Buidling Shaker - Earthquake Simulation in a CAVE™

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Abstract

In this research project, which is a collaboration between the NSF Engineering Research Center at Mississippi State University (MSU), the Department of Civil and Environmental Engineering at UC Berkeley (UCB), and the Department of Civil and Environmental Engineering at Carnegie Mellon University (CMU), Pittsburgh, PA, we are simulating the effects of a major earthquake on an urban region. We integrate earthquake ground motion modeling with modeling of structural and infrastructure systems using advanced computational and visualization methods. We are using immersive visualization environments to facilitate investigation of the performance of urban regions resulting from a major earthquake. The system has been successfully demonstrated on an ImmersaDesk and in a CAVE environment. The goal of this ongoing research project is to provide damage estimates based on best available information ultimately leading to earthquake risk analysis for an urban region.

The data is based on a ground motion and single-degree-of-freedom (SDOF) building simulation provided by CMU and UCB. The basic geometry consists of 11 million nodes with tetrahedral connectivity, and a velocity vector in over 100 time steps associated with each node. Building locations are associated with selected nodes on the top surface of the layered, block-shaped soil model. The total amount of data generated approximates a stack of 60 CD-ROMs.

For the simulation, we used the entire topology of the tetrahedal mesh, which represents an area of 400 km^2. The rupture is 20,000 m deep under the surface. By restricting the visualization to the surface grid, and the actual building response to a selected region of interest, we were able to create interactive visalizations of the ground motion and the structural response in the CAVE. The grid color represents the velocity of the field (Figure 1). The visualization is based on polygon rendering (OpenGL).

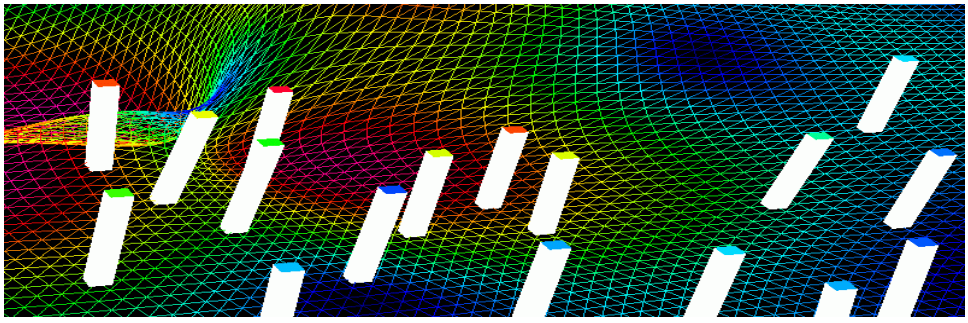

Figure 1: Ground motion and structural response (building simulation)

During the animation, the user can walk between the buildings, while the earthquake simulation is replayed repeatedly. He or she can observe the shaking buildings from different perspectives, including a bird eye's view, a 'Godzilla' view (observer has same height as buildings), or a 'drowning' view (observer is on or below ground level and sees the shockwave approaching). A wand control allows for a smooth transition between these views. The animation is enhanced by an audio track, which resembles the rumbling noise of a real earthquake.