Application of distributed micro plasma actuators

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Abstract

Plasma actuators (PAs) are flow control devices that use discharged plasma to generate wall jets from smooth surfaces. In recent years, a method of generating a distribution of body force on a surface by using a large number of small-scale PAs has been proposed by the applicants. The objective of this study is to obtain knowledge about the application method of plasma actuator and its optimization method for arbitrary control of the velocity profile of a three-dimensional boundary layer, keeping in mind the boundary layer control of high-speed flows.

Reasons and benefits of using JAXA Supercomputer System

In order to perform large-scale 3D flow analysis and aerodynamic optimization with high computational costs, a supercomputer is required. The JAXA supercomputer, which provides an environment for the use of computational tools, is the most suitable environment for this study.

Achievements of the Year

In the current year, our research advanced in exploring the efficacy of optimal design and data mining methodologies applied to our studies. We undertook a design exploration for a separation control device on two-dimensional simplistic geometry as a benchmark test, through which we validated the applicability of our design methodology to real problems. This exploration included aerodynamic analyses employing Reynolds-Averaged Navier-Stokes (RANS) computations and solving optimization problem with a developed optimal design tool. This process aimed to assess the utility of the optimal design and data mining approaches for the gathered data. Numerical simulations were conducted using FaSTAR, a tool developed by JAXA, alongside HexaGrid for automatic grid generation, also a JAXA product. The computational grid was compact, comprising 200,000 points. For the optimal design phase, a spline function facilitated the geometrical definition from an extensive array of design points. This allowed for the analysis and identification of solutions across several hundred samples, with the grid being dynamically generated via diverse modifications to the spline function.

Figure 1 presents a scatter plot matrix showing the outcomes of the design exploration. This illustrates the correlations among the forward projection (x/H), lateral extension (z/H), front edge curvature (x_curv.), lateral curvature (z_curv.), and the drag coefficient (Cd) of the control device applied to a two-dimensional prism model. The instances where Cd reduction surpassed 50% are marked with blue dots in the figure. Notably, the device configurations that achieved a lower drag coefficient featured a more extended forward projection than lateral overhang, greater curvature at the nose, and lesser curvature at the sides, aligning nearly parallel with the airflow. The methodologies employed in this study have demonstrated the potential for optimal design of the specified microfluidic device and the identification of its effective configuration characteristics.

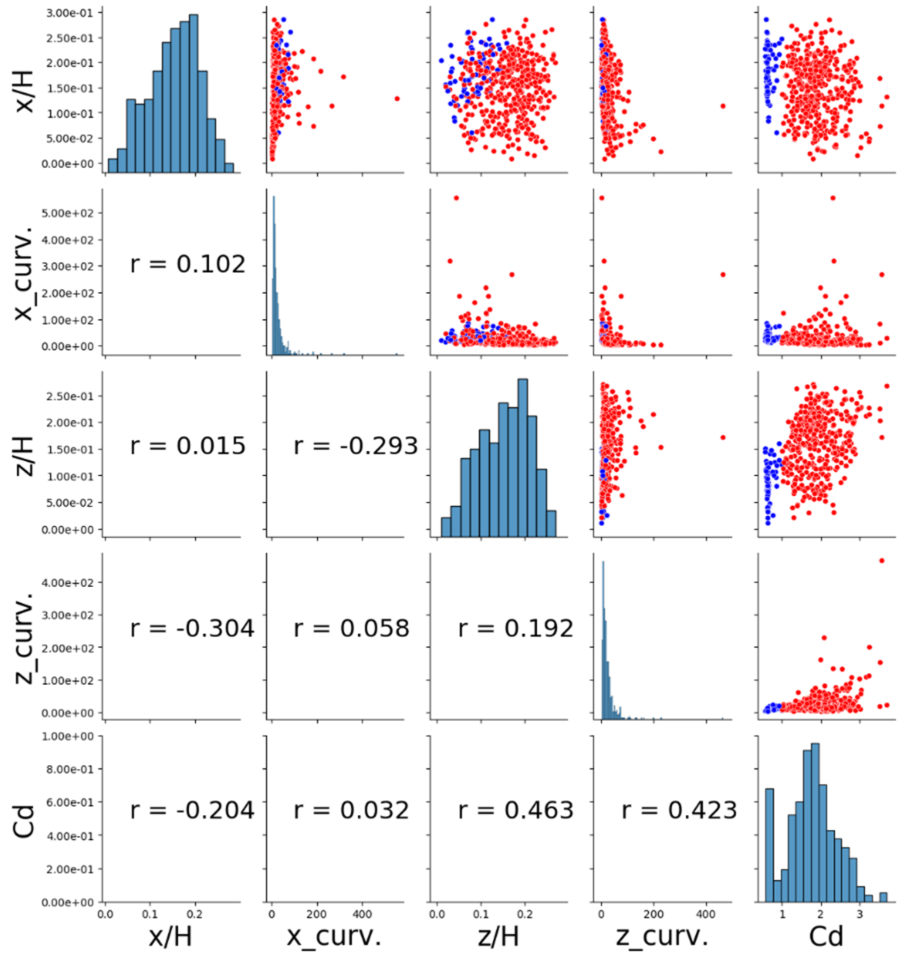

Fig. 1: Scatter plot matrix of shape features of the flow control device and drag coefficient.

Publications

N/A

Usage of JSS

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	12 - 48
Elapsed Time per Case	15 Minute(s)

- **JSS3 Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.00

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	3.68	0.00
TOKI-ST	495.27	0.00
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	0.00	0.00
TOKI-TST	0.00	0.00
TOKI-TGP	0.00	0.00
TOKI-TLM	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage[*2] (%)
/home	163.33	0.14
/data and /data2	12,913.00	0.08
/ssd	0.00	0.00

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage[*2] (%)
J-SPACE	0.00	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

- **ISV Software Licenses Used**

ISV Software Licenses Resources		
	ISV Software Licenses Used (Hours)	Fraction of Usage[*2] (%)
ISV Software Licenses (Total)	0.00	0.00

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.