DETECTION OF SHEER CHANGES IN AERIAL PHOTO IMAGES USING AN ADAPTIVE NONLINEAR MAPPING

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Abstract
We propose a method of detecting dislocation and slope failures by evaluating a pair of high-resolution aerial photographs, taken before and after the earthquake. In our approach, we compared the two images in an adaptive nonlinear mapping mechanism, to find out the discontinuous distribution of shifting vectors required for adjusting the two images.

1. Introduction:

For analyzing and prediction of dislocation earthquakes, as well as for preventing landslip disasters, it is important to detect automatically the geographical changes such as dislocation and slope failures, from a pair of high-resolution images taken before and after the earthquake [1-2]. Simple subtraction of two images may give some information regarding the land dislocations. In most cases, however, it is difficult to get a pair of images of the same photographic conditions, even after the geometric compensation using affined transformation.

In our system, we nonlinearly map an aerial photo image to another one observed at different time, of the same area [1]. During the nonlinear mapping, we generated a set of shifting vectors require for the nonlinear mapping and evaluated the discontinuity in the vector distribution, to find out the dislocation and landslips.

2. Nonlinear Mapping Algorithm:

As shown in Fig.1, our nonlinear mapping algorithm consists of the *competition* procedure to find out the best matched shift of sub-areas and the *consensus* operation among shifting vectors of near-by sub-areas for maintaining continuous transformation. After the *consensus* operation, image A will be deformed a little bit according to the set of shifting vectors. After several times of iteration, a nonlinear mapping from A to B will be formed, and the spatial derivatives of shifting vectors will demarcate the dislocations

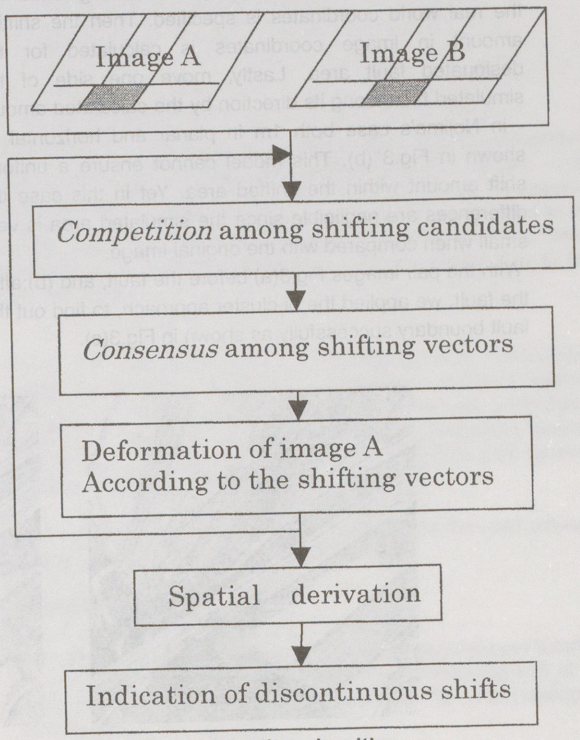

Fig.1 Sheer detection algorithm

3. Choice of Consensus Operations:

In the algorithm mentioned above, the neighborhood zone shape in the consensus operation significantly influences the failure detection ability. In our former approach [1], we defined a squared neighborhood, as indicated in dotted line of Fig.2. However, when the zone of that shape covers both sides of the sheer border S1-S2, the consensus operation dilutes the difference of shifting vectors at the boundary to be detected in the spatial derivation.

a) **Strip zone approach:** In our first trial, we defined a strip in parallel with the border, as illustrated in double solid line in Fig.2. In the strip zone approach, however, we have to hypothesize the sheer border orientation, or repeat the whole algorithm for several possible orientations to find out the most clear result.

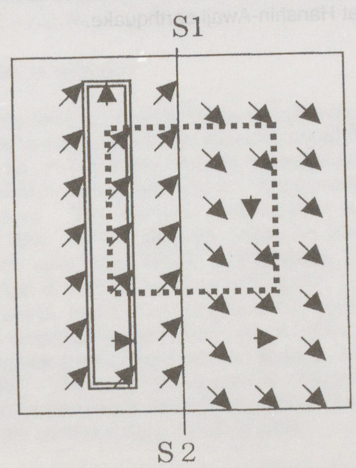

Fig.2 Neighborhood zone shapes

b) **Bi-cluster approach**: If we can classify all the shifting vectors within an area into two groups according to their vector orientations, we can make the consensus operation to each of the groups. For doing this approach, we plotted the shifting vectors on the Px-Py 2D space, where Px and Py are horizontal and vertical components of each shifting vector respectively. To each of the clusters in Px-Py space, we find the cluster center, or median vector, with which every member of the cluster should go along.

4. Experimental Results

To test our algorithms, we have simulated the Nojima fault, which accompanied the great Hanshin-Awaji earthquake of 1995 in Japan. The model has been constructed with a rectified image which has been oriented by photogrammetric approach. Firstly, the shifting amount in the real world coordinates is specified. Then the shifting amount in image coordinates is calculated for the designated fault area. Lastly, move one side of the simulated fault along its direction by the calculated amount - in Nojima's case both 1m in planar and horizontal as shown in Fig.3 (b). This model cannot ensure a uniform shift amount within the shifted area. Yet in this case the differences are negligible since the simulated area is very small when compared with the original image.
With the pair images Fig.3(a);before the fault, and (b);after the fault, we applied the bi-cluster approach, to find out the fault boundary successfully as shown in Fig.3(c).

5. Conclusion

By introducing the new consensus operations into our nonlinear mapping technique, we were able to detect the simulated fault from a pair of aerial images. Since this technique uses a self-organizing nonlinear mapping based on the principle of *coincidence enhancement*, differences in the image distortion and non-equalized quality between two images can be automatically compensated for [3].

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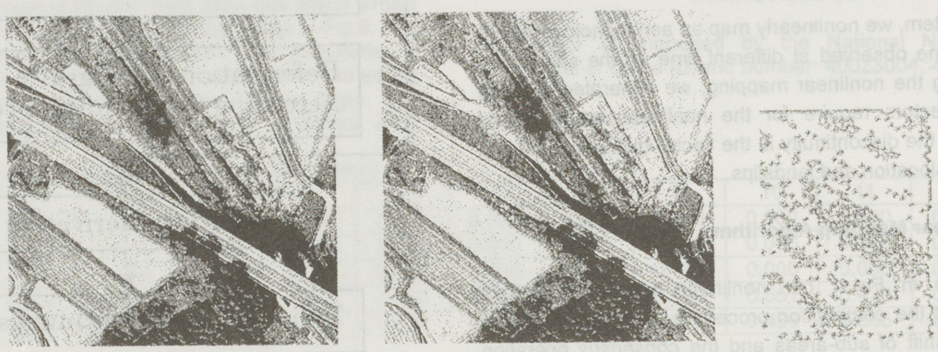

(a) before earthquake (b)after earthquake (c) detected dislocation

Fig.3 Automatically detected dislocation from a set of aerial photo images simulating the Nojima fault related to the great Hanshin-Awaji earthquake.