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Prediction of a scalar source location from remote sensors in turbulent flow using machine learning

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Abstract

In this study, we use a machine learning technique to identify the location of a passive scalar in turbulent flow based on remote sensor measurements. We consider a turbulent channel flow at the Reynolds number of 180 based on the wall shear velocity and channel half height, and solve the continuity, Navier-Stokes and passive scalar equations. A source (passive scalar) is located at (x_p, y_p, z_p), and sensors are placed at (x_s^j, y_s^j, z_s^j) (downstream of sensor location), where j = 1, 2, 3, …, n and n is the number of sensors. We fix the sensor locations and vary the source location. At each source location, we record the passive scalar signal in time at the sensor locations. The recorded signals together with the corresponding source location are used to train a convolutional neural network (CNN) by minimizing the rms error of predicted and actual source locations. A posteriori tests indicate that the ratio of the distance between the actual and predicted source locations to the distance between the actual source and sensors is around 2%. The present results are compared with those obtained by a variational algorithm (Wang et al. 2019, JFM). The CNN-based prediction is more accurate than that by a variational algorithm, and requires much less computational time, enabling faster prediction when pre-trained.

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