Data Augmentation for Turbulent Combustion Modelling by using PCA-GAN

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In recent years, machine learning has been employed in turbulent combustion modelling in several studies[1, 2]. These machine learning models are trained by the results of direct numerical simulation (DNS). However, it is difficult to obtain various combustion DNS data under many different conditions due to its huge computational cost and the lack of variety can lead to insufficient robustness of the model. In this research, a new data augmentation method PCA-GAN for combustion DNS data is proposed to obtain datasets at low cost and its effectiveness is discussed.

PCA-GAN is a data augmentation method using principal component analysis (PCA) and generative adversarial network (GAN). PCA calculates PC scores as the label information for GAN, and GAN generates synthetic data which trains a machine learning model. Augmentation is conducted in latent space. In this research, planar DNS data is augmented and augmented data is used for predicting V-flame DNS data.

A neural network model[3] for predicting sub-grid scale scalar dissipation rate is used to test the augmented data. A scatter plot of the PC scores is shown in Figure 1. Blue and red points represent planar data and augmented points, respectively. The GAN model is trained with the blue points and the augmented data is obtained by inputting red points into the trained GAN model.

The prediction results of the test neural network model are shown in Figure 2. The left one is a result of planar DNS data as a training dataset and the prediction is not accurate, especially for large values. In contrast, the right one is a result of augmented data as a training dataset and the prediction result is improved. In conclusion, PCA-GAN augmented data is applicable for machine learning model training and it can improve the robustness of model prediction without conducting other DNS.

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[1] Nakazawa *et al.*, *Combust. Flame*, **235**, 111696 (2022).

[2] Jigjid *et al.*, *Proc. Comb. Inst.*, **39** (2022)

[3] Yellapantula *et al.*, *Proc. Comb. Inst.*, **38**, 2928 (2021)

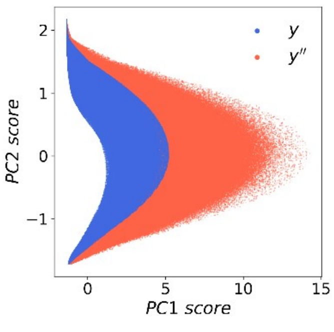

Figure 1: Augmentation in PC space

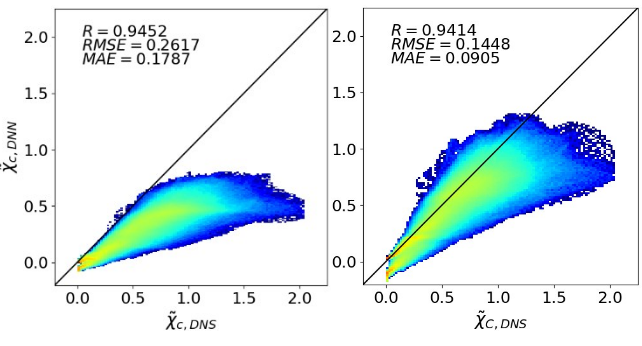

Figure 2: Prediction results of the test model