

System identification using Neural Networks applied to experimental noise-amplifier flows characterized by real-time optical flow velocimetry.

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In noise amplifiers flows initial random upstream perturbations are selectively amplified by convective instabilities via the receptivity process and convected downstream. A possible approach in flow control is to reduce the numbers of degrees of freedom of the system through the use of a Reduced Order Model (ROM). This approach alone is challenging, especially when dealing with noise amplifiers flows. A more realistic approach has been proposed by Guzman et al.[1] who propose an identification method to capture the dynamics of the flow through local sensors (velocity/ vorticity/ vortex identification criteria like swirling strength) which are linked to the full POD reduced order model to be identified and predicted. This information can be later used in a control law targeting the kinetic energy of the perturbation field calculated from the POD model. In this study, time-delay artificial feed-forward Neural Networks (NN) are used for the multi-input/ multi- output(MIMO) identification process in the form of a non-linear regression. The optimum network architecture is discussed and the results are compared to a traditional N4SID method [1]. Two examples of amplifier flows are used as benchmarks: the Backward Facing Step (BFS) and the transitional flat plate Boundary Layer (BL) flow. The goal is to create a dynamic observer to predict the full POD coefficients of a ROM from local measurements extracted from 2D-2C (two-components in a 2D plane) velocity fields using an optical flow PIV code [2] implemented on a GPU (Graphics Processor Unit). The PIV experiments are carried out in a 80 cm long, low Reynolds number, hydrodynamic channel driven by gravity. The efficiency of the training process of the system identification regarding the position and the nature of the sensor (local velocity, vorticity, swirling strength criterion or combinations) is discussed. The importance of noise filtering in the velocity time-series in the reduced order modelling as well as the identification process is discussed.

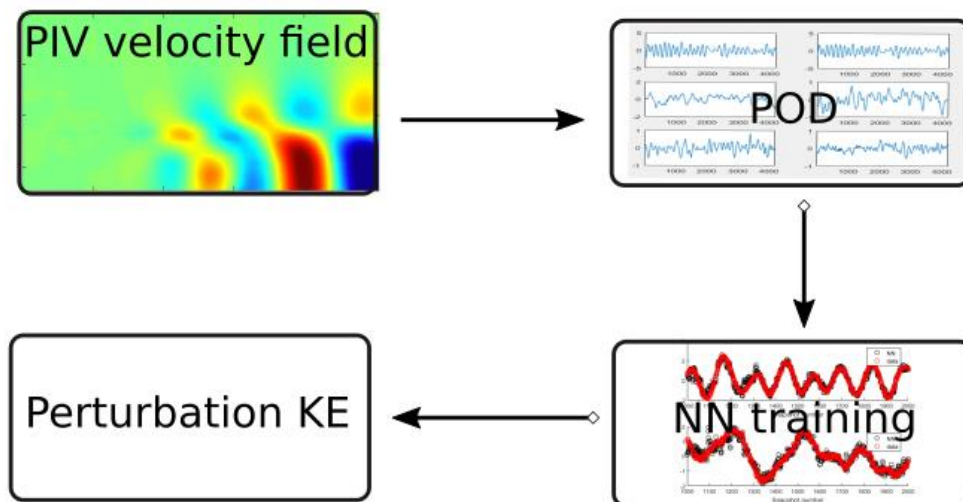


Figure 1. Calculation procedure for system identification in noise-amplifier flows

References

- [1] Guzman I, J., Sipp, D. & Schmid, P. J. A dynamic observer to capture and control perturbation energy in noise amplifiers, *Journal of Fluid Mechanics* 758, 728–753, 2014.
- [2] Gautier, N. & Aider, J.-L., Real-time planar flow velocity field measurements using an optical flow algorithm implemented on GPU, *Journal of Visualization*, 1-10, 2014