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Detection of Coherent Structures in a Flow Interaction with Large Dataset

Introduction

An important challenge in the analysis of large dataset coming from fluid dynamics (numerical or experimental dataset) is detection and tracking of coherent structures, such as eyes of vortices, curves or planes splitting the flow into distinct areas, etc. Such structures actually constitute *the skeleton* of the flow and their topology constrains the velocity field, and may sometime be only catch by exploration of the dataset.

Lagrangian Coherent Structures

- Lagrangian point of view (not eulerian field, such as velocity)
 - Material frontiers

N^o 8

- Physical relevant manifolds and hyperbolic points
- Less sensible to noise (intrinsic average) 3.
- Relevant for mixing properties or Areas identification
- Time-consuming (computations based on particle trajectories)
- Ridges of the scalar field of material divergence rate (III-posed problem) We then have to overcome these two \mathbf{X} points!

Done through :

- Physics side: New paradigm
 - \rightarrow Trajectories are seen as elements of the state vector
 - \rightarrow Chasles' property of the dynamical flow allows...
- Computer science side:
 - \rightarrow Parallelization
 - \rightarrow SIMD implementation
 - \rightarrow GPU programming

Interaction with Complex Dataset

Exploration is crucial, for the identification of structures, especially in 3D flows. Therefore, we develop platforms for interaction with dataset.



Haptic interaction :

- \rightarrow Multimodal interaction
- \rightarrow Attraction to areas of interest
- \rightarrow 6DoF interaction
- \rightarrow Fields comparison (Eulerian vs Lagrangian)



Achieved Work

Fast Computation of Lagrangian Structures



- An efficient algorithm has been developed.
- \rightarrow Gain larger than $\times 100$.







\rightarrow User Friendly \rightarrow 3DoF interaction \rightarrow Particle seeding

- Others modalities :
- \rightarrow Cutting planes
- \rightarrow Isosurface(s)
- \rightarrow 1D3C physically relevant rendering \rightarrow Time evolution

Present and Future works

- Portable platforms for interaction
- Comparison of Lagrangian Fields and Poincaré maps in chaotic flows
- Comparison of Lagrangian Fields in 2D and 3D flows 3
- Comparison of Lagrangian Fields and Eulerian Fields

Productions

Blue is for mechanical contributions, and red is for Computer-Human Interaction

Ridges of the scalar field, with experimental 2D dataset (top) and numerical 3D dataset (bottom).

ones.

- papers in French congress
- + 2 papers in International congress
- paper submitted in a International journal

1 papers in preparation for submission in International journals





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