

Project Proposal
China Scholarship Council (CSC) Research Proposal for Maastricht University
September 2022

Project title: Deep learning for improved order picking in e-commerce warehouses.

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Short Project Description: In recent years, e-commerce has gained significant importance in supply chains of today, particularly putting warehouses under high pressure. E-commerce companies typically have on offer thousands of different products and provide next day delivery. Customers tend to make rather small orders of only a single or few products. These small order sizes typically result in efficiency loss of the process of retrieving the requested products from storage. Furthermore, the short lead times require warehouses to respond to incoming customer orders within hours, while keeping low operational costs.

Warehouses are nowadays generating vast amounts of data, from tracking devices and sensors, but also from the operations occurring within the warehouse. Furthermore, e-commerce allows to gather data on shopping habits of customers. There is a large potential of using this data to provide tactical and operational decision support within warehouses. The development of high-performance data-driven optimization algorithms for warehouse operations could be a game changer.

The main goal of this research is to combine operations research and data analytics. In particular, the research will focus on the development of deep learning time series models to forecast the demand of products and to use this information to build order picking models. Warehouse operations are driven by the arrival of inbound shipments and customer orders. Currently, no research exists in which demand prediction for warehouse optimization is done at individual product level. Nor does it exist optimization algorithms for warehouse operations planning that exploit the integration of data analytics techniques.

Keywords: Deep learning, Time series models, forecasting, order picking optimization, order batching, order sequencing.

Priority areas: 信息 / Information Technology, 国际商务 / International Business, 现代交通运输 / Modern Traffic and Transportation

Main areas: 交通运输业 / Transportation Sector, 信息产业及现代服务业 / Information Industry and Modern Service Industry

Requirements for the candidate: The candidate should have a solid theoretical and practical background in machine learning, statistics and/or econometrics and solid computer programming experience in *R*, Matlab, Python or C++.

Selected Publications

Christof Defryn and Kenneth Sörensen. A fast two-level variable neighborhood search for the clustered vehicle routing problem. *Computers & Operations Research*, 83:78–94, 2017.

Christof Defryn and Kenneth Sörensen. Multi-objective optimisation models for the travelling salesman problem with horizontal cooperation. *European Journal of Operational Research*, 267(3):891–903, 2018.

Christof Defryn, Kenneth Sörensen, and Trijntje Cornelissens. The selective vehicle routing problem in a collaborative environment. *European Journal of Operational Research*, 250(2):400–411, 2016.

Rui Jorge Almeida, Nalan Basturk, Uzay Kaymak, and João M.C. Sousa. Estimation of flexible fuzzy GARCH models for conditional density estimation. *Information Sciences*, 267:252 – 266, 2014. ISSN 0020–0255. doi: <http://dx.doi.org/10.1016/j.ins.2014.01.021>.

Jan Van den Berg, Uzay Kaymak, and Rui Jorge Almeida. Conditional density estimation using probabilistic fuzzy systems. *Fuzzy Systems, IEEE Transactions on*, 21(5):869–882, Oct 2013. ISSN 1063-6706. doi: 10.1109/TFUZZ.2012.2235839.

Approved by the Head of Department

Prof. dr. Dries Vermeulen

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|  | Maastricht | 11-10-2022 |

