

Ph.D. position

Batching and picker routing problems in warehouses taking into account human factors

Supervisors: Maxime Ogier, Dominique Feillet and Frédéric Semet.

Structure: [INOCS team](#), Centrale Lille, INRIA Lille-Nord Europe, UMR 9189 CRIStAL.

Location: 40 avenue Halley, F-59650 Villeneuve d'Ascq, France (near Lille).

Duration and starting date: The position is for three years starting in 2020. The position will remain open until fulfilled.

Keywords: operations research, combinatorial optimization, warehouse management, picker routing, batching.

Context

This Ph.D. thesis is part of the project “Decision system for smart management of resources in warehouses” (AGIRE), funded by the French Research Agency (ANR). The project AGIRE aims at developing innovative and intelligent human-centered decision support tools for warehouse management. Nowadays, warehouses are under pressure due to the no inventory policy at the sale points and to the constant growth of e-commerce sales. In terms of logistics, this translates into an increasing number of parcels to prepare and to ship to satisfy an order, which is known typically a few hours in advance. A fully automated warehouse cannot be considered as a solution. Indeed, the investments required to satisfy appropriately demand peaks are too large to be considered. A more suitable approach is to combine human operators equipped with high technology devices and partially automated logistic equipment [Mar15]. However, to better manage human resources in such a dynamic environment, innovative decision support methods have to be designed to maximize the welfare of workers while guaranteeing the efficiency of the whole logistics system. This is the objective of this research project.

The AGIRE project is conducted by a consortium of three research teams: INOCS team (Centrale Lille), SFL department (CMP, Mines de Saint-Etienne), SPLOTT laboratory (UPE – IFSTTAR/AME); and a private company: HappyChic. INOCS and SFL research teams have a strong experience in developing original approaches and optimization techniques, with applications in transportation and logistics. SPLOTT is a research team in social sciences. HappyChic is a French firm specialized in men’s ready-to-wear. They have three main brands: Jules, Brice and Bizzbee, and two warehouses located near from Lille. HappyChic will provide data and their expertise in order to test and evaluate the models and algorithms developed in the project. Two Ph.D. positions, a two-year post-doctoral position, and a one-year engineer are assigned to the project.

Subject

This Ph.D. thesis deals with the modeling and solving of batching and routing problems in warehouses taking into account human factors. Usually, the objective of these problems is to minimize the total traveled distance, and the constraints consist in satisfying customer orders. However, picking activities involve repetitive tasks that may result in musculoskeletal disorders for pickers [Gro15] especially when picking in lower or higher racks. The congestion of pickers in one aisle can also be responsible

for stress or accidents [Van19a]. Only a few works integrate human factors into models and solving methods (e.g. [Glo19], [Hon12]). Integrating human factors like painful picking operations (e.g., limit consecutive picking in higher or lower racks) and congestion (avoid having too many pickers at the same time in one aisle) leads to innovative models and algorithms that take into account several criteria. Recent works have been conducted to integrate batching, routing, and scheduling for picking operations [Van19b], but without considering human-related factors.

The objectives of this thesis refer to the batching and picker routing problem:

- Propose mathematical models that describe batching and routing problems integrating human factors. It can be bi-objective models with economic and human-related criteria.
- Develop efficient solving methods for these batching and routing problems.

The scientific challenges of this thesis are the following:

- First, provide a complete state of the art on batching and picker routing problems when picking is performed by human operators. This state of the art allows us to provide a survey on problems, models, and methods developed in the literature, and to position our project with respect to existing studies. Furthermore, based on the analysis and modeling of human factors conducted by SPLOTT, we list the real constraints that should be considered.
- Second, study painful picking operations in the order batching and picker routing problems. It consists in clarifying how painful operations can be minimized by proposing a mathematical formulation for this problem. Then, it consists in developing specific solving methods, based, for example, on known heuristics (e.g. [deK07], [Bue19]) associated with specific operators considering painful operations, or on the column generation framework (e.g. [Bri20]).
- Third, study the schedule of picking tours for all the available pickers in order to minimize congestion in the aisles. It consists in modeling this problem, i.e., the assignment of picking tours to pickers, and the scheduling of the tours in order to limit congestion. Then, an iterative approach that combines the design of picking tours and the scheduling of the operations will permit to propose good solutions. Moreover, since the exact timing for the picking operations is difficult to estimate, robustness with respect to time should be taken into account by the methods proposed.

Candidate profile

Applicants must have a Master Degree (or equivalent) in Computer Sciences, Applied Mathematics, or any related discipline. Applicants should demonstrate good programming skills and a deep knowledge in combinatorial optimization and integer programming.

Location

The Ph.D. student will be located in Villeneuve d'Ascq (near Lille) in the INOCS team (<https://team.inria.fr/inocs/>). INOCS is an [INRIA](#) team, located in the research center [INRIA Lille-Nord Europe](#). The Ph.D. will be delivered by Centrale Lille.

Application procedure

Please send your application electronically (preferably as a single pdf file) including a detailed curriculum vitae and examination results, plus, if available, a list of reference letters and copies of diploma to Frederic Semet (frederic.semet@centralelille.fr) and Dominique Feillet (feillet@emse.fr). The position will remain open until fulfilled.

This offer is also available on INOCS website <https://team.inria.fr/inocs/>

For further questions regarding the position or details on the research project, please contact Dominique Feillet (feillet@emse.fr), Maxime Ogier (maxime.ogier@centraledlille.fr) or Frédéric Semet (frederic.semet@centraledlille.fr).

References

[Bri20] O. Briant, H. Cambazard, D. Cattaruzza, N. Catusse, A.-L. Ladier, M. Ogier. An efficient and general approach for the joint order batching and picker routing problem. *European Journal of Operational Research*, 285, 497-512, 2020.

[Bue19] M. Bué, D. Cattaruzza, M. Ogier, F. Semet. A Two-Phase Approach for an Integrated Order Batching and Picker Routing Problem. In: Dell'Amico M., Gaudioso M., Stecca G. (eds) *A View of Operations Research Applications in Italy 2018*. AIRO Springer Series, vol 2. Springer. 2019.

[deK07] R. de Koster, T. Le-Duc, K.J. Roodbergen. Design and control of warehouse order picking: A literature review. *European Journal of Operational Research*, 182: 481-501, 2007.

[Glo19] C.H. Glock, E.H. Grosse, H. Abedinnia, S. Emde. An integrated model to improve ergonomic and economic performance in order picking by rotating pallets. *European Journal of Operational Research*, 273(2): 516-534, 2019.

[Gro15] E.H. Grosse, C.H. Glock, M.Y. Jaber, W.P. Neumann. Incorporating human factors in order picking planning models: framework and research opportunities. *International Journal of Production Research*, 53(3): 695-717, 2015.

[Hon12] S. Hong, A.L. Johnson, B.A. Peters. Batch picking in narrow-aisle order picking systems with consideration for picker blocking. *European Journal of Operational Research*, 221(3): 557-570, 2012.

[Mar15] G. Marchet, M. Melacini, S. Perotti. Investigating order picking system adoption: a case-study-based approach. *International Journal of Logistics Research and Applications*, 18(1): 82-98, 2015.

[Van19a] T. van Gils, A. Caris, K. Ramaekers, K. Braekers, R.B. de Koster. Designing efficient order picking systems: The effect of real-life features on the relationship among planning problems. *Transportation Research Part E: Logistics and Transportation Review*, 125: 47-73, 2019.

[Van19b] T. van Gils, A. Caris, K. Ramaekers, K. Braekers. Formulating and Solving the Integrated Batching, Routing, and Picker Scheduling Problem in a Real-life Spare Parts Warehouse. *European Journal of Operational Research*, 2019.