TIE POINTS BASED PIXEL-LEVEL COMPENSATION OF MISREGISTRATION FOR CHANGE DETECTION

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1. INTRODUCTION

One important assumption in change detection techniques is that the multitemporal images used for change detection have been aligned or co-registered without error. Many registration techniques have been developed, but it is impossible to obtain perfect co-registration results. To reduce the registration error effects of change detection, some methods have been proposed. These methods can be categorized into three groups: modeling based methods [1][2][3], filter based methods [4][5], and compensating based methods [6]. In modeling based methods, the false changes caused by registration error are modeled according to the change detection methods. Then, the false detection is reduced in the change detection procedure. Some researchers applied spatial filters to the difference image between two multitemporal images to decrease the registration noise. Stow [6] proposed a compensating method to reduce the intensity error in the difference images caused by spatial misregistration. The compensation for each pixel is determined by the local gradient and the positional error. In these modeling based methods, the models of false changes are determined by the change detection method. So they cannot be combined with other change detection methods, and have the same limitations as their companying change detection methods on the type of remote sensing data. The performance of filter based methods that kind of methods is not stable for difference registration error, and is affected by the scene of images and the type of changes. Filter based methods and Stow's method can only be used for change detection based on the difference images. Because of the complication of registration error, in practice, Stow's method cannot provide better results. But Stow proposed a reasonable idea to reduce the registration noise. Therefore, an effective and independent method to reducing registration error for change detection is preferred.

In this paper, we propose a practical compensation method to reduce the registration noise in multitemporal registered image before applying change detection method, which is an improvement of Stove's idea. The proposed method contains two steps: estimating the misregistration map using the residuals of tie points and thin plate spline (TPS) transform, and modifying each pixel of the registered image with spatial shift and intensity compensation according to its local misregistration and gradient.

2. PROPOSED METHOD

f_1 and f_2 separately denote the reference image and registered images. It can be considered that the registration noise only exists in the registered image f_2. So the noise can be reduced by modifying the registered image. This approach will guarantee that the proposed method is independent of change detection methods. The proposed method is described in Fig. 1.

1. Initialize the tie points set of reference image f_1 and registered image f_2: $\{p_{1i}, p_{2i}, i \in 1,\cdots,n\}$ and calculate the registration error:

$e_i = p_{1i} - p_{2i}$.

2. Estimate the TPS transform with $\{p_{1i}, e_i, i \in 1,\cdots,n\}$:

$(W \mid A)^T = L^{-1}E_s^{\ T}$.

3. Compute the registration error map E of f_2:

$E = AP + WU$.

4. Compute the pixel-level error E_r and the subpixel-level error E':

$E_r = round(E)$,

$E' = E - E_r$.

5. Calculate the gradient maps ∇_x and ∇_y of f_2 in x and y direction with spatial filter $[0 \quad -1 \quad 1]$ and $[0 \quad -1 \quad 1]^T$.

6. Modify intensity of each pixel in f_2 as:

$f_2'(s) = f_2(s + E_r(s)) + \nabla_x(s + E_r(s) + step(e_x'))e_x' + \nabla_y(s + E_r(s) + step(e_y'))e_y'$,

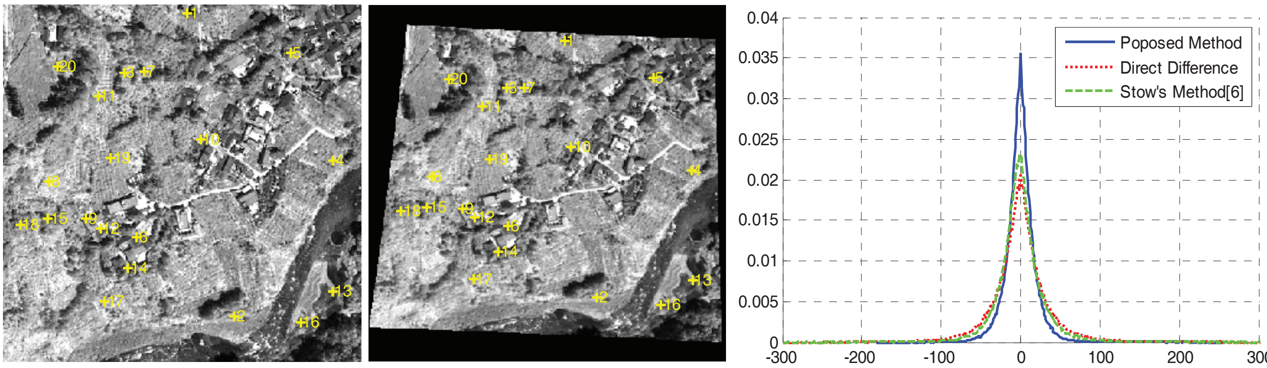
where $E'(s + E_r(s)) = (e_x', e_y')$, $step(x) = \begin{cases} 0 & if\ x \geq 0 \\ -1 & if\ x < 0 \end{cases}$, $s \in f_2$.

Fig. 1. Compensation of misregistration based on the tie points.

3. EXPERIMENTS AND RESULTS

To illustrate the effectiveness and independence of our method, two experiments are conducted.

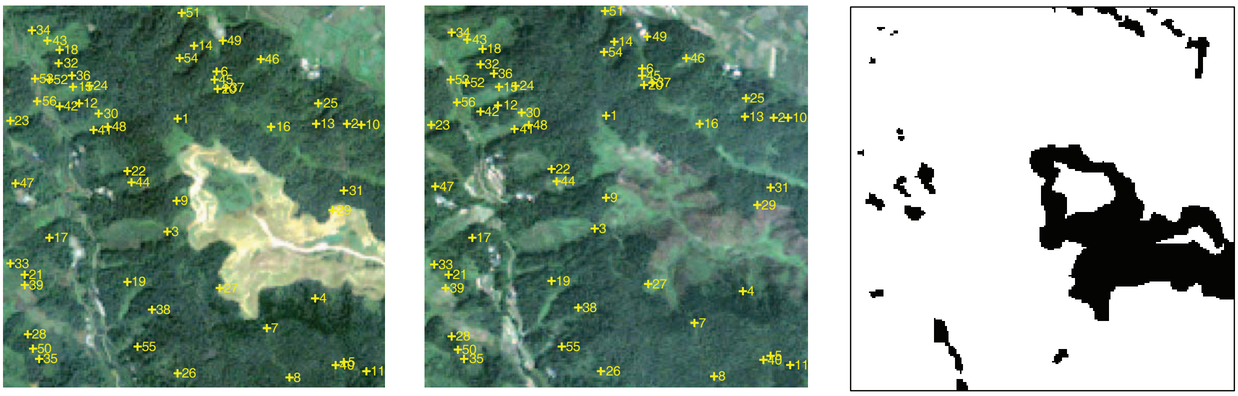
Experiment 1: An IKONOS panchromatic image, 400×400 pixels, is deformed by the known transform, including rotation, scaling, bow, skew, and translation, as shown in Fig. 2. Then, the image with registration noise is generated by registering the deformed image to the original one with a second order polynomial transform and 20 randomly generated tie points. Fig.2.c shows the histograms of difference images produced with three compensating strategies: direct difference, Stow's method [6], and the proposed method. The histogram of difference image compensated with our method is sharper than the others, which demonstrates that our method reduces more registration noise than Stow's method [6].



(a) (b) (c)

Fig. 2. (a) Original panchromatic image. (b) Deformed image. (c) Histograms of difference images with three different compensating strategies. Tie points are marked with crosses and indexed number.

Experiment 2: A IKONOS multispectral image pair, 200×200 pixels for each image, is co-registered using second order polynomial model and 56 tie points, as shown in Figure 3(a) and (b). These images are scenes of Sichuan, China, which are acquired pre (2007, 14 September) and post (2008, 28 June) earthquake. We compared the change/non-change results generated by three change detection methods: modified image difference (MID), multitemporal principle component analysis (MPCA), and modified image radio (MIR). The change detection errors incurred by the three compensating strategies are presented in Table 1-3. The Stow's method [6] is modified to fit MID and MPCA.



(a) (b) (c)

Fig. 3. (a) Image of post earthquake. (b) Registered image of pre earthquake. (c) Binary change map of ground truth. Tie points are marked with crosses and indexed number.

Tab. 1. Detection error of MID with different compensating strategy.

Compensating strategy	No comp.	Stow's comp.	Proposed comp.
False Alarms	1991	1359	1244
Missed Alarms	1676	2926	1557
Total Errors	3667	4285	2801

Tab. 2. Detection error of MPCA different compensating strategy.

Compensating strategy	No comp.	Stow's comp.	Proposed comp.
False Alarms	3241	3169	3061
Missed Alarms	271	210	208
Total Errors	3512	3379	3269

Tab. 2. Detection error of MIR different compensating strategy.

Compensating strategy	No comp.	Stow's comp.	Proposed comp.
False Alarms	2031	84	1480
Missed Alarms	1752	4328	1638
Total Errors	3783	4412	3232

4. DISCUSSION AND CONCLUSIONS

In detail, it is obvious that our proposed reduces the detection error significantly and provides better results for all these change detection methods. The performance of our method in reducing the false alarms is particularly outstanding. Stow's method [6] causes the collapse of MIR. It can be inferred that the proposed method is more effective than Stow's method and independent of change detection methods. It is convenient to be combined with other processing for reducing effects of other undesired noise to get more accurate detection results.

5. REFERENCES

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