P3.2

Sensitivity analysis of an one-dimensional pulse wave propagation model with correlated input

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1. Introduction

Patient-specific one-dimensional pulse wave propagation models (PWPM) are highly suited for outcome prediction of clinical interventions. Variance-based sensitivity analysis (SA) can be used for parameter-prioritization of these models based on their contribution to the total output uncertainty. Most variance-based SA approaches assume statistical input independence for the sake of computability while in many cases the inputs are correlated which may affect input importance ranking. This study aimed to compare the importance ranking of a SA with and without considering the correlation between model inputs on an one-dimensional PWPM.

2. Materials and Methods

A vectorial kernel orthogonal greedy algorithm [1] surrogate model-based approach is used to perform the SA of a PWPM. This approach allows for the creation of a kernel function based on a set of inputs and outputs generated with the PWPM. The kernel function relates input variables to an output, thereby drastically speeding up the SA. The correlated SA, based on the work of Li et al. [2], was performed on the surrogate model with and without considering correlated inputs. For validation, the uncorrelated analysis was compared to an established SA method for uncorrelated parameters based on adaptive generalized polynomial chaos expansion (agPCE) [3]. Later, the effects of statistical dependencies on the sensitivity indices (SIs) were investigated by changing the correlation coefficient ρ between the aortic length and diameter from $\rho \rightarrow -1$ to $\rho \rightarrow 1$.

3. Results

The correlated SA implementation method was benchmarked against analytical solutions of well-known functions, such as the Ishigami function. The surrogate-based approach in combination with the method of Li et al. resulted in similar SIs as found with the agPCE method. One surrogate-based model evaluation took about 0.05 milliseconds. Figure 1 shows the computed SI for a subset of input parameters.

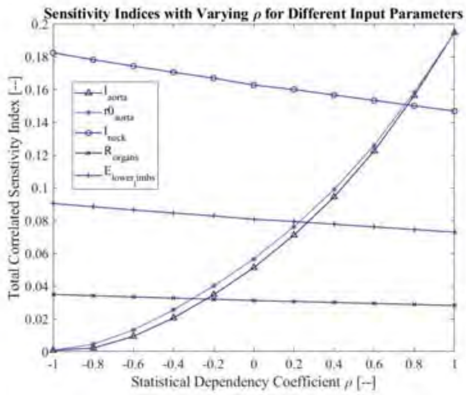

Figure 1: Computed SI for varying ρ

It was found that using a different value for the ρ considerably affects the importance ranking of the correlated input parameters. Moreover, the SIs of non-correlated input parameters were also affected, but to a smaller degree.

4. Discussion and Conclusions

The surrogate model-based approach allowed for a statistically dependent SA at a low computational cost for a relatively complex cardiovascular model. In the future, this method could be applied to more complex models. Including statistical dependency had a large impact on computed SIs. Therefore, when performing SA, it should be verified beforehand if statistical dependency should be considered.

5. References

1. *Santin G. et al., Kernel Methods for Surrogate Modeling, ArXiv preprint 1907.10556 (2019).*
2. *Li L. et al., Aerospace Science and Technology, 62; (2017).*
3. *Quicken S. et al., Journal of Biomechanical Engineering, 138; (2016).*

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