Machine learning-based reduced order modelling: Towards intelligent digital twins

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Reduced Order Modeling (ROM) is a mathematical technique that reduces the time and cost of static or dynamic numerical simulations while preserving the dominant effects of the high fidelity model. The combination of physics-based models with artificial intelligence enables the construction of Non-Intrusive ROMs (NIROMs) that constitute the backbone of real-time digital twin systems [1]. Machine Learning (ML) methods along with linear algebra techniques have proven an efficient way to construct NIROMs [2]. Motivated by this approach, in this work we present a newly developed ROM network, that combines a Singular Value Decomposition (SVD) update methodology with deep learning models. Our innovative framework, which we refer to as *FastSDV-ML-ROM* can handle large-scale full order models, predict and forecast the spatiotemporal solutions for a given parameter set in a limited amount of time. *FastSDV-ML-ROM* can be very effective for real-time monitoring driving the decisions of an active control system through a feedback process.

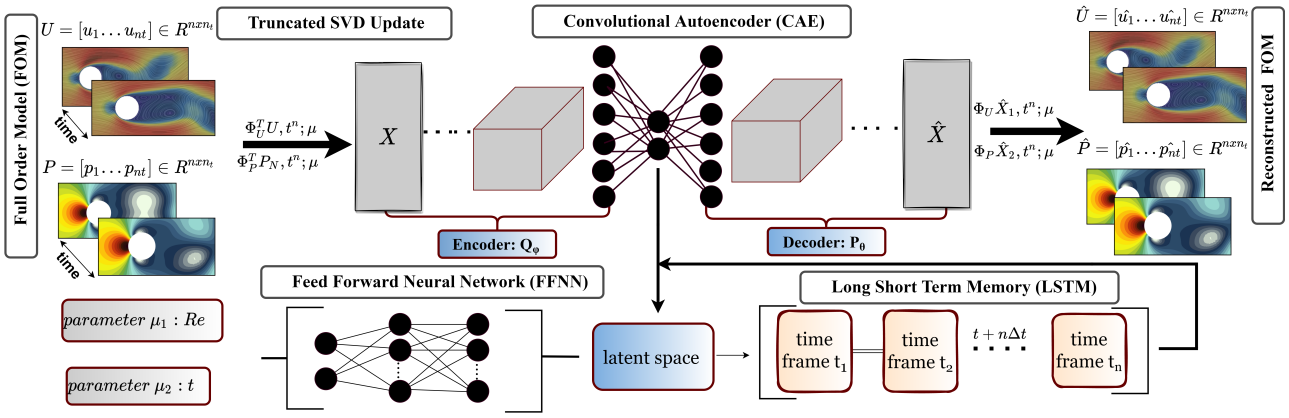

Figure 1: *FastSDV-ML-ROM* framework during the online and offline phase for the fluid flow past a cylinder case simulated in Simcenter STAR-CCM+. i) SVD is used to identify a low-rank approximation of the multi-fidelity model, ii) convolutional autoencoders for non-linear dimensionality reduction, iii) feed forward neural networks map the input parameters to the latent spaces and long short-term memory models to identify the dynamics of the system.

References

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