Deep Reinforcement Learning for Active Flow Control around a Circular Cylinder Using Unsteady-mode Plasma Actuators

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Abstract

Deep reinforcement learning (DRL) algorithms are rapidly making inroads into fluid mechanics, following the remarkable achievements of these techniques in a wide range of science and engineering applications. In this paper, a deep reinforcement learning (DRL) agent has been employed to train an artificial neural network (ANN) using computational fluid dynamics (CFD) data to perform active flow control (AFC) around a 2-D circular cylinder. Flow control strategies are investigated at a diameter-based Reynolds number $Re\_D = 100$ using advantage actor-critic (A2C) algorithm by means of two symmetric plasma actuators located on the surface of the cylinder near the separation point. The DRL agent interacts with the computational fluid dynamics (CFD) environment through manipulating the non-dimensional burst frequency (f+) of the two plasma actuators, and the time-averaged surface pressure is used as a feedback observation to the deep neural networks (DNNs). The results show that a regular actuation using a constant non-dimensional burst frequency gives a maximum drag reduction of 21.8 %, while the DRL agent is able to learn a control strategy that achieves a drag reduction of 22.6%. By analyzing the flow-field, it is shown that the drag reduction is accompanied with a strong flow reattachment and a significant reduction in the mean velocity magnitude and velocity fluctuations at the wake region. These outcomes prove the great capabilities of the deep reinforcement learning (DRL) paradigm in performing active flow control (AFC), and pave the way toward developing robust flow control strategies for real-life applications.

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1