Performing Particle Image Velocimetry using Artificial Neural Networks

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Artificial Neural Networks (ANNs) are increasingly successful at solving image analysis problems. Image analysis is widely used in Fluid Mechanics when performing Particle Image Velocimetry (PIV), and therefore it is natural to test the ability of ANNs to perform such tasks. We report for the first time the use of Convolutional Neural Networks (CNNs) and Fully Connected Neural Networks (FCNNs) for performing end-to-end PIV. Realistic synthetic images are used for training the networks and several test cases are used to assess the quality of each network predictions and compare them with state-of-the-art PIV softwares.

Introduction

Experimental Fluid Mechanics relies on using image processing for measuring flow velocities. Particle Image Velocimetry (PIV) is one such method which usually relies on computing the cross-correlation of a spatial window between two frames for finding a correlation peak, indicating the position of the particle center. As a final step aliers can be automatically detected and interpolated.

Image generation

Synthetic data are used to create arbitrarily big labeled training dataset and therefore issues common with state-of-the-art PIV codes. Benchmarking shows that ANNs may have several advantages over more traditional 2D PIV methods. Benchmarking shows that ANNs are better at performing PIV than the algorithms used today.

Results and conclusion

The level of Root Mean Square (RMS) error between ANNs predictions and the velocity values used for generating the images is slightly higher than for state-of-the-art PIV codes. However ANNs may have several advantages over more traditional 2D PIV methods. Benchmarking shows that ANNs are better at using efficiently GPUs. ANNs have better resolution compared with traditional PIV methods, which could be of interest in cases where high local flow variations are expected. We also observed good boundary performance of ANNs compared with more traditional PIV methods.

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