MERC PhD Project Proposal 2021/2022

Title of the research project:

Functional data for ground motion modelling

Keywords (up to five)

Seismic risk, mathematical engineering, earthquake engineering

Supervisors (at least two from two different areas):

Iunio Iervolino, Università degli Studi di Napoli Federico II, IUSS – Scuola Universitaria Superiore di Pavia, iunio.iervolino@unina.it, earthquake engineering, https://wpage.unina.it/iuniervo, stochastic modeling for risk analysis

Laura Maria Sangalli, Politecnico di Milano, laura.sangalli@polimi.it, https://sangalli.faculty.polimi.it/, functional data, mathematical engineering

Lucia Luzi, Istituto Nazionale di Geofisica e Vulcanologia, lucia.luzi@ingv.it, https://www.unimib.it/lucia-luzi, ground motion modelling, earthquake data.

Project description (max 5000 characters)

Earthquake engineering and seismic risk analysis require model describing the relationship between the earthquake source, the propagation of seismic waves and the ground shaking, which goes under the name of ground motion models. These are semi-empirical relationships between scalar ground motion intensity measures – obtained from the shaking waveforms – and the earthquake magnitude, source-to-site distances, and other covariates. These ground motion models are also key component of seismic hazard analysis to probabilistically predict future shaking at a site of interest.
On the other hand, structural dynamics dictates that the largest deal of information for structural and infrastructural seismic analysis is contained in the full shaking waveform, not only an intensity parameter. Nevertheless, the modelling of the entire shaking signal has not been investigated thoroughly in literature, due to its mathematical complexity.
Functional data, an advanced tool to treat functions probabilistically, seem an option to develop a ground motion model for accelerometric waveform, surpassing the concept of intensity measures. The project deals with the proof of concept of ground motion modelling via functional data, which would represent the basis for a paradigm shift is seismic hazard analysis.

Relevance to the MERC PhD Program (max 2000 characters)

The project is about a key component for seismic risk analysis of complex infrastructure systems. Thus, it fits the scope of the MERC program to the fullest extent.

Key references

Douglas, J., & Edwards, B. (2016). Recent and future developments in earthquake ground motion estimation. *Earth-Science Reviews*, *160*, 203-219.

Wang, J. L., Chiou, J. M., & Müller, H. G. (2016). Functional data analysis. *Annual Review of Statistics and its application*, *3*, 257-295.

Giovenale, P., Cornell, C. A., & Esteva, L. (2004). Comparing the adequacy of alternative ground motion intensity measures for the estimation of structural responses. *Earthquake engineering & structural dynamics*, *33*(8), 951-979.

Joint supervision arrangements

The student will be introduced steadily in the research group of professor Iervolino at the University of Naples Federico II with daily meeting with the primary supervisor. The project will include frequent periods at Politecnico di Milano and INGV Milano for meetings with the other two supervisors and to conduct research also under their advisership.

Location and length of the study period abroad (min 12 months)

The period abroad will have as primary host the Blume Earthquake Engineering Research Center at Stanford University and the ETH Zurich (arrangements yet to be made).

Any other useful information

The advisor has research partnerships with the insurance industry, which is widely interested in advanced tools for risk analysis and may be involved in the project eventually.