Control for Learning: Adaptive Control and Real-time Machine Learning

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The fields of adaptive control and machine learning have evolved in parallel over the past few decades, with a significant overlap in goals, problem statements, and tools. Machine learning as a field has focused on computer based systems that improve through experience. Often times the process of learning is encapsulated in the form of a parameterized model, whose parameters are learned in order to approximate a function. The field of adaptive control, on the other hand, has focused on the process of controlling engineering systems in order to accomplish regulation and tracking of critical variables of interest. The approach used for accomplishing such regulation and tracking in adaptive control is the learning of underlying parameters through an online estimation algorithm. Learning parameters of a model in both machine learning and adaptive control occurs through the use of input-output data. In both cases, the main algorithm used for updating the parameters is based on a gradient descent-like algorithm. Related tools of analysis, convergence, and robustness in both fields have a tremendous amount of similarity. As the scope of problems in both fields increases, the associated complexity and challenges increase as well. In order to address learning and decision-making in real time, it becomes more and more necessary to understand these similarities and connections so as to develop new methods, tools, and algorithms for addressing the emerging challenges.

This talk will examine the similarities and interconnections between adaptive control and optimization methods commonly employed in machine learning. Concepts in stability, performance, and learning, common to both fields are then discussed. Building on the similarities in update laws and common concepts, new intersections and opportunities for improved algorithm analysis will be explored. In particular, specific problems related to higher order learning and exponentially fast learning is solved through insights obtained from these intersections. We will explore how higher order learning and exponentially fast learning can be carried out and lead to provably correct methods for adaptation, learning, and estimation.

Biography of Anuradha Annaswamy

Dr. Anuradha Annaswamy is Founder and Director of the Active-Adaptive Control Laboratory in the Department of Mechanical Engineering, Massachusetts Institute of Technology, USA, where she has been a faculty since 1991. Her research interests span adaptive control theory and its applications to aerospace, automotive, and propulsion systems as well as cyber physical systems such as Smart Grids, Smart Cities, and Smart Infrastructures. Dr. Annaswamy is an author of over 100 journal publications and 250 conference publications, co-author of a graduate textbook on adaptive control, and co-editor of several cutting edge science and technology reports including *Systems & Control for the future of humanity, research agenda: Current and future roles, impact and grand challenges* (Annual Reviews in Control, 2016), *Smart Grid Control: Overview and Research Opportunities* (Springer, 2018), and *Impact of Control Technology* (IoCT-report 2011 and 2013). She is a member of the National Academy of Sciences Committee Study on modernizing the US Electric System. Her current research is supported by the US Air-Force Research Laboratory, US Department of Energy, Boeing, Ford-MIT Alliance, and NSF, at an annual amount of about $1.3M (USD).

Dr. Annaswamy has received several awards including the George Axelby (1986) and Control Systems Magazine (2010) best paper awards from the IEEE Control Systems Society (CSS), the Presidential Young Investigator award from NSF (1992), the Hans Fisher Senior Fellowship from the Institute for Advanced Study at the Technische Universität München (2008), the Donald Groen Julius Prize from the Institute of Mechanical Engineers (2008). Dr. Annaswamy has been elected to be a Fellow of the IEEE (2002) and IFAC (2017). She received a Distinguished Member Award and a Distinguished Lecturer Award from IEEE CSS in 2017.

Dr. Annaswamy is actively involved in IEEE, IEEE CSS, and IFAC. She has served as General Chair of the American Control Conference (2008) as well as the 2nd IFAC Conference on Cyber-Physical & Human Systems (2018). She is Deputy Editor of the Elsevier publication Annual Reviews in Control (2016-present). She has been a member of the IEEE Fellows Committee and the IEEE CSS Outreach Committee, and is the Chair of IEEE Smart Grid Meetings and Conferences. In IEEE CSS, she served as Vice President of Conference Activities (2015-16) and Technical Activities (2017-18), and is currently the President.