ROBUST EXTRACTION OF CONTROL-POINT PAIRS FOR ELASTIC REGISTRATION OF HIGH-RESOLUTION SATELLITE IMAGES

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1. INTRODUCTION

Image registration is the process of spatially fitting two images of the same scene acquired on different dates, from different viewpoints, and/or using different sensors. Image registration is required in a variety of applications, such as, in image fusion, 3D scene reconstruction, and multi-temporal analysis (i. e. natural disaster monitoring, urban change detection, etc.). See [1] for a comprehensive survey.

A typical image registration process is accomplished by identifying so-called control points (CP) pairs, in the involved images. Through such control points it is possible to estimate the underlying geometrical transformations between the considered images. Accuracy in image registration is strongly tied to: a) the geometrical transformation considered, which should account for the relative geometric (possibly non-rigid) differences between the images, and b) the distribution of CPs over the images. The correct selection of the latter is primordial not only to gain in accuracy but also in efficiency: while two pair of CPs would suffice to perfectly overlap images of a flat terrain (since they may only differ in shift, scale and rotation), a large number of them will be necessary to capture the relative geometric difference between images of high-relief surfaces acquired from different viewing angles, requiring, thus, complex elastic transformations.

In the absence of information about the type of terrain, the best (thought not efficient) solution is to regularly distribute CPs all over the images. However, when some information about the terrain profile is available, a more elaborated algorithm can help us to decide the density of CPs on each region of the image. In this paper we present an automatic method to extract control points for accurate registration of high-resolution images, such as Quickbird, Ikonos, etc. Our approach generates a minimal distribution of control points based on the relief information provided by digital terrain models (DTM), achieving significant speedup in the process without sacrificing accuracy.

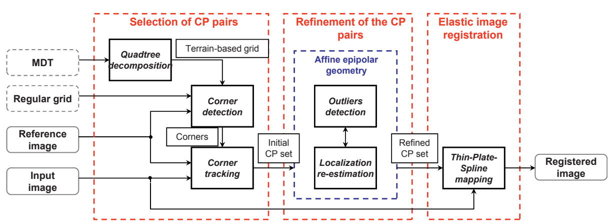

Fig. 1. Brief scheme of the proposed method. Please refer to the text.

2. DESCRIPTION OF THE PROPOSED METHOD

The proposed method combines techniques adapted from the computer vision field to robustly and precisely extract conjugate points for registering high-resolution images. In a nutshell, our method applies a corner detector [2] to identify key points in the reference image and an affinity-based feature tracker that searches for their corresponding points in the target image [3]. This feature tracker considers multiple scale for the images and relies on a variant of the sum of square differences (SSD), providing robustness to image brightness differences through local linear radiometric corrections. Additionally, robustness to mismatches is attained by exploiting the affine epipolar geometry of the two views [4]. Figure 1 shows an overview of the proposed method.

The proper density of control points is regulated by means of a quadtree decomposition of the DTM. This decomposition parcels up the image according to its relief variance yielding almost planar pieces of land. The considered feature detector is then executed in every parcel, producing (at-least) a control point. In this manner we guarantee that a higher number of control points will be assigned to regions with a high-relief while flat regions will contain less. An illustrative example of a coastal city surrounded by mountains is shown in figure 2. Upon the DTM of this region, shown in figure 2-b, our method generates a quadtree decomposition according to the relief of the different parts, i.e. high-relief areas will be more intensively decomposed (figure 2-c).

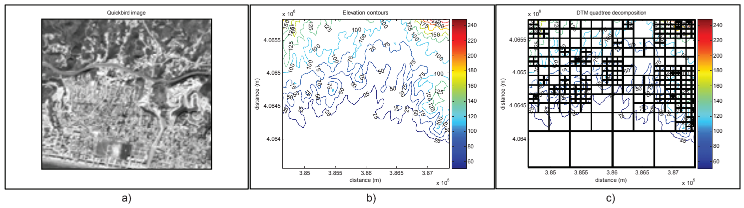

Fig. 2. DTM quadtree decomposition. Each parcel might contain a control point for posterior image registration. Notice that a minimum size is considered for planar areas in order to guarantee a sufficient number of control points.

3. EXPERIMENTAL RESULTS AND CONCLUSIONS

The proposed method for automatically extraction of control points has been successfully tested by registering a large number of panchromatic QuickBird image pairs (0.6 m./pixel) using thin-plate-spline mapping functions. The images considered in our tests exhibit significant relative geometric distortions (induced by the off-nadir observation of no-planar regions) and radiometric changes (due to their different acquisition dates). To evaluate the method reliability, we have compared the resultant control point distribution with respect to uniform and random distributions, yielding better results in terms of accuracy and efficiency. The accuracy of the registration process has been assessed comparing the geometric errors (RMSE and CE90%) of a set of independent control points manually identified, achieving errors under 1.3 m. (see fig. 3).

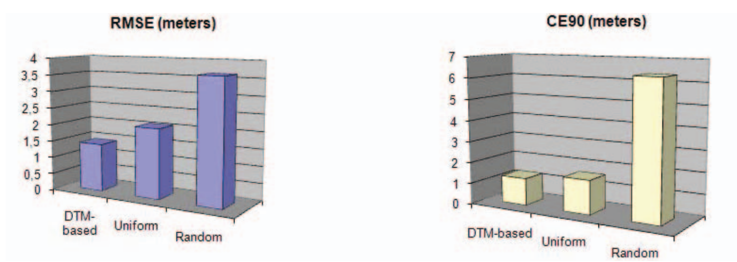

Fig. 3. Accuracy of the proposed method compared to uniform and random distribution of CP considering RMSE and CE90%.

4. REFERENCES

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