Streamlined shapes optimisation using Lattice Bolzmann simulation and neural networks

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Résumé

Today's calculation methods to design aerodynamic shapes come from last century's aeronautic development projects, which were mainly focused on military and commercial flights. However, vehicles that surround us, such as bicycles, cars or civil drones, are far from being as fast as planes. Minimising the power consumption of these engines has become a crucial matter. Those last decades, the priority has been put on the improvement of mechanical efficiency, while the aerodynamic optimisation has suffered from a lack of knowledge on moderate speed air flows. Our main mistake is that we still tend to extrapolate what we have learnt on planes on vehicles that are much slower and that evolve in conditions that are not really comparable (Reynolds number, Mach number).

The numerical air flow simulation around streamlined shapes seems to be an attractive solution when it comes to optimising a shape. However, the softwares that have been developped in the last decades give us inaccurate data regarding the localisation of the laminar-turbulent air-flow transition area, thus rendering the lowering of the air flow drag difficult.

The aim of this study is to develop a method to optimise a streamlined shape using numerical and experimental approaches. (i) The airflow velocity fields is measured around a human-powered recumbent bicycle with a streamlined shell which already holds a France speed record. (ii) in parallel, the Palabos code based on the Lattice Boltzman method is modified in order to obtain data compatible with the measurements. Air flow calculations are then made upon different streamlined shells. (iii) Both measurement and simulation results are used to train a convolutionnal neural network on mesh. (iv) The neural network is used in order to design the best streamlined shape with an internal volume constraint which includes pilot and bicycle mechanics.

Mots-Clés: aerodynamics, laminar turbulent transition, Lattice Boltzmann method, Neural networks

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