# BUILDING DAMAGE ASSESSMENT USING POST-EVENT DUAL POLARIMETRIC SAR


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## 1. Introduction

Large-scale earthquakes severely damage people's lives and properties. Fast and effective earthquake damage assessment using Synthetic Aperture Radar (SAR) provides decision-making support for post-disaster response efforts. Currently, the traditional change detection building damage assessment methodology using multitemporal SAR intensity images is highly restricted by the data availability (Matsuoka et. al, 2004; Chen et. al, 2013). In this case, Dell'Acqua (2011) proposed a texture based classifier using only post-event SAR intensity images to assess building damage caused by earthquakes; however, this method employs only one feature from the SAR image while other features have not been fully utilized to evaluate the building damage. Thus, the objective of this study is to fully utilize the multi features of post-event SAR image to enhance the accuracy of damage assessment.

## 2. Study Area and Data

The study area and dataset are shown in Fig. 1 and it is located in severely damaged city of Bhaktapur after the 2015 Nepal earthquake. A post-event ALOS-2/PALSAR-2 data acquired on April 26, 2015 provided by the Sentinel Asia was used to detect the building damage. The data was captured in StripMap mode with HH and HV polarization in a descending path. The spatial resolution of the data was 3m, and the looking angle was 44.7°. We generated three damage levels on a block scale (low damage, medium damage and high damage) ground truth data as shown in Fig. 2 by visual interpreting VHR optical satellite images (March 12, 2015 and May 3, 2015) from Google Earth.

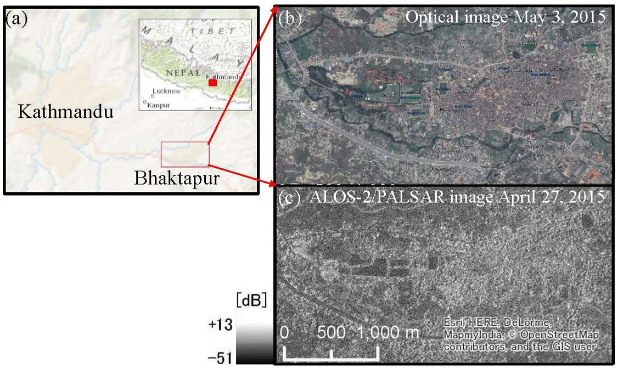


Figure 1: Study area and data. (a) Location of Bhaktapur city. (b) Post-event optical image in Bhaktapur city. (c) Post-event ALOS-2/PALSAR-2 data in Bhaktapur city.

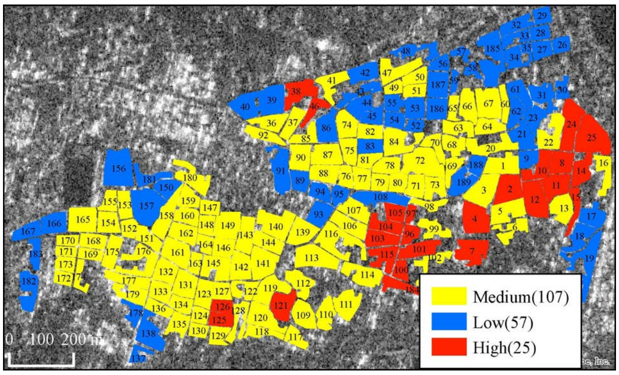


Figure 2: Three level building block scale ground truth data.

## 3. Methodology

### 3.1. Preprocessing

First, georeference was conducted to coregister the post-event ALOS-2/PALSAR-2 with the optical image. Then, the radiometric calibration described in Eq. 1 was used to convert the digital numbers into radar sigma nought (dB) values. Finally, a refined Lee filter that equipped in software of The Environment for Visualizing Images 5.0 with a kernel size of 3 3 pixels was applied for despeckling.

$$\sigma^0_{Q16} = 10 * log_{10}\langle DN^2\rangle + CF_1 \qquad (1)$$

### 3.2. Feature Calculation

With prior knowledge, eight texture features (mean, homogeneity, entropy, variance calculated from the GLCM of the co-polarization and cross-polarization respectively) which have been demonstrated to be effective for the building damage assessment (Polli, D. et al, 2010; Dell'Acqua et. al, 2011) were first chosen. In order to enhance the dimension of our dataset as well as for testing the effectiveness of the polarimetric features for building damage assessment, cross polarization ratio was included in our data set. The block footprint data produced by visual interpretation were used to calculate the above features for each block. To mitigate the error caused by georeference, a buffer was created around the block footprint data at a distance of 5 m, and all the features above were calculated within the outline of the buffer.

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*3.3. Constructing a Classifier*

First, the 20% of the ground truth data were extracted as the training data to construct the classifier. A decision tree based machine learning algorithm C4.5 which was implemented on the data mining tool WEKA (ver. 3.6.13) was applied. The created decision tree is shown in Fig.3.

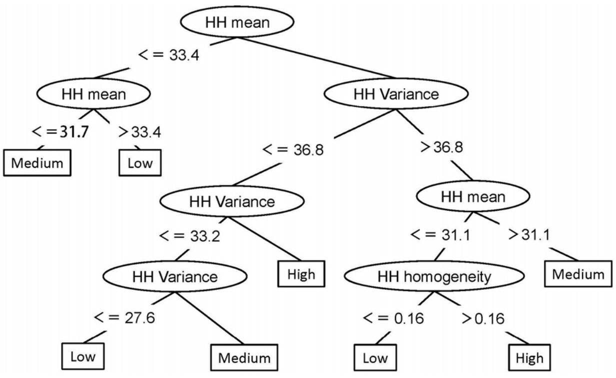


Figure 3: The constructed decision tree classifier.

*3.4. Accuracy Assessment*

To examine the effectiveness of the decision tree classifier, the commonly used KM classifier was also applied as comparison. The accuracy assessments are shown in Table 1 and Table 2. Also the damage mapping result using decision tree classifier is shown in Fig.4.

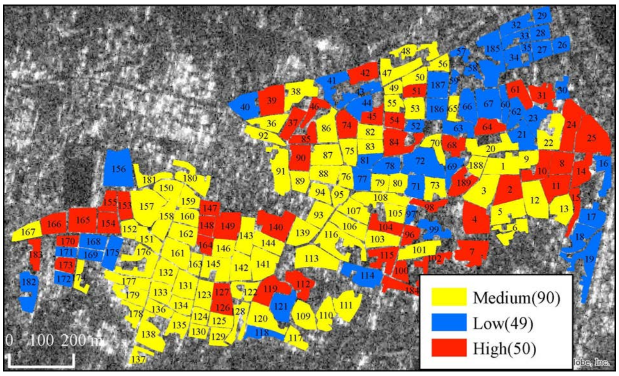


Figure 4: The building block classification result using decision tree classifier

**4. Results and Discussion**

From the decision tree framework, we found that only four texture features were selected to construct the decision tree, which demonstrated that these texture features are more suitable to assess the building damage than the polarimetric features. By comparing the ground truth data, we found that more than 70% of the medium damaged blocks were correctly identified. However, eight low damaged blocks were misclassified as high damaged buildings, those buildings are located in the north part of the city at a higher altitude and detected with a different azimuth angle compared with buildings in the south. Thus, the topographic information and the azimuth angle should be also considered in the future. The accuracy assessment result shows that the overall accuracy of the decision tree classifier is 55.5%, which is about 10% higher than the classification result of the KM classifier. The Block Damage Ratio (BDR) (the ratio between the sum of the numbers of the medium and high damage blocks over the total number blocks) is also given. The BDR of the decision tree classifier and KM classifier are 74.1% and 62.4% respectively, which are similar to the real BDR of 69.8%. Although the overall accuracy of the proposed method may not be as high as expected within a small scale; at a block scale, it can still provide useful information for the disaster response through a high accuracy of BDR.

Table 1: Building damage classification (Decision tree classifier)

| | | Decision tree classifier | | | |
|---|---|---|---|---|---|
| | | Low | Medium | High | PA(%) |
| GTD | Low | 28 | 19 | 10 | 49.1 |
| | Medium | 21 | 61 | 25 | 57.0 |
| | High | 3 | 6 | 17 | 64.0 |
| | UA (%) | 53.8 | 70.9 | 30.7 | |
| | | OA=55.5% | | BDR=74.1% | |

Table 2: Building damage classification (KM classifier)

| | | KM classifier | | | |
|---|---|---|---|---|---|
| | | Low | Medium | High | PA(%) |
| GTD | Low | 30 | 16 | 11 | 52.6 |
| | Medium | 36 | 45 | 26 | 42.5 |
| | High | 6 | 6 | 14 | 52.0 |
| | UA (%) | 41.7 | 67.2 | 26.0 | |
| | | OA=46.6% | | BDR=62.4% | |

**5. Conclusions**

The result demonstrated that the proposed Decision tree based classification fully utilizes the multi features of the SAR images to achieve a medium accuracy for a three damage level assessment. The result also shows that the texture feature is more suitable than the polarimetric feature for building damage assessment. Moreover, topographic information and azimuth angle will affect the accuracy of building damage assessment. This study is jointly sponsored by China Scholarship Council (CSC). Also we used the satellite images published by Google earth and the ALOS-2/PALSAR-2 data provided by the Sentinel Asia. We would like to express our gratitude for these contributions.

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