Metric Learning Based Collapsed Building Extraction from Post-Earthquake PolSAR Imagery

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1. Motivations

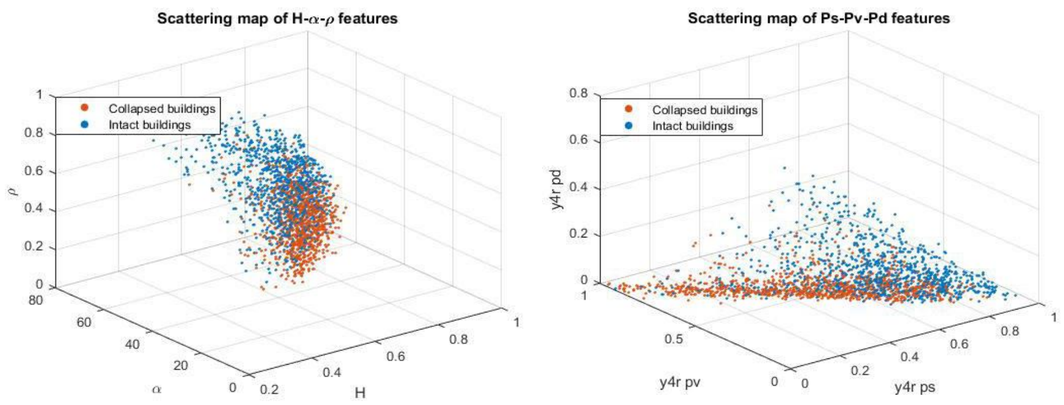
- Pre-earthquake data and other auxiliary information are generally not available.
- Topographic relief and large aspect angles may result in error identification of collapsed building, especially in mountain areas.
- Limited building samples can be obtained after a great earthquake.

➢ Topography and building related features are selected and analyzed.

➢ Metric learning-based distance is utilized to distinguish messed-up collapsed and intact building samples.

2. Feature set

Entropy H,the scattering angle α, and anisotropy A are three roll-invariant parameters from the Cloude decomposition, which can distinguish scattering mechanisms and land covers according the $H-\alpha$ plane. Scattering powers P_s, P_v, P_d, P_c from Yamaguchi decomposition with a rotation of the coherency matrix, are sensitive to the dihedral scattering and can identify urban and vegetation areas. The circular polarization correlation coefficient ρ is related to surface roughness and azimuth slope measurement. The ρ of intact buildings is higher compared to collapsed buildings.



(a) (b)

Scattering maps of building related features. (a) $H-\alpha-\rho$; (b)$P_s-P_v-P_d$.

Through the suggested features are effective for collapsed building extraction, many collapsed and intact building samples are still messed up. And the inner-class distances vary greatly.

3. ITML-based Collapsed Building Extraction

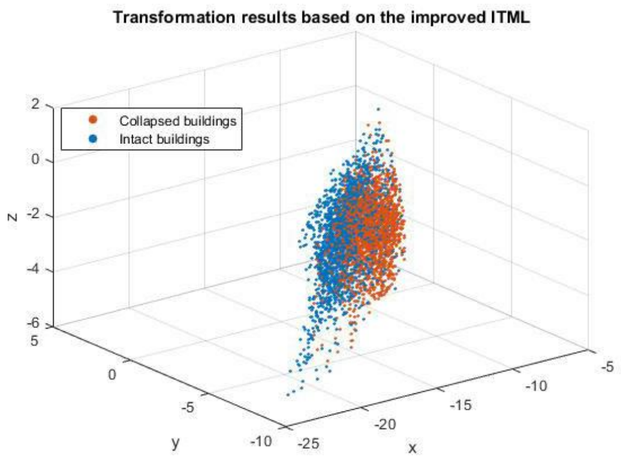
We improved the ITML by restricting the learned matrix Q to a nonsquare matrix of size $d \times K$. The inner-class distances turn out to be smaller and it can also do dimensionality reduction.

$$A = Q^T Q$$

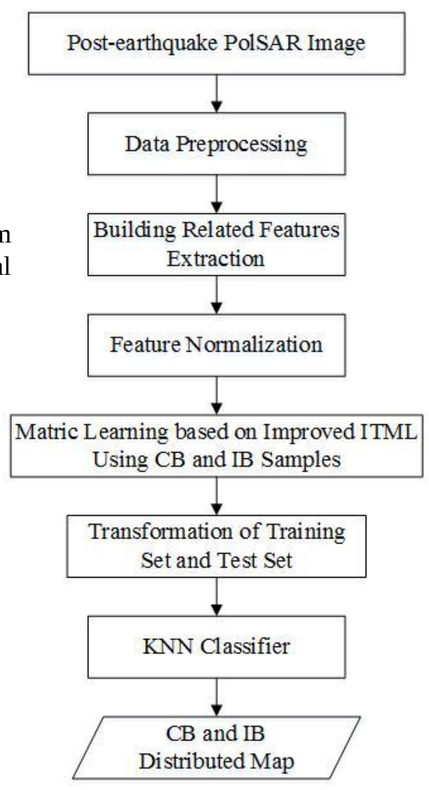
$$d(\boldsymbol{x}_i, \boldsymbol{x}_j) = (\boldsymbol{x}_i, \boldsymbol{x}_j)^T A(\boldsymbol{x}_i, \boldsymbol{x}_j)$$

$$d(\boldsymbol{x}_i, \boldsymbol{x}_j) = (Q\boldsymbol{x}_i, Q\boldsymbol{x}_j)^T A(Q\boldsymbol{x}_i, Q\boldsymbol{x}_j)$$

The ITML (Informational-Theoretic Metric Learning) algorithm learns a Mahalanobis distance by minimizing the differential relative entropy under constraints on the distance function.

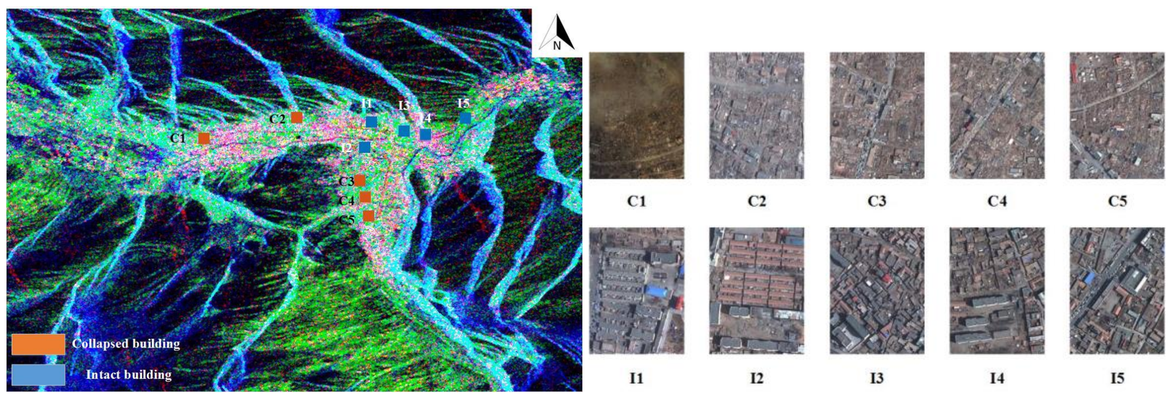


The scattering map of first 3-dimensional features after transformation with Q.



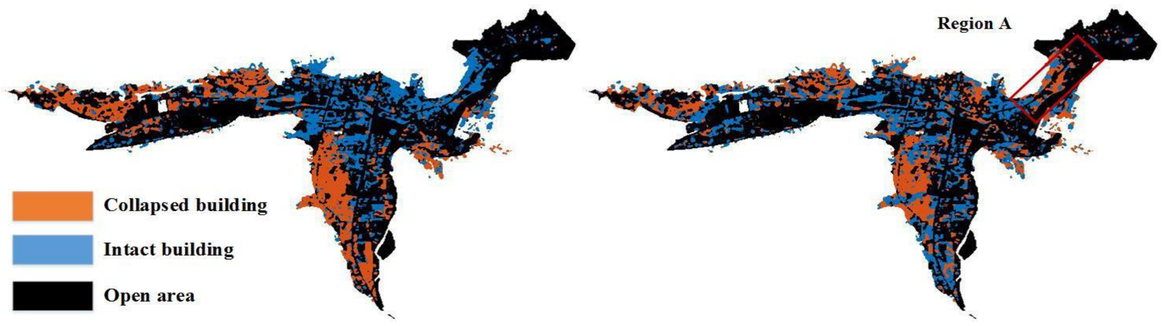
The flowchart of collapsed buildings extraction.

4. Experimental Results



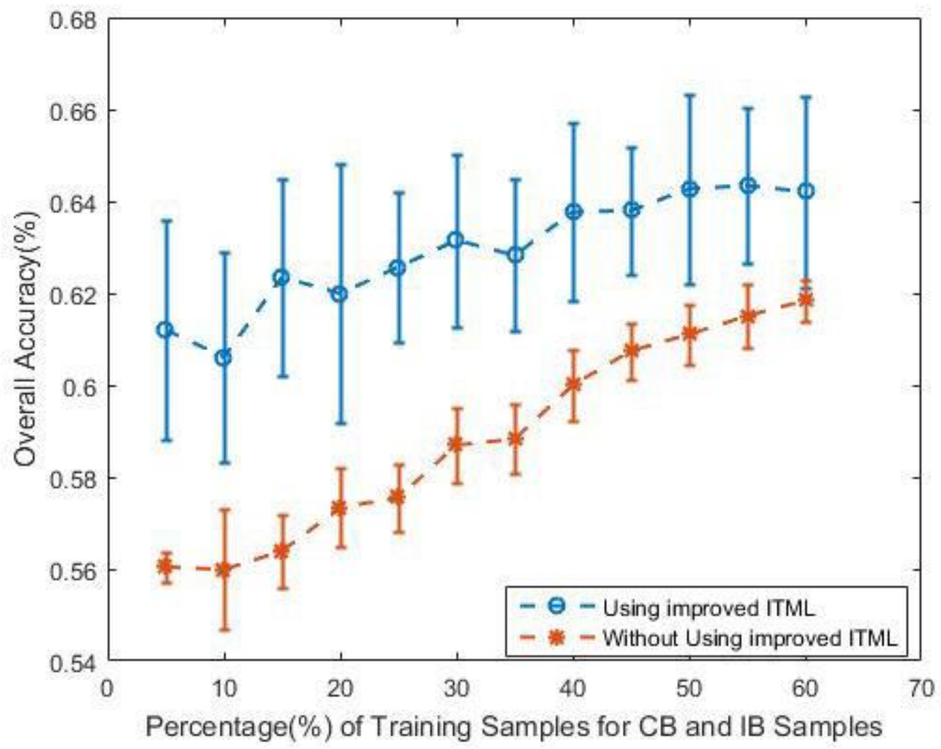
(a) (b)

The RadarSAT-2 PolSAR image with 8m resolution of Yushu Conntry, Qinghai, China. A MS 7.1 earthquake hit Yushu on 14 April 2010. (a) RGB color-coded image from Yamaguchi 4-component decomposition with a rotation of the coherency matrix ($R: P_d; G: P_v; B: P_s$) ; Five collapsed and intact building samples with a size of 20-by-20 pixels are selected; (b) Optical images corresponding to the building samples in (a) The buildings in region I3 and I5 are intact but exhibit characteristics similar to the collapsed buildings for large aspect angles.



(a) (b)

(a) The validation map manually created based on very high resolution (VHR) optical image. The validation map has been registered to the PolSAR image. (b) The collapsed and intact buildings distributed map obtained via the metric learning based collapsed building extraction method. Some buildings in region **A** are identified correctly while seriously impacted by slopes and large aspect angles.



Effects of the number of training samples based on methods with and without using the improved ITML. The selected samples are used to validate the proposed algorithm via Cross-Validation. And 10 repeated experiments are conducted. The preferred result's overall accuracies (OA) are higher by 5% than that without using the proposed algorithm.

5. Concluding Remarks

• The improved ITML algorithm helps mitigate the impact of slopes and large aspect angles. And the proposed method is effective and improve the PolSAR data's capability of extracting collapsed buildings after an earthquake disaster.

• Wrong extraction mainly appears in the foot regions of mountain. Otherwise, the validation map is created on VHR optical image without considering the scattering mechanism of buildings. Some buildings with intact dihedral structures and destroyed roofs are identified as damaged. However, they appear to be intact in PolSAR imagery. This is another reason for differences between extraction results and manually interpretation results.