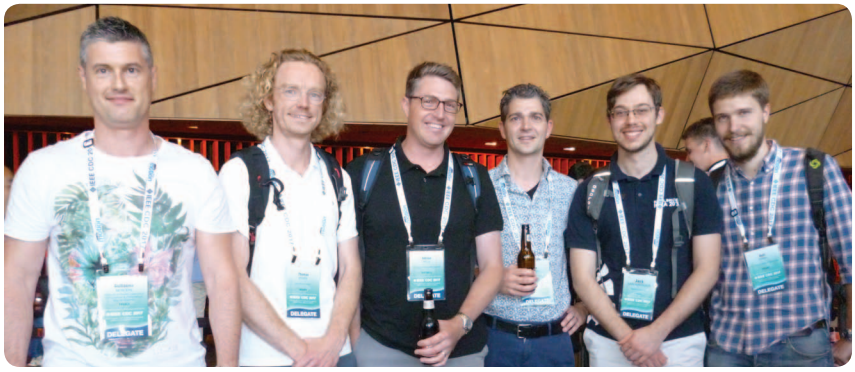
GUILLAUME MERCÈRE

Q. How did your education and early career lead to your initial and continuing interest in the control field?

Guillaume: Roughly speaking, by chance. I don't know if you are familiar with the French system of education. As usual, it is a bit complicated (typically French, isn't it?). If you want to become an engineer in France, the best way is to do the first two or three years of higher school preparatory classes (you mainly learn mathematics, physics, and the basics of engineering during these years) and then take national competitive exams to be allowed to enroll in one of the Grandes Écoles (highly selective and prestigious institutions for engineering). That is exactly what I did in 1998 after high school. In 2001, after three years of prep school, my goal was to be enrolled in a Grande École dedicated mainly to fluid dynamics, a topic I learned to appreciate during my final-year studies of physics.

To be highly enough ranked in these national competitive exams to be admitted into such a school, I somewhat neglected my initial selection of Grandes Écoles. In the end, instead of being enrolled in a school teaching fluid dynamics, I was selected to register in a Grande École (the École Nationale Supérieure d'Ingénieurs de Caen) dedicated to electrical engineering and automatic control (that is, topics where skills in fluid dynamics are far from essential). Fortunately, thanks to the interesting lectures delivered by Prof. Mohamed M'Saad and Prof. Gérard Scorletti, I rapidly learned that, once you get informative data sets on the system you want to play with, you can estimate a reliable model of the system and then design an efficient controller to do exactly what you want with the process in a robust way. It was also a very good way to see that my studies of linear algebra, numerical optimization, and mathematical analysis during my prep school years were very useful for understanding and controlling the behavior of plants.

Digital Object Identifier 10.1109/MCS.2018.2810488
Date of publication: 18 May 2018



(From left) Guillaume Mercère at the 2017 IEEE Conference on Decision and Control farewell reception with Thomas Schön (Uppsala University), Adrian Wills (University of Newcastle), Tom Oomen (Eindhoven University of Technology), Jack Umenberger (Uppsala University), and Axel Ringh (KTH Royal Institute of Technology).

During the last six months of my engineering degree, I had the great opportunity to complete an internship at the French Institute of Petroleum. The main goal of this project was to compare different system identification solutions for the determination of reliable black-box models of specific gasoline engines. During this training, in addition to beginning the study of subspace-based identification techniques, I mainly learned that, when you do research, the solution is not available directly at the end of a book or from a supervisor. You must spend time reading books and articles to select possible solutions and then test them to ascertain the best combination of mathematical tools available in the literature to determine the least complex model satisfying the list of specifications in an optimal way.

I must confess that this research experience was a bit scary for me in the first three months. You must find a solution to a specific problem that you are probably the first to tackle. This first unpleasant feeling was fortunately balanced by the opportunity to have time to develop an optimal solution. Indeed, in many cases in industry, you have a maximum of one or two weeks to determine something that works. When you do research, most of time, you can devote time to finding the best solution. That is probably the main reason why, after my engineering degree, I looked for a Ph.D. grant instead of going directly into industry.

Interested in experimental teaching as well, in September 2001, I found a position at a private engineering school to fund my Ph.D. research project. More specifically, the idea was to give 200 hours of lectures per year at this engineering school and then spend the rest of my time working at the University of Lille on my research project. This project was quite simple on paper. My supervisors wanted to develop a recursive data-driven modeling algorithm for multiple-input, multiple-output black-box model identification involving mainly least-squares techniques to reduce its numerical complexity. Thanks to my studies of subspace-based techniques during my internship, I directly focused on this model identification method class. In 2005, just after obtaining my Ph.D. degree, I began an assistant professor position at the University of Poitiers. This is the place where I learned from the beginning that playing with black-box models is not always the best solution. That is probably the main reason why I now mainly deal with gray-box models.

Q. What are some of your research interests?

Guillaume: The keyword of my last 15 years of research is data-driven modeling. Although I am the chair of the IEEE Technical Committee on System Identification and Adaptive Control, I am not fond of the term "system identification." When you talk with people not familiar with

Guillaume Mercère and his wife Céline on the Great Ocean Road, Victoria, Australia, in front of one of the 12 Apostles.

automatic control, it is very complicated for them to determine what system identification means. For instance, some of my relatives still think that I spent my research time labeling processes. Anyway, as I said before, my main research interest is determining a good model of a plant from available data sets and prior knowledge. I love this research topic because 1) it can be used in many practical fields, and 2) it is the first step of most of the automatic control solutions. Without a good model, designing a reliable controller is far from being easy, isn't it?

As far as data-driven modeling theory is concerned, thanks mainly to a fertile and friendly collaboration with Prof. Marco Lovera from Politecnico di Milano in the early 2000s, then with Mihaly Petreczky (who works now at the École Centrale Lille) in the last three years, I have worked a lot on LPV model identification with a specific attention to what we call the local approach. Such a class of methods is very interesting from a practical viewpoint because it can be viewed as one of the missing bridges between linear time-invariant representations and nonlinear and/or time-varying models.

My second theoretical point of interest is the link between black-box and gray-box data-driven modeling. It is clear that many algorithms and toolboxes are now available to obtain reliable black-box models of complex dynamical systems under different experimental conditions. Getting gray-box models of such systems can be a bit more complicated because of the use nonlinear optimization algorithms subject to local minima issues. Again, thanks to a collaboration with Olivier Prot, associate professor at Limoges University and specialist of nonsmooth optimization, I try to find new paths to transform accurate black-box models into gray-box linear fractional representations thanks to a smart combination of convex optimization and computer algebra.

My last research interest focuses on multidimensional systems. First, I work with Prof. José Ramos from Nova Southeastern University on nD Roesser model identification for image processing. I also work with colleagues from my university on models for dynamical systems, the behavior of which is governed by partial differential equations. All these models are very interesting from a practical viewpoint because of their wide application fields like aeronautics, robotics, heat transfer, or image processing. They allow me to work more specifically on very challenging projects like fluttering detection on Airbus planes, fouling detection in heat exchangers for General Electric, or data-driven modeling of flexible robot arms for remote surgery.

Working on all these interesting projects would not have been possible without amazing meetings and scientific collaborations with many researchers like Olivier, José, or Marco. Meeting and working with researchers from all over the world is probably the best part of this job, isn't it? You know what? All this really makes me realize that my projects are not only guided by theory or science but mainly by human beings. Indeed, my research generally starts with a friendly encounter with researchers before leading to a fruitful collaboration. I think that human relationships are what gives sense to my job. I also use the opportunity of this interview to thank all my former Ph.D. students who worked hard to help me find very interesting solutions to challenging data-driven modeling problems.

Q. What courses do you teach relating to control? Do you have a favorite course? How would you describe your teaching style?

Guillaume: At the bachelor's level, twice a year, I teach the basics of signal processing and then an introduction to classical control theory. I then have three main lectures at the master's level. The first is dedicated to the principles of modern control theory, that is, the classical time-domain, state-space, representation-based control techniques. The second one focuses on the fundamentals of unconstrained and constrained numerical optimization. I also have a lecture addressing the problem of linear-quadratic regulator/linear-quadratic Guassian control of continuous-time linear systems. Finally, I have a short lecture dealing with least-squares, curve fitting, and the basic ideas of machine learning and then a nice project on system identification and control with Matlab involving students from my university and the University of Iceland.

Thanks to two main research projects addressing the problem of fouling

detection in heat exchangers, I have had the opportunity to visit Iceland several times over the last ten years. It is an amazing country inhabited by fantastic people. That is one of the reasons why I promptly took the opportunity to work with Prof. Anna-Soffia Hauksdottir from the University of Iceland on the idea of asking Icelandic and French students to work together (in groups of two or three Icelandic and French students) on an automatic control project involving data-driven modeling and controller design.

Next March will be the second edition of this project. Until now, everything is done remotely with Matlab-Simulink and Skype. Our goal now is to apply for dedicated international master's-level education grants to buy real systems we could share between our two universities. We also aim to travel a bit by obtaining funding to pay for students' traveling and accommodation expenses when Icelandic students visit my university and vice versa. As far as my teaching style is concerned, I would say that I am a bit stringent with the students. I continuously try to push them beyond their limits, but I still believe that it is a good way for them to be trained for their future professional lives.

Profile of Guillaume Mercère

- *Current position:* associate professor, University of Poitiers.
- *Visiting positions:* University of Iceland.
- *Contact information:* Laboratoire d'Informatique et d'Automatique pour les Systèmes, Bâtiment B25, 2 rue Pierre Brousse, TSA 41105, 86073 Poitiers cedex 9, France, guillaume.mercere@univ-poitiers.fr, https://www.lias-lab.fr/members/guillaumemercere?lang=en.
- *IEEE Control Systems Society experience highlights:* chair, Technical Committee on System Identification and Adaptive Control, 2016–present; associate editor, IEEE CSS Conference Editorial Board, 2015–present.

Guillaume Mercère doing overhead squats during one of his CrossFit workouts.

Q. What are some of the most promising opportunities you see in the control field?

Guillaume: As highlighted recently in the review article "Systems & Control for the Future of Humanity, Research Agenda: Current and Future Roles, Impact, and Grand Challenges" and published in *Annual Review in Control* last April, it is crystal clear for the automatic control community that systems and control should play a crucial role in a mid-term and long-term period in a tremendous number of applications. The main issue is probably the fact that, contrary to our community members, decision makers are not conscious that systems and control are essential to yield reliable solutions to critical issues like global warming, thanks to their rigorous mathematical roots as well as paramount notions like feedback you find everywhere in nature.

We thus have a promising opportunity to be among the decision makers or, at a minimum level, convince the decision makers that, in addition to a compulsory behavior change of the world population, our data-based and system theory solutions must be taken into account the paradigm shift required, for instance, by global warming. For that, we must take inspiration from our colleagues working on machine learning and artificial intelligence, who are currently able to impose their data-based techniques and solutions everywhere technology plays an essential role. To think that, in a way, my research field could help change the world is very exciting and a source of constant renewable of my interest for it.

Q. What are some of your interests and activities outside of your professional career?

Guillaume: CrossFit for sure. I came across some YouTube videos five or six years ago showing athletes like Anníe Mist Þórisdóttir working out and doing impressive movements combining gymnastics, weightlifting, and track and field. I immediately told myself that it was exactly what I needed and wanted to do after work. After learning the basics and some of the main movements involved in CrossFit, I now train eight times per week, each weekday at lunch time for a maximum of one hour to improve my weightlifting and gymnastic skills, then three "workouts of the day" (WODs) per week in the evenings. I love this sport because you stop thinking during the 20–30 min. It involves all of your body skills, it is not repetitive at all, and each WOD is a new experience. On each training day, you learn a new way to use your core as well as the elasticity of your body to improve a movement you have already repeated many times before. On top of that, I share this passion with my wife. It is always very exciting to push ourselves beyond the limits several times per week by challenging and teasing each other. She is a fantastic athlete because she never gives up. When you find time, try CrossFit. You won't regret it.

Q. Thank you for your comments.

Guillaume: You are most welcome. It was a real pleasure.