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Paper Review: A synthetic turbulent inflow generator using machine learning

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We propose a methodology for generating time-dependent turbulent inflow data with the aid of machine learning (ML), which has a possibility to replace conventional driver simulations or synthetic turbulent inflow generators. As for the ML model, we use an auto-encoder type convolutional neural network (CNN) with a multi-layer perceptron (MLP). For the test case, we study a fully-developed turbulent channel flow at the friction Reynolds number of Re_τ=180 for easiness of assessment. The ML models are trained using a time series of instantaneous velocity fields in a single cross-section obtained by direct numerical simulation (DNS) so as to output the cross-sectional velocity field at a specified future time instant. From the a priori test in which the output from the trained ML model are recycled to the input, the spatio-temporal evolution of cross-sectional structure is found to be reasonably well reproduced by the proposed method. The turbulence statistics obtained in the a priori test are also, in general, in reasonable agreement with the DNS data, although some deviation in the flow rate was found. It is also found that the present machine-learned inflow generator is free from the spurious periodicity, unlike the conventional driver DNS in a periodic domain. As an a posteriori test, we perform DNS of inflow-outflow turbulent channel flow with the trained ML model used as a machine-learned turbulent inflow generator (MLTG) at the inlet. It is shown that the present MLTG can maintain the turbulent channel flow for a long time period sufficient to accumulate turbulent statistics, with much lower computational cost than the corresponding driver simulation. It is also demonstrated that we can obtain accurate turbulent statistics by properly correcting the deviation in the flow rate.
arXiv link: https://arxiv.org/abs/1806.08903