Generative Adversarial Networks to infer velocity components in rotating turbulent flows

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Inference problems are studied for two-dimensional snapshots extracted from an open database of rotating turbulent flows[1]. We perform a systematic quantitative benchmark of point-wise and statistical reconstruction capabilities of the linear Extended Proper Orthogonal Decomposition[2] (EPOD) method, a non-linear Convolutional Neural Network (CNN) and a Generative Adversarial Network[3,4,5] (GAN). The objective is to infer one velocity component out of the measurement of a second one, and two cases are studied: (I) both components lay in the plane orthogonal to the rotation axis and (II) one of the two is parallel to the rotation axis. Results indicate that EPOD works well only for the former case when both components are highly correlated, whereas CNN and GAN outperform EPOD in both point-wise and statistical reconstructions. For the second case, where the input and output data are weakly correlated, all methods fail to reconstruct faithfully the point-wise information. In this case, only GAN is able to reconstruct the field in a statistical sense. The analysis uses standard validation tools based on L_2 spatial distance and more advanced multi-scale analysis using wavelet decomposition. Statistical validation includes Jensen-Shannon divergence, spectral properties, and multi-scale flatness. This work was supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (Grant Agreement No. 882340).

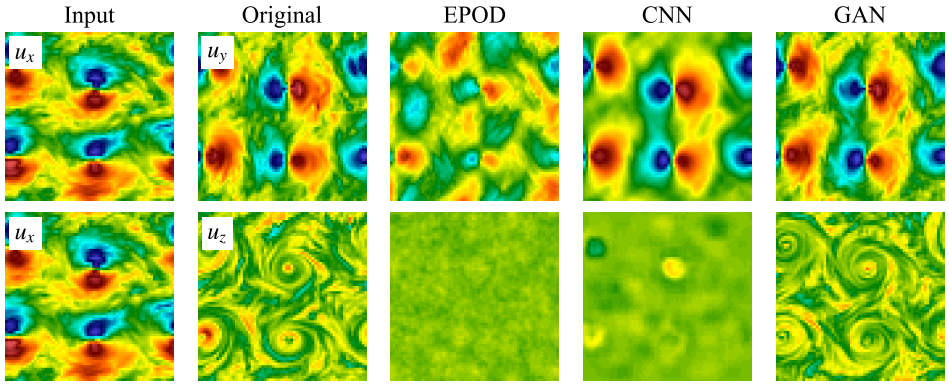

Figure 1: Prediction visualizations of the inference task (I) (1st row) and the inference task (II) (2nd row). The objective is to use the measured velocity component in the 1st column to infer another velocity component in the 2nd column. The predictions from EPOD, CNN and GAN are shown from the 3rd to 5th columns, respectively.

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[5] Li et al., *arXiv preprint arXiv:2301.07541* (2023) (submitted to *Eur. Phys. J. E.*).