Master's thesis proposal

Technische Universität München

Ingenieursfakultät Bau Geo Umwelt
Engineering Risk Analysis Group
Prof. Dr. Daniel Straub

Performance estimation of infrastructure distribution systems based on random graphs

Background

Reliability analysis of infrastructure systems under natural hazards requires the simulation of the load distribution among the components during normal conditions (i.e. all components functioning) and contingencies (at least one component is not working). Systems like power and water networks typically have two subsystems: The transmission system, which consists of components with high capacity, and few redundancy in the topology, and the distribution system, with multiple components with small capacities and a highly redundant topology. Representing both subsystems in a single network model is not practical, since the number of components would be too large for performing any type of flow analysis.

The aim of this project is to provide a probabilistic description of the performance of distribution systems, considering a common cause dependence model, which allow to represent them in a network model of the transmission system without increasing substantially the number of components. The idea is to relate graph parameters (e.g. the pmf of node degrees and the pdf of edge lengths) with the pdf of a performance measure. For that purpose, we provide shape files with the power transmission and distribution systems of Chile and a Python code that evaluates the system performance of a network.

We expect that the student has successfully completed the course *Reliability of Engineering Systems*, and is familiar with the basics of probability theory (e.g. through completing the courses *Risk analysis,* or similar courses). Good mathematical and programming skills (particularly with Python or equivalent, and ArcGIS/QGIS) certainly prove helpful in this project. For understanding the documentation of the study case, basic knowledge in Spanish is also helpful but not compulsory.

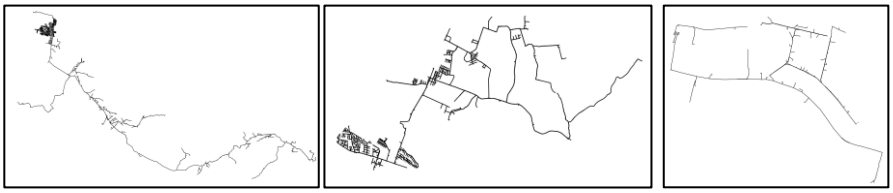

Figure 1 Different topologies of power distribution systems. Source: Superintendencia de Electricidad y Combustibles, Chile (2017)

Objectives

The student conducting the proposed MSc thesis will learn:

- The concept of fragility function.
- The structure and functioning of a power network.
- Basic concepts of graph theory and random graphs.
- How to perform a reliability analysis of a lifeline systems by using topological properties.

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Methodology

The suggested work flow is as follows:

- The student will first review in the literature about graph theory, random graphs and fragility functions for power systems.
- The student will define parameters for describing the distribution systems as random graphs.
- The student will derive a correlation (e.g. through machine learning or Bayesian analysis) between the parameters of the graphs and the performance.
- The student will test the methodology with shape files of real distribution networks.

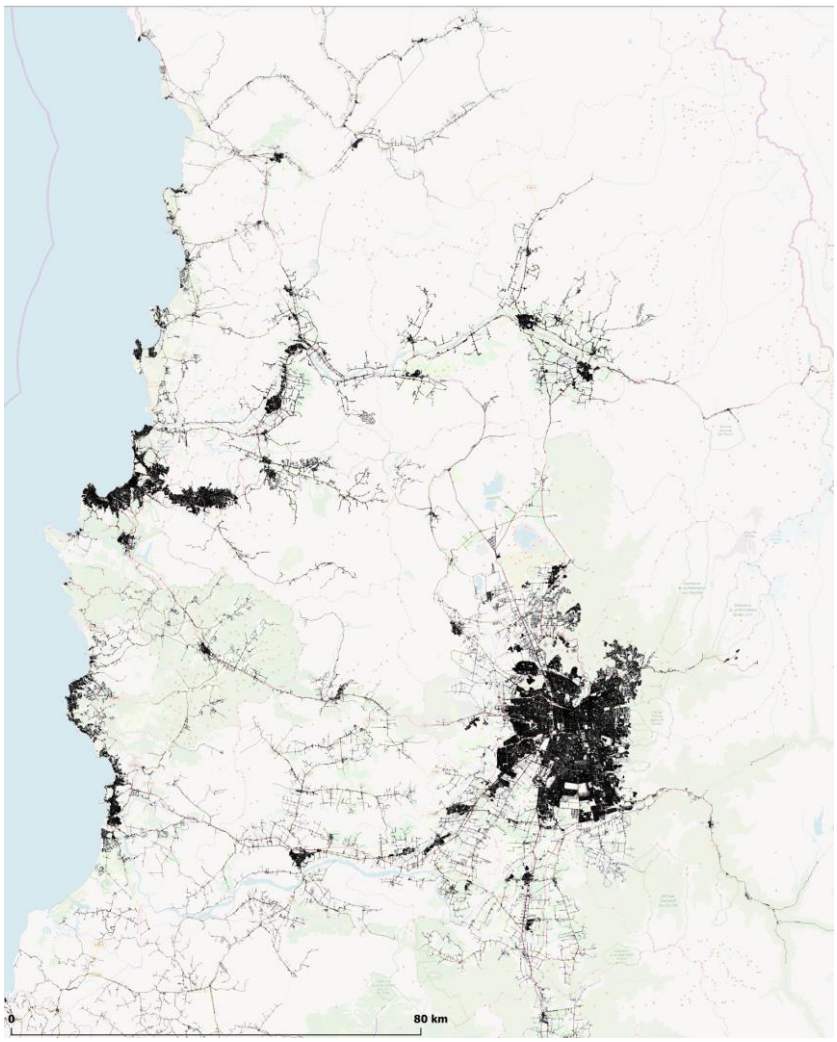

Figure 2 Power distribution network in central Chile. Source: Superintendencia de Electricidad y Combustibles (2017)

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Starting date: As soon as possible

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