Postdoctoral opportunity on the real-time deterministic wave prediction applied to floating wind turbines.

Location: LHEEA Lab at Centrale Nantes (France)

Contract duration: 18 months (with possible extension)

Expected starting date: September, 2021

Recommended skills: Numerical analysis; scientific computing; programming proficiency; PhD thesis in applied mathematics or related field; writing skills; English language proficiency.

Contact details: Interested candidates should submit a cover letter, statement of research, curriculum vitae and two reference letters to yves.perignon@ec-nantes.fr, guillaume.ducrozet@ec-nantes.fr and jean-christophe.gilloteaux@ec-nantes.fr

Applications close: Open until filled

Context

Centrale Nantes has a new postdoctoral position available within the framework of two funded projects: EU (H2020) FLOATECH and French (ANR) CREATIF. Both those collaborative projects aim at increasing the technical maturity and the cost competitiveness of floating offshore wind energy. Among the different objectives, a numerical tool will be developed to predict in real-time the wave field from a set of measurements.

Within this project, Centrale Nantes is seeking a person to work on the enhancement of the numerical efficiency of a recently developed wave prediction algorithm [1]. The procedure relies on i) the spatio-temporal optical measurement of the free surface (using LIDAR pointing toward incoming waves), ii) a data-assimilation procedure and iii) the wave propagation up to the location of the floating wind turbine. With the final objective of using this algorithm in operating conditions on real wind turbines, it needs to operate faster than physical time (allowing control strategies of wind turbine for instance).

Work description

Phase-resolved wave prediction is an active research topic in recent years. At Centrale Nantes, earlier works [1, 2, 3] conducted by the implied research team focused on defining the relevant wave model to achieve a given level of accuracy for a target prediction horizon.

To date, the physical wave models are mastered and implemented. The complete problem is consequently accurately formulated with an existing implementation of the whole prediction procedure (written in Python). The remaining bottleneck toward practical application is the computational effort that should be enhanced during the proposed research work.

This project is initially planned through different tasks that may be adjusted regarding the evolution of the research activities.

- Development of efficient solutions of the linear inverse problem

This task is the central part of the project. The wave prediction algorithm, after data assimilation procedure and the use of relevant wave propagation models, reduces to a least squares problem. In practical applications (due to spatial distribution of measurements, noise, etc.), it appears necessary to regularize the problem, which is then solved in the present implementation thanks to Singular Value Decomposition.
The successful candidate will propose, implement and test the efficiency of alternative numerical methods for the solution of this linear discrete inverse problem in the present numerical code. The objective is to compare the efficiency and robustness of the different numerical strategies with the constraints associated to the application targeted.

- Development of a real-time wave prediction simulation tool

This task intends to develop the final real-time numerical model, porting the actual Python implementation toward relevant programming language (Fortran, C++, etc.) if necessary. The implementation and developments will be carried out in a collaborative development environment (GitLab). This task will include a demonstrative example of the real-time efficiency of the wave prediction algorithm. This will use synthetic wave data representing possible measurements at sea in the case of unidirectional waves. The objective is to mimic realistic configurations for offshore wind turbines (amount of data, time scales involved, etc.). Once real-time is successfully achieved and demonstrated, the performance for multi-directional waves will be investigated and the possible bottlenecks identified.

- Application of the simulation tool to model-scale experiments

The funding projects include several other actions, including tests at model-scale that will be conducted in the experimental facilities of Centrale Nantes (ocean wave tank: 50m*30m*5m). Depending on the qualifications of the chosen candidate as well as the time-frame of the work conducted, participation to those experiments is possible.
This will at least involve the application of the real-time prediction model to the wave-basin experiments. Experimental free surface measurements will be used to predict the wave field propagating on the model-scale offshore wind turbine.

According to the progress of the work, the postdoctoral researcher will be able to work on complementary tasks relevant with his background. For instance: extension of the simulation tool to directional wave fields, application of data-driven strategies to the wave-prediction, inclusion of floating wind-turbine motions to the measurements, etc.

The position is available for 18 months, with renewal for additional 18 months upon performance and funding.

Objectives / Expected results

- Development of a real-time wave prediction numerical model
- Application/demonstration of the developed model to model-scale experiments
- Diffusion of the results in international conferences and top-ranked journals
- Work in a collaborative environment through the active participation to national and international consortia.

Technical skills and knowledge

Required qualifications are related to:

- PhD in Applied Mathematics or relevant field of engineering such as Fluid Dynamics, Inverse Problems, Signal Processing, etc.
- Experience in scientific computing and numerical analysis
- Proficiency in a scientific language: Python, Fortran, C++
- Previous experience in development in a shared environment would be appreciated
- Interest in ocean engineering problems
- Knowledge of the marine environment appreciated

Personal qualities:

- Autonomous and dynamic
- Ability to interact with researchers working on numerous and varied research topics

References

[1] Desmars, N., Bonnefoy, F., Grilli, S. T., Ducrozet, G., Perignon, Y., Guérin, C. A., & Ferrant, P. (2020). Experimental and numerical assessment of deterministic nonlinear ocean waves prediction algorithms using non-uniformly sampled wave gauges. *Ocean Engineering*, *212*, 107659.

[2] Guérin, C. A., Desmars, N., Grilli, S., Ducrozet, G., Perignon, Y., & Ferrant, P. (2019). An improved Lagrangian model for the time evolution of nonlinear surface waves. *Journal of Fluid Mechanics*, *876*, 527-552.

[3] Desmars, N., Pérignon, Y., Ducrozet, G., Guérin, C. A., Grilli, S. T., & Ferrant, P. (2018, June). Phase-resolved reconstruction algorithm and deterministic prediction of nonlinear ocean waves from spatio-temporal optical measurements. In *ASME 2018 37th International Conference on Ocean, Offshore and Arctic Engineering*. American Society of Mechanical Engineers Digital Collection.