In this issue of *IEEE Control Systems*, we speak to Raphaël Jungers, chair of the Applied Mathematics Department at UCLouvain, Belgium; Ufuk Topcu, an associate professor at the University of Texas at Austin and the 2020 recipient of the IEEE Control Systems Society (CSS) Antonio Ruberti Prize; and Malcolm Smith, head of the Control group in the Department of Engineering at the University of Cambridge, England.

Raphaël Jungers is chair of the Applied Mathematics Department at UCLouvain, Belgium. He received the Ph.D. degree in mathematical engineering from UCLouvain (2008) and the M.Sc. degree in applied mathematics, from both the Ecole Centrale Paris (2004) and UCLouvain (2005). He has held various invited positions at the Université Libre de Bruxelles (2008–2009), Laboratory for Information and Decision Systems of Massachusetts Institute of Technology (2009–2010), University of L´Aquila (2011, 2013, 2016), and University of California, Los Angeles (2016–2017). He is a FNRS, BAEF, and Fulbright fellow. He has been an editor-at-large for the IEEE Conference on Decision and Control, associate editor for the IEEE CSS Conference Editorial Board, NAHS (2015–2016), *Systems and Control Letters* (2016–2017), *IEEE Transactions on Automatic Control* (2015–2020), and *Automatica* (2020–present). He was the recipient of the IBM Belgium 2009 Award and a finalist for the ERCIM Cor Baayen Award 2011. He was the corecipient of the SICON Best Paper Award 2015 and the HSCC2020 Best Paper Award. He is also an ERC 2019 laureate.

Ufuk Topcu is an associate professor at the University of Texas at Austin. He holds the W.A. "Tex" Moncrief, Jr. Professorship in Computational Engineering and Sciences I. He received the B.S. degree from Bogazici University in 2003, the M.S. degree from the University of California, Irvine, in 2005, and the Ph.D. degree from the University of California, Berkeley, in 2008. He held a postdoctoral research position at the California Institute of Technology until 2012 and was a research assistant professor at the University of Pennsylvania until 2015. He is an associate editor for *IEEE Transactions on Automatic Control*. His honors include being the recipient of the Antonio Ruberti Young Researcher Prize, the NSF CAREER Award, and the Air Force Young Investigator Award. His research focuses on the theoretical, algorithmic, and computational aspects of the design and verification of autonomous systems through novel connections between formal methods, learning theory, and controls.

Malcolm Smith is the head of the Control group in the Department of Engineering at the University of Cambridge, England. He received the B.A. and M.A. degrees in mathematics, the M.Phil. degree in control engineering and operational research, and the Ph.D. degree in control engineering from the University of Cambridge in 1978, 1979, and 1982, respectively. He was subsequently a research fellow at the German Aerospace Center, Oberpfaffenhofen, Germany, a visiting assistant professor and research fellow with the Department of Electrical Engineering at McGill University, Montreal, Canada, and an assistant professor with the Department of Electrical Engineering, Ohio State University, Columbus. In 1990, he joined the Engineering Department, University of Cambridge, where he is currently a professor and a fellow of Gonville and Caius College. His current research includes passivity based control, circuit synthesis, mechanical networks, mathematical systems theory, control design, estimation, and automotive applications. He is well known for his invention of the inerter mechanical device currently used in Formula One motor racing and elsewhere. He is a Fellow of IEEE and the Royal Academy of Engineering. He received the 1992 and 1999 George Axelby Best Paper Awards in *IEEE Transactions on Automatic Control*, both times for joint work with Tryphon Georgiou. He is the winner of the Sir Harold Hartley Medal 2009 of the Institute of Measurement and Control for "outstanding contribution to the technology of measurement and control" and the winner (together with Will Hoult and Panos Brezas) of the 2020 IEEE Control Systems Technology Award "for the development of the McLaren 720S semi-active suspension control system."

Rodolphe Sepulchre

RAPHAËL M. JUNGERS

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

Raphaël: I think that, at first, I was attracted by the personality of some of my professors in the applied math courses: Georges Bastin, Michel Gevers, and especially Vincent Blondel, who agreed to accept me as an M.S. and then Ph.D. student. However, I quickly realized that the field was concentrating all the challenges that I was looking for: deep mathematical questions that

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are crucial for the development of modern and exciting technologies.

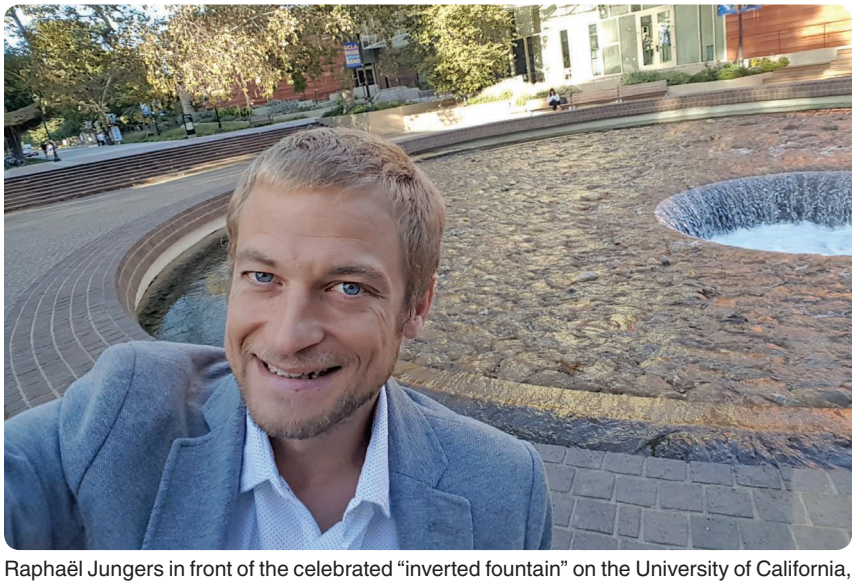
Q. What are some of your research interests?

Raphaël: I like it when our intuition is violated. That is, when the basic principles that (rightfully) guide any engineer turn out to be misleading. Most often, this intuition comes from the beautiful theory of linear systems. Think of the superposition principle. Because linear operators satisfy it, we can decouple the construction of an observer and a controller. This is magic! However, real life is often not that simple. It can be nonlinear, combinatorial, quantized, or adversary, for example. These "nonidealities" force us to question our intuition, rework the math from first principles, and design more complicated solutions.

Switching systems and, more generally, hybrid systems are a good example of this. Here, combining two stable systems may lead to an unstable one. This is shocking to an engineer's intuition but very simple when you look at the equations. In such situations, the goal of the game is to "leverage as much as you can" from the classical theories—and be inventive for the rest!

I also think the formal methods are fascinating. In this subfield of control, we put ourselves in the shoes of a computer, which does not understand all the complicated theorems that we know and does not have intuition at all. We then look at control systems in an abstract way and study control problems on an avatar of the real system (its abstraction). Thus, the goal there, in my view, is to transform complicated theorems into something actionable by an entity that cannot think.

Raphaël Jungers (at left) with colleagues, celebrating the 2018 IFAC Conference on Analysis and Design of Hybrid Systems (during a memorable World Cup semifinal game).



Raphaël Jungers in front of the celebrated "inverted fountain" on the University of California, Los Angeles, campus.

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

Raphaël: I was lucky enough to be appointed as a professor when the class of Paul Van Dooren titled Matrix Theory became vacant, and I was selected to teach it. I believe that one cannot properly do nonlinear control if he/she does not understand in depth concepts from linear algebra. The class starts at the bottom of it with a mathematical/formal point of view. I cannot resist going through the history of linear algebra, which is fascinating. I always stun the students when we see that determinants were invented way before matrices.

When I teach, I try to look relaxed and enjoyable but be rigorous. I alternate formal theoretical developments with anecdotes and informal discussions. I believe that to realize the context in which a theory was developed (or is used) helps to understand the most technical reasonings.

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

Raphaël: Data. They have pervaded many scientific fields but arguably not entirely ours yet. Of course, system identification is definitely a crucial technology, which I see as a core subfield of data science (and, in this aspect, our field has been leveraging data for decades). However, today, data are more "qualitative," badly noisy, or with nonstandard structure. This opens an avenue for beautiful research questions, where notions like information, privacy, dynamics, and feedback interplay.

Raphaël Jungers (fifth from left) and his team visiting the beautiful Ardennes region in Belgium.

Profile of Raphaël M. Jungers

- *Current position:* professor of applied mathematics, UCLouvain.
- *Visiting and research positions*: University of l'Aquila; Massachusetts Institute of Technology; University of California, Los Angeles; University of Newcastle, Australia.
- *Contact information:* UCL/ICTEAM Avenue Georges Lemaître, 4-6 (office A.102) 1348 Louvain-la-Neuve, Belgium, raphael.jungers@uclouvain.be, http://perso.uclouvain.be/raphael.jungers/.
- *Notable awards:* SICON Best Paper Award (2015); Fulbright Fellow (2016); ERC Award (2019); HSCC Best Paper Award (2020).

Q. You recently obtained an European Research Council grant. What is the project about?

Raphaël: The goal of the project is to bridge the world of formal methods with more classical optimization-based control techniques. In my previous research (mainly on switched systems or "simple" hybrid systems), I realized that one can reinterpret many optimization techniques (sum-of-squares, linear matrix inequalities, set-theoretic techniques) in a formal way, as computing some kind of abstraction for the dynamical systems. My goal is to massively generalize these techniques to arbitrarily complex systems to build "smart" abstractions that can beat the curse of dimensionality. Our techniques will come with "data-driven" or model-free versions. By the way, I'm constantly looking for bright students or postdocs interested in joining the team!

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

Raphaël: As an impressive majority of the people that are interviewed in these columns do, I love hiking. We should organize a nice hike together at some conference one day! I also like to take on personal challenges, just to see how far I can go. Recently, with the COVID crisis, I've launched with my wife, who is a school teacher, an educational website for helping kids at school. Our end goal is to develop machine learning techniques for personalized teaching. We have more than 1000 kids training regularly on our platform after only a few months of development!

Q. Thank you for your comments.

Raphaël: Thank you!

UFUK TOPCU

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

Ufuk: I was attracted initially because I just liked the material in the undergraduate controls courses more than that in the other courses. I later realized that rigor and abstract thinking, which we value in control theory, are critical for adapting to ever-changing technical and societal challenges in which our field can make an impact.

Q. What are some of your research interests?

Ufuk: I enjoy thinking about problems in which we need to go across disciplinary boundaries to make progress. My group's research often falls on the intersection of control theory, formal methods, and reinforcement learning. We typically tackle relatively abstract problems that are motivated by the challenges and opportunities in and due to autonomous

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