STUDY ON INTEGRATING DISASTER SIMULATIONS IN URBAN AREAS USING A COMMON CITY MODEL AND APPLICATION TO INTEGRATED EARTHQUAKE-TSUNAMI SIMULATION IN URBAN AREAS

Kohei FUJITA, Tsuyoshi ICHIMURA, Muneo HORI, M. L. L. WIJERATHNE, Seizo TANAKA
University of Tokyo

ABSTRACT**:** We develop a method to integrate disaster simulations using a common city model to simulate the response of urban areas under a series of natural hazards. As an application of the developed method, we integrate seismic response analysis of structures and tsunami simulation; a numerical example shows that we can perform a seamless simulation of earthquake and tsunami disasters targeted on a real urban area.

KEYWORDS: integrated natural disaster simulation, common city model

1. INTRODUCTION

Evaluating urban disasters under hazard scenarios are needed for designing effective mitigation strategies. Some of the severe disasters are caused by a series of hazards; strong ground motion and tsunami hit the same area in the 2011 Tohoku Earthquake. We regard such disasters as a system of multiple inputs (configuration of structures, ground motion, etc.) and outputs (damage of structures, inundation area, etc.). Most of the current methods aim to simulate a single hazard using physics-based disaster simulations on city models made from data stored in the Geographic Information System (GIS).

In this study, we simulate a system of urban disasters by coupling urban information and disaster simulations. Urban information is stored in a Common City Model (CCM) which is accessible from each of the disaster simulations. As an application of the developed method, we integrate Seismic Response Analysis (SRA) of structures and tsunami simulation. We compare the results of tsunami simulation with/without regarding damage of structures due to strong ground motion. By such a simulation, we aim to improve the accuracy of estimation of the response of urban areas under a series of hazards, which are currently obtained using statistical methods based on data of past disasters.

2. METHODOLOGY

We integrate simulations as illustrated in Figure 1. We first convert GIS datasets to CCM. Then, each component simulation reads and modifies CCM; for example, the SRA component reads information of structures from CCM, analyzes damage of structures due to strong ground motion, and writes the changes of structural properties back to CCM. Since each of the component has different input/output interfaces (vector/raster, ASCII/binary, etc.), we develop data conversion modules for each arrow in Figure 1. By exchanging data via CCM, we can easily accommodate multiple GIS datasets and simulations. In this study, we use the one component model for non-linear seismic response analysis of structures, and tsunami simulation using three dimensional fluid analysis methods in high resolution.

3. NUMERICAL EXAMPLE

We perform an example of integrated earthquake-tsunami simulation. GIS data is converted to CCM, which consists of outer shapes of buildings and ground elevation. Structures are excited using a waveform observed in the 2011 Tohoku Earthquake (K-NET MYG013). Figure 2 is a snapshot of the results; each structure has different response according to its height and shape. We assume that a structure will collapse if the maximum drift angle is larger than 1/40, and modify its shape. Figure 3 shows the results of tsunami simulation performed on the modified and original city model; tsunami flow changes with change in city configuration, showing that a seamless simulation is performed.

4. CLOSING REMARKS

In this study, we developed a method to simulate a system of multiple disasters by coupling urban information and component simulations. We aim to use these results to obtain quantitative estimates of damage that can be readily used to design disaster mitigation strategies such as distribution of building damage or inundation area. By automating the whole simulation process, we plan to use this method to simulate multiple scenarios with/without possible countermeasures to compare its effectiveness under multiple hazard scenarios. We can easily extend this method to integrate other simulations, such as multi agent simulations for simulating evacuation of residents between earthquake and tsunami hazards.

ACKNOWLEDGMENTS

The authors thank Dr. Toshikazu Kabeyasawa of Building Research Institute for providing structural analysis code used in this study. Waveforms observed by K-NET of NIED and GIS data provided by Geospatial Information Authority of Japan and NTT Geospace Corporation are used in this study.

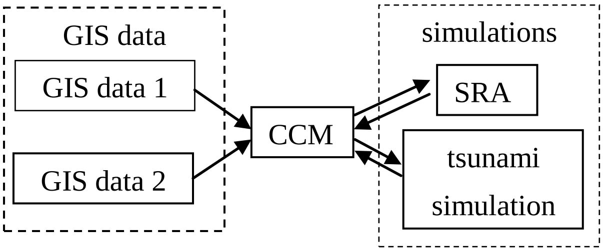

Figure 1. Integration of simulations using CCM. Urban information is stored in CCM, and coupled with simulations to analyze a system of disasters.

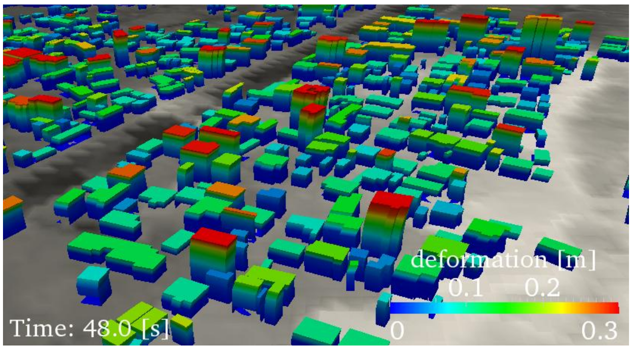

Figure 2. Results of seismic response analysis. Seismic response of each structure is analyzed. Colors indicate magnitude of deformation.

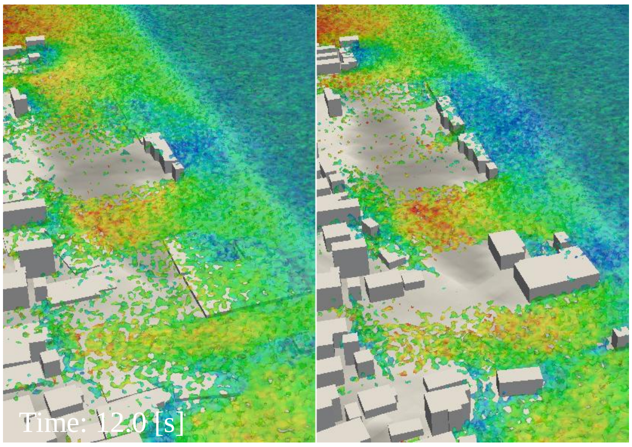

Figure 3. Results of tsunami simulation. Left: with modifications, right: without modifications to city model based on results of seismic response analysis. Damage caused by earthquakes change the flow of tsunami. Colors indicate magnitude of velocity.