

# **Predictability or Early Warning: Using Social Media in Modern Emergency Response**

**Marco Avvenuti** • *University of Pisa, Italy*

**Stefano Cresci and Andrea Marchetti** • *National Research Council (CNR), Italy*

**Carlo Meletti** • *National Institute of Geophysics and Volcanology (INGV), Italy*

**Maurizio Tesconi** • *National Research Council (CNR), Italy*

**M**ariluz Congosto and her colleagues<sup>1</sup> recently mentioned the possibility of predicting natural disasters using social media data. They support their claims by adding references to two works that employed Twitter data for the detection of earthquakes.<sup>2,3</sup> Within this context, we feel that the references to these two other works<sup>2,3</sup> might be overstated. For instance, in our work,<sup>2</sup> we discussed a system for the detection and damage assessment of earthquakes in Italy. Similarly, in Takeshi Sakaki and his colleagues' work,<sup>3</sup> they propose a system for detecting earthquakes as well as detecting and estimating the trajectory of tornadoes in Japan. In both works, no claims are made about the systems' capabilities to predict earthquake occurrences, but more about their ability to detect and report. We believe this opens an even more interesting discussion.

A potential source of ambiguity, and a possible reason for this claim by Congosto and her colleagues could lie in the meaning given to "predict," when the definition "say or estimate that a specific thing will happen in the future" is interpreted as the action of figuring on (and notifying) the imminent arrival of the shake, following a significant earthquake that has occurred far away. However, this isn't true prediction; rather, this is an early warning system enabled by the difference existing between

the propagation speed of communication media and that of seismic waves. Instead, adhering to a more genuine interpretation, the hypothesis of predicting earthquakes using social media data can be ruled out straightaway as the relevant data are produced and shared as a result of the earthquake itself. As such, it's not available before the earthquake occurs.

Another source of ambiguity could be a few references in Sakaki and his colleagues' work<sup>3</sup> mentioning research efforts aimed at investigating the possibility for intermediate- and short-term earthquake prediction. However, in this work,<sup>3</sup> there's no specific reference to the results of such studies, and ultimately, neither the effectiveness nor the applicability of such predictive techniques are supported.

Over the course of more than 100 years, the potential promise of earthquake prediction has attracted researchers in seismology as well as amateurs and impostors. Many theories have been tested and systematically rejected.<sup>4</sup> Recent works in seismology have demonstrated once more that current knowledge in this field is unable to predict earthquake occurrences in any way,<sup>5</sup> let alone using Twitter (or other social media) data. Answering the question raised by Robert Geller and his colleagues as to whether earthquake prediction is "inherently impossible or just fiendishly difficult" will probably require other decades of research in seismology.<sup>4</sup>

What social media data actually can contribute to is assisting emergency responders in assessing and mitigating natural and manmade disasters. The most promising application for crowdsourced and fast-paced social media data is in the time span between the disaster's occurrence and the impact/damage assessments performed by means of traditional – and typically less responsive – technologies. Indeed, this is supported by the growing interest of civil protection agencies, such as the US Federal Emergency Management Agency (FEMA), in social media emergency communications.<sup>6</sup>

Furthermore, state-of-the-art approaches in social media-based emergency response have recently led to the first results in the fields

of qualitative and quantitative damage assessment,<sup>7,8</sup> and to important advances in the fields of situational awareness and crisis mapping.<sup>9</sup> Among the most notable findings of such works are the evidence of moderate-to-strong correlations between tweet-derived predictors and earthquake intensity. Other interesting results are about the possibility of producing impromptu crisis maps solely from social media, in a real-time fashion, thus allowing unpredictable disasters to be tracked as they unfold. However, quantitative and verifiable results in these fields are still few and far between, and despite these compelling findings, many questions still remain unanswered. Among the most pressing research challenges are the evalua-

tion of the extent to which models developed for a type of disaster (such as an earthquake) can be carried over to other disasters (for example, floods or wildfires), and the design of hybrid solutions that combine the strengths of social media with those of traditional emergency-response technologies.

The achievement of reliable results in this critical field involves designing a system based on past disasters and then thoroughly testing it against future ones, which requires a great deal of effort and time. Meanwhile, current societal and environmental challenges, such as climate change, are bound to cause more frequent and more severe

## IEEE Internet Computing

### Editor in Chief

M. Brian Blake • MBrian.Blake@drexel.edu

### Associate Editors in Chief

Barry Leiba • barryleiba@computer.org  
Anirban Mahanti • anirban.mahanti@gmail.com  
George Pallis • gpallis@cs.ucy.ac.cy

### Columnists

Backspace  
Vinton G. Cerf • vgc@ucla.edu  
Digital Citizen  
Kieron O'Hara • kmo@ecs.soton.ac.uk  
From the Editors  
M. Brian Blake • MBrian.Blake@drexel.edu  
Peering  
Charles J. Petrie\* • cjpetriejr@gmail.com  
Practical Security  
Hilarie Orman • hilarie@purplestreak.com

### Department Editors

Beyond Wires  
Yih-Farn Robin Chen • chen@research.att.com  
Big Data Bites  
Jimmy Lin • jimmylin@uwaterloo.ca  
Developing World  
Kamal Bhattacharya • kabhatta@gmail.com  
Internet Governance  
Virgilio Almeida • virgilio@dcc.ufmg.br  
Internet of Things, People, and Processes  
Schahram Dustdar • dustdar@dsg.tuwien.ac.at  
Linked Data  
Carole Goble • cag@cs.man.ac.uk  
Natural Web Interfaces  
Munindar P. Singh\* • singh@ncsu.edu  
Spotlight  
Gustavo Rossi • gustavo@lifa.info.unlp.edu.ar

### Standards

Yong Cui • cuiyong@tsinghua.edu.cn  
View from the Cloud  
George Pallis • gpallis@cs.ucy.ac.cy

### Additional Editorial Board Members

Elisa Bertino • bertino@cerias.purdue.edu  
Fabian Bustamante • fabianb@cs.northwestern.edu  
Fred Douglas\* • f.douglas@computer.org  
Stephen Farrell • stephen.farrell@cs.tcd.ie  
Elena Ferrari • elena.ferrari@uninsubria.it  
Robert E. Filman\* • filman@computer.org  
Michael N. Huhns • huhns@sc.edu  
Arun Iyengar • aruni@us.ibm.com  
Anne-Marie Kermaec • anne-marie.kermaec@inria.fr  
Peter Mika • pmika@hotmail.com  
Dejan Milojicic • dejan@hpl.hp.com  
Michael Rabinovich\* • michael.rabinovich@case.edu  
Amit Sheth • amit.sheth@wright.edu  
Weisong Shi • weisong@wayne.edu  
Maarten van Steen • m.r.vansteen@utwente.nl  
\* EIC emeritus

### CS Magazine Operations Committee

Forest Shull (chair), M. Brian Blake, Maria Ebling, Lieven Eeckhout, Miguel Encarnacao, Nathan Ensmenger, Sumi Helal, San Murugesan, Yong Rui, Ahmad-Reza Sadeghi, Diomidis Spinellis, George K. Thiruvathukal, Mazin Yousef, Daniel Zeng

### CS Publications Board

David S. Ebert (VP for Publications), Alfredo Benso, Irena Bojanova, Greg Byrd, Min Chen, Robert Dupuis, Niklas Elmquist, Davide Falessi, William Ribarsky, Forrest Shull, Melanie Tory

### Staff

Editorial Management: Tammi Titsworth  
Manager, Editorial Services Content Development: Brian Brannon, bbrannon@computer.org  
Publications Coordinator: internet@computer.org  
Director, Products & Services: Evan Butterfield  
Senior Manager, Editorial Services: Robin Baldwin

Senior Business Development Manager: Sandy Brown  
Advertising Coordinator: Deborah Sims, dsims@computer.org

### Technical cosponsor:



IEEE Internet Computing  
IEEE Computer Society Publications Office  
10662 Los Vaqueros Circle  
Los Alamitos, CA 90720 USA

**Editorial.** Unless otherwise stated, bylined articles, as well as product and service descriptions, reflect the author's or firm's opinion. Inclusion in *IEEE Internet Computing* does not necessarily constitute endorsement by IEEE or the IEEE Computer Society. All submissions are subject to editing for style, clarity, and length.

**Submissions.** For detailed instructions, see the author guidelines ([www.computer.org/internet/author.htm](http://www.computer.org/internet/author.htm)) or log onto *IEEE Internet Computing's* author center at ScholarOne (<https://mc.manuscriptcentral.com/cs-ieee>). Articles are peer reviewed for technical merit.

**Letters to the Editors.** Email lead editor Brian Brannon, bbrannon@computer.org

**On the Web.** [www.computer.org/internet/](http://www.computer.org/internet/).

**Subscribe.** Visit [www.computer.org/subscribe/](http://www.computer.org/subscribe/).

**Subscription Change of Address.** Send requests to [address.change@ieee.org](mailto:address.change@ieee.org).

**Missing or Damaged Copies.** Contact [help@computer.org](mailto:help@computer.org).

**To Order Article Reprints.** Email [internet@computer.org](mailto:internet@computer.org) or fax +1 714 821 4010.

**IEEE prohibits discrimination, harassment, and bullying.** For more information, visit [www.ieee.org/web/aboutus/whatis/policies/p9-26.html](http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html).

## Introducing “Editor’s Select”

Perhaps one of the greatest aspects of being the Editor in Chief of a magazine that’s central to my own research area is the ability to read early work on the most innovative topics. As EIC, I also get the opportunity to experience firsthand the interplay between our researchers as they develop new approaches to real-world problems.

Often, contributions from one article can provide significant insights into other works, even when the approaches are different. Other times, authors get to challenge the work of others in such a way that a greater understanding for both projects can be attained.

In this issue of *IEEE Internet Computing*, I’m using the “From the Editors” column as a special “Editor’s Select” feature — a platform similar to letters to the editor, but with adequate space for discussion. This “Editor’s Select” highlights insights from authors who read one of our earlier published articles and want to express a deeper insight. I hope that you enjoy their comments and appreciate the scholarly spirit of what they observed from reading the works of *IEEE Internet Computing*.

I would also like to take a moment to thank the guest editors for this issue, Kausubh Joshi and Theophilus Benson. This special issue focuses on network function virtualization (NFV), a burgeoning area of interest to many.

— M. Brian Blake, Editor in Chief

disasters. Thus, globally we must increase scientific and technological efforts in this direction, because it’s destined to be of crucial importance for years to come. □

### References

1. M. Congosto, D. Fuentes-Lorenzo, and L. Sánchez, “Microbloggers as Sensors for Public Transport Breakdowns,” *IEEE Internet Computing*, 2015, vol. 19, no. 6, pp. 18–25.
2. M. Avvenuti et al., “EARS (Earthquake Alert and Report System): A Real Time Decision Support System for Earthquake Crisis Management,” *Proc. 20th ACM SIGKDD Int’l Conf. Knowledge Discovery and Data Mining*, 2014, pp. 1749–1758.
3. T. Sakaki, M. Okazaki, and Y. Matsuo, “Tweet Analysis for Real-Time Event Detection and Earthquake Reporting System Development,” *IEEE Trans. Knowledge and Data Eng.*, vol. 25, no. 4, 2013, pp. 919–931.
4. R.J. Geller et al., “Earthquakes Cannot Be Predicted,” *Science*, 2007, vol. 275, no. 5306, p. 1616; doi:10.1126/science.275.5306.1616.
5. T. Jordan et al., “Operational Earthquake Forecasting: State of Knowledge and Guidelines for Implementation,”

*Annals of Geophysics*, 2011, vol. 54, no. 4; doi:10.4401/ag-5350.

6. Federal Emergency Management Agency (FEMA), *2014–2018 FEMA Strategic Plan*, tech. report, FEMA, 2014; www.fema.gov/media-library/assets/documents/96981.
7. Y. Kryvasheyev et al., “Rapid Assessment of Disaster Damage Using Social Media Activity,” *Science Advances*, vol. 2, no. 3, 2016, p. e1500779; doi:10.1126/sciadv.1500779.
8. M. Avvenuti et al., “Nowcasting of Earthquake Consequences Using Big Social Data,” *IEEE Internet Computing*, 2016, preprint; doi:10.1109/MIC.2016.47.
9. M. Avvenuti et al., “Impromptu Crisis Mapping to Prioritize Emergency Response,” *Computer*, vol. 49, no. 5, 2016, pp. 28–37.

**Marco Avvenuti** is a professor of operating systems in the Department of Information Engineering at the University of Pisa. His research interests include human-centric sensing and social media analysis. Avvenuti has a PhD in information engineering from the University of Pisa. He’s a member of the IEEE Computer Society. Contact him at marco.avvenuti@unipi.it.

**Stefano Cresci** is a PhD student in the Department of Information Engineering at the University of Pisa and a Research Fellow at the Institute of Informatics and Telematics of the National Research Council (CNR), Italy. His research interests include social media mining and knowledge discovery. Cresci has an MSc in computer engineering and an MSc in Big Data analytics and social mining from the University of Pisa. He is a student member of IEEE and member of the IEEE Computer Society. Contact him at stefano.cresci@iit.cnr.it.

**Andrea Marchetti** is a technologist at the Institute of Informatics and Telematics of the National Research Council (CNR), Italy. His research interests include social media analysis, e-government services quality, and the Semantic Web. Marchetti has a degree in computer science from the University of Pisa. Contact him at andrea.marchetti@iit.cnr.it.

**Carlo Meletti** is a senior technological scientist at the National Institute of Geophysics and Volcanology (INGV), Italy. His research interests include seismic hazard, seismic risk, and loss-reduction policy. Meletti has an MSc in geological sciences from the University of Pisa. Contact him at carlo.meletti@ingv.it.

**Maurizio Tesconi** is a computer science researcher at IIT-CNR. His research interests include social Web mining, social network analysis, and visual analytics within the context of open source intelligence. Tesconi has a PhD in information engineering from the University of Pisa. He is a member of the permanent team of the European Laboratory on Big Data Analytics and Social Mining. Contact him at maurizio.tesconi@iit.cnr.it.

Read your subscriptions through the myCS publications portal at <http://mycs.computer.org>.