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An Analytical Study of SIFT and SURF in Image Registration

Vivek Kumar Gupta, Kanchan Cecil
Department of Electronics & Telecommunication, Jabalpur engineering college, Jabalpur, India

Abstract - ***This paper present point matching using Speeded-Up Robust Features (SURF) and scale invariant feature transform (SIFT) and comparison between them and removing outliers using Restricted Spatial Order Constrains (RSOC) in image registration. Surf outperforms previously proposed schemes with respect to repeatability, distinctiveness, and robustness Computed and compared much faster. This is achieved by relying on integral images for image Convolution; by building on the strength of the leading existing detectors and descriptors. RSOC is proposed to remove outliers for registering image with monotonous back ground, simple patterns, low overlapping areas, and large affine transform. Based on adjacent spatial order, an affine invariant descriptor is defined in RSOC. In order to eliminate dubious matches, a filtering strategy is designed. The strategy integrates two way spatial order constraints and two decision criteria restrictions, i.e. the stability and accuracy of transformation error.***

I. INTRODUCTION

Lowe (2004) presented SIFT for extracting distinctive invariant features from images that can be invariant to image scale and rotation [1]. Then it was widely used in image mosaic, recognition, retrieval etc. Bay and Tuytelaars (2006) presented speeded up robust features and used integral images for image convolutions and Fast-Hessian detector [2]. Their experiments turned out that it was faster and it works well. There are also many other feature detection methods; edge detection, corner detection and etc [3]. Different method has its own advantages. This paper focuses on two robust feature detection methods which are invariant to image transformation or distortion. Furthermore, it applies the two methods in recognition and compares the recognition results by using RSOC methods. In the experiment, we use repeatability measurement to evaluate the performance of detection for each method [4]. When a method gives a stable detector and matching numbers we can say that it is a stable method and if we want to know how correct the method is, we need to use correct matches number that can be get from the RSOC method. The related work is presented in Section 2 while Section 3 discusses the overview of the method. In section 4 we can see the experiments and results. Section 5 tells the conclusions and future work of the paper.

II. RELATED WORK

In [1], Lowe did not only presented SIFT but also discussed the key point matching which is also needed to find the nearest neighbor. He gave an effective measurement to choose the neighbor which is obtained by comparing the distance of the closest neighbor to the second-closest neighbor. Both methods use the same RSOC model and parameters, which will explain more in the following. In [7], they showed how to compute the repeatability measurement of affine region detectors also in [4] the image was characterized by a set of scale invariant points for indexing. Some researches focused on the application of algorithms such as automatic image mosaic technique based on SIFT [9][11], stitching application of SIFT [10][15][12] and Traffic sign recognition based on SIFT [12]. In [2], the author used Fast-Hessian detector which is faster and better than Hessian detector. Section 3 will show more details of the both methods and their differences.

III. VERVIEW OF THE METHODS

A. SIFT detector

SIFT consists of four major stages: scale-space extreme detection, key point localization, orientation assignment and key point descriptor. The first stage used difference-of-Gaussian function to identify potential interest points [1], which were invariant to scale and orientation. DOG was used instead of Gaussian to improve the computation speed [1].

$$D(x, y, \sigma) = (G(x, y, k\sigma) - G(x, y, \sigma)) * I(x, y)$$
$$= L(x, y, k\sigma) - L(x, y, \sigma). \quad (1)$$

In the keypoint localization step, they rejected the low contrast points and eliminated the edge response. Hessian matrix was used to compute the principal curvatures and eliminate the low contrast points. An orientation histogram was formed from the gradient orientations of sample points within a region around the keypoint in order to get an orientation assignment [1]. According to the paper's experiments, the best results were achieved with a 4 x 4 array of histograms with 8 orientation bins in each. So the descriptor of SIFT that was used is 4 x 4 x 8=128 descriptors

B. SURF detector

SIFT and SURF algorithms employ slightly different ways of detecting features [9]. SIFT builds an image pyramids, filtering each layer with Gaussians of increasing sigma values and taking the difference. On the other hand, SURF creates a "stack" without 2:1 down sampling for higher levels in the pyramid resulting in images of the same resolution [9]. Due to the use of integral images, SURF filters the stack using a box filter approximation of second-order Gaussian partial

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derivatives, since integral images allow the computation of rectangular box filters in near constant time [2]. In keypoint matching step, the nearest neighbor is defined as the keypoint with minimum Euclidean distance for the invariant descriptor vector. Lowe used a more effective measurement that obtained by comparing the distance of the closest neighbor to that second-closest neighbor [1].

C. RSOC outlier remover

The proposed RSOC algorithm takes one to one corresponding sets from reference image and floating image as an input. First two way spatial order constraints method based on distance sequence matrix and angular spatial order matrices is performed. According to spatial order differences, some real matched points may be taken for outliers or mismatched points may be preserved as a real matched pair. In this situation, a restricted filtering strategy is stipulated to determine which candidate is more likely to be an outlier, particularly when the spatial order differences of the candidates are slight. Then, two decision criteria restrictions are applied to select one outlier to be removed from candidate ones. The outlier removal process is performed iteratively, until an optimal solution is obtained. The convergence speed is related to the number of outliers [16].

The repeatability measurement is computed as a ratio between the numbers of point-to-point Correspondences that can be established for detected points and the mean number of points detected in two images [4]:

$$r_{1,2} = \frac{C(I_1, I_2)}{mean(m_1, m_2)}$$

Where C (I_1, I_2) denotes the number of corresponding couples, m_1 and m_2 means the numbers of the detector. This measurement represents the performance of finding matches. Another evaluation measurement is RSOC, which is used to reject inconsistent matches. The inliers are point that has a correct match in the input image. Our goal is to obtain the inliers and reject outliers in the same time. In this paper the image dataset from same object for image registration are taken. For point detestation and matching SURF and SIFT algorithm are used and to find outlier RSOC algorithm is used as shown in figure 1. All the experiments work on Intel(r) core(TM) i3-3110M CPU @ 2.40GHZ processor, 2GB RAM with window 7 operating system in MATLAB environment.

IV. EXPERIMENTS & RESULTS

A. Evaluation measurement

B. Experiment of image registration

These are two images from same object for image registration. Result of SURF with RSOC and result of SIFT with RSOC are shown in experiment 1 and experiment 2 respectively.

Image courtesy of Massachusetts Executive Office of Environmental Affairs

Image 1

Image courtesy of mPower3/Emerge

image 2

1. Experiment of SURF with RSOC

Point detection using SURF algorithm

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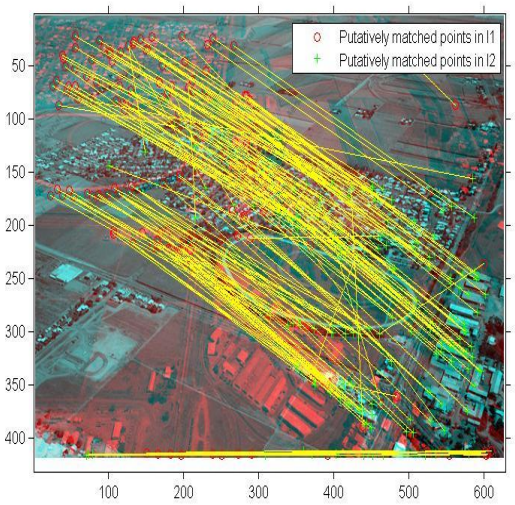

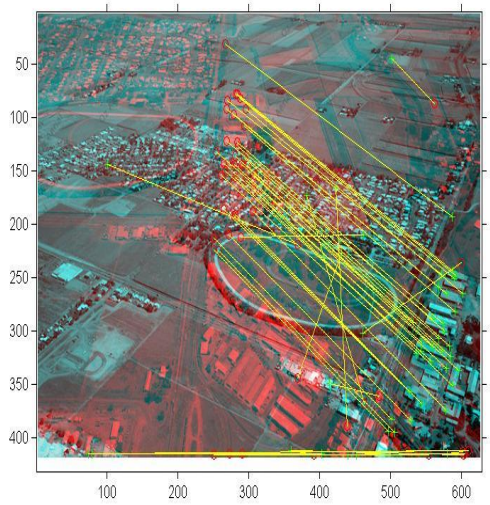

Matched point

Remove outlier by RSOC

Final result of SURF and RSOC

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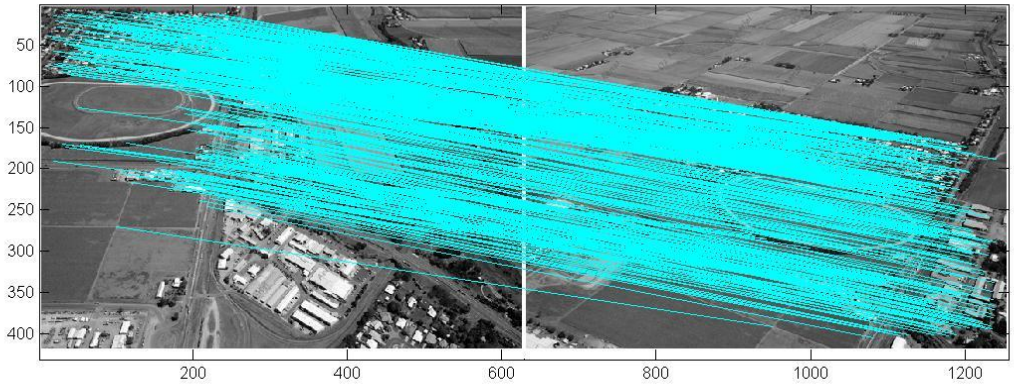
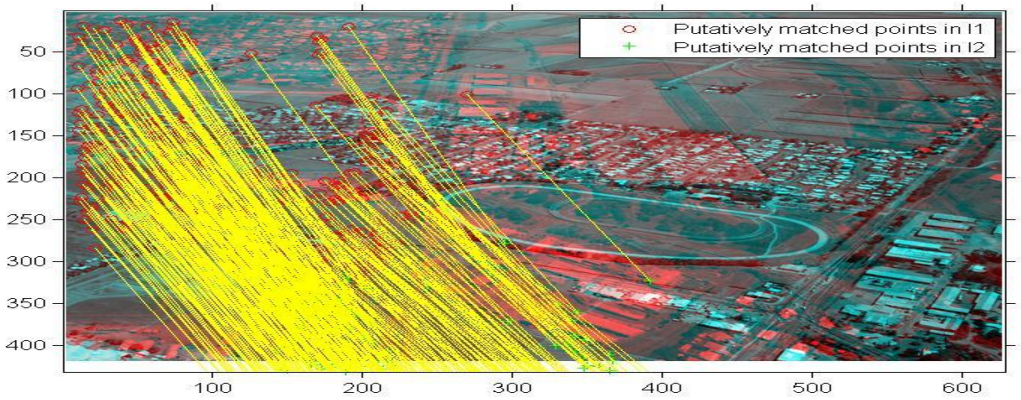
2 Experiment of SIFT with RSOC



Point matching using SIFT algorithm



Remove outlier by RSOC

Final result of SIFT and RSOC

The experimental results are summarized in Table

Algorithm	Detected Points		Matching point	matching Time (sec)	Repeatability In %	RSOC	outliers	Outlier finding time(min)	Rmse (pixel)
	Image1	Image2							
SURF	1131	780	192	3.252	20.09		149	36.56	50.167
SIFT	3082	2273	434	8.34	16.20		251	314.05	0.0219

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V. CONCLUSIONS

This paper has evaluated two feature detection methods for image registration. Based on the experimental results, it is found that the SIFT has detected more number of features compared to SURF but it is suffered with speed. The SURF is fast and has slightly less performance than SIFT. Our future scope is to make these algorithms accurate image registration in all types of image and work for the video registration.

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