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KEYNOTE TALK TITLE:

On the Relationship between Machine Learning and System Identification: what can the two communities learn from each other?

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On the surface, the disciplines of system identification and machine learning appear to be very similar. Both are data-driven methodologies that construct mathematical models using numerical optimizations to minimize a loss function derived from the errors in predicting the desired signals. That said, the two fields evolved separately within separate communities.

Machine Learning (ML) evolved within the broader computer science community. In ML, the emphasis has been on finding static nonlinear mappings using nonparametric methods: artificial neural networks, support vector machines, Gaussian process models, to name a few. These can be viewed as "black box" models, they transform their inputs into outputs, but their internal workings are not relevant to the problem at hand.

System identification embodies the construction of mathematical models of dynamic systems based on measurements of their inputs and outputs (Ljung, 1987). It evolved within the broader discipline of control systems engineering, where it was initially used in the controller design. The application domains have expanded to include financial and economic systems, medical and biological systems, and many more (Billings, 2013). Depending on the application, the identified model can now be a "white-box" model, where there is a direct correspondence between the elements of the model and system, or a black box model not unlike those generated by ML methods, or somewhere in between. Indeed, Ljung (2017) has described this variety as a "palette of grey shades".

The two communities have started from very different assumptions and requirements, and as a result have developed very different approaches.However, with the explosion in the availability of both data and computational power, the reasons for those differences are becoming less and less relevant. Indeed, many of the methods pioneered in the ML community have been incorporated in the models and methods used in nonlinear system identification.

References

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David T. Westwick the B.A.Sc. degree in engineering physics from The University of British Columbia (1986), and the M.Sc.E. and PhD. degrees in electrical engineering from The University of New Brunswick (1988) and McGill University (1995), respectively. His doctorate was followed by postdoctoral fellowships in the Department of Biomedical Engineering at Boston University, and the Systems and Control Engineering Group at Delft University of Technology. Since 1999, he has been a faculty member in the Department of Electrical and Computer Engineering at the Schulich School of Engineering, where he is currently holds the position of Professor and Department Head. He has held appointments as a Visiting Scholar at the Department of Fundamental Electricity and Instrumentation (ELEC) at the VrijeUniversiteit Brussel, and at the Sensory Motor Performance Lab at the Rehabilitation Institute of Chicago / Northwestern University. His research interests include developing system identification techniques for diverse applications ranging from neuromuscular control and robotics to power systems and electrical machines. His publications include over 150 papers in peer-reviewed journals and international conferences, as well as the book “Identification of Nonlinear Physiological Systems” (2003) published by John Wiley and Sons as part of the IEEE Engineering in Medicine and Biology Society book series. He is a Fellow of Engineers Canada, an Honourary Fellow of Geoscientists Canada, and a Senior Member of the IEEE.