4.2 Automated Damage Detection using Aerial HDTV

4.2.1 Method of Automated Damage Detection for Kobe Area

An automated detection method for building damage was investigated using the aerial HDTV images taken after the Kobe earthquake (Hasegawa et al., 2000b). The degree of building damage by a field survey was correlated with color indices and edge intensity from the aerial images by image processing. The characteristics of damage to wooden buildings were defined based on hue, saturation, brightness and edge intensity. Using the threshold values of these parameters, the typical areas were classified into damaged and undamaged pixels. A texture analysis was then introduced to these pixels and the damaged buildings were identified (Figure 4.2.1). The extracted damage distribution by the proposed method agreed well with the ground truth data and the visual inspection of the HDTV images (Figure 4.2.2). The steps of the automated detection method are followings:

1. The intensities of edge elements are calculated by a general gradient filter with 3 x 3 pixel window and are allocated to one byte (256) value.
2. The pixels of the intensity value between 32 and 90 are selected.
3. The variances in the edge intensity are evaluated for the area of 7 x 7 pixels and are allocated to one byte value for the center pixel.
4. The pixels with the variance between 0 and 30 are selected.
5. The relative frequencies of color indices such as hue, saturation and intensity (HSI) are also calculated using the RGB values and are allocated to 0-360 degrees for hue and one byte value for saturation and intensity.
6. The pixels contains the range of 92-148 degrees (this color range is from red to yellow) for hue, 0-90 for saturation, and 0-175 for intensity are selected.
7. The local density of the selected pixels within 31 x 31 pixel windows is calculated by a texture analysis.
8. The pixel blocks whose density values are smaller than or equal to 6 %, between 6 and 14 %, and larger than or equal to 14 % are assigned as nondamaged, possibly damaged, and collapsed buildings, respectively.

4.2.2 Application to the Chi-Chi earthquake

Aerial shootings from helicopters for the area affected by the Chi-Chi earthquake started shortly after the occurrence of the event by Japan Broadcasting Corporation (NHK). We used some of these images taken 2 and 4 days after the event. The HDTV images were converted to RGB image data prior to use. Four images used in this analysis are shown in Figures 4.2.3(a) - 4.2.6(a). Two images each were selected for Chi-Chi and Chungliao areas as sample data for the automated damage detection.

First, the damaged buildings in the studied areas were extracted visually. In the visual extraction, the building damage level was classified into two categories: damaged and undamaged. The outlines of undamaged buildings were clearly observed in the images while for collapsed buildings, the images were seen to be vague due to the mixture of the debris of buildings.

The proposed automated detection method for building damage was applied to the aerial HDTV images taken after the 1999 Chi-Chi, Taiwan earthquake. For the snapshots of the hard-hit areas from a helicopter, the automated damage detection was conducted and the results (Figures 4.2.3(b) - 4.2.6(b)) were compared with those of visual inspection of the images in Figures 4.2.3(c) - 4.2.6(c). These comparisons indicated that the identified areas by the automated detection method almost agree with those by the visual inspection. But it should be pointed out that, in Taiwan, the roofs of wooden houses are different from those in Kobe area. Hence, even for visual inspection, damage detection for wooden buildings was more difficult in Taiwan. Considering the difference in the

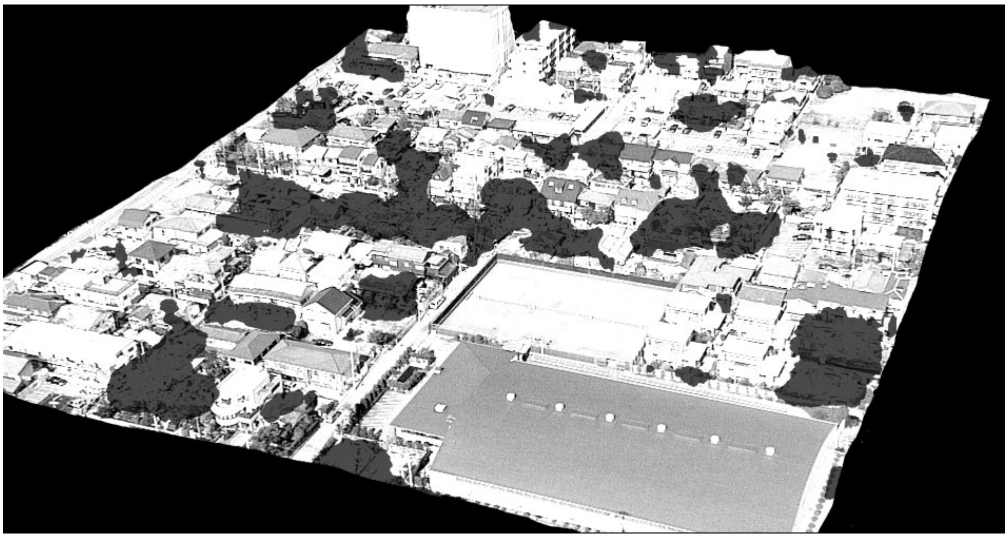


Figure 4.2.1. Collapsed buildings extracted from the area of Nishinomiya City by texture analysis for the identified pixels by image processing of HDTV images (Hasegawa et al., 2000b).

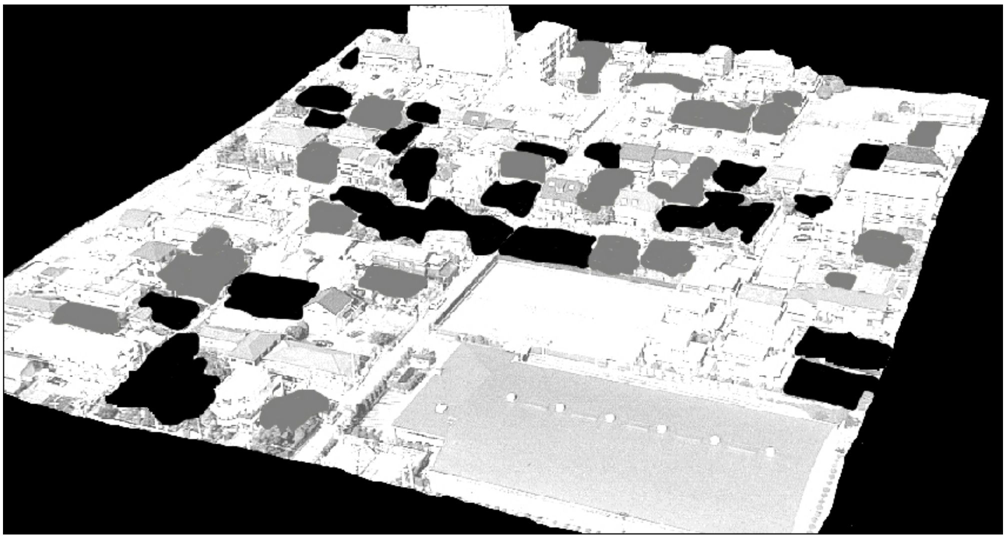


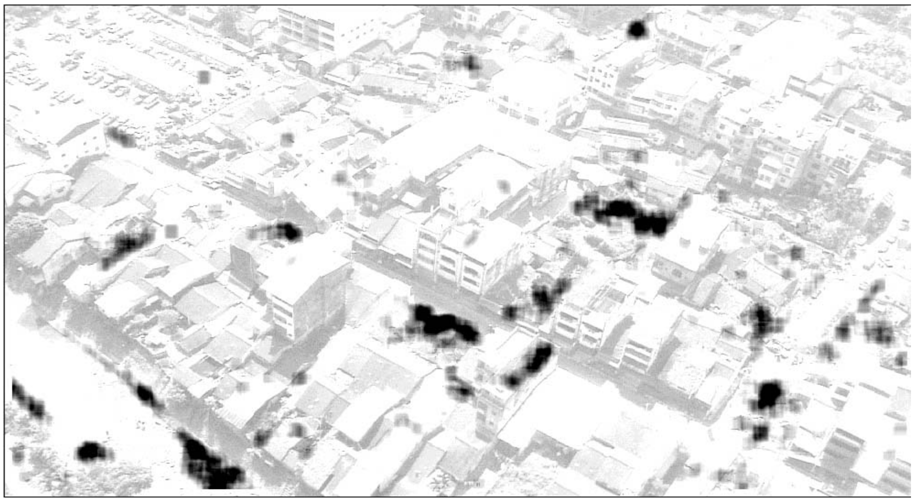
Figure 4.2.2. Collapsed (black) and heavily damaged (gray) buildings in the area of Nishinomiya City detected by a field survey and a visual inspection of HDTV images (Hasegawa et al., 2000b).

HDTV shootings between in Kobe and Taiwan, some adjustments for local averaging and threshold values were employed.

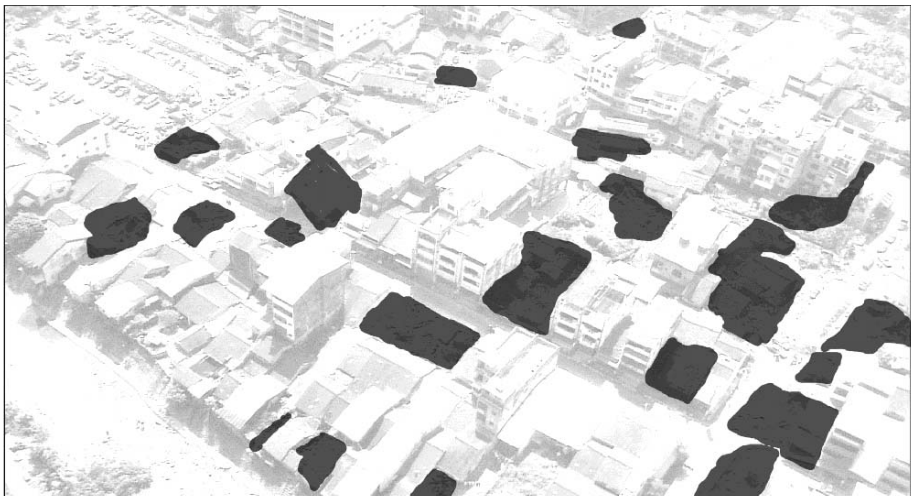
For reinforced concrete or concrete block buildings, automated damage detection was more difficult since the typical damage patterns for them were inclination and story collapse. Except for buildings reduced to debris, the current automated damage detection method was difficult to apply for engineered buildings, as already shown for the images of the Kobe earthquake.

It is pointed out that the building materials and pattern of damage are influential factors to determine the indices and threshold values to be used. Hence, the images for supervised learning are required when we apply the automated damage detection method to the areas hit by a natural disaster.

(a) Aerial HDTV image



(b) Building damage distribution obtained by the automated detection



(c) Building damage distribution obtained by the visual inspection

Figure 4.2.3. Building damage detection based on aerial HDTV image for Chi-Chi area (1).

(a) Aerial HDTV image

(b) Building damage distribution obtained by the automated detection

(c) Building damage distribution obtained by the visual inspection

Figure 4.2.4. Building damage detection based on aerial HDTV image for Chi-Chi area (2).

(a) Aerial HDTV image

(b) Building damage distribution obtained by the automated detection

(c) Building damage distribution obtained by the visual inspection

Figure 4.2.5. Building damage detection based on aerial HDTV image for Chungliao area (1) (Refer to color figure 6).

(a) Aerial HDTV image

(b) Building damage distribution obtained by the automated detection

(c) Building damage distribution obtained by the visual inspection

Figure 4.2.6. Building damage detection based on aerial HDTV image for Chungliao area (2).

4.2.3 Summary

We introduced the images of aerial HDTV observed the hard-hit areas after the Chi-Chi earthquake and applied the automated damage detection method, developed for the affected area due to the Kobe earthquake, to those images. In this automated damage detection method, the characteristics of building damage were defined based on hue, saturation, brightness and edge intensity. Using the threshold values of these parameters, the typical areas were classified into damaged and undamaged pixels. The texture analysis was then introduced to these pixels and the damaged buildings were identified.

The extracted damage distribution by the proposed method agreed well with the visual inspection of the images. Although the examples used here for the automated damage detection were still limited, the possibility of early damage extraction from aerial HDTV images could be demonstrated. In order to establish more general methodologies and threshold values, the authors intend to perform further case studies in the near future.

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