Automatic Change Detection of Digital Elevation Models Using Matching Method

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Abstract : The changes of DEMs(Digital Elevation Models) will be detected to correct the information of DEMs and/or to get the information about themselves. This study suggests the evaluation of DEM using correlation coefficient value between the target and the reference DEMs for detect the changes.
Keywords : DEM, Matching, Change Detection

1. Introduction

DEMs(Digital Elevation Models) which extracted from stereo aerial photographs and/or satellite images using image matching method[1][2] will be changed by nature or human being for the few decades. These changes must be detected to correct the information of DEMs and/or to get the information about changes themselves. When DEMs are extracted for huge area, however, it is very hard for experts to detect the areas which have been changed. Also the high cost and the low reliability will be occurred to detect the changes. This study suggests the evaluation of DEM using correlation value between the target and the reference DEMs for the change detection.

2. DEM Matching for Change Detection

1) DEM Matching and Change Detection Method

The change of DEMs will be detected by differences between reference and target DEM. But DEMs have the horizontal and vertical errors. The only way perfectly to detect them is to survey every cell by GPS etc. However, to detect the acceptable changes, the horizontal errors must be eliminated or reduced at least. That is, to detect the changes of DEMs, horizontal errors must be corrected using the DEMs matching[3][4][5].

The relation between the original DEM and the destination can be defined as shown in (1).

$$Hr(X,Y) = Ht(X+ex, Y+ey) + ez \qquad (1)$$

where, Hr (X, Y) is the reference DEM, Ht (X,Y) is the target for ground coordination (X, Y), (ex , ey) is the horizontal errors and ez is vertical error. The horizontal and vertical errors are nonlinear function. Comparing the reference DEM with target directly will not consider those errors. For this reason, to find the matching DEM for reference in target is needed. This study uses the statistic evaluation by correlation coefficient values to find the matching DEMs. The (1) shows the equation for correlation value ρ.

$$r = \frac{\sum_{x=1}^{N}\sum_{y=1}^{M}\left(Hr(x,y)-\overline{Hr}\right)\cdot\left(Ht(x,y)-\overline{Ht}\right)}{\left(\sum_{x=1}^{N}\sum_{y=1}^{M}\left(Hr(x,y)-\overline{Hr}\right)^2\cdot\sum_{x=1}^{N}\sum_{y=1}^{M}\cdot\left(Ht(x,y)-\overline{Ht}\right)^2\right)^{1/2}} \qquad (2)$$

where, ρ is correlation efficient value of DEM, Hr(x,y) and Ht(x,y) are heights of reference DEM patch and target DEM patch (x,y.), $\overline{Hr}$ and $\overline{Ht}$ are the means of heights of reference DEM patch and target DEM patch.

The size of patch of reference DEM is decided as large as enough to show the feature of area. The searching area for matching cell is limited by acceptable horizontal errors. The cell which ρ is highest will be the candidate matching cell. When ρ is normalized, it have the value limited as $-1 \le \rho \le 1$. If ρ is 1, it means that the feature is same. If –1, then negative feature. The threshold of correlation efficient value is needed to detect matched DEMs. This study suggests the condition

of change detection, as followed,

1. Find a cell which is a maximum of ρ's. That is, the maximum of $-1 \leq t \leq \rho \leq 1$, where t is threshold.
2. If the candidate cell exists, Get the difference of elevation both cells. If the difference is higher than threshold of error(e), then that cell is detected as a change.
3. If the candidate cell does not exist, then that cell is detected as a change.

2) Results

The reference DEM and the target is shown in Fig.1. and 2. The Original DEM made in 1990 and the destination in 1995.

The threshold of correlation value is 0.5. and the threshold of error is 3σ. In Fig. 3. and 4. the result which uses the 5×5 patch size with 7×7 searching area is shown.

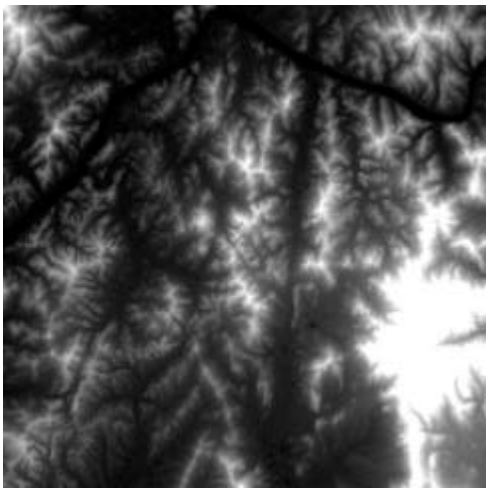

Fig. 1. Reference DEM (1990)

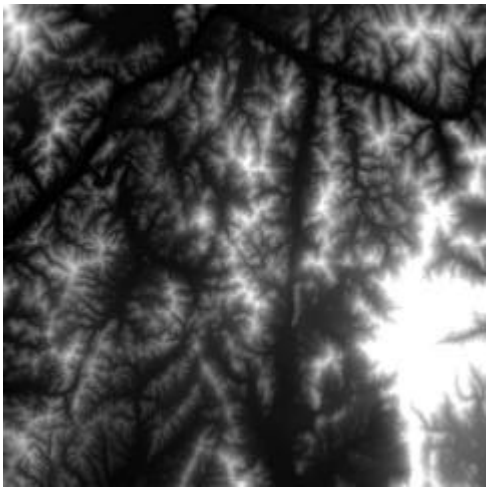

Fig. 2. Target DEM (1995)

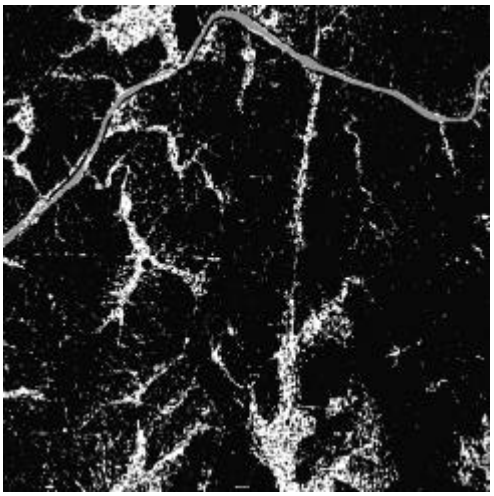

Fig. 3. Evaluation of Correlation Coefficient values

Fig. 4. Differences between Matched DEMs

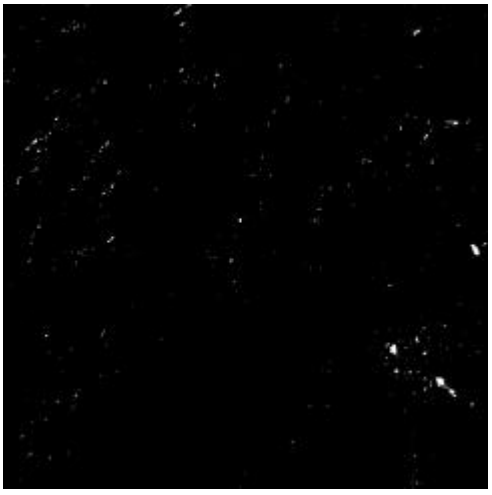

Fig. 5. Candidate Areas of Changes (threshold = 3σ)

In Fig. 3, the white pixels mean that all of ρ's are lower than the threshold of correlation and the gray pixels mean the flat areas which the variance is zero. Most of white pixel mean water or wet ground areas. To be sure if those are changes or natural errors, more information is needed.

In Fig. 4, the differences of heights are shown. The pixel value is the difference of heights of DEMs.

If those information are used then expert can detect the changed DEM more effectively.

In Fig. 5, however, the candidate areas of changes are detected. The candidate areas are selected using the threshold 3σ. There are some noises but some areas ,specially lower right areas, can be decided as changes.

To detect more precisely, the process to filter the noises is needed.

3. Conclusions

This study suggested the automatic method to detect the change of DEMs using matching method. As shown in result, the matching DEMs can be found by using the correlation coefficient values. This means that the horizontal errors' effect s can be reduced. As the information of difference of DEMs can be more acceptable, this method will be usable to detect the changes of DEMs automatically.

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