DIGITIZATION OF EARTHQUAKE SIGNALS STORED AS IMAGES

Tatian-Cristian Malin [1], Gilbert-Rainer Gillich[1], Dorian Nedelcu[1], Vasile Iancu[1]
[1] "Eftimie Murgu" University of Resita, Resita, ROMANIA
cristian.malin@student.uem.ro, gr.gillich@uem.ro, d.nedelcu@uem.ro, v.iancu@uem.ro

Abstract: *The retrieval of information from historical analogical records is essential for the study of the seismic activity and of the seismic danger in the vulnerable areas during the earthquake. This is possible due to modern techniques and methods of processing and converting analog data into digital data. This paper presents a method of the digitization of earthquake signals stored as images. For this method, we used the software WebPlotDigitizer to extract the signals and the numerical values from an image.*
Keywords: *digitization, earthquake signals, WebPlotDigitizer, ground motion database*

1. INTRODUCTION

Earthquake is the definition for earth movements, consisting of vibrations produced in the internal areas of the Earth, propagated in the form of waves through the rocks. High economic losses, thousands of casualties and even deaths are the consequences of earthquakes over time. Also, in Romania are some regions that originate from the Vrancea source, which presents a high risk because of the seismic activity [1]-[3]. In the present are available many solutions to reduce the effect of the ground motion [4]-[6]. The most important devices are based on elastomeric element [7]-[10] for sliding bearings [11]-[14].
The historical view related to earthquakes is an important concern for seismic risk evaluation, especially for strategic constructions and infrastructures like nuclear power plants. The knowledge about the evolution of earthquakes over long time ranges is imperative.
Due to the availability of historical instrumental data, so important from the scientific point of view, the earthquake instrumental catalogs can be developed over 100 years. The original recordings, like bulletins and seismograms, are kept still in most observatories around the world, even in Romania.
In order to keep the unique seismological heritage consisting of earthquake bulletins, seismograms, and other documents, new digital archiving techniques have been created recently. The digital format allowed the re-analysis of past earthquakes using modern techniques and re-evaluation of seismic hazard [15],[16].
For our future research we need digital signals describing various earthquake movements, which will be used as an input for dynamic simulation. The purpose of this paper is to present a rapid and accurate method of the digitization of earthquake signals stored as images with the help of the *WebPlotDigitizer* software.

2. MATERIALS AND METHODS

The *PEER Ground Motion Database* (Pacific Earthquake Engineering Research Center) was used for this study. The archive of seismograms is accessible on the website: https://ngawest2.berkeley.edu. The web-based database provides tools for searching, selecting and downloading ground motion data [18].
To extract the signals, we use the software *WebPlotDigitizer*, which permits extracting the signal from an image and convert it in numerical values. In the flowchart displayed in Fig. 1 we explain the procedure followed to extract the signals from an image.
The software *WebPlotDigitizer* runs within web browsers and does not require to be installed by the user [17]. *WebPlotDigitizer* is a semi-automated tool that makes easy and accurate data extraction:

- Works with many types of charts (XY, bar, polar, maps, etc.);
- Makes easier to extract many data points with automatic extraction algorithms;
- Useful for measuring distances and angles between diverse features;
- Permits manual adjusting and other intervention of the user;
- Opensource software and free to use.

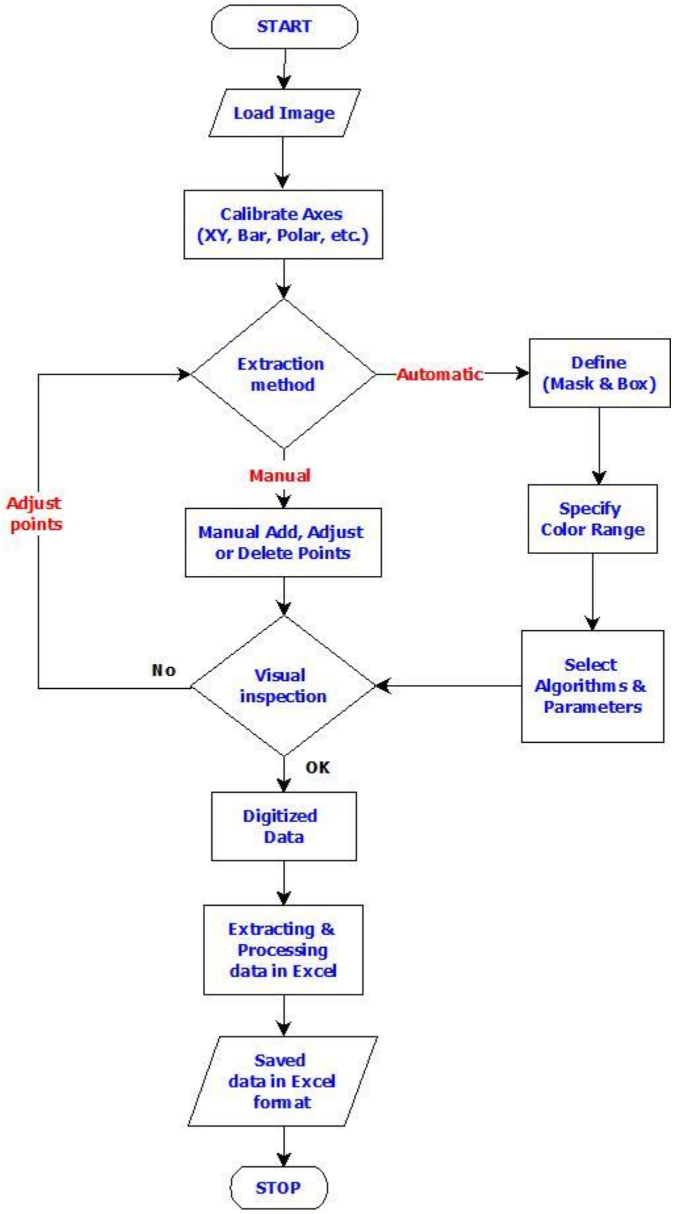

Figure 1: Flowchart for the extraction of the signals with *WebPlotDigitizer*

3. RESULTS AND DISCUSSIONS

We saved the image (Fig.2), as .jpg format, from *PEER Ground Motion Database* and uploaded the image in the *WebPlotDigitizer* software.

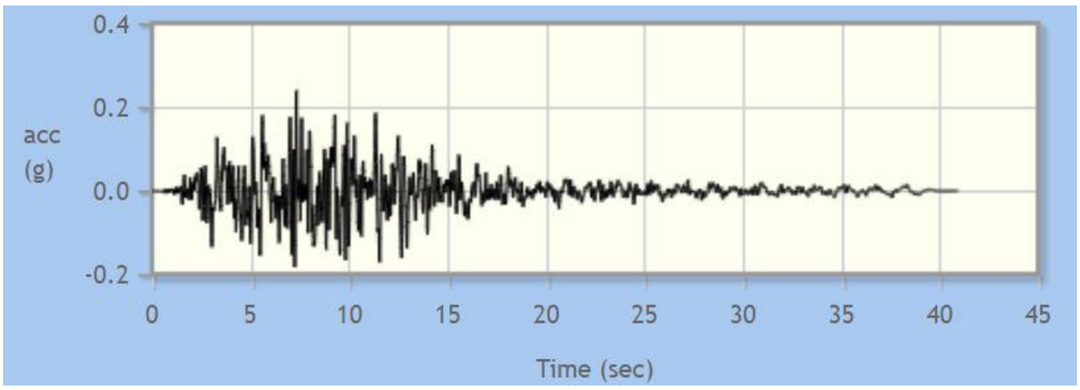

Figure 2: Kobe Earthquake, 1995, Japan (https://ngawest2.berkeley.edu)

After loading the image, we specified the type of axis (Fig.3), *2D X-Y Plot* that is used in the plot. The software required this to correctly map the image pixels to the corresponding data values in the image.

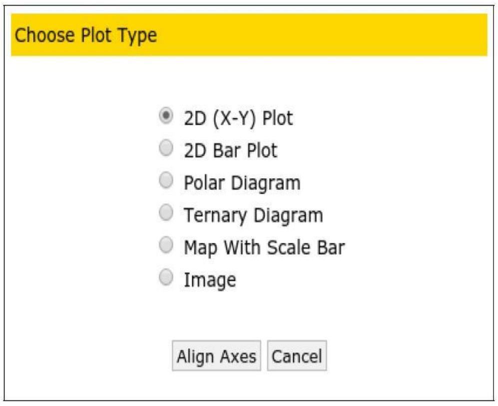

Figure 3: Type of axis

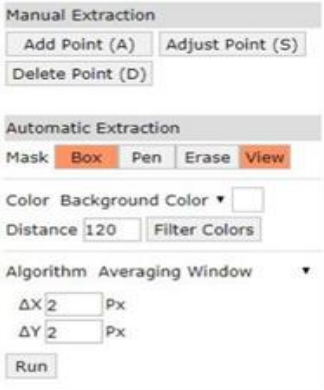

Figure 4: Data acquisition controls

Once the axis XY of the signal has been calibrated, we chose the automatic extraction method and we set up the controls for data acquisition (Fig.4). The controls from the automatic mode are used for choosing the proper algorithm and providing the necessary inputs required for the automated extraction of data points.
Automatic data extraction is based on separating the color of the data points or curves from the background in the image. The controls from the *Mask* tab are used to mark the region for the extraction algorithms, from this tab, we used the *Box* tool to mark the searching region (Fig.5).

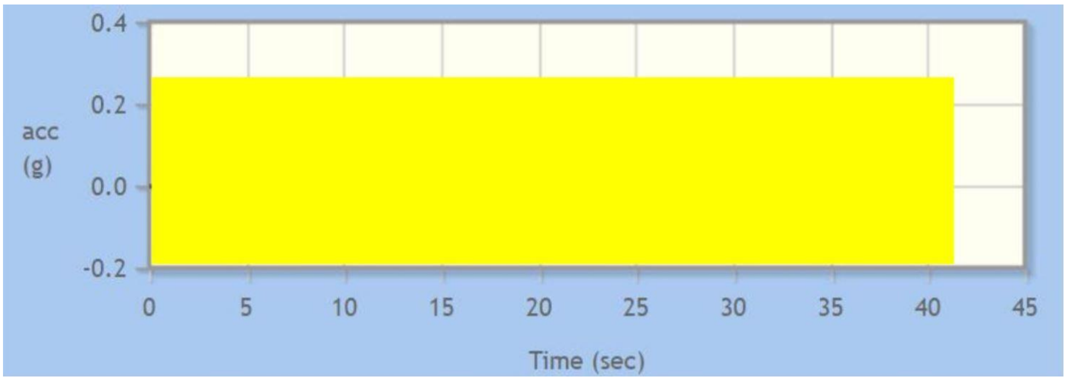

Figure 5: Rectangular region used for the extraction data points

After we marked the region for the extraction data points, we used the color controls to specify the color of the data points. From the drop-down menu of the *Color* tab we chose the *Background Color* white, we tested the color selection and the specified distance value from the *Filter Colors* tab (Fig.6). The *Averaging Window* algorithm is set for calculating the average locations of pixels with acceptable color that lie in small regions that are ΔX pixels (on-screen) wide and ΔY pixels (on-screen) tall.

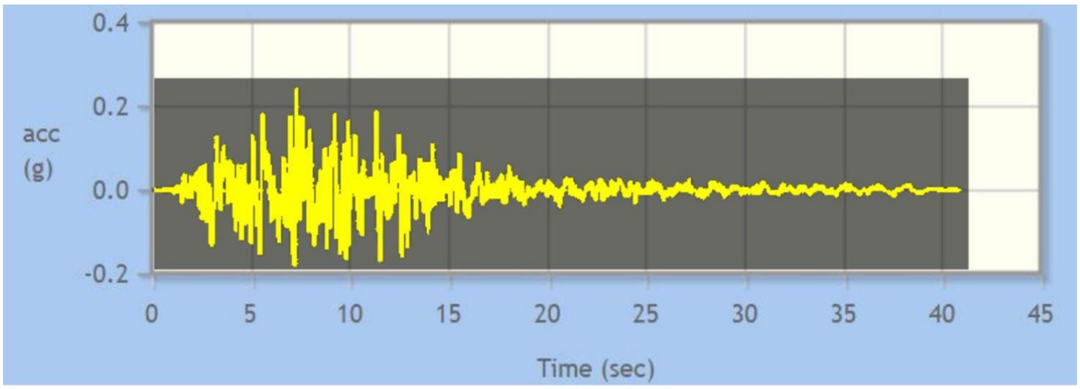

Figure 6: The region used by the automatic extraction algorithms

Once all the settings were done, we started the auto-detection algorithm from the *Run* button. After this is completed, the detected points appeared over the image (Fig.7).

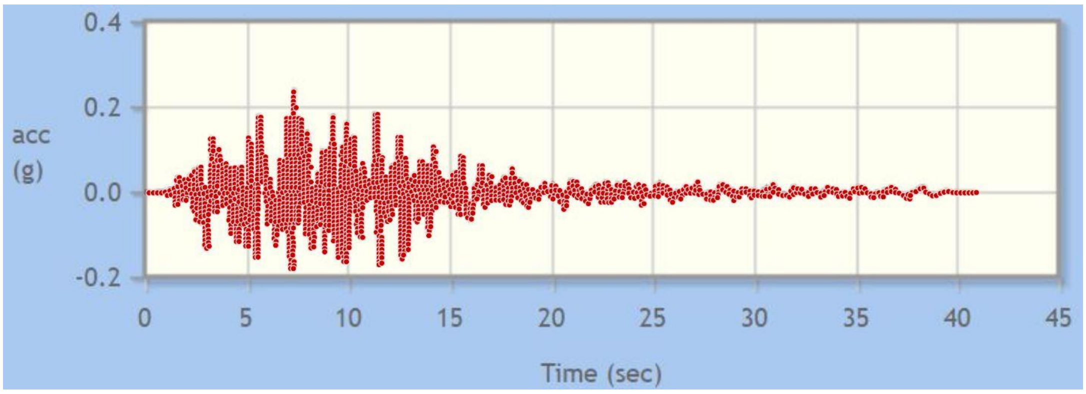

Figure 7: Points extracted in *WebPlotDigitizer*

The acquired data (Fig.8) can be viewed from the *View Data* tab and exported to a .CSV file.

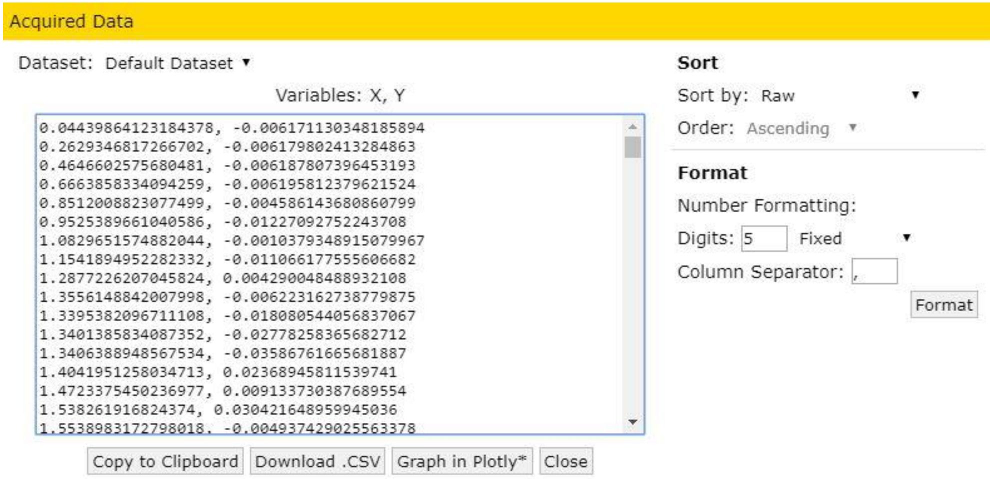

Figure 8: Acquired data

After the data has been obtained, we downloaded as .CSV file the numerical values and processing them in an Excel file. We got 1648 points from the signal processing obtained from the initial picture (Fig.2) and we digitized the signal in Excel (Fig.9).

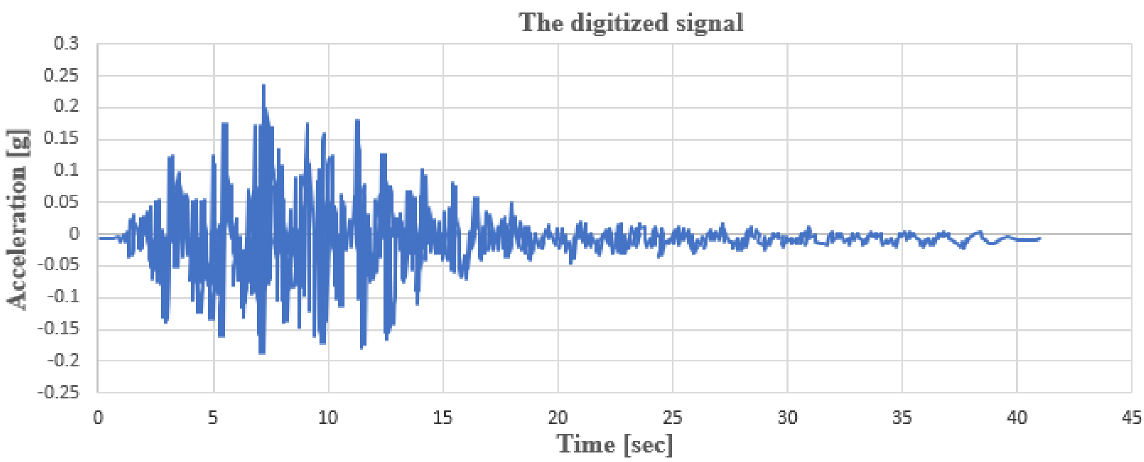

Figure 9: The digitized signal in Excel

4. CONCLUSION

The digitization of the original earthquake recordings it is very important to avoid deterioration and loss over time. The paper presents a method of the digitization of earthquake signals stored as images with the help of the *WebPlotDigitizer* software. We digitized a signal from a database stored as a jpg file and found that the extraction was made with high accuracy. The digital format will allow us to re-analyze the past earthquakes and to use digital data as input for dynamic simulation made for base isolated structures.

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