Kirchhoff Reconstruction for Real-Time Fault Rupture Determination

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We present a method for locating earthquake ruptures in real time using Kirchhoff reconstruction. The method determines not the hypocenter, but the actual shape and dimensions of the earthquake fault rupture. The real time capability to generate a detailed rupture map will provide emergency response teams with information about the region of damage and thereby allow them to optimize the distribution of resources and personnel. In addition, it will allow for rapid deployment of instruments focused on collecting observations of post-seismic activity. Computational time does not scale with event magnitude, so the Kirchhoff reconstruction method can accurately handle earthquakes of any magnitude.

The Kirchhoff method uses measurements of ground motion from an array of sensors. A grid is generated covering the area of interest. The ground motion at each grid coordinate is summed based on the measurements at contributing sensor locations and the wave propagation time and distance from these locations. Correlation of the measurements occurs at the grid points that correspond to the trace of the event. Our implementation handles arbitrary grid densities and configurations, allowing high resolution over areas of interest. The method is furthermore independent of any particular sensor geometry. The software is capable of integrating the most detailed rheology or wave velocity model available, in order to achieve greater accuracy.

Preliminary results are presented for tests of the method on both simulated and historic data. We demonstrate the robustness of the method with respect to signal noise, and show the level of detail and precision available for example historic events.

We intend for the software to be integrated into the TriNet earthquake information system. This will enhance the service TriNet provides to emergency response teams and scientists and researchers assessing the status of seismic activity. The Kirchhoff method can contribute to development of a computerized alert network. The continuous sequence of ground motion images generated by the method provide a rich source of data for further types of science analysis, including the application of various pattern recognition and data mining techniques.

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