OPINION

SeismOlympics

On 23 May 2017, a clear day in Chengdu, the capital city of Sichuan Province in China, located ~80 km away from the epicenter of the 2008 M_s 8.0 Wenchuan earthquake, Alibaba Cloud (the largest cloud computing company in China, a subsidiary of Alibaba Group; see Data and Resources) and the Institute of Geophysics of the China Earthquake Administration (IGPCEA), jointly launched a seismological programming contest titled "Aftershock Detection Artificial-Intelligence Contest." The initial target of this contest was to identify as many aftershocks as possible from the continuous seismic waveforms of the 2008 Wenchuan earthquake, which is the first in a series of seismological programming contests. According to the public relations manager of Alibaba Cloud and the scientists at IGPCEA, this activity has the dual mission of exploring the limits of computational capability for seismological research, as well as enlisting seismologists and data scientists to participate in earthquake risk mitigation. Since the opening ceremony, the contest has drawn wide attention in the cyber world.

Large earthquakes typically are followed by increased seismic activity, known as aftershocks, throughout the mainshock rupture region. The spatial–temporal evolution of the aftershocks can provide valuable information for earthquake emergency response and the physics of earthquake faulting. But a significant portion of early aftershocks are missing in the manually processed earthquake catalogs, mainly because seismicity right after the mainshock can be masked by overlapping arrivals of waves from the mainshock and aftershocks (Utsu *et al.*, 1995; Kagan, 2004; Enescu *et al.*, 2007; Peng *et al.*, 2007; Peng and Zhao, 2009). In addition, the low signal-to-noise ratio of the waveforms of small aftershocks and the sparse distribution of the seismic stations also make phase–event association difficult and contributes to the lack of early aftershock detection. So far, more than 90,000 aftershocks have been registered by the Sichuan regional seismic network. The large numbers of aftershocks require further automatic processing for the timeline of the earthquake emergency response and rapid aftershock forecasting (Omi *et al.*, 2013, 2016). Quick and complete detection, along with accurate locations of the aftershocks, are challenges that can be clearly formulated and attacked by interdisciplinary efforts.

Specifically, seismologists are technologically challenged to pick the arrivals of aftershocks automatically, accurately, and scientifically to detect the smaller aftershocks from the waveforms of the mainshock or large aftershocks. To simplify the contest, a metric was designed similar to the rules of the game in gymnastics. The contest has two kinds of scores; the automatic picking of the aftershocks is a set exercise, whereas the association and location are optional and can gain extra bonus points.

The Data Management Centre of the China National Seismic Network at IGPCEA provides three-component broadband seismic-waveform data recorded by 16 permanent seismic stations surrounding an aftershock area of the Wenchuan mainshock. The data format is a standard binary Seismic Analysis Code with 100 Hz sampling frequency. The total volume of the waveform data reaches 240 GB. The waveform dataset begins one month before the mainshock and ends four months after the mainshock. The continuous waveforms can be downloaded freely after registering on Tianchi, a data-mining platform by Alibaba Cloud.

This contest encourages participants from different professional fields to team up and apply state-of-the-art tools, including digital signal processing, time-series analysis, machine learning, deep learning, and other artificial intelligence algorithms. The total amount of the reward is 350,000 Renminbi (RMB; or about $51,000 U.S.). The contest registration deadline is 11:59 p.m. on 11 August 2017 (Beijing Time). Scientists in China and around the world have equal opportunity to take part. Although the problem is international and the data are openly available after registration, scientists must come to China for the final round of the competition, and in some circumstances, communication must be in Chinese. Hence, it would be more effective to form collaborations with scientists in China.

China, a country that has historically suffered greatly from catastrophic earthquakes, has a long tradition of public participation in seismological monitoring and public preparedness for earthquake disaster reduction (P4, in Chinese "Qun Ce Qun Fang," in which Qun = public, Ce = monitoring, and Fang = preparedness). The P4 tradition can be traced back to the 8 March 1966 M_s 6.8 and 22 March 1966 M_s 7.2 Xingtai earthquakes. The miraculous preshock preparedness and evacuation of the 4 February 1975 M_s 7.3 Haicheng earthquake was a successful case of P4, although later studies found that the forecast was mainly due to the clear foreshock sequence and the readiness of local officials (Chen and Wang, 2010). Because of rapid socioeconomic development in recent years, the Chinese seismological community is now facing a new social/technological environment and new challenges in promoting P4. Meanwhile,

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scientists in other regions and other fields developed different approaches to involve different groups of people into their research, from the citizen seismology of Europe (Bossu *et al.*, 2008) and Taiwan (Liang *et al.*, 2016) to the Twitter detection system in the United States (Earle *et al.*, 2012), and from the community models in Earth system science (Voinov *et al.*, 2010) to the web-based organization of computation games in biology (Cooper *et al.*, 2010). Mathematical modeling contests and data science computation contests have also attracted the attention of the seismological community.

In the context of the actor–network theory (ANT) in science studies or in the sociology of science (Latour, 2005), there is a need for a hierarchical actor network to transform the scientific understanding into public action that reduces earthquake disaster risk. The role of the seismological agency such as China Earthquake Administration (CEA) is to foster the growth of such a network of actors. Such coordination, according to ANT, is enabled through four key ingredients of the translation process: problematization, interessement, enrollment, and mobilization of allies (Callon, 1986). This contest is a showcase example of such coordination and translation processes, especially problematization.

Yu Shuming, the deputy director of the Department for Earthquake Monitoring and Forecast of the CEA, recently said "The philosophy of this contest is to attack the problems for which the answers are unknown, you sometimes need unknown task forces." So far, this contest has attracted 1100 teams (~4000 participants) from both within and outside the seismological community. This contest marks an exciting start. A series of seismological programming contests are planned for the following years. These include predicting the magnitude of the largest earthquake in the next year based on previously recorded earthquake catalogs that are of practical importance for the annual assessment of the seismic hazard, and estimating the magnitude of large earthquakes with the initial 1–2 s of the *P* waveforms which have a clear significance for the earthquake early warning (Strauss and Allen, 2016). Seismologists from all around the world are welcome to participate in these competitions together with scientists in other fields.

DATA AND RESOURCES

The data on Alibaba Cloud (the largest cloud computing company in China) can be found at https://intl.aliyun.com (last accessed July 2017).

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