A roadmap for spatial sensitivity analysis

Abstract

1 Introduction

1.1 Sensitivity analysis methods

[Lilburne and Tarantola, 2009] study how standard sensitivity analysis methods can be applied to spatial models, and show that Sobol sensitivity index is the most suited for such models. [Saint-Geours and Lilburne, 2010] benchmark three sensitivity analysis techniques and also concludes that Sobol is better in reflecting changes in model behavior.

In environmental science, multi-criteria decision analysis based on GIS has been tested for the sensitivity to weight [Chen et al., 2010].

1.2 Synthetic data

[Cottineau et al., 2017] suggest the use of synthetic data generation to test the sensitivity of simple agent-based models to their spatial initial configuration.

[Obled et al., 1994] combine observational data with a baseline model to understand to sensitivity of hydrographs to the spatial distribution of rainfall.

Link with methods in geostatistics [Gotway and Young, 2002] (extrapolation generates synthetic data ?)

1.3 Real data

[Thomas et al., 2017] show that city boundary selection can have a significant impact on model behavior for Luti models.

[Möderl and Rauch, 2011] sensitivity of infrastructure network to spatial distribution of hazards

1.4 Literature mapping

2 Roadmap

2.1 General view

Two global axis can be formulated:

1. The generation of synthetic spatial data
2. The import and manipulation of real spatial data

A longer term goal is a stronger link between these two. The different axis belong to different knowledge domains [Raimbault, 2017] and their relations foster integrative approaches.

2.2 Generation of synthetic spatial data

2.2.1 Raster data

- Single layer synthetic grids ; several methods implemented :
  - Kernel mixtures [Anas et al., 1998]
  - Reaction-diffusion model generating population distributions [Raimbault, 2018]
- Multi-layer synthetic grids
- Multi-layer with specified correlation structure

2.2.2 Vector data

- Transportation networks
- Spatialized 'classic' network generation models
- Correlated layers
- Correlated network and raster

2.3 Perturbation of real data

[Constantine et al., 2012] example of Gaussian field perturbation

3 Implementation

3.1 Architecture

- Methods available as a standalone library
- Integrated into OpenMOLE as a plugin

3.2 Example of a workflow

We illustrate spatial sensitivity analysis by coupling a spatial generator embedded into OpenMOLE as a `Sampling` with a toy Luti model, using new features of the `NetLogoTask`

- Generate realistic correlated spatial grids with an exponential mixture using a `SpatialSampling`
- Plug this into a NetLogoTask (recursive arrays inputs) for a toy Luti model
- Get successive system states (recursive array outputs)

4 Application

First application : comparison of the scala implementation and the netlogo implementation of the Luti part of the Lutecia model (only spatial setup is random).

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