Turbulence control for drag reduction through deep reinforcement learning

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In this study, the goal is to find control strategy for drag reduction through blowing and suction on the wall in turbulent channel flow. In previous studies, Opposition control, a simple feedback method was applied to cancel sweep and ejection events. Although this method resulted in a 25% drag reduction, there is a limitation in that the speed sensor must be placed inside the flow. This is reason why there have been many studies of approaching the above problem based on off-line (supervised) learning with a prior assumption. That is, predicting the target velocity inside the flow field using channel wall information such as pressure, shear stress. But the performance decreased by about 20% compared to the opposition control method.

In order to increase this low performance, we used Deep reinforcement learning (DRL) algorithm. Unlike the supervised learning, DRL algorithm has the characteristics that it can recognize the situation or state and learn by itself to find optimal action, even in the manipulated flow field. Based on these characteristics, we can expect to find a new optimal mechanism for drag reduction with only wall-shear stress. The simulation of channel flow is carried out under the condition of initial friction Reynolds number Re = 180, domain size = $4\pi\delta \times 2\delta \times 2\pi\delta$, and fixed flow rate. As a result, we found that our model has better performance than the supervised model and drag reduction result and vorticity contour are presented in Figure 1. details including action distribution and statistics will be presented.

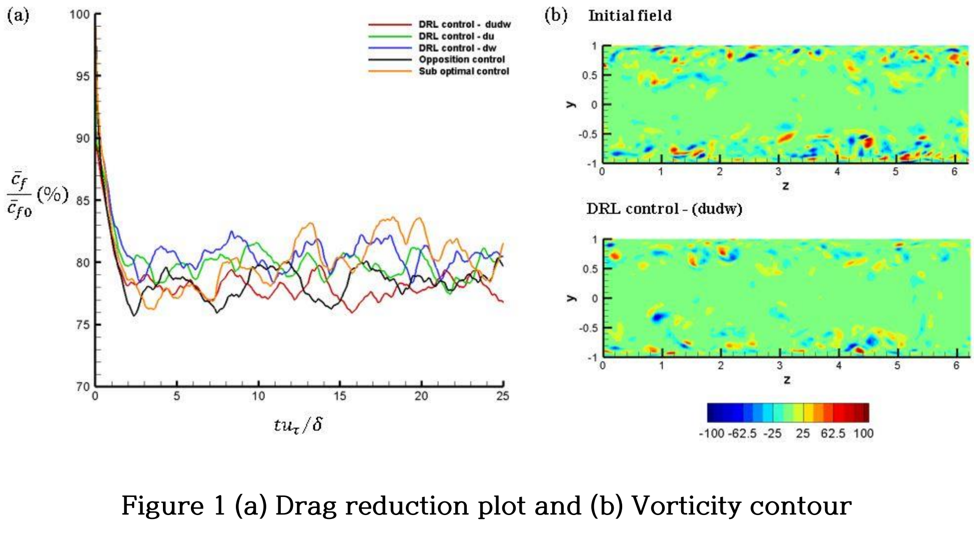

Figure 1 (a) Drag reduction plot and (b) Vorticity contour

References

[1] C.H. Lee et al., "Application of neural networks to turbulence control for drag reduction," *Phys. Fluids*, Vol. 9, No. 6 (1997).