INTERNSHIP – LMI, INSA Rouen

Boundary Element Method for Wind Turbine Simulations

LMI - EA 3226

1 General informations

If interested, please contact:

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before october 31, 2018. Intership will start from january 2019.

Internship: "Boundary Element Method for wind turbine simulations" 6 months INSA Rouen Normandie approximately 1100/1200 euros per month

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Keywords: *Numerical simulation, Galerkin method, Boundary Element Method (BEM), Fast Multipole Method (FMM)*

2 Description of the subject

Introduction

This internship takes place in the general context of the development offshore wind energy in Normandie. Numerical simulation tools are an essential part of the design process and are used to analyze and validate designs of wind turbines. In this context, the goal of this internship is to study the efficiency of a BEM method for numerical simulations.

The project will be supervised by LMI. This topic has been proposed by ADWEN offshore through a subcontracting agreement between the LMI and ADWEN. ADWEN is a subsidiary of Siemens Gamesa Renewable Energy which is a world leader in the field of offshore wind turbine.

Description of the subject

We are interested in the numerical simulation of air flow around wind turbine blade. In order to consider realistic effects (like non-uniform incident wind), we cannot use "classical" approaches like Blade Element Momentum Theory or the methods of Computational Fluid Dynamics. Indeed, these methods are either too inaccurate or too costly. Recently, there has been a renewed interest in Boundary Element Method [3] since they enable to take into account realistic effects for reasonable computational costs.

To discretize the integral equation involved in BEM, we can consider three approaches:

1. <u>Collocation method:</u> this method is easy to implement but it is in general very dependent on the choice of the collocation points and the convergence is not ensured.

2. <u>Galerkin method:</u> this second approach is more difficult to implement but has the strong advantage to ensure stability and convergence. Moreover, to exactly compute the integral term and avoid numerical quadrature we would like to use the recent method proposed by M. Lenoir and N. Salles [1,2].

3. <u>Fast Multipole Method:</u> this third approach consists in developing the kernel involved in integral equation as a series expansion [4], yielding an approximate solution that converges quickly in the far field. This method is interesting since it avoids the complexity of integral computation and it considerably reduces the computational cost of an iterative resolution.

Goals for the internship

The purposes for the internship are the following:

- Implementation of the Fast Multipole or Galerkin Method as a prototype in Matlab.
- Evaluation of the implemented method and comparison with the existing Collocation point method (uncertainties, convergence rates, computational costs)
- If time permits, implement a parallelized version of the method or implement a prototype for the remaining method

3 Bibliography

. [1] Lenoir M. Influence coefficients for variational integral equations. Comptes Rendus Mathematique, 343(8), 561-564. (2006)

. [2] Lenoir M. & Salles N. Evaluation of 3-d singular and nearly singular integrals in Galerkin BEM for thin layers. SIAM Journal on Scientific Computing, 34(6), A3057-A3078. (2012)

. [3] Sauter S. A. & Schwab C. Boundary element methods. In Boundary Element Methods (pp. 183-287). Springer Berlin Heidelberg. (2010)

. [4] Rokhlin V. Rapid Solution of Integral Equations of Classic Potential Theory. J. Computational Physics, Vol. 60, pp. 187–207. (1985)