Coupling simulation and machine learning for decision aid in supply chains

Simulation and machine learning are two decision support tools commonly used independently for predictive analysis. Each of these methods has advantages and disadvantages, but they are also very complementary.

The simulation models rely on in-depth knowledge of business processes. It allows to observe and to understand causal effects between the events and offers an overview of the levers by which the system can be controlled. This provides the user with some transparency and explainability of the results obtained by these techniques. One of the advantages of simulation is that it does not require lots of input data to predict a future state of the system it models. As a consequence, it can be applied to cases where the data are missing or insufficient. However, the construction and the exploitation of the simulation models are time consuming. Even though the quantity of data is small, the models need to test lots of scenarios in order to capture as much relevant information on the system as possible. An important problem is then to be able to define the most interesting scenarios to test for the analysis. Nowadays, in most industries, these scenarios are defined using the judgement and the expertise of professionals, but they do not include all the scenarios that are potentially promising. In this context, the techniques of machine leaning can help to define the initial potentially promising scenarios to increase the efficiency [1, 2].

Contrary to the simulation, machine learning is a data centric approach. It is able to learn and to predict future data using exclusively information about what has already happened or is about to happen. The quality of data used is then critical: if the data include errors or bias, or if they are not representative of the future data or incomplete, the reliability of the predictions provided by machine learning is affected. Furthermore, machine learning can be seen as a black box. It provides a predictive analysis without explanations on how the learning algorithm determines the results. In this case, the simulation can be used, for example, to validate the recommendations provided by the learning method and to explain the results. It can also be useful to generate missing data of a data base in order to reduce the potential bias (e.g. for rare events).

In this thesis, we will explore the coupling of these two approaches to develop predictive decision support tools for industrial applications, in particular for the design and the management of supply chains.

Work environment

The thesis is funded by MIAI, the Industry 4.0 Chair "AI for data-driven and reconfigurable supply chains" (https://miai.univ-grenoble-alpes.fr/research/chairs/industry-4-0/ai-for-data-driven-and-self-configurable-supply-chains-851234.kjsp?RH=6499588038450843). The PhD student will be hosted by G-SCOP Lab. He/she will participate to the activities of MIAI and the chair.

The main tasks

- A state of the art on the simulation and machine learning algorithms is expected. This literature review should help to enumerate the complementary characteristics of these two approaches.
- Design and development of models and algorithms
- Design and application of experimental studies on academic data and real system. This latter requires the co-construction of a case study, either with industrial partners of the

chair, or by the development of a real case study using the Operations Management platform of S.Mart.
- Analysis of the performance of the coupling approaches and the limits of the proposed methods

Profile and required skills

The candidate must hold (or is about to obtain) a Master degree in Industrial Engineering or Computer Science, with knowledge on production/supply chain systems and basic skills in programming, data analysis and discrete event simulation.

The candidate may have basic knowledge in machine learning (or is open to learn about these methods).

The desired personal skills: dynamic, rigorous, autonomous and transversal, synthesis ability, fluent English

How to apply

Applicants should send us their application with:

- A full curriculum vitae, including a summary of previous research experience (master's degree project, internship, …)
- A transcript of grades (master degree and previous university studies)
- A motivation letter
- 2/3 support letters, or the contacts of at least 2 references
- A certificate mentioning the level in English is appreciated

For additional information and to apply, please send an email to:
Gülgün Alpan (gulgun.alpan@grenoble-inp.fr)
Siao Leu Phouratsamay (siao.phouratsamay@grenoble-inp.fr)

References

[1] M. S. S. R. B. C. G. J. von Rueden L., Combining Machine Learning and Simulation to a Hybrid Modelling Approach: Current and Future Directions, vol. 12080, C. Springer, Éd., Berthold M., Feelders A., Krempl G. (eds) Advances in Intelligent Data Analysis XVIII. IDA 2020. Lecture Notes in Computer Science. , 2020.

[2] D. Ivanov et A. Dolgui, A digital supply chain twin for managing the disruption risks and resilience in the era of Industry 4.0, vol. 32:9, T. &. Francis, Éd., Production Planning & Control, 2021, pp. 775-788.