PhD Position in model predictive control for compressor room control

at Atlas Copco Airpower, Belgium

The PhD position is part of the European Training Network "ELO-X – Embedded Learning and Optimization for the neXt generation of smart industrial control systems". ELO-X will recruit altogether 15 PhD fellows at 6 research universities and 5 international companies from 5 European countries, who will meet regularly during exchange visits, training events, workshops, and summer schools organized by the network. The position at Atlas Copco is focused on developing performant optimal control problems for compressor room control. The position is based on Atlas Copco premises near Antwerp in Belgium. The aim is the design and development of tailored model predictive algorithms for compressor room control executable on constraint CPUs. There will be a close cooperation with the other ELO-X PhD fellows, in particular with those partners that will host mutual exchange visits of several months durations: At Albert-Ludwigs-Universität Freiburg, K.U.Leuven (MECO research team) and Politecnico di Milano, the connection with generic methodological advances in the field of computational control and mathematical optimization will be strengthened.

COMPANY DESCRIPTION

Atlas Copco provides industrial compressors, gas and process compressors and expanders, air and gas treatment equipment and air management systems. The business area has a global service network and innovates for sustainable productivity in the manufacturing, oil and gas, and process industries. Principal product development and manufacturing units are located in Belgium, the United States, China, Germany and Italy. Compressors are used in a wide range of applications. In industrial processes, clean, dry and oil-free air is needed in food, pharmaceutical, electronics, and textiles. Compressed air is also used for power tools in assembly operations and in applications as diverse as snow-making, fish farming, on high-speed trains, and in hospitals.

BACKGROUND

Thanks to the increasing capabilities of digital technologies, the next generation of industrial control systems are expected to learn from streams of data and to take optimal decisions in real-time, leading to increased performance, safety, energy efficiency, and ultimately value creation. Numerical optimization is at the very core of both learning and decision-making, and machine learning algorithms and artificial intelligence raise huge worldwide research interest, often using cloud computing and large data centers for their optimization computations. However, in order to bring learning- and optimization-based automated decision-making into smart industrial control systems (SICS), two important bottlenecks have to be overcome: (1) computational resources on industrial control systems are locally embedded and limited, and (2) industrial control applications require reliable algorithms, with interpretable and verifiable behavior. Both requirements partially stem from safety aspects, which are crucial in applications where a single computation error can cause high economic and environmental cost or even damage to people. Pushing the performance boundary of SICS to leverage advanced digital technologies will therefore involve both fundamental new research questions and technological solutions, calling for a new set of advanced methods for embedded learning- and optimization-based control algorithms.

The applicant will be embedded in the compressor room control research team of Atlas Copco Airpower (headquarter of the compressed air business area) The team focusses on the identification, analysis and control of air treatment devices such as compressors, dryers and air separation installations. The theoretical research is in close collaboration with the MECO team at the K.U.Leuven and therefore you will join the PhD program at the MECO group in Leuven under the supervision of Prof. Jan Swevers. The MECO team focusses on the identification, analysis and control of mechatronic systems such as autonomous guided vehicles, robots, and machine tools. It combines theoretical innovations with experimental validations.

The applicant will further be embedded in the ELO-X ecosystem which encompasses leading experts in mathematical modelling and optimization-based control and estimation and shall prepare the fellows for a high-level career in advanced control engineering in industry or in academia.

PHD PROJECT DESCRIPTION

PhD Project: Embedded optimized regulation of the compressor room.
A compressor room ecosystem consists of compressors, auxiliary devices, buffer vessels and complex networks of pipes. Every compressor and the auxiliary device (dryers and air separators) that leave the production area are steered via a so-called local controller which adjusts the required pressure, sets alarms, monitors sensors and controls the different actuators. In many cases, however, customers require air demand that cannot be provided by a single compressor, while air demand can vary throughout time. In both cases multiple compressors are typically used in parallel. A group of compressors is termed a compressor room and is typically regulated by a central controller whose main purpose is to regulate the compressors in such a way so that they provide pressurized air in the most energy efficient way and/or ensure an equal number of running hours for all involved compressors. Lately, new applications are emerging with a strong focus on high quality pressurized air flows (marginal oil and particle contamination, extreme low humidity, etc.). However, current control algorithms do not have the flexibility to support these new applications. Providing control algorithms that have the flexibility to deal with a wide range of requirements (e.g., flow, pressure, air quality) puts serious constraints on the type of control technologies requires new control algorithms and control concepts. A significantly improved control algorithm will open new opportunities and is also expected to provide solutions with a further reduction of the energy consumption in the compressor room. MPC is believed to offer a good answer to the latter challenges.

Timeline and renumeration: The ideal start time is early summer 2021. The PhD project lasts for the duration of four years, and is mainly carried out at Atlas Copco Airpower, Antwerp. The PhD years include international seasonal schools and three longer visits – so called ”secondments” – of two months at other groups in the ELO-X network, depending on the project needs and the scientific interests of the PhD fellows. Three years are funded by the ELO-X project, with a fourth year funded by Atlas Copco. The remuneration is generous and will be in line with the EC rules for Marie Curie grant holders. It consists of a salary augmented by a mobility allowance, resulting in a net monthly income of about 1900-2300 Euro depending on family status.

SUPERVISORS AND MAIN CONTACTS

Supervising team at Atlas Copco: dr. Kasper Masschaele (engineering manager), Wim Van Roy (PhD student at Atlas Copco)

Main Contacts at the ELO-X Partner Institutes which could host secondments: *École Polytechnique Fédéral de Lausanne:* Prof. Colin Jones ; *Albert-Ludwigs-Universität Freiburg:* Prof. Moritz Diehl, *Katholieke Universiteit Leuven*: Prof. Jan Swevers; *Politecnico di Milano*: Prof. Lorenzo Fagiano.

CANDIDATE PROFILES

Ideal candidates hold a Master's degree in engineering, computer science, or applied mathematics. Successful candidates are typically ranked at or near the top of their classes (obtained at least a distinction), have a solid background in systems and control, robotics, optimization, relevant computer programming skills (Python or Matlab, C++), and enthusiasm for scientific research, including real-hardware implementations and experiments. Team player mentality, independence, and problem solving attitude are expected, and proficiency in English is a requirement.
Applicants whose mother tongue is not English must present an official language test report. The acceptable tests are TOEFL, IELTS, and Cambridge Certificate in Advanced English (CAE) or Cambridge Certificate of Proficiency in English (CPE). Required minimum scores are:

- TOEFL: 600 (paper-based test), 100 (internet-based test);
- IELTS: 7 (only Academic IELTS test accepted);

To apply, send an email to elo-x@imtek.uni-freiburg.de in form of **one single PDF attachment containing all contents or links** (any other information within the email will not be processed). Subject of your email should be: "ELO-X PhD Application - ESR 13".
Please include, in your single PDF document, the following items in this order:
1. A cover letter incl. statement of research interests and career goals (max. 2 pages);
2. An academic CV;
3. Contact details of at least two referees incl. phone numbers and emails;
4. Your diplomas and transcript of course work and grades;
5. Sample of technical writing (publication or thesis);
6. Proof of English language proficiency test results.

Please send your application before August 31, 2021.

Note that your PDF will be forwarded to several people in the ELO-X institutions and that in particular all Supervisory Board members of ELO-X will have access to your application material. If you want to apply to more than one ELO-X position, please create and send separate PDFs.

MARIE CURIE ELIGIBILITY CRITERIA IN SHORT

To be eligible, you need to be an "early stage researcher" i.e. simultaneously fulfill the following criteria **at the time of recruitment**:
a) Nationality: you may be of any nationality.
b) Mobility: you must not have resided or carried out your main activity (work, studies, etc...) in Belgium for more than 12 months in the 3 years immediately prior to your recruitment under the ELO-X project.
c) Qualifications and research experience: you must be in the first 4 years of your research career after the master degree was awarded.

For more information, please visit the following webpages:

https://www.atlascopco.com and http://www.elo-x.eu