Numerical simulations for the development of an active flow control methodology focusing on the characteristic structures of fluid flows

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Abstract

Controlling fluid flows to a preferred state in terms of energy efficiency is an important issue in fluid mechanics. However, it is still challenging to accurately estimate the fluid flow state and accurately determine the control inputs when the fluid flow exhibits a turbulent state. This study aims to develop a framework that provides insights into active flow control based on characteristic structures extracted from experimental or numerical simulation results.

Reasons and benefits of using JAXA Supercomputer System

The objective of this study is to model the parameter dependence of the characteristic structures extracted from experimental or numerical simulation results in order to gain insight into active flow control. The time-series flow field dataset containing flow fields (turbulent flows) for a variety of flow parameters is required to achieve this objective. Therefore, the use of supercomputers is indispensable to achieve the objective of this study.

Achievements of the Year

We performed large eddy simulations of fluid flows around an airfoil for different angles of attacks in order to extract characteristic structures. We plan to extract some modes from the obtained dataset and investigate the relationship between modes for different angles of attack. In addition, we have developed a framework based on matrix manifolds that can investigate the relationship between modes for different parameters.

Publications

- Oral Presentations

1) S. Sato, "Estimation of subspace spanned by proper-orthogonal-decomposition modes for parameterized reduced-order-model in aerodynamics," AIAA AVIATION Forum, July 2025, Las Vegas.

2) S. Sato, "Development of a robust ROM based on the estimation of subspace," The Japan Society of Fluid Mechanics Annual Meeting 2024, Sendai.

3) S. Sato and O. T. Schmidt, "Parameterized reduced-order-modeling based on matrix manifold", APS Division of Fluid Dynamics Annual Meeting 2024, Salt Lake City, UT.

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	1 - 1024
Elapsed Time per Case	72 Hour(s)

JSS3 Resources Used

Fraction of Usage in Total Resources[*1](%): 0.07

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	1,460,956.87	0.07
TOKI-ST	0.00	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	95.00	0.06
/data and /data2	117,710.00	0.56
/ssd	0.00	0.00

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2 (%)
J-SPACE	3.47	0.01

*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.