

Thibaut Cuvelier

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Applications of mathematical optimisation to machine learning and industrial issues

Research keywords: mathematical optimisation, reinforcement learning

Education

2017 – 2020: **PhD in Information and Communication Technology**, CentraleSupélec (Paris-Saclay university¹).

2010 – 2015: **Master's degree in Computer Science and Engineering**, university of Liège, Belgium, magna cum laude (second year and master's thesis: *summa cum laude*).

Master's thesis: Implementing and comparing stochastic and robust programming.

In the optimisation literature, two paradigms are often used to model uncertainty: **stochastic and robust programming**. For the facility location and unit commitment problems, I have conducted an **in-depth comparison study** of the cost and the **robustness** of the obtained solutions.

Under the supervision of Prof. Quentin Louveaux.

Full text: <http://hdl.handle.net/2268/197090>. Related publications: [A5], [A1], [T3].

*Award: **best master's thesis in computer science and engineering, AIM, 2015.***

Topics:

- artificial intelligence (machine learning, intelligent robotics),
- applied mathematics (discrete and numerical optimisation, high-performance scientific computing),
- networks (advanced networking, information theory, telecommunications).

First-aid training (BEPS, Belgian Red Cross), 2015.

2004 – 2010: secondary education at Saint-Barthélemy, Liège, Belgium, magna cum laude.

Electives: mathematics, Latin, ancient Greek.

Finalist for the Belgian round of the **Olympics of Informatics** (2010).

Top-5 contestant for the ancient Greek translation competition of the Rencontres Grecques, Institut du Sacré-Cœur de Mons, Belgium (2010).

Student mentor in 2008-2009 and 2009-2010.

Online courses

- [Deep learning specialisation, Andrew Ng, Coursera, March 2018 \(overall score: 100%\)](#).
- Reinforcement Learning Explained, Microsoft DAT257x, edX.
- [Artificial Intelligence A-Z™: Learn How To Build An AI, SuperDataScience, Udemy, April 2020](#).
- [Advanced AI: Deep Reinforcement Learning in Python, Lazy Programmer, Udemy, August 2020](#).

¹ Ranked 1st in mathematics in the world in 2020 [by Shanghai Ranking Consultancy](#).

Research experience

Since October 2017: **doctoral researcher** at Orange Labs and CentraleSupélec (université Paris-Saclay).

Keywords: mathematical optimisation, reinforcement learning, bandit algorithms, network routing.

Machine-learning algorithms are often based on optimisation techniques, but do not always take the most of them. For example, combinatorial bandit algorithms tend to have exponential complexity, even when the deterministic combinatorial problem has a known polynomial-time algorithm (matching, shortest path, etc.): using more advanced tools from mathematical optimisation, **I reduce the bandit-problem complexity to polynomial** in many useful cases, for two state-of-the-art algorithms (ESCB, based on the optimism principle; OSSB, based on an information-theoretic bound on the regret). The result of this work is available as open-source software: <https://github.com/dourouc05/CombinatorialBandits.jl>

The second aspect of my thesis revolves around network routing problems, more specifically the relationships between routing under uncertainty (more specifically, oblivious routing) and fair routing. The result of this work is available as open-source software: <https://github.com/dourouc05/Seleroute.jl/>

PhD schools:

- 2018 school on column generation (Prof. Guy Desaulniers, Prof. Jacques Desrosiers, Prof. Marco Lübbecke, Prof. Roberto Wolfler-Calvo).
- TMA 2018 PhD school (Franck Brockners, Joseph Allemandou, Prof. Idilio Drago).
- TMA 2019 PhD school (Dr. Sara Dickinson, Prof. Narseo Vallina-Rodriguez, Dr. Mirja Kühlewind, Tim Bruijnzeels, Martin Hoffmann).
- ECML PKDD 2019 Summer School, quality-of-experience track (Prof. Frank Hutter, Dr. Grégoire Montavon, Dr. Florian Lemmerich, Dr. Nico Piatkowski, Dr. Vlad Hosu, Dr. Raimund Schatz, Matti Strese, Prof. Lea Skorin-Kapov).
- Combinatorial Optimization at Work (CO@W) 2020 (Dr. Timo Berthold, Prof. Thorsten Koch, Prof. Sebastian Pokutta, Prof. Michael Joswig, Dr. Pietro Belotti, Dr. Bob Bixby, Dr. Julian Hall, Leon Eifler, Prof. Marc Pfetsch, Ksenia Bestuzheva, Prof. Marco Lübbecke, Prof. Andrea Lodi).
- 1st International Summer School on Artificial Intelligence and Games (Prof. Georgios Yannakakis, Prof. Julian Togelius, Matteo Hessel, Dr. África Perriáñez, Dr. Alessandro Canossa, Dr. Emily Short, Arthur Juliani, Olivier Delalleau, Christoffer Holmgård, Antonios Liapis).

IEEE compliance trainings: anti-bribery and corruption, antitrust and fair competition, conflicts of interest, GDPR, discrimination and harassment prevention.

Other trainings:

- Law and intellectual property (Karim Tadrict).
- European projects Horizon 2020 (Magali Mares).
- Ethics and technology (Dr. Thomas Baudel, Prof. Christine Froidevaux).
- Workplace first aider (UNASS, December 2018 and February 2020).

Under the supervision of Dr. Zwi Altman, Dr. Éric Gourdin (Orange Labs), and Prof. Richard Combes (CentraleSupélec).

January 2016-September 2017: **research engineer** at the university of Liège, Belgium, working on the InduStore project.

Keywords: mathematical optimisation, data analytics.

Industry may take advantage of the **increasing electricity price volatility**, by organising its production around price forecasts, and provide flexibility services to the grid. Moreover, respecting the well-being of the workforce is a requirement in this context, albeit often disregarded. My responsibilities were to develop, apply, and evaluate mathematical **optimisation models** of plant operations, including HR concerns.

The result of this work is available as open-source software: <https://github.com/dourouc05/IndustrialProcessFlexibilisation.jl>.

Related publications: [A2], [A3], [P1], [J3].

Trainings:

- IPCO 2016 Summer School (Prof. Michel Goemans, Dr. Nicolas Stier, Prof. Juan Pablo Vielma).
- Algorithmic Convex Optimisation, organised by the SOCN Graduate School (Prof. François Glineur and Prof. Yurii Nesterov).

Project in partnership with N-SIDE (project coordinator), UCL (ICTEAM and CRECIS), and ICEDD.

July-August 2014: **intern** at N-SIDE (Louvain-la-Neuve, Belgium), working on the ENERTOP project.

Keywords: mathematical optimisation.

The context is the **optimisation of electricity production** in a complex plant to minimise the total energy costs, mostly using cogeneration, using a mathematical optimisation model. My **responsibilities** were to investigate specific issues to make the solutions more **robust to uncertain events**, such as failures, and to analyse different ways of handling the electricity price uncertainty inside the model. Most of my source code has been deployed in production at the end of my internship within the ENERTOP platform.

Under the supervision of Prof. Bertrand Cornélusse (N-SIDE, now ULg).

Communication experience

Journal articles

- [J3] *Embedding Reservoirs in Industrial Models to Exploit their Flexibility.*
Thibaut Cuvelier.
SN Applied Sciences, accepted in November 2020. In press.
- [J2] *Adaptive and Reinforcement Learning Approaches for Online Network Monitoring and Analysis.*
Sarah Wassermann, Thibaut Cuvelier, Pavol Mulinka, Pedro Casas.
IEEE Transactions on Network and Service Management, November 2020.
<https://ieeexplore.ieee.org/document/9256319>
- [J1] *Comparison Between Robust and Stochastic Optimisation for Long-term Reservoir Operations Under Uncertainty.*
Thibaut Cuvelier, Pierre Archambeau, Benjamin Dewals, Quentin Louveaux.
Water Resources Management, vol. 32, no. 5, pp. 1599–1614, March 2018.
<http://hdl.handle.net/2268/219394>

Conference articles

- [C1] *ADAM & RAL: Adaptive Memory Learning and Reinforcement Active Learning for Network Monitoring.*
Sarah Wassermann, Thibaut Cuvelier, Pedro Casas, Pavol Mulinka.
15th International Conference on Network and Service Management (CNSM) 2019, Halifax (Canada), October 2019.
<https://hal.archives-ouvertes.fr/hal-02301393>

Workshop articles

- [W2] *RAL: Improving Stream-Based Active Learning by Reinforcement Learning.*
Sarah Wassermann, Thibaut Cuvelier, Pedro Casas.
European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases (ECML-PKDD) Workshop on Interactive Adaptive Learning (IAL), Würzburg (Germany), September 2019.
<https://hal.archives-ouvertes.fr/hal-02265426/>
- [W1] *NETPerfTrace — Predicting Internet Path Dynamics and Performance with Machine Learning.*
Sarah Wassermann, Pedro Casas, Thibaut Cuvelier, Benoît Donnet.
ACM SIGCOMM Workshop on Big Data Analytics and Machine Learning for Data Communication (Big-DAMA), Los Angeles (USA), August 2017.
<http://hdl.handle.net/2268/211667>

Abstracts

- [A7] *Improving Stream-Based Active Learning with Reinforcement Learning.*
Sarah Wassermann, Thibaut Cuvelier, Pedro Casas.
Workshop for Women in Machine Learning (WiML) 2019.
<https://hal.archives-ouvertes.fr/hal-02375296>
- [A6] *Operation rules of the Vesdre reservoir revisited.*
Benjamin Dewals, Thibaut Cuvelier, Pierre Archambeau, Sébastien Epicum, Michel Piroton, Quentin Louveaux.
6th International Symposium on Hydrological Modelling of the Meuse basin, September 2019.
<http://hdl.handle.net/2268/239415>
- [A5] *Comparing Oblivious and Robust Routing Approaches.*
Thibaut Cuvelier and Éric Gourdin.
Programme Gaspard Monge pour l'optimisation, la recherche opérationnelle et leurs interactions avec les sciences des données (PGMO Days) 2018, November 2018.
<http://hdl.handle.net/2268/229784>
- [A4] *Retour d'expérience sur Julia pour la recherche et l'enseignement en recherche opérationnelle.*
Thibaut Cuvelier.
Congrès de la Société française de recherche opérationnelle et d'aide à la décision (ROADEF) 2018, February 2018.
<http://hdl.handle.net/2268/220267>
- [A3] *Optimising workforce and energy costs by exploiting production flexibility.*
Thibaut Cuvelier and Quentin Louveaux.
21st Conference of the International Federation of Operational Research Societies (IFORS), Québec (Canada), July 2017.
<http://hdl.handle.net/2268/207330>
- [A2] *Modelling the industrial flexibility from the electricity consumption and HR points of view.*
Thibaut Cuvelier and Quentin Louveaux.
22nd Belgian Mathematical Optimization Workshop, COMEX (combinatorial optimisation: metaheuristics and exact methods), La Roche-en-Ardenne (Belgium), April 2017.
<http://hdl.handle.net/2268/209469>

- [A1] *Optimisation and uncertainty: comparing stochastic and robust programming.*
Thibaut Cuvelier.
30th Annual Conference of the Belgian Operational Research Society (ORBEL), Louvain-la-Neuve (Belgium), January 2016.
<http://hdl.handle.net/2268/197081>

Posters

- [P4] *RAL — Reinforcement Active Learning for Network Traffic Monitoring and Analysis.*
Sarah Wassermann, Thibaut Cuvelier, Pedro Casas.
Proceedings of the ACM SIGCOMM Conference Posters and Demos, online, August 2020.
<https://hal.archives-ouvertes.fr/hal-02932839>
- [P3] *Oblivious Routing: Static Routing Prepared Against Network Traffic and Link Failures.*
Thibaut Cuvelier and Éric Gourdin.
Network Traffic Measurement and Analysis (TMA) PhD School 2019, Paris (France), June 2019.
<https://hal.archives-ouvertes.fr/hal-02161708/>
- [P2] *Oblivious Routing: Worst-Case Routing is not Breaking the Internet's Legs.*
Thibaut Cuvelier.
Network Traffic Measurement and Analysis (TMA) PhD School 2018, Vienna (Austria), June 2018.
<http://hdl.handle.net/2268/227128>
- [P1] *Characterising Industrial Sites' Flexibility with Reservoir Models.*
Thibaut Cuvelier.
DS3 Data Science Summer School (École Polytechnique), Paris (France), August 2017.
<http://hdl.handle.net/2268/212703>

Books

- [B3] *Créer des applications graphiques en Python avec PyQt5*, published by D-Booker, March 2017.
Thibaut Cuvelier, Pierre Denis.
ISBN-13: 978-2-8227-0518-9.
- [B2] *Créer des applications avec Qt 5 – les essentiels*, published by D-Booker, November 2013.
Guillaume Belz, Thibaut Cuvelier, Ilya Diallo, Louis du Verdier, Vincent Meyer, Florent Renault.
ISBN-13: 978-2-8227-0108-2.
- [B1] *Web sémantique : méthodes et outils pour le Web de données*, published by Pearson, May 2012.
Translated by Thibaut Cuvelier, Julien Plu, Antoine Seilles.
Original title: *Linked Data: Evolving the Web into a Global Data Space.*
Tom Heath and Christian Bizier.
ISBN-13: 978-2-7440-2519-8.

Talks

- [T3] *Voyage incertain : découvrir l'optimisation stochastique et robuste*, February 2018, Orange Labs (internal), Châtillon (France).
<http://hdl.handle.net/2268/219824>
- [T2] *A Journey through Julia*, May 2017, IEEE Student Branch Liège (Belgium).
<http://hdl.handle.net/2268/210211>
- [T1] *A Journey through Julia*, November 2016, Geeks anonymes, Liège (Belgium).
<http://hdl.handle.net/2268/203491>

Open-source contributions

Research codes:

- Main developer of [CombinatorialBandits.jl](#) (combinatorial bandits, 2020), 7,000 lines of Julia.
- Main developer of [Seleroute.jl](#) (computer-network routing, 2020), 6,000 lines of Julia.
- Main developer of [IndustrialProcessFlexibilisation.jl](#) (flexible industrial-plant operations, 2017-2018), 5,000 lines of Julia.
- Main developer of [ReservoirManagement.jl](#) (for water-reservoir operations, 2016-2018), 10,000 lines of Julia.
- Co-developer of [RAL](#) (for stream-based active learning, 2019-2020), 200 lines of Python.

Libraries used for research:

- Main developer of [NonsmoothOptim.jl](#), a nonsmooth-optimisation Julia package (2020).
- Main developer of [Kombinator.jl](#), a combinatorial-optimisation Julia package (2020).
- Main developer of constraint-programming prototypes for Julia: [ConstraintProgrammingExtensions.jl](#) (2020), [JuCP.jl](#) (2020), [CPLEXCP.jl](#) (2020).
- Regular contributor to several optimisation-oriented Julia packages: [JuMP.jl](#) (2019-2020), [MathOptInterface.jl](#) (2019-2020), [MathOptFormat.jl](#) (2019, since then merged with the latter).
- Regular contributor to several optimisation-solver wrappers: [CPLEX.jl](#) (2019-2020), [Gurobi.jl](#) (2019-2020), [SCS.jl](#) (2019), [Xpress.jl](#) (2019).
- Occasional contributor to several Julia packages: [TimeSeries.jl](#) (2015-2016), [Distributions.jl](#) (2016), [Nemo.jl](#) (2017), [Hungarian.jl](#) (2018), [LightGraphsMatching.jl](#) (2018), [SimpleWeightedGraphs.jl](#) (2018), [JavaCall.jl](#) (2020).

Documentation tools:

- Main developer of [QtDocTools](#) (management of the translation of Qt's documentation, including tooling to work with DocBook documents, 2014-2020).
- Developer of [LyX](#) (C++/Python, since 2018).
- Occasional contributor to [Apache POI](#) (Java, 2019-2020), to [Qt](#) (C++, 2019-2020).
- Occasional external contributor to the [DocBook](#) OASIS standard (2016-2020).

Miscellaneous (related to my other activities on Developpez.com):

- Contribution to the translation into French of [Qt Creator](#) (2012-2013)
- Occasional contributor to PHP libraries: [GeSHi](#) (2014), [Silex](#) (2012)

Service to the community

Session co-chair at IFORS 2017.

Reviewer for the WiOpt 2018 and JuliaCon 2019 conferences.

Reviewer for the Journal of Hydrology in 2019 and 2020 and for the Journal of Water Resources Management in 2019.

Work experience

2019–now: book-reviews manager for **Developpez.com**. Partnership management and development (5 new publishers).

August 2015: development of a real-time car-sharing prototype application for the **ULg**. This prototype evolved into the UGo platform (<https://ugo.be/>).

Technologies: Python, Django.

Under the supervision of Prof. Bertrand Cornélusse (ULg).

- July 2015: translation into English of a 100-page numerical-analysis textbook (2nd year students) for the **ULg**.
Under the supervision of Prof. Quentin Louveaux (ULg).
- 2011–2017: officer for the ULg **IEEE Student Branch**. Event organisation, website and server maintenance, poster design.
- 2009–now: section manager for **Developpez.com** (Qt since 2009, project hosting in 2010 and 2011, semantic Web between 2011 and 2013, HPC since its creation in 2018, algorithms and mathematics since 2018). Team management, website maintenance, application development.
- 2008–now: author (30+ articles), translator (100+ articles), proofreader, columnist (750+ news articles), and technical book critic (70+ books) for **Developpez.com**.
<http://tcuvelier.developpez.com/> and <https://tcuvelier.wordpress.com/>

Pedagogical experience

- Spring 2019: exercise sessions for the **combinatorial optimisation** course (master's students), in French, with a 20-student class. University of Paris-Sud (Paris-Saclay university).
Lecturer: Prof. Abdel Lisser.
- Winter 2018: instructor for the introduction to **object-oriented programming and Java** (bachelor's students), in French, with a 20-student class. University of Paris-Sud (Paris-Saclay university).
Lecturer: Prof. Guillaume Wisniewski.
- exercise sessions for the introduction to **probabilities** course (bachelor's students), in French, with a 30-student class. University of Paris-Sud (Paris-Saclay university).
Lecturer: Prof. Abdel Lisser.
- Spring 2017: project supervision for the **intelligent robotics** course (master's students), in English, with a 50-student class. Includes contributions to an open syllabus (TRS: <https://github.com/ULgRobotics/trs>). University of Liège.
Lecturers: Prof. Bernard Boigelot, Philippe Latour, Antoine Lejeune, Dr. Raphaël Marée, Prof. Marc Van Droogenbroeck, Prof. Louis Wehenkel.
- Winter 2016: exercise sessions and project supervision for the **discrete optimisation** course (master's students), in English, with a 50-student class. Includes the design of a complete exercise book. University of Liège.
Lecturer: Prof. Quentin Louveaux.
- Spring 2016: project supervision for the **intelligent robotics** course (master's students), in English, with a 50-student class. University of Liège.
Lecturer: Dr. Renaud Detry.
- Winter 2016: exercise sessions and project supervision for the **discrete optimisation** course (master's students), in English, with a 50-student class. University of Liège.
Lecturer: Prof. Quentin Louveaux.
- Spring 2015: student instructor for the **numerical analysis project** (1st year students), in French, with a 20-student class. University of Liège.
Lecturer: Prof. Quentin Louveaux.

Open course material

Discrete optimisation: development of an exercise book with solutions and Julia source-code examples, available at <https://github.com/dourouc05/OptimisationTeachingKit>.

Intelligent robotics: contributions to the TRS project (*teaching robotics with a simulator*), including updates of the webpages and video making. Official website: <https://github.com/ULgRobotics/trs>

Formal training

Several courses at the *Institut de Formation et de Recherche en Enseignement Supérieur* (IFRES, ULg):

- Design multimedia material for face-to-face teaching
- Competency-based approach
- Motivate my students
- Introduction to evaluation: principles and quality criteria
- Customising teaching by considering students' characteristics
- Triple concordance between objectives, methods, and evaluation
- Organising practical lessons in science and applied science courses
- Introduction to the Blackboard Learn platform
- Using Blackboard Learn to create tests
- Evaluate and regulate one's teaching activities

Language skills

French	Mother tongue
English	Cambridge FCE (B2 level) in 2010, English-taught Master (2013-2015), British Council EnglishScore (C1) in 2020
German	B1-level training from 2014 to 2017

IT skills

Programming

Programming languages	Julia, Python, C++, Scala, Java, PHP, C
Data analytics	scikit-learn
Mathematical modelling	JuMP (Julia), AMPL
Optimisation solvers	Gurobi, CPLEX
Query languages	SQL, SPARQL
XML technologies	XSLT, XPath, RELAX NG
Development environments	Visual Studio Code (Julia), PyCharm (Python), Mathematica, MATLAB, IntelliJ IDEA (Java), CLion (C++)
Graphical user interfaces	Qt 5 (especially Qt Quick), PyQt

Office software

Office	LyX (LaTeX), Microsoft Word, Microsoft Excel
Technical documentation	Oxygen XML Author, XMLmind, DocBook
Drawing	Microsoft Visio, Adobe Photoshop

Personality

Detail-minded, results-driven, autonomous, energised by challenges.

Sports: climbing (since 2002, both indoor and outdoor, including competitions), walking.

Hobbies: reading novels (thrillers); listening to music (progressive rock, electronica); active contribution to the *Revue des Ingénieurs* at the ULg (satiric play; 2013, 2016).