SAR AND OPTICAL IMAGES REGISTRATION USING SHAPE CONTEXT

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1. INTRODUCTION

In emergent events, such as earthquake and flood, airborne SAR and optical images are efficient and flexible data sources, which can provide repeated images within short time intervals. In key areas large amounts of images are collected, and commonly they need to be combined together to analyze the ground situation. It becomes a large challenge to register multi-sensor images in time for many applications in remote sensing.

Automatic registration falls into two types: area-based and feature-based techniques. Feature-based methods are typically applied when the local structural information is more significant than the image intensity information [1]. In previous research, many feature-based matching strategies have been employed on remote sensing images. The hausdorff distance measures the extent to which each point of a data set lies near some point of an 'image' set [2], and it is improved and utilized in remote sensing [3]. Patch features are used in Spot and ERS-1 images matching [4]. In urban areas, line features can be extracted from roads and be matched with Modified Iterated Hough Transform [5]. In [6], spatial relations and organically feature similarity were combined as a matrix, and its global maximum was assumed to be reached when two images matched well with each other.

Generally, the feature matching strategies mentioned above rely on strong features, such as special points, islands, closed lakes or straight lines. In this paper, an effective method to enhance edge features is employed, and a broadly suitable algorithm for registration named shape context is introduced, even for weak feature areas.

2. METHOD

Shape context is presented for object recognition on silhouette images [7], and it is briefly introduced in this section. In addition, we make some improvements to make it fit for more complex remote sensing images. As far as we know, this is the first time that shape context has been used for remote sensing images.

2.1 Shape context

For a point on the first image, we try to find the best matching point on the second image according to the edge features. It is identified that the distribution over relative positions as a more robust and compact, yet highly discriminative descriptor. This method is implemented with a circular log-polar template, as shown in figure 1(a). For a point p_i on the shape, we compute a coarse histogram h_i of the relative coordinates of the remaining n-1 points.

This histogram is defined to be the shape context of p_i. Consider a point p_i on the first shape and a point q_j on the second shape. Let $C_{i,j} = C(p_i, q_j)$ denote the cost of matching these two points. As shape contexts are distributions represented as histograms, it is natural to use the χ^2 test statistic:

$$C_{i,j} \equiv C(p_i, q_j) = \frac{1}{2}\sum_{1}^{K} \frac{\left[h_i(k) - h_j(k)\right]^2}{h_i(k) + h_j(k)} \quad (1)$$

where $h_i(k)$ and $h_j(k)$ denote the K-bin normalized histogram at p_i and q_j, respectively; C_{ij} is the cost for matching two point sets.

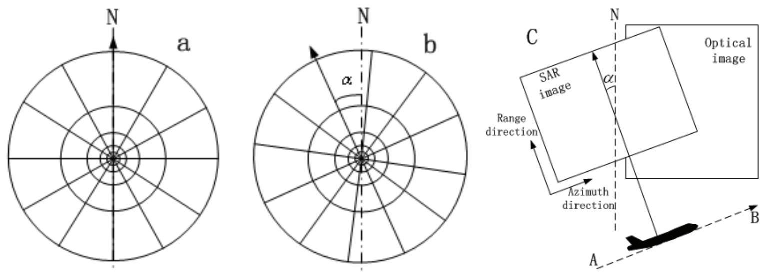

Fig 1. (a) The log-polar template of shape context; (b) The template rotated with an angle; (c) The rotation angle estimated from the flight line.

2.2 Improvement

In this paper we give the circular template an orientation. In silhouette image matching, one can use a relative frame, based on treating the tangent vector at each point as the positive x-axis. For multi-sensor images, it does not work because edge features are too complex to determine the tangent vector stably. In a more practical way, it is supposed that the SAR image has a rotation, compared to an ortho-image; thus we give the circular template a general rotation angle α to correspond with the SAR image, as shown in figure 1(b). The rotation angle is obtained from the flight line of the airplane, as figure 1(c), and its influence on the registration accuracy is evaluated in our study.

3. EXPERIMENTS

To validate the robustness of the proposed method, the following experiment is performed using airborne optical and SAR images. First, edge features are extracted using Canny operator, and then enhanced by expanding the features; second, the edge features on two images are matched with the improved shape context.

3.1 Edge enhancement

Edge features are extracted from optical and SAR images using Canny operator, and then they are expanded to suppress invalid edges (edges of trees) and connect discontiguous edges.

(a) (b)

Figure 1. Edge enhancement. (a) The edges extracted from the optical image. The areas in the red outlines are trees; (b) The edge features generated by expanding edges in (a).

3.2 Registration of Airborne Optical and SAR image

The airborne optical ortho-image, obtained from ADS40, and the C-band SAR image are employed in the first group of experiments. The results are shown in figure 2.

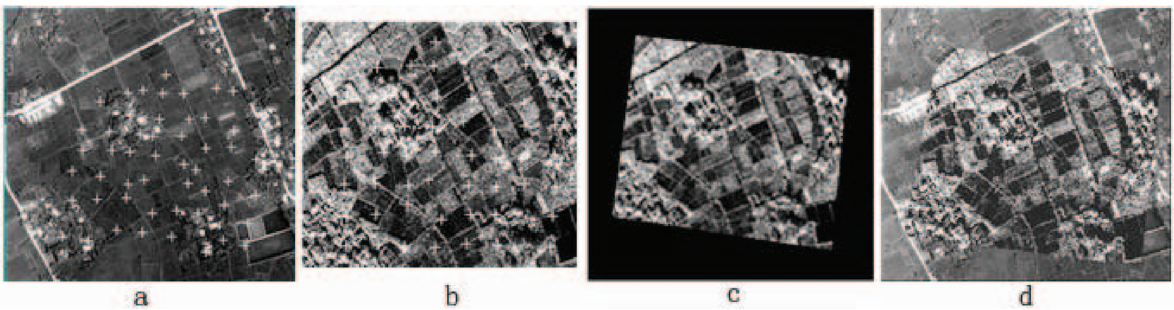

Figure 2. Registration of optical and SAR images. (a) CPs on the reference image. (b) CPs on the sensed image (c) The warped sensed image. (d) The matching result.

4. REFERENCE

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