Parallel in time algorithms for data assimilation.

Internship proposal

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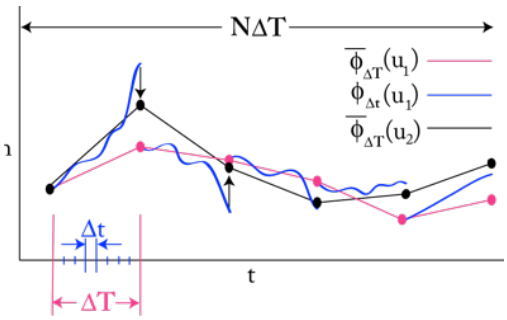
Keywords

Data assimilation, optimal control, multigrid, high performance computing, parallel in time.

Description

Variational data assimilation[1] is a very common method for the initialisation of numerical models. It is widely used for instance in Numerical Weather Prediction systems (Météo-France, UK MetOffice, ...). It aims at finding an optimal initial solution that will bring the model trajectory closer to observations of the system over a given time window. This is done using optimal control techniques where a cost function depending on the sought initial condition is minimised using an iterative method.

Recent trend in computing resources leads to a spectacular increase in the number of numerical cores while the efficiency of said cores remain stable. This implies that new sources of parallelism have to be found in demanding applications. Even though the model can be fully parallel, variational data assimilation algorithms are by essence sequential (minimisation). A possible way out is to increase parallelism through the time dimension using Parareal[3,4]- or Pita[2]-type approaches. Here a coarser (cheaper) problem is solved on the entire time window, then the time dimension is split into separate sub-windows where the full problem is solved in parallel starting from initial conditions given by the coarser solution. This process is iterated several times until convergence.



Schematic representation of the parareal algorithm

The topic of this internship is to study, on a simple case, the interactions between iterations of the data assimilation minimisation and of the parallel in time algorithm. Specific focuses will be on their convergence properties and on proper and efficient ways of preconditioning. If time permits, this can be extended to the so-called weak constraint variational data assimilation where the full 4D model trajectory is controlled instead of the initial condition only.

This internship may lead to a PhD

prerequisites

- Basic knowledge in numerical analysis and optimisation.
- Programming skills in python and/or Fortran.

Bibliographie

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[4] Maday, Y., and Turinici, G. (2003). Parallel in time algorithms for quantum control : Parareal time discretization scheme. International Journal of Quantum Chemistry, 93(3), 223–228. doi :10.1002/qua.10554