Rapid Characterization of Earthquakes Using Social Networks

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Introduction

Seismologists have long relied on personal accounts to characterize earthquake effects and to understand their impact. Isoseismal maps generated from personal diaries and newspaper reports are sometimes the only constraints on magnitude and epicenter for pre-instrumental earthquakes.
The advent of modern regional, national, and global seismic networks has not replaced the utility of personal accounts. There will always be more people than seismometers and the abundance of personal observations can sometimes be more meaningful than a few precise measurements. Personal accounts fill geographic voids in instrumentation and describe macroseismic effects such as building damage and urgent needs of the impacted population that cannot be conveyed by instrumental measurements.
With the advent of Internet-based information sharing, the speed at which personal accounts are obtained is astounding. National and international seismic networks produce robust maps of seismic Intensity in 10's of minutes following widely felt earthquakes using calibrated questionnaires voluntarily submitted by the public. Moreover, personal accounts of shaking are available to the world within seconds via social networking sites such as Twitter and Facebook.
Macroseismic observations are collected from many sources. Some sources are specifically targeted for the purpose such as intensity questionnaires, whereas others, such as newspaper accounts, are intended for informing the public. The latter can be considered as secondary sources that are not scientifically motivated but provide useful content when interpreted with caution. In this presentation, we focus on extracting information from a newly available secondary source: the micro-blogging service Twitter.

Twitter

Twitter is a service that allows anyone to send and receive 140-character text messages (tweets) via the Internet or cell phone. Tweets can be sent publicly or privately to a specified user. All users who opt to "follow" a Twitter user will receive that user's tweets and messages. It is these public messages that separate Twitter from instant message services that typically involve person-to-person chatting rather than person-to-world.
The potential to use tweets for earthquake characterization is based on the fact that public tweets are stored in an openly searchable database. Using utilities provided by Twitter, anyone can continuously stream tweets containing desired keywords to their computer. The geographic origin of the tweets can often be derived from locations specified in a user's profile or the tweet can optionally be tagged with accurate latitude and longitude coordinates, if sent from a GPS enabled device.

Twitter-based earthquake assessment and alerts

People tweet following earthquakes. Figure 1 shows the tweets per minute containing the word "earthquake" or its equivalent in Spanish and Indonesian generated from September to November 2009. Clear peaks exist in the data, most of which are associated with earthquakes. In regions with high densities of Twitter users, initial earthquake tweets are generally submitted within 20 seconds of the event (Figure 2). This can be compared with the 2 to 20 minutes required for the U.S. Geological Survey (USGS) to publicly distribute instrumentally derived estimates of location and magnitude.
A prototype internal application at the USGS automatically gathers, summarizes, and maps earthquake tweets (Figure 3) to provide a rapid overview of what people experienced. The application is currently triggered by instrumentally derived locations and we are investigating detecting possible earthquake events directly from an increase of Twitter "earthquake" messages. Using this application we receive firsthand accounts of shaking at the same time as previous alerts that only contained hypocenter and magnitude estimates.
In ideal situations, a rough qualitative map of the felt area can be generated from tweets (Figure 4) (Earle et al., 2010). These maps are in basic agreement with results that are produced by the USGS "Did You Feel It" system (Wald et al., 1999a). However, the usefulness of the Twitter-based maps is time limited. They are superseded by quantitative maps of ground shaking produced from "Did You Feel It" and instrumentally derived ShakeMaps (Wald et al., 1999b) that provide a superior overview of the shaking distribution.
Other social-networking tools and Internet data mining techniques beyond Twitter have similar potential. Automatically scanning other services such as Facebook and Flickr could yield firsthand accounts and damage photos. Internet-based systems that do not rely on social networking are also feasible. The European-Mediterranean Seismological Centre has implemented a system to map out the felt region of an earthquake by geocoding the IP addresses of people visiting their Web site (Bossu et al., 2008). The rapid increase in web visits is sometimes EMSC's first indication that an earthquake has occurred.