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Data-Driven Analysis of Velocity Gradient Dynamics Using Neural Network

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Abstract : We perform an investigation of the unclosed terms in the evolution equation of the velocity gradient tensor (VGT) in compressible decaying turbulent flow. Velocity gradients in a compressible turbulent flow field influence several important nonlinear turbulent processes like cascading and intermittency. In an attempt to understand the dynamics of the velocity gradients various researchers have tried to model the unclosed terms in the evolution equation of the VGT. The existing models proposed for these unclosed terms have limited applicability. This is mainly attributable to the complex structure of the higher order gradient terms appearing in the evolution equation of VGT. We investigate these higher order gradients using the data from direct numerical simulation (DNS) of compressible decaying isotropic turbulent flow. The gas kinetic method aided with weighted essentially non-oscillatory scheme (WENO) based flow- reconstruction is employed to generate DNS data. By applying neural-network to the DNS data, we map the structure of the unclosed higher order gradient terms in the evolution of the equation of the VGT with VGT itself. We validate our findings by performing alignment based study of the unclosed higher order gradient terms obtained using the neural network with the strain rate eigenvectors.

Keywords : compressible turbulence, neural network, velocity gradient tensor, direct numerical simulation
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