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Extended Abstract

Archives of Physics Research, 2021, 13 (8)
(https://www.scholarsresearchlibrary.com/journals/archives-of-physics-research/)

ISSN 0976-0970
CODEN (USA): APRRC7

From order to disorder in ensembles: Back and forth localization and pattern formation in hierarchies

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Present a universal framework for generation, analysis and control of non-trivial states/patterns in the complex systems like kinetic hierarchies describing general set-up for non-equilibrium dynamics and their important reductions. We start from the proper underlying functional spaces and their internal hidden symmetries which generate all dynamical effects. The key ingredients are orbits of these symmetries, their representations, and local nonlinear harmonic analysis on these orbits. All these provide the possibility to consider the maximally localized fundamental generic modes, non-linear (in case of the non-abelian underlying symmetry) and non-Gaussian, which are not so smooth as Gaussians and as a consequence allowing to consider fractal-like images and possible scenarios for generation chaotic/stochastic dynamics on the level of representation theory. As a generic example we consider the modeling of fusion dynamics in plasma physics. Recent advances in the computational capability for computational fluid dynamics (CFD) simulations have resulted in typical problems that require parallel computing involving a large number of processors. Therefore, it becomes imperative for developers to optimize codes for efficiency during a simulation and ensure parallel scalability. Data interpolation between overlapping domains, such as in overset grids or adaptive grids, requires a sufficiently fast search algorithm to find donors and their corresponding interpolation weights. One such class of search algorithms requires identification of a node’s host element on the donor grid, which is called localization. Grid adaptation may be utilized in a time-dependent simulation to retain the desired time accuracy. Subsequent grid modifications require a solution transfer at the current time step. If an implicit time integration scheme is used, the solutions at previous time steps (backplanes) also need to be transferred from the background grid to the receptor grid. Second-order finite volume methods require trilinear interpolation for an accurate solution transfer, which ensures local second-order spatial accuracy. A further increase in accuracy may be achieved using a conservative interpolation scheme, which is needed as well for simulations involving fluid-structure interactions. A major impediment of an accurate interpolation scheme is the ability to efficiently localize nodes of the receptor grid to the enclosing elements of the background grid. In addition to solution transfers.

For grid adaptation, applications of such localization algorithms include other CFD related concerns such as grid sequencing , overset grid interpolation, and particle tracing algorithms. Noack applied octree based data structures to perform the stencil search for overset interpolation. An improved method using kd-tree based data structures was demonstrated for actuator blade source interpolation by Lynch et al.. Roget and Sitaraman employ an alternating digital tree based data structure for overset interpolation stencil searches. Additionally, they explore subdividing the domain into blocks to help speed up the search procedure. Other efforts that use tree-based data structures to perform searches include Plimpton et al. and Lee et al. An accurate interpolation scheme requires a sufficient interpolation stencil. The search process of each node’s interpolation stencil in an adaptive grid may become a bottleneck in terms of computational cost. An exhaustive naïve search process for stencils requires O.Nnodes Melems/ searches, where Nnodes is the number of nodes in the receptor grid and Melems is the number elements in the background grid. Independent load balancing of the receptor (or adapted) grid will complicate the parallel search algorithm. Therefore, a novel approach is presented involving a sweeping advancing front scheme that robustly expedites localization and results in an overall cost of O.Nnodes/ searches. This scheme utilizes neighbor walks, which speed up individual searches. Schemes based on neighbor walks have shown promise on serial applications to minimize the number of searches. Löhner et al. extended this method for distributed systems by the use of bounding boxes to limit the number of parallel queries. However, this method limits itself to grids that have sufficient overlap rather than grids that are independently partitioned or load balanced. Plimpton et al. address this concern with the introduction of a separate “rendezvous” decomposition that geometrically balances the background and receptor grids using a recursive coordinate bisection partitioning algorithm.

Bottom Note: *This work is partly presented at 5th International Conference on Theoretical and Applied Physics*