iShake: Mobile Phones as Seismic Sensors

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Emergency responders must “see” the effects of an earthquake clearly and rapidly so that they can respond effectively to the damage it has produced. Great strides have been made recently in developing methodologies that deliver rapid and accurate post-earthquake information. However, shortcomings still exist. The iShake project is an innovative use of cell phones and information technology to bridge the gap between the high quality, but sparse, ground motion instrument data that are used to help develop ShakeMap and the low quality, but large quantity, human observational data collected to construct a “Did You Feel It?” (DYFI)-based map.

Rather than using people as measurement “devices” as is being done through DYFI, the iShake project is using their cell phones to measure ground motion intensity parameters and automatically deliver the data to the U.S. Geological Survey (USGS) for processing and dissemination. In this participatory sensing paradigm, quantitative shaking data from numerous cellular phones will enable the USGS to produce shaking intensity maps more accurately than presently possible.

The phone sensor, however, is an imperfect device with performance variations among phones of a given model as well as between models. The sensor is the entire phone, not just the micro-machined transducer inside. A series of 1-D and 3-D shaking table tests were performed at UC San Diego and UC Berkeley, respectively, to evaluate the performance of a class of cell phones. In these tests, seven iPhones and iPod Touch devices that were mounted at different orientations were subjected to 124 earthquake ground motions to characterize their response and reliability as seismic sensors. The testing also provided insight into the seismic response of unsecured and falling instruments.

The cell phones measured seismic parameters such as peak ground acceleration (PGA), peak ground velocity (PGV), peak ground displacement (PGD), and 5% damped spectral accelerations well. In general, iPhone and iPod Touch sensors slightly over-estimated ground motion energy (i.e., Arias Intensity, I_a). However, the mean acceleration response spectrum of the seven iPhones compared remarkably well with that of the reference high quality accelerometers. The error in the recorded intensity parameters was dependent on the characteristics of the input ground motion, particularly its PGA and I_a, and increased for stronger motions. The use of a high-friction device cover (e.g., rubber iPhone covers) on unsecured phones yielded substantially improved data by minimizing independent phone movement. Useful information on the ground motion characteristics was even extracted from unsecured phones during intense shaking events.

The insight gained from these experiments is valuable in distilling information from a large number of imperfect signals from phones that may not be rigidly connected to the ground. With these ubiquitous measurement devices, a more accurate and rapid portrayal of the damage distribution during an earthquake can be provided to emergency responders and to the public.