Professorship of Operations and Supply Chain Management
TUM School of Management
Technical University of Munich

Prescriptive Neural Networks

The operations research (OR) literature is generally concerned with the problem of allocating resources with the goal of optimizing some objective function, subject to a set of constraints defining the problem. In practice, however, the parameters defining the problem may not be known exactly because they might be subject to stochastic phenomena which are difficult or impossible to describe. In this context, the decision-maker may use data consisting of past observations of the uncertain parameters and related contextual features to model the problem more truthfully.

Recent research has proposed to incorporate machine learning (ML) models into solving OR problems where uncertainty plays a role and data is available. In particular, Bertsimas and Kallus (2020) proposed a general framework based on (weighted) sample average approximation (SAA), in which training samples are associated to weights derived from machine learning models, such as k-nearest neighbors, local linear regression, and tree-based methods. However, their framework is currently restricted to more classical ML models.

This master thesis aims to extend current ML-based OR approaches to use neural network models, which have been successfully applied in a variety of different contexts.

Aims and scope of the thesis
It is the subject of this thesis to formulate, implement, and evaluate data-driven approaches based on neural network models for solving OR problems under uncertainty in the presence of contextual features. This comprises the following research taks:

- Literature review on OR problems under uncertainty in the presence of contextual features
- Development and implementation of a solution methodology based on neural network models
- Definition of a case study for the assessment of the methodology
- Generation of a suitable dataset for computational experiments
- Comparison of the neural network based methodology against other ML models

Requirements
This thesis targets students of Management & Technology (with a major in Supply Chain Management), Informatics, Engineering or similar study programs. Knowledge of mathematical programming, optimization, and a general-purpose programming language (e.g. C++, Java, Python) is required. Prior participation in one of the seminars offered by the chair (i.e. Modeling Future Mobility Systems, Advanced Seminar) is recommended. The thesis should be written in English.

Related Research
- Bertsimas D., Kallus N. (2020) From predictive to prescriptive analytics. *Management Science* 66(3):1025–1044.
- Bertsimas D., Dunn J., Mundru N. (2019). Optimal prescriptive trees. *INFORMS Journal on Optimization* 1(2):164–183.
- Bertsimas D., McCord C. (2019) From predictions to prescriptions in multistage optimization problems. *arXiv preprint* arXiv:1904.11637.

Begin: as soon as possible

Advisor: Breno Serrano de Araujo

Application: See `https://www.ot.mgt.tum.de/osm/education/master-thesis/`