Determination of the earthquake epicenter from the Geographic Profiling of the digital footprints left by eyewitnesses

When an earthquake is felt, eyewitnesses digitally manifest themselves thanks to various collect methods developed by the European-Mediterranean Seismological Centre. Those observations are mostly collected through the website traffic analysis (site and mobile), a Twitter earthquake detection bot (TED), the Lastquake mobile application and a dedicated questionnaire. The idea developed here consists in considering the pattern printed by the entirety of these observations (which can be considered the digital footprint left by the eyewitnesses) as being the signature of an earthquake. Through several examples, a method for fusing and combining all eyewitness observations collected is presented. Especially, in the framework of the statistical method of the Geographic Profiling (GP), this approach leads to fast determination of a seismic epicenter. And, because the propagation of the information on the Internet network is faster than the propagation of the seismic waves, this approach leads also to compare the GP solution to that obtained from conventional geophysical procedures (detection/ location of the seismic waves).

1 - EMSC data Centre

Collect

Seismic + Crowdsourced data

Process

Fusion and standardize

Disseminate

Social Networks

WebServices

The medium is the message

SCHEMA 1 - Overview of EMSC data Centre activities: Collect, Process and Disseminate data.

2 - Crowdsourced Data

2 - Crowdsourced Data

European-Mediterranean Seismological Centre was established in 1975 to provide aggregated and authoritative parametric earthquake information (location, magnitude, moment-tensor, damage assessment) for the European-Mediterranean region and serves as European coordination platform for the further development and integration of seismological products. 85 seismological agencies from 56 countries contribute data to EMSC which is governed by a Coordination Bureau and an Executive Council.

3 - Geographic Profiling (GP)

a. Physical case studies

Euclidean distance

Decay-functions

\[ d(y) = \begin{cases} k y^h & \text{if } d \leq B \\ kB^h \left(\frac{28-B^2}{d^2}\right) & \text{if } d > B \end{cases} \]

where \( k, g, h, B \) are the constants, \( d \) is a distance and \( y \) are the observations (digital footprints).

Special cases: If \( B = 0 \), take into account of the “Doughnut effect” (Bossu et al., 2017), if \( B = 0 \) and \( h = 2 \):

- "Geometrical spreading" of the seismic waves.

b. Fusion of Observations

An observation \( X \) is a vector of dimension 4 composed of:
- latitude, longitude, an origin time and an attribute (intensity).

Felt reports intensity reported
Other data type Asume unity value EMS 1998 scale

c. Alternative models

Probability distance strategies.

3 - Geographic Profiling (GP)

4 - Applying the GP method on an Mw 4.9 earthquake in Greece on 2016-11-18 23:23:48

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