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INSTITUT de MATHÉMATIQUES de MARSEILLE

Master 2 internship offer: Neural implicit flow for decomposing transports.

This work builds on the shifted proper orthogonal decomposition (sPOD) [1, 2], which is a method to separate transport-dominated data fields as shown for the vorticity of a flow ω in Figure 1. Such fields are relevant in many fluid dynamical applications and especially challenging in computational fluid dynamics. The task of this project consists of using the existing methodology [2] for separating flows based on a neural network approach and extending it with the ideas of neural implicit flow [3]. The final goal is to apply the existing methods to higher dimensional data such as the vortex shedding behind cylinders shown in Figure 1.

This internship is targeted toward Computer Science or Applied Mathematics master students who are comfortable with programming in Python. Basic knowledge of machine learning and optimization is expected.

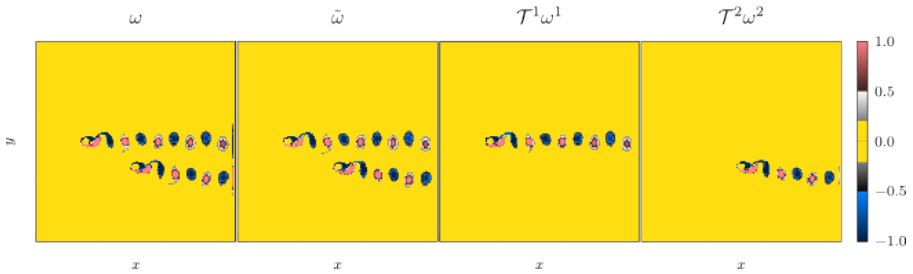

Figure 1. *Separation of the two moving cylinders using the shifted Proper Orthogonal Decomposition (sPOD). From left to right: the original data, the estimated field, the two separated cylinders flows*

Workplan

The tasks for this project can be divided into the following points:

- Implementing neural implicit flow for a synthetic test example.
- Theoretical formulation of the neural sPOD with neural implicit flow.
- Extension of the neural implicit flow for multiple co-moving data fields.
- (optional) Using Physics-Informed Neural Networks (PINNs) to simulate time dynamics of physics systems.

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References

[1] Philipp Krah, Arthur Marmin, Beata Zorawski, Julius Reiss, and Kai Schneider. A robust shifted proper orthogonal decomposition: Proximal methods for decomposing flows with multiple transports. *arXiv preprint arXiv:2403.04313*, 2024.

[2] Beata Zorawski, Shubhaditya Burela, Philipp Krah, Arthur Marmin, and Kai Schneider. Automated transport separation using the neural shifted proper orthogonal decomposition. *arXiv preprint arXiv:2407.17539*, 2024.

[3] Shaowu Pan, Steven L Brunton, and J Nathan Kutz. Neural implicit flow: a mesh-agnostic dimensionality reduction paradigm of spatio-temporal data. *Journal of Machine Learning Research*, 24(41):1–60, 2023.