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Emulating turbulence via a Physics-Informed Deep Learning framework MOHAMMADREZA MOMENIFAR, Department of Civil and Environmental Engineering, Duke University, Durham, North Carolina, ENMAO DIAO, VAHID TAROKH, Department of Electrical and Computer Engineering, Duke University, Durham, North Carolina, ANDREW D. BRAGG, Department of Civil and Environmental Engineering, Duke University, Durham, North Carolina — We use a data-driven approach to model a three-dimensional turbulent flow using cutting-edge Deep Learning techniques. The deep learning framework incorporates physical constraints on the flow, such as preserving incompressibility and global statistical invariants and relationships for the filtered strain-rate and vorticity. The accuracy of the model is assessed using statistical and physics-based metrics. The data set comes from Direct Numerical Simulation of an incompressible, statistically stationary, isotropic turbulent flow in a cubic box. Since the size of the dataset is memory intensive, we first generate a low-dimensional representation of the velocity data, and then pass it to a sequence prediction network that learns the spatial and temporal correlations of the underlying data. The dimensionality reduction is performed via extraction using Vector-Quantized Variational Autoencoder (VQ-VAE), which learns the discrete latent variables. For the sequence forecasting, the idea of Transformer architecture from natural language processing is used, and its performance compared against more standard Recurrent Networks (such as Convolutional LSTM). Detailed results on the multi-scale turbulence properties predicted by the model will be presented in the talk.

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