays they only receive very little attention. Much of the early work on sparse stereo matching has been summarized in [4].

In [5], a framework to evaluate stereo vision methods is proposed. The author has also explicitly identified the constraints used in each of the studied methods. The work presented in [18] breaks down the matching process and reviews several matching methods, setting the stage for an empirical comparison, and [6] presents an algorithm for matching which exploits many constraints that are visually validated. Many authors use an iterative process in their matching algorithm before using a robust estimator. Relaxation is such an iterative process [7]. In this case, an energy function, corresponding to some aggregate value of a constraint applied to the pairs in a candidate set, is iteratively minimized. Testing the same constraint outside of such an iterative scheme represents a good way to establish its effectiveness. This why we have chosen to limit the scope of this study to the direct application of constraints.

Most methods have a sometime complicate algorithmic formulation. For tasks such as estimating the fundamental matrix where only a few tens of initial matches are needed leaner methods would perhaps be more suitable.

ISSN: 2348 9510
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Volume 1, Issue 7, October 2014

Preprocessing And Feature Point Extraction From Images

Detecting foreground object and feature extraction play an important role in video understanding. Foreground objects can be considered as those objects that are interested in the scene, which could be moving objects, static large objects, text, and human face.

The successive images are taken by hanging the camera positions. The camera focal length is 5mm and image of object is acquired from 100 cm apart. The distance between the two camera centers is set to 70 mm. The distance between the object position and camera position is 140 cm.

The bottom left image, bottom right image, upper left image and upper right image are defined as $I(0,0)$, $I(1,0)$, $I(0,1)$ and $I(1,1)$, respectively. The four acquired stereo images are shown in Fig. 1. The three dimensional depth measurements are computed based on the multi stereo camera system for obtaining the exact 3D measurements [8].

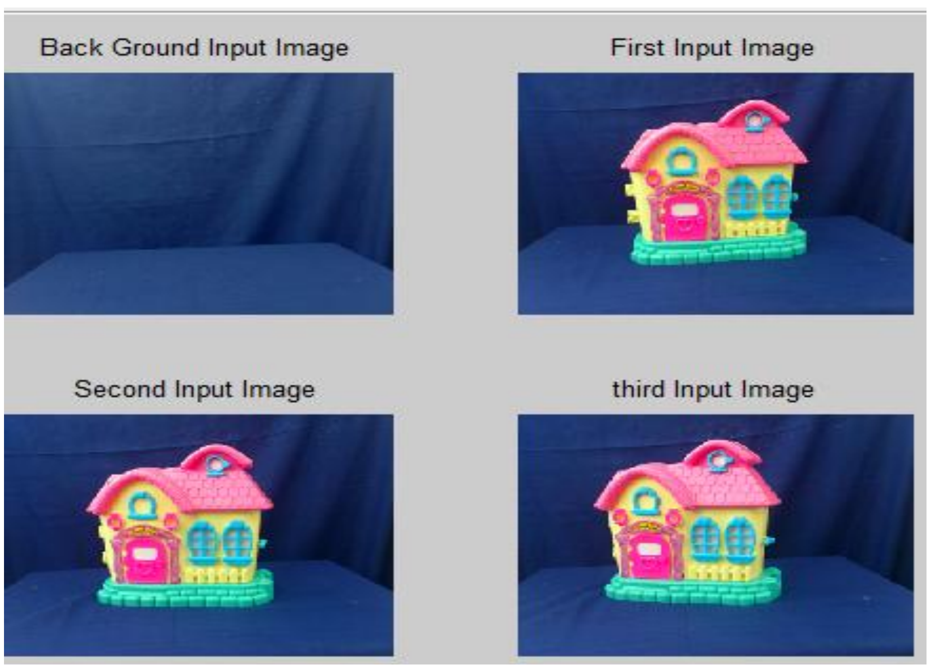

Figure 1. Acquicition of stereocopy images

The foreground image is extracted and this image is enhanced by using image enhancing method of morphological processing.

ISSN: 2348 9510
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Volume 1, Issue 7, October 2014

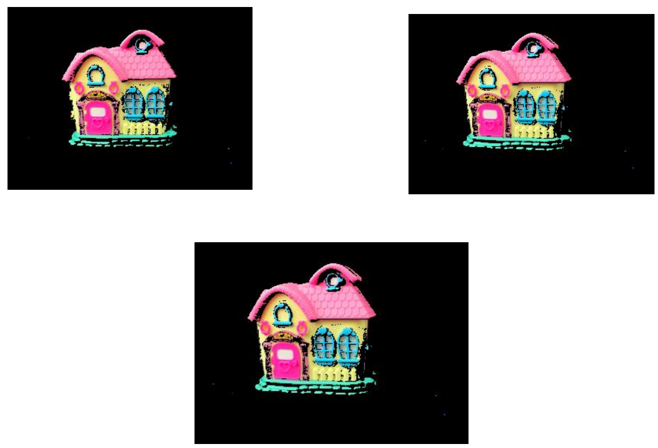

Figure 2. Foreground extraction.

After the morphological processing feature pointof the image is extracted as shown in figure 3.

Figure 3. Feature point extraction of images

The feature points of an object are obtained from the extracted foreground image. Sampling process is required for integrating two feature point set.

Detecting The Correspondence Feature Pairs Among Two Stereo Image Pairs

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 1, Issue 7, October 2014

Gaussian correlation based on the singular value decomposition approach is applied for computing the matching pairs between images.

First, Matching pairs of two images are finding from edge image by Gaussian method.

A proximity matrix ***G*** is build by the two sets of feature points of an object from **image I** and **image J**. equation (1) is their Euclidian distance, $i=1,2,\ldots,m$ and $j=1,2,\ldots,n$.

$$\boldsymbol{r}_{ij} = \left\| \boldsymbol{I}_i - \boldsymbol{J}_j \right\| \qquad (1)$$

Then compute the Gaussian weighted distance between two features I*i* and J*j*:

$$G_{ij} = \frac{(C_{ij}+1)}{2} e^{-r_{ij}^2/2\sigma^2} \qquad (2) \quad ,$$

If we represent two $W\,xW$ areas centered on features I*i* and J*j* as two $W\,xW$ arrays of pixel intensities A and B , respectively, the normalized correlation is defined as

$$C_{ij} = \frac{\sum_{u=1}^{w} \sum_{y=1}^{w} (A_{uv} - \overline{A}).(B_{uv} - \overline{B})}{W^2.\sigma(A).\sigma(B)} \qquad (3)$$

Ā is the mean of A. Once build the matrix G, decompose the matrix into the multiple of orthogonal matrices *T*, *U* and diagonal matrix *D* as follow.

$$G = TDU^T \quad (4)$$

Convert ***D*** to a new matrix ***E*** obtained by replacing every Diagonal element with **1** and then compute the product

$$P = TEU^T \quad (5)$$

P contains the matched pairs of feature points. The detected edge of the images and feature of two images are as shown in figure 4 and figure 5.

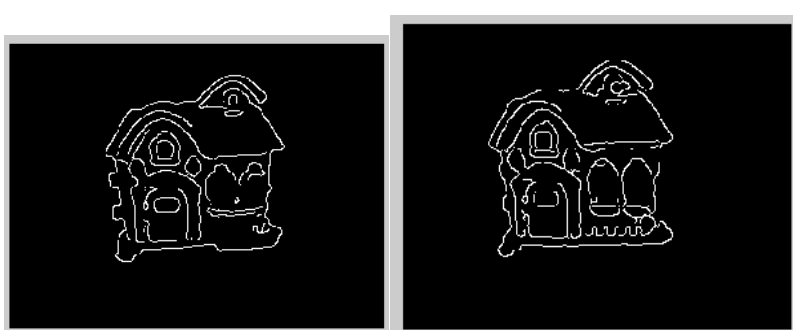

Figure 4. Image with detected edges.

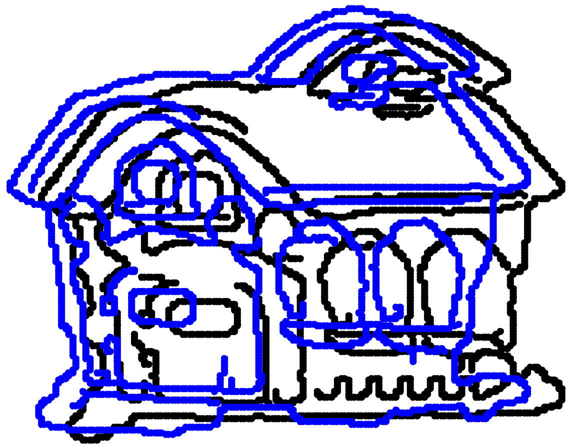

Figure 5. Feature of two images

Then all corresponding image pairs between two images are computed by the transformation matrix. The transformation matrix T is computed as follow:

The two feature set S1=V(:,1:2); S2=V(:,3:4);

$S_2 = TS_1$

$S_2(S_1)' = TS_1S_1'$

$S_2S_1'\ (S_1S_1')^{-1} = T(S_1S_1')^*\ (S_1S_1')^{-1}$ $\qquad T = S_2S_1'\ (\ S_1S_1'\ )^{-1}$

Then the matched points of N1 (the whole feature points of an object) are computed by the above transformation.

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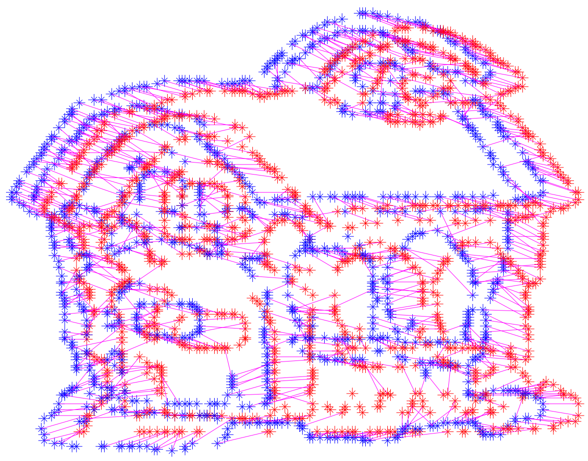

Figure 6. Matching of images by 2 pair

Experimental Result

The performance of the stereo images matching procedure is measure by execution time. Execution time is measured as the time taken from getting input images to foreground object extraction, Feature point extraction of images, edges detection time, feature matching of images and stereo images feature point matching with only one paired, two pair and three pair of stereo images. To evaluate our method, we conducted a translation experiment was made as follows. We implemented the system with MABLAB programming language on Core i3 CPU with 2.27 GHz processor with 4 GB of RAM in 32 bit operating system.

Table 1. Comparison table for processing step and no. of pair

	One pair (seconds)	Two pair (seconds)	Three pair (seconds)
Foreground object extraction	2.96	3.11	3.51
Feature point extraction	1.15	1.26	1.32
Edge detection	0.44	0.57	0.62
Feature	79.48	86.75	87.63

matching of images			
Feature point matching for 3D image	56.40	79.61	89.54

Acorrding to the table, the procedure of the matching technique is efficient for execution time and effective for any number of pair between stereo images.

Conclusion

In this paper, we have demonstrated that gaussian correlation based on single value decomposition approach on stereo image matching. Our algorithms are simple to implement and computationally efficient, and result in better quality estimates, especially near discontinuities in the disparity surface. We believe that further study of the basic support and aggregation methods in stereo matching is central to developing for 3D model generation.

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