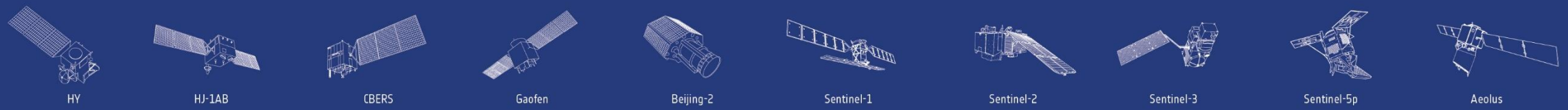


2023 DRAGON 5 3rd YEAR RESULTS SYMPOSIUM

YOUNG SCIENTISTS POSTER SESSION

12 SEPTEMBER 2023

[PROJECT ID. 59308]

[SEISMIC DEFORMATION MONITORING AND ELECTROMAGNETISM ANOMALY DETECTION BY BIG SATELLITE DATA ANALYTICS WITH PARALLEL COMPUTING (SMEAC)]

INTRODUCTION

- Dragon 5 project id: 59308
- Poster Title: Recognising Building Earthquake Damage Using Texture Features from SAR Images in Frequency and Spatial Domains
- Authors: Wei Zhai, Yaxin Bi
- Presented by: Wei Zhai

OBJECTIVES & RESEARCH APPROACH

Objectives

- In SAR imagery, the scattering intensity of some standing buildings is as weak as collapsed buildings because of the depolarization effect, and they are easily misclassified. Some texture features can identify collapsed buildings and undamaged buildings with similar scattering characteristics. Generally, the texture features in spatial domain are used to extract the building damage information.
- The standing buildings always show banded textures with consistent arrangement, but collapsed buildings often show more random textures with a disordered distribution. The spatial frequency of SAR images can be clearly rendered in the frequency domain.
- In order to understand the building earthquake damage recognition performance of the frequency domain texture feature, we compared the classification performance of the texture feature in the frequency domain CV_AFI and the spatial domain texture feature MSD.

Research Approach

We proposed the variable coefficient of angle domains based on the Fourier amplitude spectrum parameter (CV_AFI) and the mean standard deviation (MSD) parameter based on the statistical characteristics to discriminate standing buildings and collapsed buildings.

The CV_AFI and MSD parameters are defined, respectively as follows:

$$CV\_AFI = \frac{\mathrm{std}(\sqrt{[\mathrm{real}(FFT(\mathbf{I}_{ip}))]^2 + [\mathrm{imag}(FFT(\mathbf{I}_{ip}))]^2})}{\mathrm{mean}(\sqrt{[\mathrm{real}(FFT(\mathbf{I}_{ip}))]^2 + [\mathrm{imag}(FFT(\mathbf{I}_{ip}))]^2})}$$

$$MSD = \mathrm{mean}\left(\mathbf{I}_{ip}\right) - \sqrt{\mathrm{variance}\left(\mathbf{I}_{ip}\right)}$$

where $\mathbf{I}_{ip}$ is part of intensity image of PolSAR data; ‘FFT’, ‘std’, ‘mean’ and ‘variance’ represent the function of 2D fast Fourier transform, standard deviation, mean values and variance, respectively; ‘real’ and ‘imag’ represent the real parts and imaginary parts of complex numbers, respectively.

Research Approach

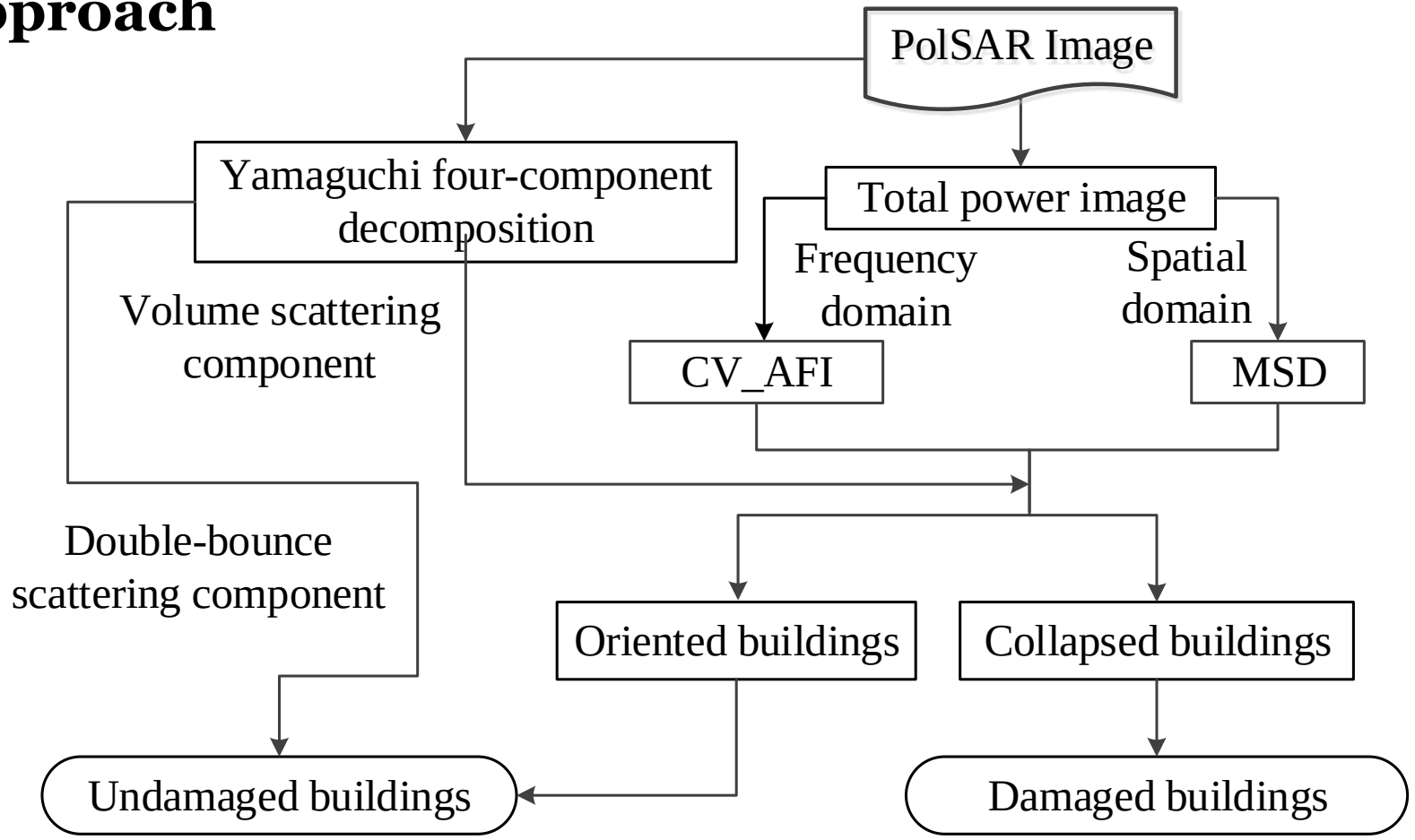


Figure 1. The procedure of extracting building damage information.

KEY RESULTS

As shown in Figure 2 and Figure 3, both frequency domain texture feature CV_AFI and spatial domain texture feature MSD have classification capabilities. For both CV_AFI and MSD, the values of collapsed buildings are greater than those of standing buildings. During the process of classifying the collapsed buildings and standing buildings using CV_AFI and MSD, the threshold values between standing buildings and collapsed buildings were set to 1.35 for CV_AFI and 24 for MSD based on the samples of collapsed buildings and standing buildings.

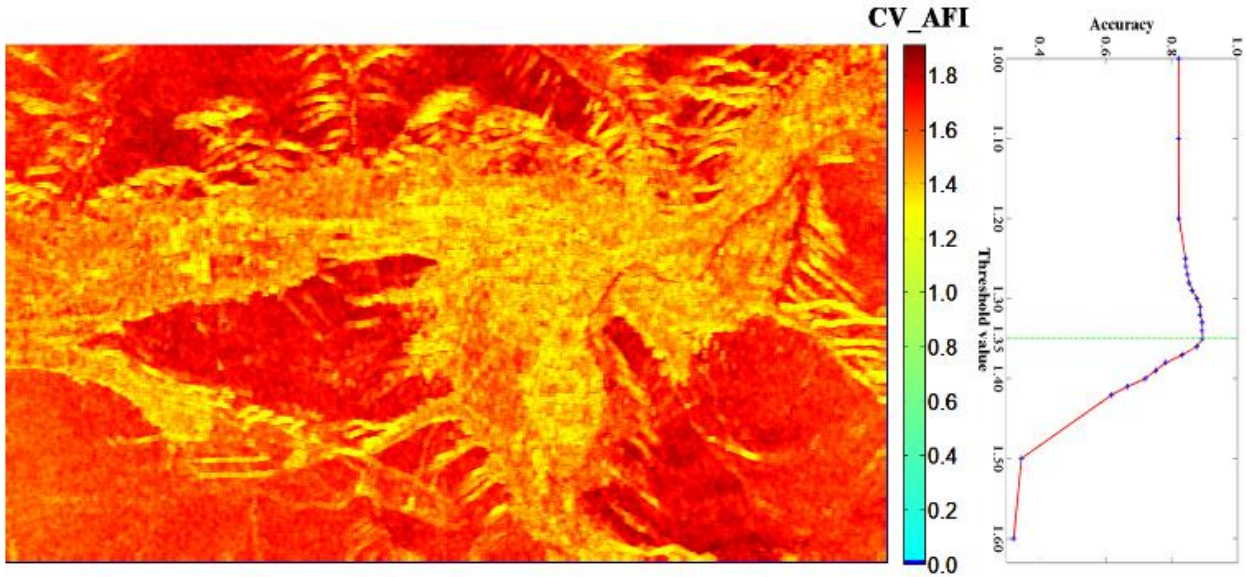


Figure 2. The map of CV_AFI values and its threshold value selection.

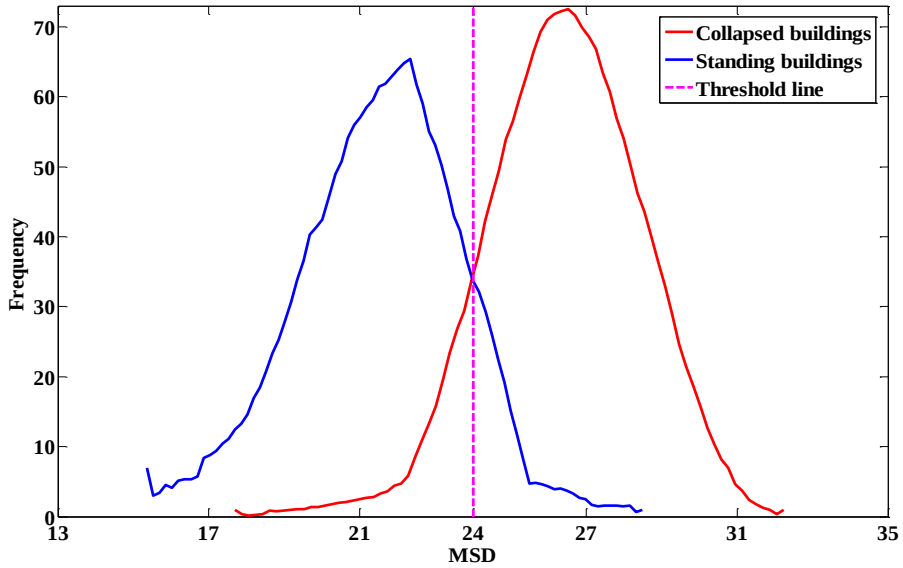
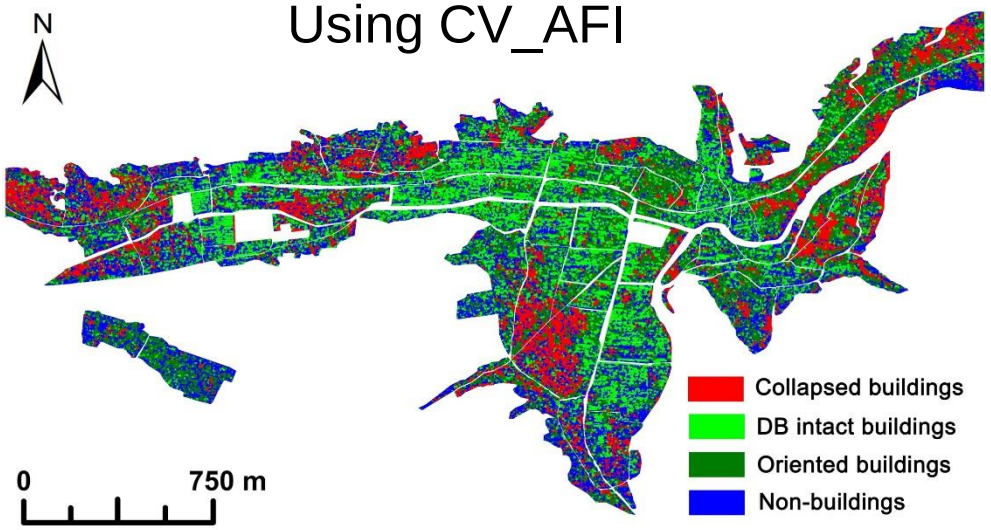
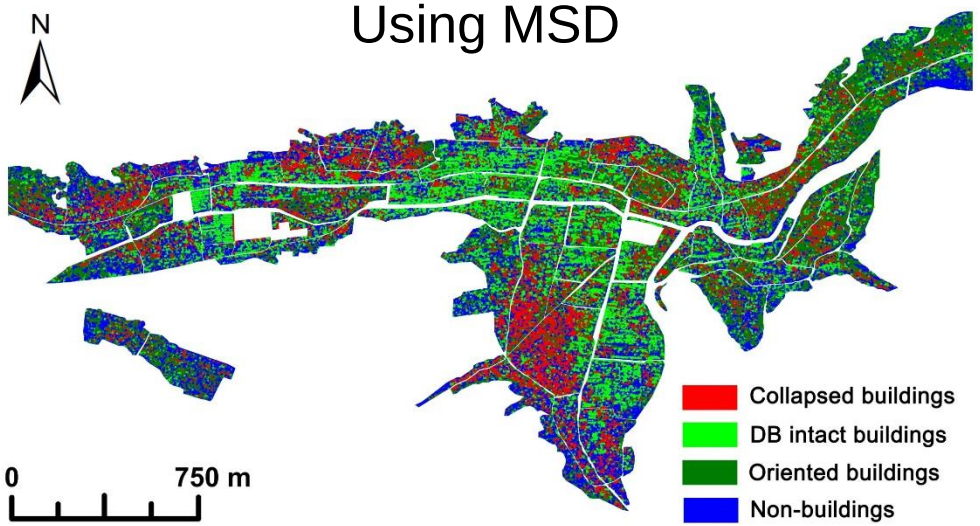


Figure 3. Histograms of MSD index for the standing buildings and the collapsed buildings.

KEY RESULTS





	Experiment (CV_AFI)		
	OB	CB	DB
	(No. of samples)		
Reference			
OB	19433	5567	0
CB	4263	20737	0
PB	1124	710	23166

	Experiment (MSD)		
	OB	CB	DB
	(No. of samples)		
Reference			
CB	20608	4392	0
OB	8293	16717	0
PB	1566	268	23166

CB, OB, and DB represent collapsed buildings, oriented buildings and DB intact buildings.

Brief discussion

- There are many collapsed residual walls formed dihedral structures with the ground are easier to misclassified as the standing buildings with high scattering intensity.
- The greater the threshold of CV_AFI or MSD for discriminating collapsed buildings and standing buildings, the more standing buildings and the less collapsed buildings in the recognition results. If the misclassification rate for collapsed buildings was excessively high, the emergency response could be severely affected and the risk could significantly increase. Hence, the thresholds of CV_AFI and MSD should not be set too large or too small. The experimental results show that the identification results are fairly balanced for damaged buildings and undamaged buildings. There are neither the overestimation of damaged buildings, nor the underestimation of damaged buildings. Therefore, the identification results obtained by the two texture features are effective for assessing building damage after earthquakes.

Conclusions

- The accuracy of correct identification of collapsed and undamaged buildings using CV_AFI, as well as the overall accuracy of building damage identification, is higher than that of MSD.
- More standing buildings with orientation are correctly recognized using CV_AFI, that is, less oriented standing buildings are misclassified as collapsed buildings.
- The texture features in the frequency domain better reflect the differences in spatial distribution between standing buildings and collapsed buildings.
- In addition to the application of texture features in the spatial domain, texture features in the frequency domain are more effective in the identification of building damage and they should be given more consideration in the development of earthquake damage assessment methods.

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