An experimental study of sensitivity analysis methods

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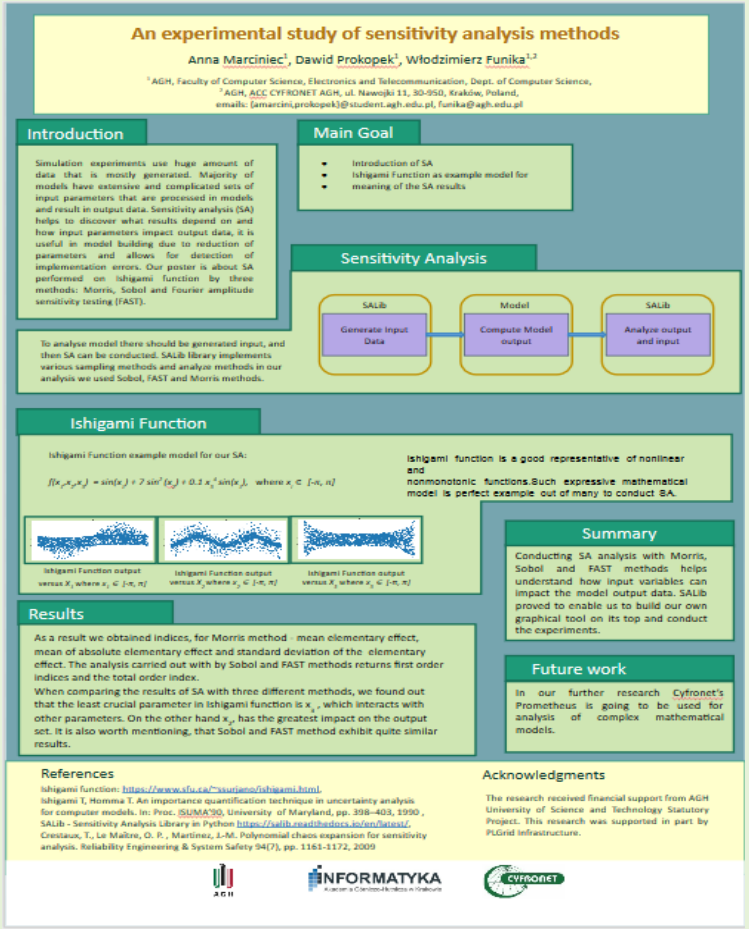
Motivation

Simulation experiments use huge amount of data that is mostly generated. Majority of models have extensive and complicated sets of input parameters that are processed in models and result in output data. Sensitivity analysis (SA) helps to discover what the *results depend* on and how input parameters *impact output data*, it is useful in model building due to the *reduction of parameters* and allows for *detection* of implementation errors.

To assess the usability of three popular SA methods, we picked a nonlinear, nonmonotonic Ishigami function. The SA methods are: Sobol, Morris, and FAST. We obtain similar analysis results by using different metrics.

Poster No 8

For more details we would like to encourage you to get acquainted with our poster which contains a more detailed information on the research and solution.



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Introduction

Simulation experiments use huge amount of data that is mostly generated. Majority of models have extensive and complicated sets of input parameters that are processed in models and result in output data. Sensitivity analysis (SA) helps to discover what results depend on and how input parameters impact output data, it is useful in model building due to reduction of parameters and allows for detection of implementation errors. Our poster is about SA performed on Ishigami function by three methods: Morris, Sobol and Fourier amplitude sensitivity testing (FAST).

Main Goal

- Introduction of SA
- Ishigami Function as example model for
- meaning of the SA results

Sensitivity Analysis

SALib: Generate Input Data → Model: Compute Model output → SALib: Analyze output and input

To analyse model there should be generated input, and then SA can be conducted. SALib library implements various sampling methods and analyse methods in our analysis we used Sobol, FAST and Morris methods.

Ishigami Function

Ishigami Function example model for our SA:

$$f(x_1,x_2,x_3) = \sin(x_1) + 7\sin^2(x_2) + 0.1\,x_3^4\sin(x_1), \quad \text{where } x_i \in [-\pi, \pi]$$

Ishigami function is a good representative of nonlinear and nonmonotonic functions.Such expressive mathematical model is perfect example out of many to conduct SA.

Ishigami Function output versus X_1 where $x_1 \in [-\pi, \pi]$ | Ishigami Function output versus X_2 where $x_2 \in [-\pi, \pi]$ | Ishigami Function output versus X_3 where $x_3 \in [-\pi, \pi]$

Summary

Conducting SA analysis with Morris, Sobol and FAST methods helps understand how input variables can impact the model output data. SALib proved to enable us to build our own graphical tool on its top and conduct the experiments.

Results

As a result we obtained indices, for Morris method - mean elementary effect, mean of absolute elementary effect and standard deviation of the elementary effect. The analysis carried out with by Sobol and FAST methods returns first order indices and the total order index.
When comparing the results of SA with three different methods, we found out that the least crucial parameter in Ishigami function is x_2, which interacts with other parameters. On the other hand x_1 has the greatest impact on the output set. It is also worth mentioning, that Sobol and FAST method exhibit quite similar results.

Future work

In our further research Cyfronet's Prometheus is going to be used for analysis of complex mathematical models.

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