Universität Bremen

CENTER OF APPLIED SPACE TECHNOLOGY AND MICROGRAVITY

ZARM

Bachelor thesis:

Are machine learning methods good at identifying reduced order models of turbulent flows?

Turbulent flows are extremely complex: they are difficult to accurately simulate and to understand. Thus, whenever possible, turbulence is preferably simplified and modeled with 'reduced order models' (ROM): models that are much simpler to simulate/understand but retain the most relevant dynamics of turbulent flows. However, correctly identifying ROMs is extremely difficult: there are only a few successful examples in the literature. In the recent years, machine learning methods have risen as a viable way to identify ROMs. Some methods such as convolutional neural networks or SINDy (Sparse Identification of Nonlinear Dynamics[1]) have successfully found ROMs for simple nonlinear systems. But their successful application to more complex problems, such as three dimensional turbulence, is still debated.

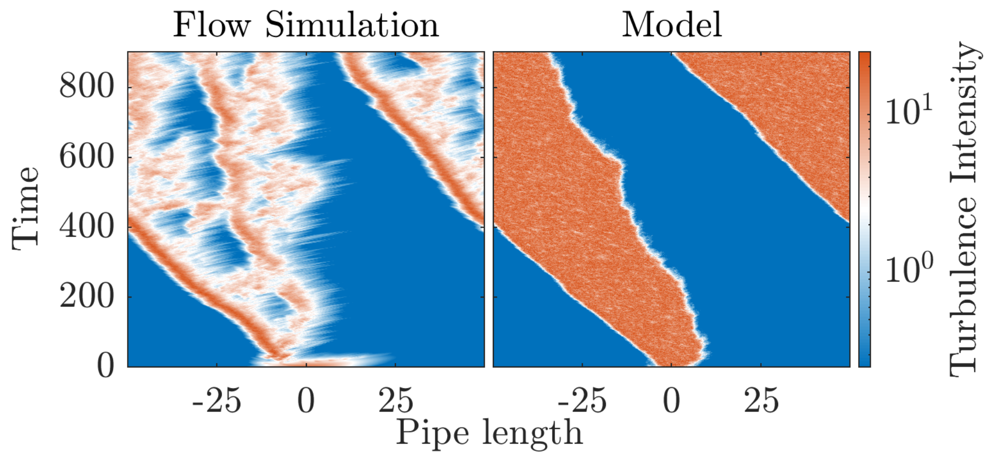

Figure 1: Space (x) time (y) diagram of a turbulent puff in a pipe flow. Red means turbulence, blue not. Left: in the case of an exact numerical simulation. Right: using the ROM.

In this thesis you will use state of the art data driven techniques (SINDy) to find ROMs of transitional pipe flow. In this flow regime, turbulence takes the form of localized turbulent patches called turbulent puffs that move at certain velocities, and can split or decay. Researchers managed to model these complex dynamics with a simple (but still smart) ROM. The question you will answer here is: can machine learning methods, on their own, come up with this ROM too? And, can they find even better ROMs?

Requirements:

- Basic knowledge in numerical methods and fluid mechanics.
- High interest and motivation on data-driven methods and modelling.

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1 *Discovering governing equations from data by sparse identification of nonlinear dynamical systems*. S. Brunton et al. PNAS (2016) 113(15):3932-3937, 10.1073/pnas.1517384113