PhD Position Available at Dalhousie University

Project Title**: CFD-Driven Aerodynamic Modeling and Dynamic Simulation for Autonomous Sailing Control**

Position: **PhD Candidate**

PhD subject: **Autonomous Sailing and Navigation**

Supervisor: Dr. **Mohammad Saeedi**, Dept. of Mechanical Engineering at Dalhousie University, Halifax, Canada

Co-supervisor: Dr. **Emmanuel Wtirant**, Université Grenoble Alpes - CNRS/GIPSA-lab, Grenoble, France

PROJECT OVERVIEW

We are seeking a research student to work on high-fidelity computational fluid dynamics (CFD) simulation of flow around sails and its integration with physics-based dynamic modeling for real-time sail control. The overarching goal is to develop accurate aerodynamic models that can support automatic sail decision-making under variable wind and sea conditions. This PhD forms a core part of an interdisciplinary project involving CFD, fluid–structure interaction, system dynamics, reduced-order modeling, and intelligent control of sail-assisted propulsion.

The CFD work will be tightly integrated with experimental validation using a wind-tunnel, the small-scale autonomous sailboat (MiniJI) and the 6-meter Birdie Sailboat available in the Advanced Control and Mechatronics Laboratory (ACM Lab: http://acm.me.dal.ca) at Dalhousie University and in the Infinity team (https://www.gipsa-lab.grenoble-inp.fr/en/team/infinity) at Université Grenoble Alpes. High-fidelity CFD simulations will also support the development of physics-informed performance maps and reduced-order models used by the control research team. Dedicated data-driven learning methods will be developped to tailor the model to real-time measurements. The student may have the opportunity to work as a visiting research graduate student in the research group located at the Université Grenoble Alpes – CNRS/GIPSA-lab, Grenoble, France.

The PhD candidate will be fully supported at a comparable annual stipend up to 4 years supported by the Natural Sciences and Engineering Research Council of Canada (NSERC). The overall project is co-funded by the Canada-France CFP on AI by NSERC and French National Research Agency (ANR) in France. The student will be supported to attend international conferences, provided that the student has conference papers accepted.

SCOPE OF THE PHD THESIS

CO_2 emissions from shipping contributed 2.9% of human-induced global emissions in 2018 and may increase by 44% by 2050, as reported by the International Maritime Organization (IMO). While the environmental impacts of shipping are well understood, the latest Intergovernmental Panel on Climate Change (IPCC) report highlights that adaptation measures remain largely at the planning stage. Among the promising strategies for decarbonizing maritime transport is wind-assisted propulsion (WAP), where sails or other aerodynamic devices reduce fuel consumption by harnessing wind energy.

This PhD, titled **"CFD-Driven Aerodynamic Modeling and Dynamic Simulation for Autonomous Sailing Control,"** focuses on developing the aerodynamic and dynamic foundations needed for real-time sail adaptation. The first part of the thesis will involve high-fidelity simulation of the unsteady aerodynamic environment around flexible and rigid sails using Reynolds-averaged Navier-Stokes (RANS), Large-eddy Simulation (LES) and Detached Eddy Simulation (DES), and/or hybrid CFD techniques. These simulations will quantify flow separation, vortex dynamics, unsteady loading, and trim-dependent variations, forming a detailed understanding of the physics required for dynamic modeling.

Beyond aerodynamics, the project includes modeling the coupling between sail flow physics, structural flexibility, and the dynamic response of the sailboat. This requires integrating CFD-derived force and moment data into nonlinear dynamic models that describe the time evolution of the vessel state under changing wind conditions. Reduced-order modeling techniques (e.g., Proper Orthogonal Decomposition, Koopman-based modeling) may be employed to derive computationally efficient representations suitable for real-time control.

The resulting aerodynamic and dynamic models will be used to support decision-making algorithms developed by the control research team. These models will feed into hybrid control frameworks combining physics-based modeling with AI-driven strategies for selecting optimal sail and rudder configurations under uncertainty. As part of the interdisciplinary effort, the PhD student will collaborate closely with researchers working on reinforcement learning (RL), model-based control, and system identification of infinite-dimensional dynamics.

Finally, experimental validation using a wind tunnel and instrumented sailboats (MiniJI and Birdie 6-meter sailboat) will be carried out to assess the accuracy and robustness of the developed models. Onboard sensors—including pressure measurements, flow attachment sensors, mast strain gauges, IMUs, and anemometers—will provide the real-world data needed to close the loop between CFD predictions, dynamic simulation, and the final adaptive sail-control strategies. By bridging high-fidelity physics-based modeling, experimental validation, and interdisciplinary control research, this PhD will contribute to enabling the next generation of intelligent, wind-assisted autonomous vessels.

QUALIFICATIONS

- Master's degrees in Mechanical or Aerospace Engineering.
- Background knowledge in one or multiple fields: CFD, dynamic modeling, simulation and implementation.
- Technical writing skills for scientific publications. Communication skills in English.
- A problem-solving-oriented mindset, self-motivation, initiative, resourcefulness, and dependability. Ability to both work independently and as part of a team.
- For international student, a minimum IELTS score of 7.0 or TOEFL iBT score of 92 is required.

HOW TO APPLY

Interested applicants, please send your CV, copies of transcripts, support letters and previous publications (if any) to Dr. Mohammad Saeedi (mohammad.saeedi@dal.ca) and Dr. Emmanuel Witrant (emmanuel.witrant@univ-grenoble-alpes.fr) using the subject line "PhD Position Application – Automatic Sail".

OTHER DETAILS

All qualified applicants are encouraged to apply. However, only candidates under consideration will be contacted. The starting date is as early as possible.