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Development of an hybrid GMPE-less ShakeMap implementation for real-time ground shaking maps reconstruction

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Ground shaking maps are an essential tool for seismic monitoring and civil defence operations as they provide information about the area and amplitude of the ground motion relative to a seismic event.

Such maps are developed integrating spatially sparse data recorded by the stations, which also provide a constraint to the process, and theoretical values obtained from ground motion prediction equations (GMPEs), given the magnitude and location of the earthquake, also accounting for local site effects.

One of the problems arising during the development of a real-time implementation of these techniques is the lack of information in real-time needed to compute the GMPE.

One possible solution to the problem is to develop algorithms that can constrain the interpolation process using only the ground motion parameters recorded at the stations (Fornasari et al., 2022).

We propose a hybrid model combining the conditioned multivariate normal distribution (MVN; Worden et al., 2018) technique adopted by ShakeMap and a neural network replacing the GMPE.

The neural network provides a purely data-driven approximation of the GMPE results based only on the spatially sparse data from the stations, with possible correction for the site effects.

The network is trained using a supervised approach with labelled data obtained from GMPEs used for the Italian territory. Moreover, by limiting the use of a neural network to a specific task we improve its explainability with respect to end-to-end models.

This approach is easily integrable into the existing workflow, combines the well-studied interpolation techniques and neural networks in a clearly explainable structure, and provides high-resolution estimates of the ground-shaking fields in real-time with potential relevance in the context of early warning.

References:

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