Department of Numerical Analysis and Scientific Computing Simula Research Laboratory Oslo, Norway

# Optimization in Oslo

A Seminar Series on Continuous Optimization

Date:

### Wednesday October 19, 2022 at 14:00 (GMT+2, CEST)

#### Speaker:

#### Prof. Dr. Karl Kunisch

University of Graz & Radon Institute of the Austrian Academy of Sciences

#### Title:

## Solution Concepts for Optimal Feedback Control of Nonlinear Partial Differential Equations

#### Abstract:

Optimal feedback controls for nonlinear systems are characterized by the solutions to a Hamilton Jacobi Bellmann (HJB) equation. In the deterministic case, this is a first order hyperbolic equation. Its dimension is that of the statespace of the nonlinear system. Thus solving the HJB equation is a formidable task and one is confronted with a curse of dimensionality.

In practice, optimal feedback controls are frequently based on linearisation and subsequent treatment by efficient Riccati solvers. This can be effective, but it is a local procedure, and it may fail or lead to erroneous results.

In this talk, I give a brief survey of current solution strategies to partially cope with this challenging problem. Subsequently I describe three approaches in some detail.

The first one is a data driven technique, which approximates the solution to the HJB equation and its gradient from an ensemble of open loop solves. The second one is based on Newton steps applied to the HJB equation. Combined with tensor calculus this allows to approximately solve HJB equations up to dimension 100. Results are shown for the control of discretized Fokker Planck equations. The third technique circumvents the direct solution of the HJB equation. Rather a neural network is trained by means of a succinctly chosen ansatz. It is proven that it approximates the optimal feedback gains as the dimension of the network is increased. This work relies on collaborations with B.Azmi, S.Dolgov, D.Kalise, D. Vasquez-Varas, and D.Walter.

#### Brief Bio:

Karl Kunisch is professor emeritus of mathematics at the University of Graz, and Scientific Director of the Radon Institute of the Austrian Academy of Sciences in Linz. He received his PhD and Habilitation at the Technical University of Graz in 1978 and 1980. His research interests include optimization and optimal control, inverse problems and mathematical imaging, numerical analysis and applications.

Before joining the faculty at the University in Graz he was professor of numerical mathematics at the Technical University of Berlin. Karl Kunisch is the author of two monographs and more than 350 papers. He is editor of numerous journals, including SIAM Numerical Analysis and SIAM Optimization and Optimal Control, and the Journal of the European Mathematical Society. Also, he is the recepient of an ERC advanced grant and of the W.T. and Idalia Reid Prize.