Rapid Earthquake Loss Assessment through Digital Twins: A Machine Learning and Sensor-Based Approach

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ABSTRACT

This study looks at how digital twins can improve earthquake impact assessment in cities, focusing on the civil parish of Alvalade, within the district of Lisbon (Portugal). We create a detailed exposure model at the building level for Alvalade, and analyse each structure using nonlinear time history analysis to simulate their response to a specific seismic event. To capture variability in structural response, each building is assigned a unique capacity curve based on its structural class, which introduces differences in behaviour during seismic events. These results gave us a benchmark for measuring economic losses, damage, and casualties.

To test the potential benefits of a digital twin of Alvalade, we re-calculate the impact of the seismic event, considering different configurations of the digital twin, spanning from traditional approaches that employ fragility and ground motion models, to advanced settings in which sensors are combined with machine learning algorithms to capture the ground shaking and the response of buildings.

The results show that digital twins can make a significant difference in rapid earthquake loss assessment. By using detailed data for each building and real-time updates, they can provide faster and more accurate estimates of damage and risk. This work also shows how machine learning can be used to improve earthquake loss models. By analysing large amounts of simulation data, machine learning can predict building damage more accurately and efficiently.