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ShakeMapple : Tapping Laptop Motion Sensors to Map the Felt Extents of an Earthquake

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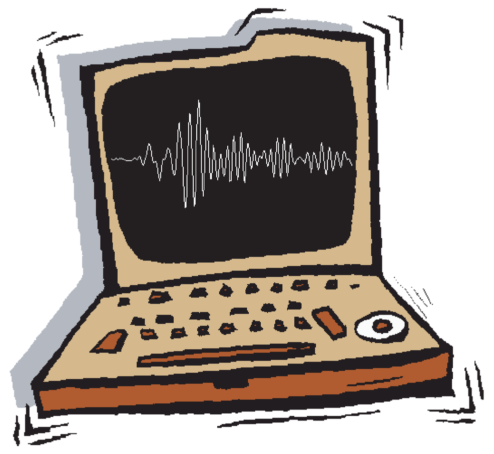

There are insufficient deployments of accelerometric sensors to provide detailed localized earthquake intensity maps. However, there is a significant pool of untapped sensor resources available in portable computer embedded motion sensors. With the ShakeMapple project, we have developed a system to capture strong-motion accelerometric data from these sensors to map earthquake shaking intensity. Through this approach, we hope to engage the general population to increase seismic hazard awareness, and analyze the effectiveness of using a volunteer network of laptop-based sensors to fill in the data gap in strong motion data in urban areas.

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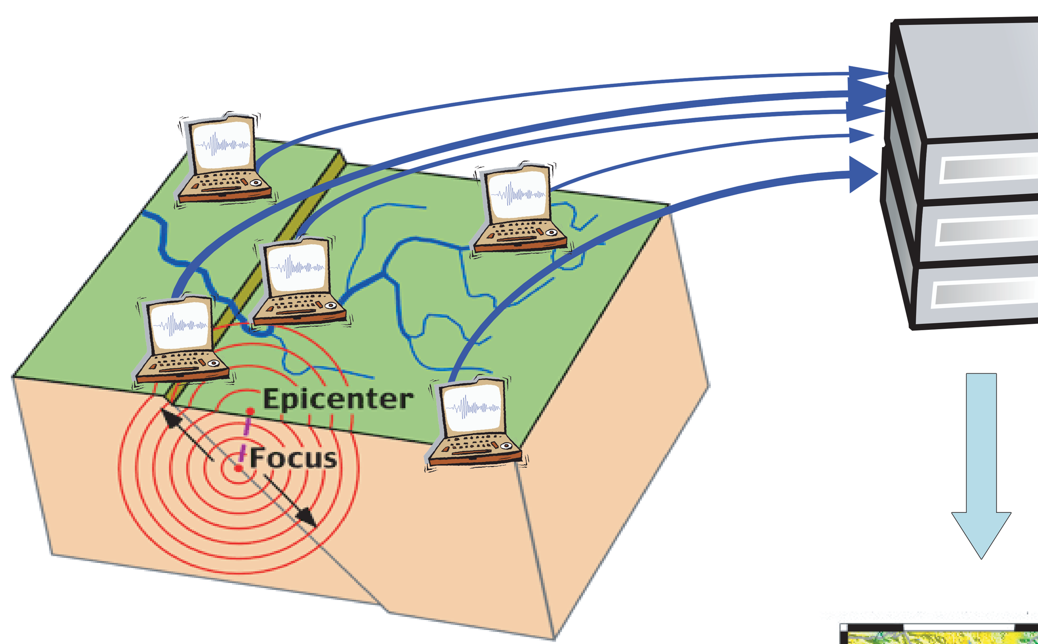
Motivation - Embedded sensors in laptop computers provide a significant pool of available untapped sensor resources. Included primarily to detect sudden strong motion in order to park the disk heads to prevent damage to the disks in the event of a fall or other severe motion, these sensors may also be tapped for other uses as well. Deployment of a dense accelerometric network is often prohibitively expensive. However, in populated areas where a significant number of laptops may available, these sensors may be tapped and the data could be used to better constrain the localized shaking intensities of an earthquake. This may in turn assist in the direction and deployment of emergency response personnel to areas of greater impact.

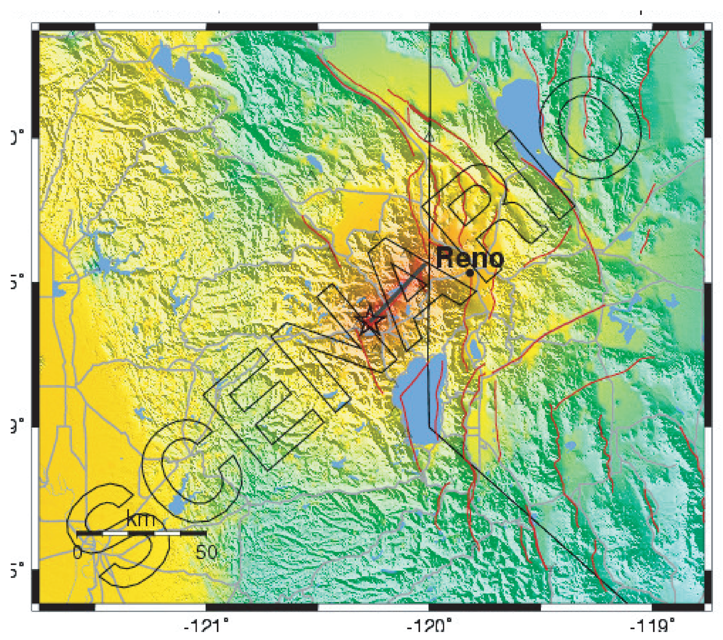
The ShakeMapple application runs in the background, continuously recording the embedded sensor data in a time-limited buffer.

When an earthquake occurs, participating laptops in the vicinity of the earthquake calculate and submit their PGA data to the ShakeMapple servers.



The EMSC gathers the submitted PGA data to produce a Shake Map of the region.

Shake Maps - Shake Maps provide graphical representation of the level of shaking in a region. There are, however, often constrained by the limited number of sensors in the earthquake region. By harnessing the available laptop sensors, we hope to provide more data points for generation of local shake maps.



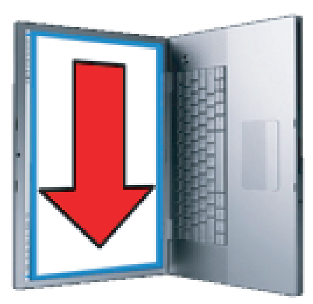
Related Work - The Quake Catcher Network uses a distributed network of volunteer computers with embedded or attached sensors to detect earthquakes. Using the Berkeley Open Infrastructure for Network Computing (BOINC), the QCN runs a triggering algorithm on idle computers to monitor for earthquakes. When triggered, the computer sends in a window of waveform data. With the noise in urban environments, false triggers are common, so a number of near-simultaneous triggers are necessary to indicate a possible earthquake. A significant difference from ShakeMapple is that the QCN is attempting to provide more rapid earthquake detection, whereas ShakeMapple aims to provide a more accurate map of earthquake intensity immediately following a significant earthquake.

Acknowledgements - We would like to thank

Daniel Griscom of Suitable Systems, for the smsLib code.

Vitus Lorenz-Meyer, for his smsLib JNI bridge.

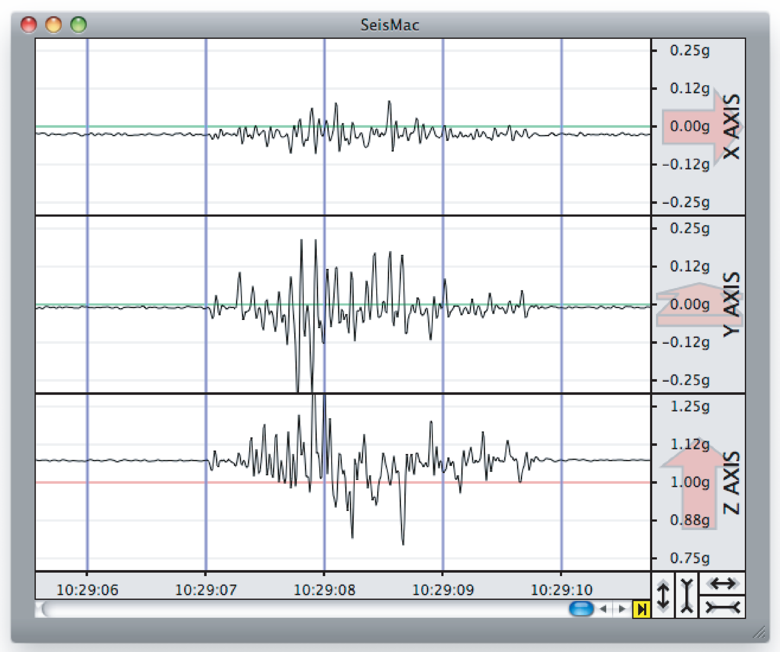
ShakeMapple - The EMSC, in conjunction with the University of Edinburgh, has developed an application to take advantage of Apple laptop sudden motion sensors to record shaking and generate felt maps of locally-felt earthquakes. When an earthquake has been felt, the application sends its recorded motion data in to the EMSC. From this, a felt map representing the measured intensity of the shaking across the region is produced. This can help civil authorities identify areas where the most shaking - and therefore the highest probability for damage - has occurred, as well as help seismologists understand the variability of local conditions and site effects. With additional information provided by the user about their building, the gathered information can also help engineers understand the building response to shaking.



Challenges - Their are numerous challenges in harnessing and using the laptop sensor resources, including testing in the face of infrequent significant local seismicity, deploying the application to a significantly dense as well as distributed network, availability of the machine in the event of an earthquake, and data quality.

One aspect of data quality is the calibration of the sensors. As the SeisMac screen capture below demonstrates, the default calibration of the sensors may be incorrect. To address this aspect of the data quality issue, we ask the users to calibrate their sensors after installing the application using the SeisMacCalibrate utility. In the event of a felt earthquake, raw PGA values are automatically submitted, after which we invite them to recalibrate to provide more accurate data. This recalibrated data is also submitted and processed in to more accurate intensity maps.

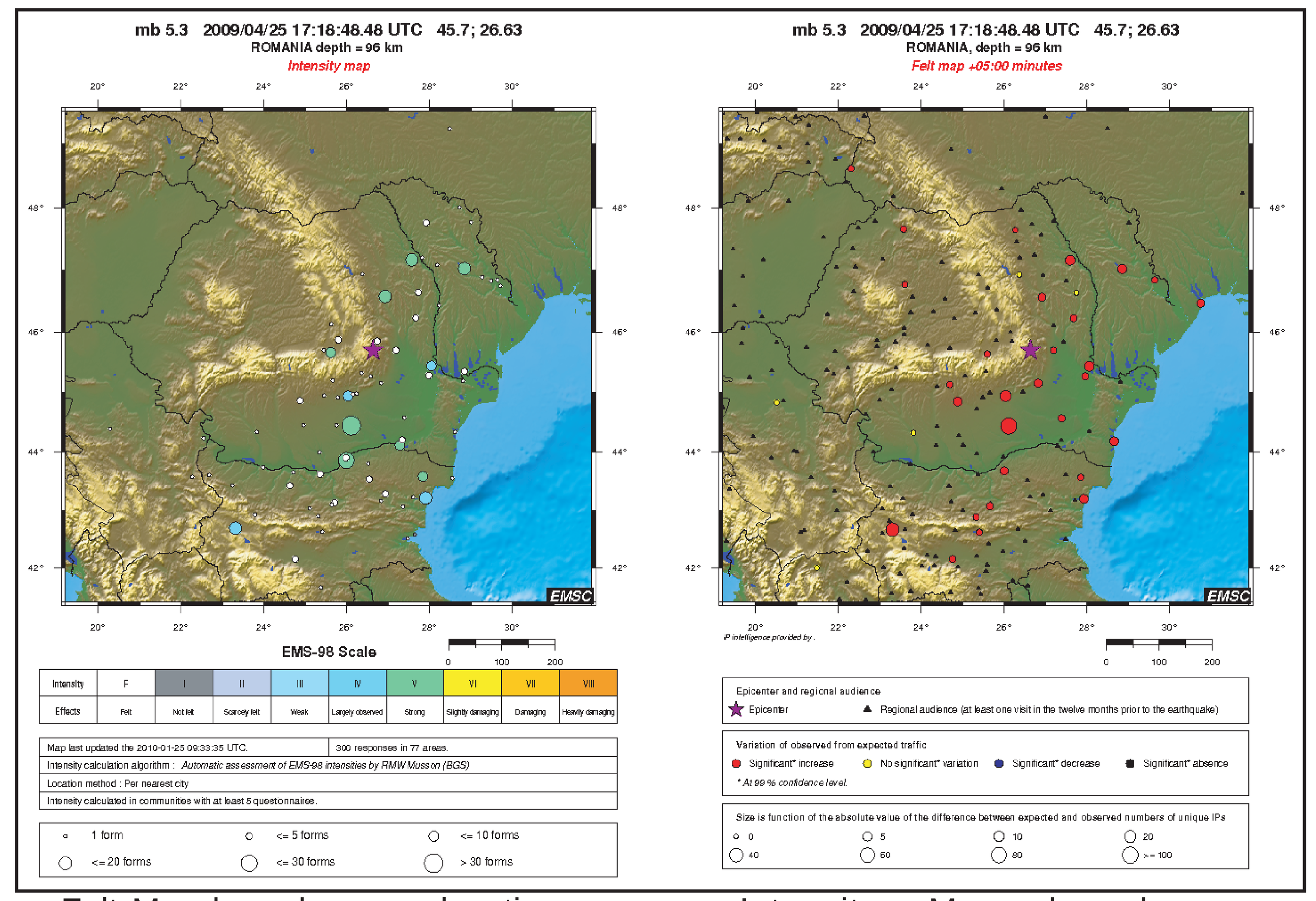
Testing - Because large-scale testing of such an application is inherently difficult, we propose to organize a broadly distributed "simulated event" test. The software will be available for download this summer, after which we plan to organize a large-scale test by the end of the summer. At a pre-determined time, participating testers will be asked to create their own strong motion to be registered and submitted by the ShakeMapple client. From these responses, an intensity map will be produced representing the broadly-felt effects of the simulated event.



SeisMac - The ShakeMapple leverages the Sudden Motion Sensor Library and sensor calibration tool provided by the author of the SeisMac application. The SeisMac application provides a continuous display of the Apple laptop embedded sensor data.

Felt Maps - The EMSC has developed a mechanism to automatically detect and map where an earthquake has been felt by monitoring web site traffic surges and plotting the visitors' locations based on IP address geo-location. The generated felt maps are well-correlated with earthquake intensity maps generated from macroseismic questionaires.

We hope to capture the measured acceleration from the network of laptop motion sensors to provide additional data points to augment the intensity maps.



Felt Map based on geo-location of web traffic surge after an earthquake.

Intensity Map based on eyewitness reports in macro-seismic questionnaires.

Citizen Participation - One of the missions of the EMSC is to engage the general population in order to promote awareness of seismic hazard. One way to involve citizens is to provide to them a way to contribute to the scientific knowledge base. The EMSC has several initiatives along these lines, including online macro-seismic questionnaires and the SHERPA eyewitness photo archive. The ShakeMapple application provides both the opportunity to fill in gaps in accelerometric data coverage, and also to engage the citizens through their participation in the network, providing an educational opportunity and the chance to increase seismic hazard awareness.

Status - The ShakeMapple client application and server systems are complete and are currently being tested. We plan a larger-scale proof-of-concept test this summer in which participants will be asked to simulate an event to be registered by the application. After successful test and demonstration, we expect to have deployed a small network in earthquake-prone regions by the fall.

We are currently collecting email addresses for individuals interested in participating in the testing and/or deployment of the application network.

If you are interested in participating, please contact the authors at:

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or visit our web site at:

http://www.emsc-csem.org/shakemapple