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AI/MACHINE-LEARNING IN EARTHQUAKE ENGINEERING: INSIGHTS FROM SEISMIC RISK TOWARDS DISASTER-RESILIENT CITIES

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ABSTRACT

The revolutionary integration of artificial intelligence (AI) and machine learning (ML) in earthquake engineering is driven by the expansion of seismic networks, resulting in a future abundant with extensive data encompassing building damage and earthquake records. This integration facilitates the acquisition of valuable insights from extensive data for seismic risk assessment, thus contributing to the development of disaster-resilient cities [1-2]. Seismic risk assessment encompasses crucial components such as seismic hazard, vulnerability, and exposure. Seismic hazard analysis, incorporating deterministic and probabilistic frameworks, plays a critical role in characterising ground motion intensities [3]. Advanced ground motion simulations offer an alternative approach to assess the response of structures to unseen seismic events [4], enhancing our understanding of structural behaviour and improving infrastructure resilience. The integration of AI and ML algorithms has significantly enhanced the accuracy and reliability of these analyses [5-8], enabling seismic risk assessment on a larger scale and with increased accuracy.

This minisymposium proposal aims to provide a comprehensive overview of recent advancements, focusing on AI and ML approaches in deterministic and probabilistic seismic hazard analysis, including seismological and ground motion simulation techniques. Aligned with the importance of seismic hazard assessment, the minisymposium aims to explore a progressive approach that encompasses dynamic analysis of structures, vulnerability assessment, the impact of earthquakes on building responses, and exposure. Through a

comprehensive exploration of these topics, we aim to encompass the latest studies utilising AI/ML techniques in the field of risk assessment, all with the ultimate goal of fostering the development of resilient cities. Participants are invited to share their research, methodologies, and case studies, fostering knowledge exchange and collaboration to advance seismic risk assessment and promote the development of resilient communities. The minisymposium will bring together experts, researchers, and practitioners, facilitating meaningful discussions and paving the way for innovative strategies to enhance the safety and resilience of cities in the face of seismic events.

The minisymposium will cover various topics related to AI and ML techniques in seismic risk assessment, including:

- Big data analysis for signal processing and microzonation studies
- Seismic hazard assessment using deterministic and probabilistic frameworks
- Ground motion simulation and modelling techniques
- Dynamic analysis of structures under seismic loading
- Seismic vulnerability assessment
- Development of exposure models
- Development of seismic risk assessment framework
- Optimisation approaches in seismic risk mitigation studies

These topics, among others, will be explored to uncover new insights and approaches for effective seismic risk assessment and resilient city planning.

REFERENCES

[1] R. Jena, B. Pradhan, G. Beydoun, A. Al-Amri, and H. Sofyan, "Seismic hazard and risk assessment: a review of state-of-the-art traditional and GIS models" *Arabian Journal of Geosciences*, Vol. **13**, pp.1-21, (2020).

[2] Y. Xie, M. Ebad Sichani, J.E. Padgett, and R. DesRoches, "The promise of implementing machine learning in earthquake engineering: A state-of-the-art review", *Earthquake Spectra*, Vol. **36**(4), pp.1769-1801, (2020).

[3] G. Candia, J. Macedo, M.A. Jaimes, and C. Magna-Verdugo, "A new state-of-the-art platform for probabilistic and deterministic seismic hazard assessment", *Seismological Research Letters*, Vol. **90**(6), pp. 2262-2275, (2019).

[4] S. Rezaeian and X. Sun, *Stochastic Ground Motion Simulation*, In Encyclopedia of Earthquake Engineering, pp. 1–15, Springer Berlin Heidelberg, 2014.

[5] A. Alimoradi and J.L. Beck, "Machine-learning methods for earthquake ground motion

analysis and simulation", *Journal of Engineering Mechanics*, Vol. **141**(4), pp. 04014147, (2015).

[6] A. Mohammadi, S. Karimzadeh, S.A. Banimahd, V. Ozsarac, and P.B. Lourenço, "The potential of region-specific machine-learning-based ground motion models: Application to Turkey", *Soil Dynamics and Earthquake Engineering*, Vol. **172**, pp. 108008, (2023).

[7] Q. Kong, D.T. Trugman, Z.E. Ross, M.J. Bianco, B.J. Meade, and P. Gerstoft, "Machine learning in seismology: Turning data into insights", *Seismological Research Letters*, Vol. **90**(1), pp. 3-14, (2019).

[8] V. Sreenath, B. Podili, and S.T.G. Raghukanth, "A hybrid non-parametric ground motion model for shallow crustal earthquakes in Europe", *Earthquake Engineering and Structural Dynamics*, (2023). doi:10.1002/eqe.3845