

Digital-Ensemble Concept for Making Resilient Society against Natural Hazard

*Satoru Oishi¹

1. RIKEN Center for Computational Science

In order to designing resilient society including developing or renovating cities, infrastructure management like making redundant route for not only transportation but also supplying water, energy as well as waste, we need digital-twin for simulating situations under catastrophic disasters. Digital-twin is a concept meaning “a virtual model of process, product or service and the paring of virtual and physical worlds allows analysis of data and monitoring of systems to head off problems before they even occur, prevent downtime, develop new opportunities and even plan for the future by using simulations” , according to Marr (2017). Previously, digital-twin concept was used for product manufacturing through computer aided engineering (CAE) to examining the performance and duration of target manufacture like rocket engine. Now, we are using the word for designing resilient society against natural hazard because designing resilient society requires paradigm shift of disaster mitigation strategy from “government saves public and it costs” to “private invests cities through market” . Private sectors require precise statistics of impacts of natural hazard for considering investment, however, we could not expect the quantitative impact without numerical simulation of large-scale disaster.

Large-scale disaster simulations consists of solvers and urban construction objects. Integrated Engineering System (IES) has both functions (Hori et al. 2018). There are several solvers for each kind of disasters like earthquake and tsunami. However, urban construction objects have been made one by one. Therefore, it is required to develop a tool that automatically generates the detailed construction objects of urban buildings for target cities. O-tani et al. (2014) have been developing such an automation tool, named Data Processing Platform (DPP), so that it can deal with multiple numerical simulations including tsunami inundation and evacuation, and seismic response analysis of ground and buildings. We have implemented a MPI-based parallelization of DPP, then it has generated objects of urban cities in the whole Japan which includes about sixty million buildings. Now, once given a certain appropriate ground property and motion, a simulation-based assessment of disasters can be achieved for the whole Japan.

Digital-twin of urban structures gives quantitative impacts of earthquake by putting expected seismic wave which has been calculated or monitored through the seismic simulation. Simulation of the earthquake impact by using the pair of the seismic wave and its probability revealed the risk of the society numerically. It changes the concept of fragility curve coming from extrapolation of experience to physics-based numerical simulation with multi-scenario. In other word, we assume digital-ensemble concept for numerically calculated risk of natural disaster which is required for our paradigm that private invests cities through market.

Marr, B. (2017): What is Digital Twin Technology -Why is it so important?, Forbes web site
<https://www.forbes.com/sites/bernardmarr/2017/03/06/what-is-digital-twin-technology-and-why-is-it-so-important/#50400e052e2a>

Hori, M., Ichimura T., Wijerathne L., Ohtani H., Chen J., Fujita K., Motoyama H. (2018): Application of High Performance Computing to Earthquake Hazard and Disaster Estimation in Urban Area, *Frontiers in Built Environment*, DOI=10.3389/fbuil.2018.00001

O-tani, H., Chen, J. and Hori, M. (2014): AUTOMATIC COMBINATION OF THE 3D SHAPES AND THE ATTRIBUTES OF BUILDINGS IN DIFFERENT GIS DATA, JJournal of Japan Society of Civil Engineers, Ser. A2 (Applied Mechanics), Vol.70 No.2, pp. I_631-I_639, DOI=10.2208/jscejam.70.I_631

Keywords: Digital-Ensemble, Resilient Society, Quantitative Risk Assessment