OBSERVING CRUSTAL DEFORMATION WITH CONTINUUM FINITE ELEMENTS AND REMOTE IMAGEODESY

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Finite element analysis has proven to be a powerful tool for precision engineering, and its use has proliferated to increasingly smaller spatial scales of design and manufacture; for example, in the mechanical design and analysis of cell phones and hard disk drive components. In these commercial settings, finite-element techniques have been shown to be robust and reliable sustaining computational technologies that enable simulation-based design within the professions of mechanical, electrical, and civil engineering. We have found that these same finite-element techniques can also be used in settings that are near-antipodes of commercial engineering practice, for example, exploratory scientific investigations into less-well-understood applied mechanics problems such as geophysics. In these venues, material properties and geometric boundaries are often *a priori* unknown, but finite-element analysis techniques can be utilized in concert with high-performance computing and scientific curiosity to explore "what if?" scenarios towards the goal of scientific discovery.

One such example is the use of finite-element models to explore the full-physics response of the earth's crust. This arena of scientific understanding has often been limited to purely kinematic response (e.g., location of faults and other contacts between large-scale geological formations), because of the difficulty of estimating and modeling constitutive properties of geological materials. The explosion of kinematic information made available by emergent remote-sensing technologies (e.g., satellite imagery) creates great opportunities for using these geometric datasets to promote full-physics scientific exploration of the mechanics of the earth's surface, because the overall conservation laws involved are reasonably well-understood, and the proliferation of finite-element technology in engineering practice has made available a wide variety of accurate inelastic material models that can be used to complete the triad of required physical laws.

This project combines satellite imagery (i.e., imageodesy) to detect ground-surface displacements over large portions of the earth's surface, which are then used to drive strain and stress calculations using an advanced finite-element framework that has been optimized to provide inelastic constitutive models appropriate for geomaterials. In addition to the image-processing and finite-element modeling tools, we utilize a visually-based web portal to provide a friendly means for scientists to develop, analyze, and interpret material and geometric scenarios towards the goal of discovering information about regional and local seismicity. The resulting "scientist in the loop" software environment has been validated using information from recent earthquakes in Tibet, and this technique shows great promise for service as a virtual geologic observatory.

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