

Multiscale Analysis, Modeling and Simulation

-Top Global University Project, Waseda University-

Report on Study Abroad

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- 1. Destination:** Rice University, Houston, USA
- 2. Dates of stay:** January 15, 2022 - March 30, 2022 (74 days)
- 3. Purpose:** Developed and verified the Carrier Domain Method (CDM)
- 4. Host Professor:** Tayfun E. Tezduyar (Rice University)
- 5. Study at Rice University**

I was very lucky to get such a chance to study at Rice University and the main purpose was to go deeper and further into CDM. Some of the works had already been done to prove the efficiency and accuracy of CDM on simulating long wake flows behind a 2D cylinder. I summarized the 2D computation, and then extended the CDM on a 3D cylinder computation during my study at Rice University.

Research Results

The computational framework consists of space–time variational multiscale method (ST-VMS), ST isogeometric discretization, which offers higher order of accuracy, and the CDM, which was developed to greatly reduce the computational costs of predicting long wake flows without losing accuracy. Figure 1 shows that the CDM is accurate enough to capture the time periodic solutions behind the 2D cylinder. Figure 2 shows that the CDM is successfully extended to a 3D cylinder case.

Significance

This work will be one of the most important part of my Ph.D thesis, which demonstrates the innovative aspect of the computational frame work which is of high accuracy and efficiency. Since we proved that the CDM also worked well in 3D, we will apply the new computational frame work to a two back-to-back horizontal wind turbines computation, predicting the long wake flow generating by upstream wind turbine and studying its influence on downstream wind turbine.

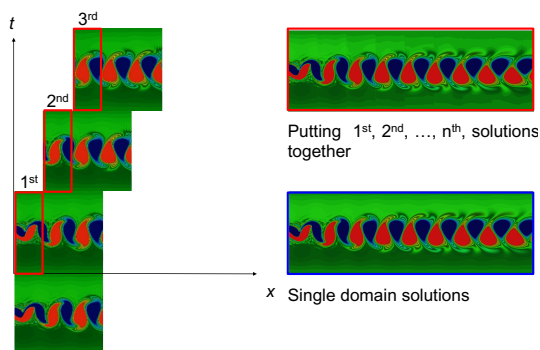


Figure 1: Illustration of CDM at 2D

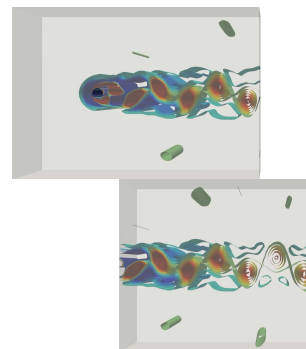


Figure 2: CDM verification at 3D

6. Life at Rice University

I was really impressed by the consistent Mediterranean revival architecture style of Rice (which I googled specifically), among which I loved the Duncan Hall most, locating near the mechanical engineering building. Another famous Rice architecture that I am interested in is the James Turrell Twilight Epiphany Skyspace (see Figure 3), which was acoustically engineered to host musical performances, and sometimes, you could see students playing music there. When mentioning the food at Houston, the Texas standard barbecue was really impressive.



Figure 3: James Turrell Twilight Epiphany Skyspace

7. Thanks

The study experience was really worth mentioning. I would like to express my sincere gratitude to Professor Takizawa and Professor Tezduyar (see Figure 4). They not only instructed and encouraged me to develop the innovative computational method, but also helped me in every aspects of safety flight under COVID-19, giving advices on local housing and native life. Besides, I would like to express my thankfulness to Dr. Kuraishi at Rice University, who helped me quite a lot and answering all the questions I encountered in study and in local life. I was very lucky to meet Dr. Cengizci who always encouraged me to work harder in the upcoming semesters during coffee break at campus. I was in debt to Ms. Yukari Ishizaki at SGU at Waseda University, who helped me dealing with all the required documents with a lot of patience during my whole stay at Rice. Finally, I hope to thank Professor Terahara and all the other lab members, I feel very happy to go back to Waseda University and continue my study at TAFSM.



Figure 4: Professor Tezduyar and Yang