Machine learning control apply to fluidic pinball in drag reduction and wake stabilization

Flow control has always been one of the main directions of fluid mechanics research. Traditional flow control methods mostly use passive control or open-loop active control. Some achievements have been made, but are limited by the complexity of the fluid mechanism, and the control theory is still not suitable for different problems. imperfect. In recent years, artificial intelligence technology has developed rapidly, and more and more artificial intelligence methods have been applied to the field of flow control, which reflects the characteristics of good control effect and fast exploration process at the application level. This paper uses a machine learning method-linear genetic programming to control the flow, and uses this spontaneous learning, control method without a control model to generate a complex control law to control the fluidic pinball. Fluidic pinball is a typical nonlinear flow model. It is composed of three equidistant cylinders. The fluid behavior is changed by rotating each independent cylinder to provide a speed. The control goal of this article is to reduce the drag of the pinball and control its wake stability. In terms of drag reduction, we first use the lift & drag coefficient as the sensor to generate the control rate. When the Reynolds number is 100, 1000 individuals learn from 10 generations, and the net drag is reduced by 66.5% under the conditions of contrast and no control, and then continue to apply linear genetic programming control to the other 5 Reynolds numbers, each The optimal individuals under the Reynolds number have achieved an average reduction in resistance of 60.65% to a large extent. For the best individual control rate learned under each Reynolds number, we tested its performance in other Reynolds numbers, and found that the control rate learned by linear genetic programming is very robust, for example, learning under the Reynolds number 60 The best individual found out achieved an average resistance reduction of 80.01% under other Reynolds numbers. This paper also explores the wake stability control of the fluidic pinball. When the Reynolds number is 100, the control law is applied from the uncontrolled flow field to make it as close as possible to the steady solution flow field. We set up multiple speed sensors in the wake section and proposed three simple to complex control models for the control law model. Finally, after 10 generations of 1000 individuals' evolutionary learning, the three models learned to generate optimal control rates to achieve 60.5%, 68.1%, and 82.6% reductions in flow field distances, respectively.