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Integrating Machine Learning with Earthquake Engineering: For Innovations in Risk-Informed Performance-Based Approaches

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Abstract: Deep learning technologies have the potential to innovate the current practice within risk-informed and performance-based approaches in earthquake engineering. Earthquake engineering is an integrated discipline encompassing seismology, engineering and decision making (Itoi, 2020). In this keynote lecture, two challenges related to this aspect is discussed.

For seismic hazard assessment, a ground-motion model (GMM) that can directly model the probability distribution of ground motion acceleration time histories is presented, utilizing styleGAN2, one of generative adversarial networks (GANs) (Matsumoto et al, 2024). The proposed model can generate ground motions conditioned on moment magnitude, rupture distance, and site conditions.

Then, for performance assessment of existing building structures, a framework for Bayesian structural model updating (Lee et al., 2025; Itoi et al, 2024) is presented. This proposed method utilizes variational autoencoders (VAEs). The method facilitates an approximation of the likelihood for various dynamic analysis models. It is suitable for high-dimensional correlated simultaneous observations.

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