Parameter control in the presence of uncertainties

Msc research internship proposal

Supervisors

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Location

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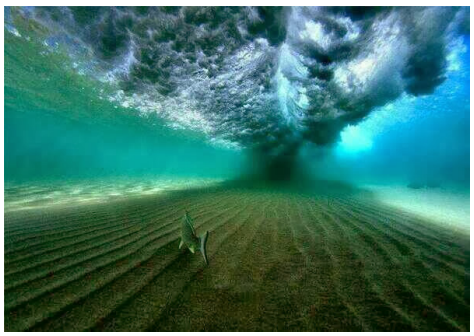
Keyword

optimal and robust control
sensitivity analysis

Context

Many physical phenomena are modelled numerically in order to better understand and/or to predict their behaviour. However, some complex and small scale phenomena can not be fully represented in the models. The introduction of ad-hoc correcting terms, can represent these unresolved processes, but they need to be properly estimated.

A good example of this type of problem is the estimation of bottom friction parameters of the ocean floor. This is important because it affects the general circulation. This is particularly the case in coastal areas, especially for its influence on wave breaking. Because of its strong spatial disparity, it is impossible to estimate the bottom friction by direct observation, so it requires to do so indirectly by observing its effects on surface movement. This task is further complicated by the presence of uncertainty in certain other characteristics linking the bottom and the surface (eg boundary conditions). The techniques currently used to adjust these settings are very basic and do not take into account these uncertainties, thereby increasing the error in this estimate.



Topic description

Available methods, based on the optimal control theory, allows for determining an optimal parameter set for a given criteria. This is done by minimising an appropriate objective function. In this framework, one can extend this approach, using what is sometimes called robust control, in order to take into account the uncertainties on external conditions. Typically, one then seeks an optimal parameter set that would minimise the variance or the mean of the original objective function. This has never been applied to this problem and need to be adapted for large scale problems.

After a bibliographic study on these algorithms, the student will conduct a preliminary study on a simple 1-D free surface equation, with variable bottom friction. This study will consist in first setting up a classical optimal control algorithm and perform sensitivity analyses on the impact of uncertain boundary condition upon the estimation of the optimal bottom friction parameters. The second part of this study will see an extension of this problem to the so-called "robust" approach mentioned above.

The internship will be conducted within the Airsea team at Laboratory Jean Kuntzmann, and could lead to a PhD.

Prerequisites

— Applied math skills (optimisation, numerical analysis, probability / statistics)
— Programming skills (Matlab, python, C or Fortran)

Bibliographie Sahinidis, N. (2004). Optimization under uncertainty : state-of-the-art and opportunities. Computers & Chemical Engineering, 28(6-7), 971–983. doi :10.1016/j.compchemeng.2003.09.017