

DETERMINING THE INFLUENCE OF THE EARTHQUAKE ON THE CHANGE(S) OF OBJECTS USING REMOTE SENSING DATA

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Summary

Two methods of determining changes of objects (structures) using remote sensing data obtained in different times are considered in this article. The comparison of the percentage of destroyed buildings as a consequence of the earthquake in L'Aquila city (Italy) was implemented. For comparison two ways of data collection were used: obtaining data by the digitalization of objects before and after the disaster (using MapInfo software) and by automatic image classification using a special module Delta Cue (Erdas software).

Keywords

aerial image • space image • Erdas Imagine • vector layer • classification

1. Introduction

Earthquakes often cover large areas. As a result, the integrity of the soil is violated, buildings and facilities are destroyed, communal and infrastructure networks are decommissioned, and the loss of life is possible. Today, scientists around the world, especially in countries with a high risk of earthquakes, pay a great deal of attention to the issue of forecasting and calculating the devastating results due to natural disasters. This allows you the prediction of economic costs for reconstruction and to reduce the impact of such destruction. However, even now there are still many issues that should be resolved to reduce or realistically assess the results of such problems.

As a result of natural disasters, high-rise buildings and structures usually incur significant destruction. The architectural significance of these building is invaluable, not only at the national level where the disasters are experienced, but also for the whole world. Mainly, all of such national objects are under supervision of local government and special bodies for the preservation of cultural heritage. Quite often their funding is very limited, even in economically highly developed countries. Therefore, it is necessary to develop technological schemes that would fully give an objective assessment of

the destroyed facilities, and therefore make possible the reconstruction or restoration. This phase becomes less expensive.

It should be noted, that many years researchers were dealing with the problem of searching the optimal solution for counting losses due to various natural disasters [Imamaliyeva 2011, Kussul 2011, Samoylenko et al. 2009, Skakun 2010]. But even as of today, an elaborate technological scheme that would become the standard, has still not been found. In the literature, a great deal of consideration is paid to the problem of areas damaged due to flooding [Samoylenko et al. 2009, Skakun 2010] and/or fires and less attention is focused on the destruction of urban facilities due to earthquakes. The aim of this work is to evaluate the degree of destruction of buildings due to the earthquake in L'Aquila. This was achieved using "manual" and automatic methods of data gathering, using materials for remote sensing.

2. Obtaining data about the destruction of buildings in L'Aquila by "manual" and automatic methods using remote sensing materials

The earthquake in L'Aquila occurred on April 6, 2009 at 3:32 pm local time. Its power was 6.3 on the Richter scale [<http://www.leleky.org>]. According to the data of the National Institute of Geophysics and Volcanology in Italy the hypocenter of the earthquake was located at a depth of 8.8 kilometres and a distance of five kilometres from the city centre. L'Aquila is located at a distance of 95 kilometres from Rome. This earthquake was the most destructive in Italy for the last 30 years. It is known that the earthquake was preceded by a period of abnormal geological activity. However this did not forced the government to warn the public about the potential consequences. After the earthquake, about 15.000 buildings were damaged, this is about 50 percent of the city. The old part of the city and the villages, on the east of the city were most affected. Onna which belonged to the commune L'Aquila was almost destroyed. More than 279 people died as a result of this disaster.

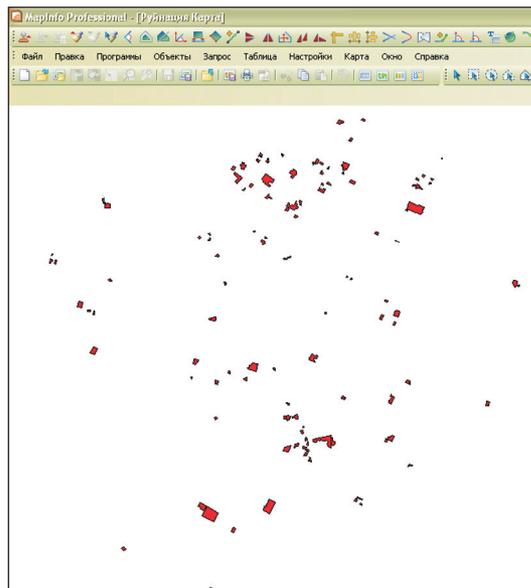
2.1. Characteristics of used remote sensing data

For the acquisition of information on the degree of destruction of buildings of the old town of L'Aquila, due to the earthquake, two space images were obtained. A before and after the disaster images were used for comparison purpose. Both images were obtained by the satellite GeoEye-1 with 1.65 m spatial resolution (multispectral band) [Dorozhynskyy and Tukaj 2009] and referenced to the coordinate system WGS84.

2.2. Digitalization of destroyed buildings of L'Aquila downtown using remote sensing data processed by software MapInfo

Professional GIS MapInfo was selected for “manual” method of processing space images to detect changes in the geometry of destroyed buildings, as the most user-friendly software for this kind of work.

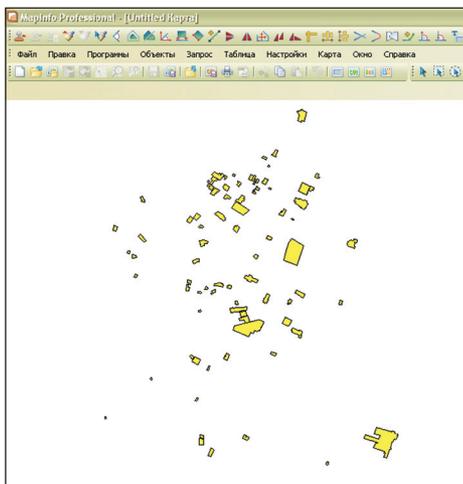
At the first stage of the work they were interpreted and the damaged parts of buildings destroyed after earthquake were digitized using space image of 2009. The obtained data was stored in a separate layer (Figure 1).



Source: authors' study

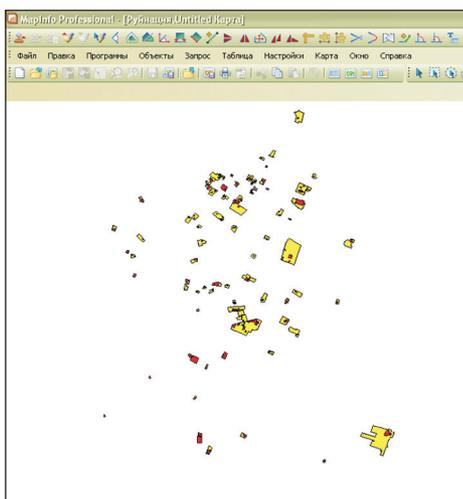
Fig. 1. Fragment of digitized layer of damaged parts of buildings, data of 2009

The next step of the work is to digitize the total areas of the destroyed and damaged buildings before the earthquake, in accordance to the previously created layer using the space image obtained in 2006 (Figure 2). Overlaying one layer with the other allowed the creation of a comprehensive visual representation of the degree of the destructions (Figure 3).



Source: authors' study

Fig. 2. Fragment of digitized layer of buildings before the earthquake, data of 2006

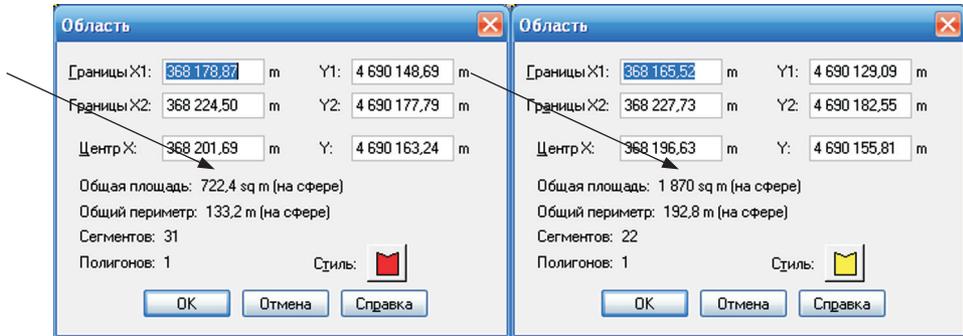


Source: authors' study

Fig. 3. The digitized and overlapping layers of buildings before and after the earthquake

During the computer statistical calculation of digitized objects, it was revealed that the total number of buildings which were highly damaged or totally destroyed were calculated to be 144 on the space image. To estimate the percentage of objects destroyed,

the detail comparison of each areas had to been done. For example, the windows with a total area of objects on both layers, for one large building are shown on Figure 4.



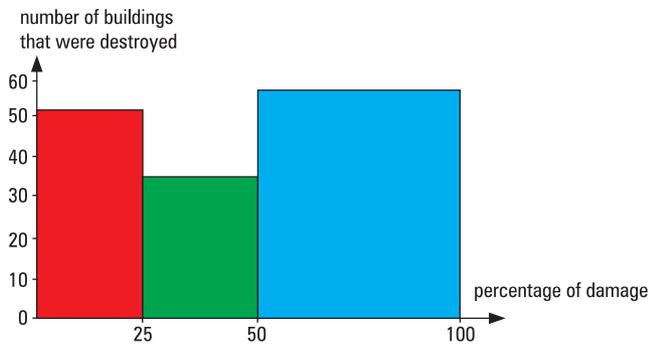
Source: authors' study

Fig. 4. Comparison of the total area of the building with an area that was destroyed

According to the calculation data it is determined that:

- the number of buildings destroyed up to 25% = 53,
- the number of buildings destroyed between 25–50% = 34,
- the number of buildings destroyed between 50–100% = 57.

According to these indicators, the diagram of dependant percentages of damaged areas to the number of buildings that were destroyed is shown on Figure 5.



Source: authors' study

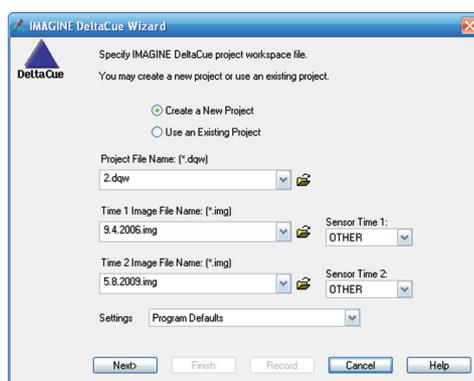
Fig. 5. Diagram of dependant percentage of damaged areas to the number of buildings that were destroyed

2.3. Automatic classification of buildings destroyed in L'Aquila downtown area using software package ErdasImagine

For the automatic detection of buildings that were destroyed as a consequence of the earthquake, software Erdas Imagine was used [http://www.erdas.com.ua]. It was used because it contains the module for searching difference changes of objects DeltaCue. This is very convenient to use.

Using this module, a new project for searching changes of buildings over time was created. Its contents are two space images obtained before and after the earthquake.

The type of sensor for both images was selected as "Other", because sensor GeoEye-1 is not listed by the software (Figure 6).



Source: authors' study

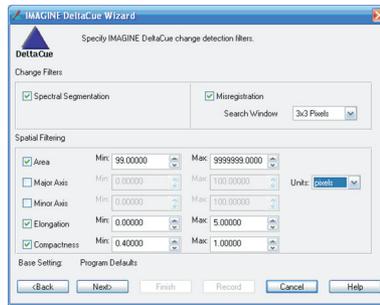
Fig. 6. Menu for settings input data of the module DeltaCue

Three types of filtration that can be achieved with this module. They were used for obtaining data about the change of buildings, after the earthquake. They are:

- spectral segmentation,
- incorrect pixel registration on pair of images,
- spatial filtering.

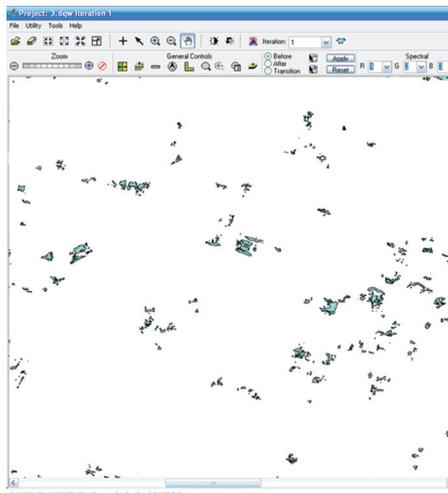
Spatial filter calculates several geometric properties, based on the objects outline. For this case we used the following geometric properties: area, compactness and elongation (Figure 7).

In the result of automatic filtration, the program displays a layer of difference indexes. After sorting of the data for urban area only, the plane objects which show destroyed parts of buildings were obtained (Figure 8). This layer is saved in shape format for easy counting of areas of destroyed objects.



Source: authors' study

Fig. 7. Menu for setting filters of image processing of the module DeltaCue



Source: authors' study

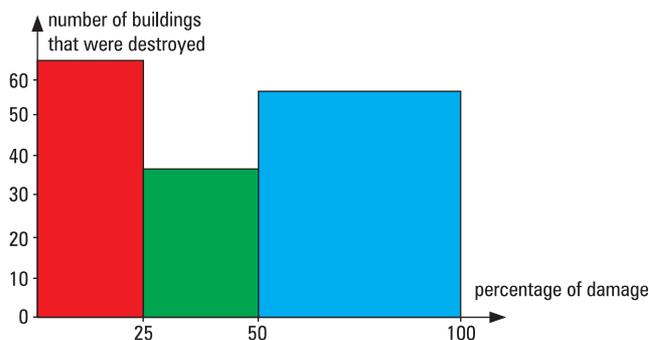
Fig. 8. The data of differences between the areas of buildings on space images before and after earthquake

After computer calculation of the total number of objects which had been significantly damaged or totally destroyed was 158 units.

According to the data obtained by the automatic detection of changes, the number of objects that were destroyed in percentage terms was calculated as follows:

- the number of buildings destroyed up to 25% = 66,
- the number of buildings destroyed between 25–50% = 35,
- the number of buildings destroyed between 50–100% = 57.

According to these indicators, the diagram of dependence of the percentage of damaged areas to the number of buildings that were destroyed is shown on Figure 9.



Source: authors' study

Fig. 9. Diagram of dependence of percentage of damaged areas to the number of buildings that were destroyed (automatic method)

3. Conclusions

After determining the total number of buildings that were damaged due to the earthquake in L'Aquila and their percentages using remote sensing data, it was revealed that:

- The number of damaged buildings determined using the “manual” method in the software package MapInfo was calculated as 144 objects. Among which buildings destroyed up to 25% = 53, buildings destroyed between 25–50% = 34, and buildings destroyed between 50–100% = 57.
- The number of damaged buildings determined using an automatic method in the software Erdas Imagine was calculated as 158 objects. Among which buildings destroyed up to 25% = 66, buildings destroyed between 25–50% = 35, buildings destroyed between 50–100% = 57.

Analysis of the obtained data shows that when automatically recognizing the changes of objects that are based on spectral data, the number of damaged of buildings is larger on 14 units. These are objects that were destroyed up to 25% and apparently not visible to human eye, and one object that was destroyed between 25–50%. This can be caused by the influence of shading due to the different heights between buildings.

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<http://www.erdas.com.ua>

<http://www.leleky.org>

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