Seismic risk assessment on a territorial scale based on Bayesian approaches and machine learning

(Proposer: Prof. Francesca da Porto)

Background. Among the countries subject to "natural" disasters, Italy is, unfortunately, at the top of the list because of the numerous types of phenomena that affect its territory (from volcanic eruptions to earthquakes, landslides, flooding, etc.) and their frequency and intensity. This determines very high social and economic costs for the country. In particular, Italy is a country with high seismicity, with consequences of earthquakes that in terms of casualties, damage and affected population proved to be quite dramatic. In order to devise feasible and cost-effective seismic risk mitigation strategies, a better vulnerability assessment of our building stock is essential - together with the estimate of seismic hazard and exposure of a certain site - to appropriately evaluate the expected seismic losses.
The vulnerability of a building stock is generally evaluated through appropriate fragility models. Two main methodologies can be applied to evaluate seismic fragility: one is based on empirical approaches, whereas the other uses mechanical models suitable for describing structural behavior. Empirical methods are calibrated on the basis of macroseismic intensity observation of previous seismic events, whereas mechanical methods require information like building type, structural scheme, geometrical and structural parameters, and other factors (e.g., presence of structural retrofitting) that may affect the seismic vulnerability. Although mechanical methods can provide more general results, as their application is not limited to specific areas affected by the earthquakes, the reliability of the models implemented requires the knowledge of the features of building stock, the in-depth characterization of which is very time-consuming at the territorial level.

Aim. The research aim is the development of a framework for calibrating seismic vulnerability and fragility models to be used for seismic assessment at a territorial scale; in particular, this framework should be based on the mechanical approach and be addressed at reducing computational times and costs. For this purpose, Machine Learning algorithms are useful to retrieve and process large amounts of building data, derived from satellite images and aerial photographs. These algorithms can also be combined with statistical inference methods (e.g., Bayesian methods), which can be used to extrapolate further relevant structural information. The automated procedures developed in this research must therefore constitute a valid tool for the rapid, but accurate, assessment of the seismic vulnerability at a large-scale, based on the main information of the buildings.

Expected results. The PhD candidate should be able to:

- develop machine learning approaches and statistical methods to automatically collect information on buildings and extrapolate typological and structural parameters;
- define meaningful and cost-effective sets of features suitable to describe appropriately the seismic vulnerability of building stocks;
- develop sets of empirical/mechanical fragility curves for building stocks in order to assess vulnerability at a large scale;
- derive damage and seismic risk scenarios (maps), examining both the case of buildings 'as-built' and that with possible retrofitting interventions.
- perform cost-effectiveness analyses on seismic retrofitting strategies.

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