Bursty behaviour found to have similar features across complex systems

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Several complex systems live in periods of short bursts of high activity followed by long uneventful intermissions. This phenomenon called burstiness can be modelled and predicted with mathematical algorithms. Research of Dr Márton Karsai of Aalto University Department of Biomedical Engineering and Computational Science, now shows that burstiness has universal features in very different systems.

Karsai and his collaborators – Dean Kimmo Kaski of Aalto University School of Science, FidiPro Professor in Aalto University János Kertész, and the world-renowned physicist and network theorist Professor Albert-László Barabási – studied burstiness in human mobile and email communication, in neuron spike trains, and in seismic activity in earthquakes. The results have recently been published in Nature Scientific Reports.

"The method we developed helped us to highlight a novel universal feature of bursty behaviour. This is one step beyond the state of the art assumptions regarding the phenomena of burstiness," assesses Karsai the significance of the group's work.

The research focuses on the dynamic phenomena of burstiness, that is, the mechanisms of temporal fluctuation of levels of activity. We make, for instance, several phone calls and send many emails in a short spurts of time, and otherwise not so much. Neurons fire in spike trains, and earth quakes in similar temporal patterns.

There are not only connections between consecutive events but also in events within bursty periods.

The common feature shared by the studied systems is that beyond being bursty, the bursty events evolve rather in long trains of events than in pairs – contrary to what existing modelling methods have lead to assume.

"We observed that bursts are not independent but rather clustered and they evolve in long bursty trains, which contain several correlated events. The universality of the analysed systems come from the fact that the size distribution of these trains scale very similarly in human communication, neuron firing and earthquakes," describes Karsai the group's results.

All the systems share both a threshold mechanism of a sort and memory effects within their processes. Earth begins to shake when accumulated stress relaxes, and one quake can trigger several aftershocks. Neurons fire in consecutive spike trains when they receive enough excitatory stimuli. Humans make choices between countless virtual options; one phone call or email often turns into many.

"These correlations can be interpreted as a very simple memory process where the actual state of the system depends not only on the previous bursty event but also from all the other events that have evolved in the actual burst train," points out Karsai.

"We hope that our approach will help to disclose other unknown features of correlated heterogeneous temporal behaviour. The methodology can be applied in many different fields of science, engineering and business. For instance, by predicting human communication behaviour, one can better design the usage of resources in telecommunication or help service providers make better business plans."

More information: The original article by Márton Karsai, Kimmo

Kaski, Albert-László Barabási & János Kertész (2012) 'Universal features of correlated bursty behaviour', *Nature Scientific Reports* (2) 397. www.nature.com/srep/2012/12050 … /full/srep00397.html

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