BUILDING DAMAGE INFORMATION EXTRACTION FROM FULLY-POLARIMETRIC SAR IMAGES BASED ON VARIOGRAM TEXTURE FEATURES

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KEY WORDS: Earthquake, Yamaguchi decomposition, variograms texture, Polarimetric SAR, buildings

ABSTRACT: Rapid evaluation of building earthquake disaster information is of great significance for earthquake emergency rescue. In this paper, the full polarization SAR data of Yushu area in 2010 is taken as the research object. Firstly, building area, road, water system and other non-building information in SAR image are extracted by using the volume scattering component PV of Yamaguchi decomposition. On this basis, the variograms of collapsed building and intact building area in T11 component of coherent scattering matrix is calculated. After getting the variograms texture results, FCM algorithm is used to extract intact building and collapsed building area. Finally, verified the accuracy by combing the optical remote sensing image after the earthquake, the extraction accuracy of intact buildings is 80.18%, collapsed buildings is 84.54%, and road water system is 77.58%.

1. Introduction

It is of great significance to acquire the information of buildings in earthquake disaster area quickly. Earthquakes are often accompanied by bad weather, and polarimetric SAR images have the advantage of all-weather and all-time in the study of earthquake damage information evaluation [1]. Polarimetric SAR can get rich polarimetric information through polarimetric decomposition, and different objects have different performance in polarimetric information [2]. Because of the sudden occurrence of earthquakes and the uncertainty of climate, it is difficult to obtain the multi temporal remote sensing data or the optical remote sensing data of seismic regions in a short time, especially for the underdeveloped areas, the possibility of archiving the satellite remote sensing data before earthquakes is very low, so the extraction of seismic damage information based on the single temporal (post-earthquake) polarimetric SAR image is of great significance.

In this paper, we take the Yushu earthquake of Ms of 7.1 in 2010 as the research object, and an aerial full polarization SAR remote sensing image with a resolution of 1 m after the earthquake is adopted.

2. METHODOLOGY

2.1 Polarization decomposition method

The polarization decomposition data used in this paper are: T11 and PV. The T11 component is obtained by the decomposition of coherent scattering matrix and the volume scattering component PV is obtained by Yamaguchi decomposition.

It was found in the experiment that the volume scattering component PV in Yamaguchi decomposition can distinguish the building area and non-building area well, and the Yamaguchi four-component decomposition has fast calculation speed and high calculation efficiency [3].

2.2 Clustering method

The K-means core idea is the process of dividing many n-dimensional data into K sub-data according to the cluster center [4-5]. The central idea of fuzzy C-means clustering algorithm is to classify an n-dimensional data set into c-type fuzzy clustering and find the cluster center of each class, so that the objective function is optimal [6-7].

2.3 Variogram

Generally, half of the variance defined as the difference between two points is the variograms function of the regionalized variogram in the h direction, that is:

$$\gamma(x,h)=\frac{1}{2}Var[f(x+h)-f(x)]=\frac{1}{2}E[f(x)-f(x+h)]^2$$

In the experiment, the variogram cannot be obtained directly, and it is usually estimated by the following formula:

$$\gamma^{*}(x,h) = \frac{1}{2N(h)}\sum_{h=1}^{N(h)}\{f(x_k-f(x_k+h)\}^2$$

Where N(h) is the number of point pairs with a distance h of data points within the observation range, $\gamma(x,h)$ was called as experimental variogram[8-9].
Before performing the variogram calculation of the texture information of the intact building and the collapsed building in the SAR image, it is necessary to determine the range of the intact building and the collapsed building. The calculation process is as follows:
(1) In the building area, select intact buildings and collapsed building areas with a window size of m, calculate the variogram function value when h = 1,2..n, and draw the variograms function curve, as shown in Figure 1.
(2) Select the value of h as a when the variogram of collapsed and intact buildings tend to converge and the difference is greatest and we call a as the best range value. When h = 11, the average residuals of the intact building and the collapsed building are the largest. So we determine a as 11. According to previous studies, Faster and more accurate calculation of the variogram of intact buildings and non-buildings generally uses a window of 3-5 times the range [10-11]. In this paper, the variogram window is w = 3 *a.
(3) The changing direction of h is 0 degrees, 45 degrees, 90 degrees, and 135 degrees. Finally, the average of the four directions is used as the final variogram value. The calculation formula is as follows:

$$\gamma^{*}(x_0,y_0)=\frac{1}{4}[\gamma^{*,0}(x_0,y_0)+\gamma^{*,45}(x_0,y_0)+\gamma^{*,90}(x_0,y_0)+\gamma^{*,135}(x_0,y_0)]$$

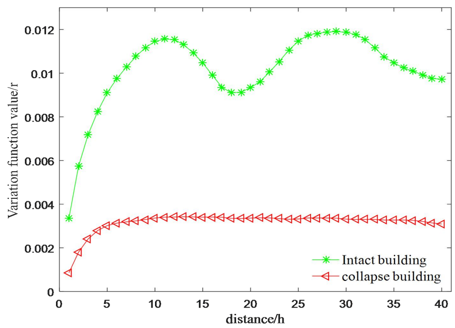


Figure 1. Curve of calculation result of variogram

3. BUILDING EARTHQUAKE DAMAGE INFORMATION EXTRACTION EXPERIMENT

3.1 Experiment flow

The main idea of this paper is to extract the seismic damage information of buildings in the earthquake area based on Yamaguchi coherent polarization decomposition and texture information. Firstly, use the Sobel operator to enhance the edge of the volume scattering component, so that the difference between the volume scattering component of the building area and the non-building area become obvious. Extracting the building area of PV components using K-means algorithm, and get a mask of building areas with GIS software. Secondly, Calculate the variograms of the building area where the T11 component is extracted using a mask. Plot the curve of variograms for complete and collapsed buildings. When the distance between the two curves is the largest, the corresponding abscissa value is determined as an appropriate value to distinguish the two kind of buildings, we call this value as a. Then, calculate the variograms of the entire building area use the window size of w (w=3×a). And next, use fuzzy mean classification algorithm (FCM) to perform a cluster analysis on the calculation results to obtain the collapsed building area and the integrity building area. Finally, the post-earthquake optical remote sensing image is used to detect the extraction accuracy separately. The main technical route is shown in Figure 2.

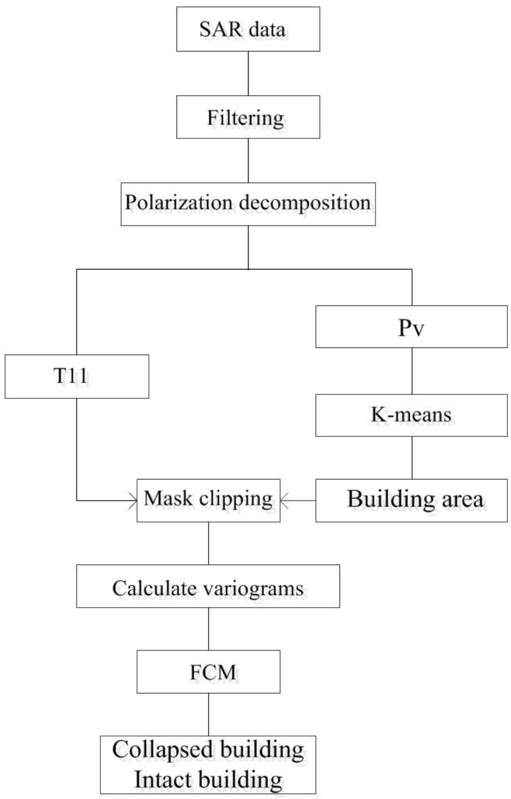


Figure 2 Experiment flow.

3.2 Experiment

In order to determine the classification threshold of the building area and the non-building area, 100 sample matrices are selected for the building and non-building areas in Fig.3c, and the sample matrix averages are calculated respectively. The sample mean is used as the initial clustering center, and the K-means algorithm is used to extract the building area to obtain a binary map of the building area. The outer contour of the building area is masked in GIS to facilitate classification of building areas.

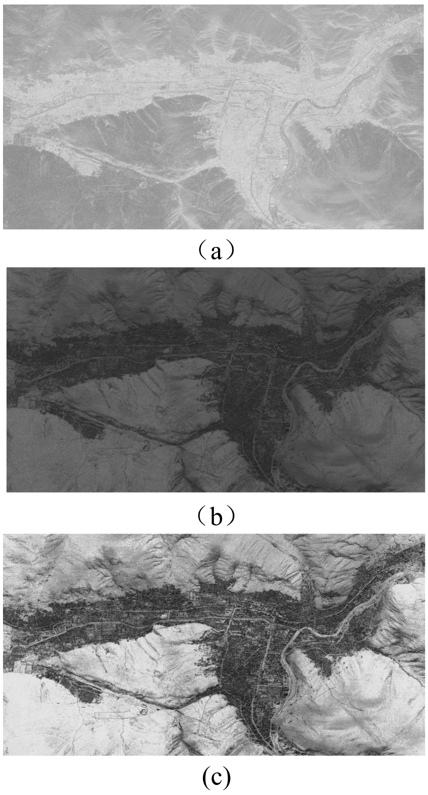
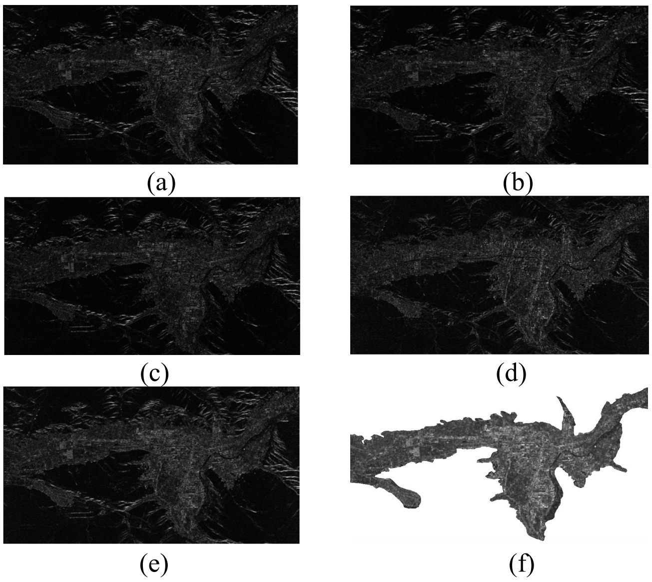


Figure 3. P_V component map of Yushu area. (a) is obtained by normalizing the volume scattering component P_V; In (b), edge enhancement using Sobel operator is to sharpen the edges of the building envelope and non-building areas; In (c), stretching and enhancing the gray range of the building area.

Using the variograms calculation, the image obtained by calculating the variograms values in the four directions is shown in Figure4 below. The four images are averaged and masked to obtain Fig4 (f).



Figures 4. (a-d) are the combined figures of the variograms values in the four directions, (e) is the final variograms figure after averaging the four figures, (f) is the variograms value figure after cutting according to the mask.

Fig 4 (f) is clustered using FCM and divided into three categories: intact building area, collapsed building area and non-building area (road, water system, etc.).

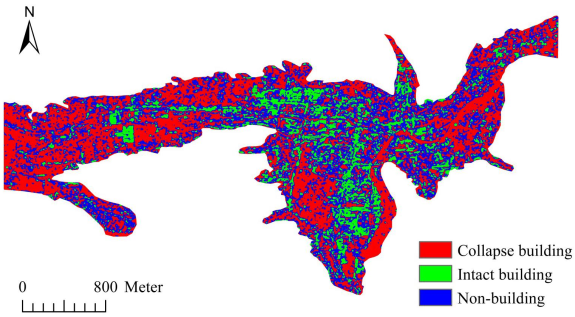


Figure 5. Classification results of variogram. The red part is the collapsed building area, the green part is the intact building, and the blue part is the non-building (road, water system).

It can be seen that some of the non-building areas and the collapsed building areas are confused. The obvious is the water system. The river and non-building areas in the lower right of the figure are shown in red.

The K-Means algorithm is used to classify the building areas and non-building areas (roads, water systems, etc.) in the PV component. It is found in the classification that the PV components are well distinguished for non-building areas (roads, water systems, etc.) Combined with the variograms function, the non-buildings (roads, water systems, etc.) in Figure 5 are modified again to get Figure 6.

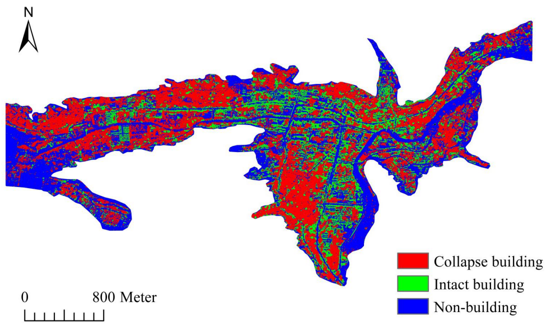


Figure6. Classification results combined with texture information. The red part is the collapsed building area, the green part is the intact building, and the blue part is the non-building (road, water system).

3.3 Experiment analysis

In order to evaluate the classification accuracy of the above three images, a comparative evaluation was performed with Google-Earth optical images. Randomly select 1200 sample pixel coordinate points in the three categories of intact buildings, collapsed buildings, roads, and water systems in Fig. 6, and manually select these three types according to their corresponding positions on the optical image. The matching coordinate points are then used to calculate the extraction accuracy according to formula

$$p_k = 1 - \frac{n_k}{N_k} \qquad k = 1,2,3$$

Where Pk is the extraction accuracy of the k-th category (k=1,2,3 in this article corresponds to intact buildings, collapsed buildings, roads, water systems, etc.), nk is the number of coordinate sample points in which the k-th category does not match in the optical image, Nk is the total number of sample coordinate points of the k class.

The calculation accuracy of the intact building is 80.18%, the extraction accuracy of the collapsed building is 84.54%, and the road water system is 77.58%.

4. CONCLUSION

Using variogram to extract texture information of collapsed and intact buildings is a successful experiment. Many domestic researches only use GLCM and variogram to extract texture information of buildings, but there is no further classification of collapsed buildings and intact buildings in building information. In this paper, only the volume scattering component is used to extract the non- building information such as road and water system, and the extraction accuracy is 77.58%, which is of great help to extract the building damage information in the earthquake area quickly and accurately.

5. ACKNOWLADGEMENT

This work was supported by the Science for Earthquake Resilience of China Earthquake Administration (XH18049); the National Natural Science Foundation of China (41601479); the Earthquake Science and Technology Development Fund Program of Lan-zhou Earthquake Research Institute, China Earthquake Administration (2015M02); the Gansu Earthquake Administration innovation team special fund; the Object-oriented High Trusted SAR Processing System of the National 863 Subject Program; and the Airborne Multiband Polari-metric Interferometric SAR Mapping System of the National Major Surveying and Mapping Science and Technology Special Program.

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