Oscillating Pattern Decomposition (OPD)

Flow stability analysis of Time-resolved PIV data

Applications
- Analysis of TR-PIV vector fields
- Temporal flow stability analysis

Features
- DynamicStudio add-on
- Import of PIV data
- Transient nonmodal growth and pseudospectra

**OPD analysis of a pulsed jet.** Left: spatial representation of the least stable OPD mode, Right: e-fold time (i.e. decay time) of the OPD modes plotted against their associated frequencies. The OPD highlights convected vortices and exactly captures the excitation frequency.

Flow stability analysis

The goal of any fluid dynamic research is the uncovering of dominant mechanisms that govern the system behavior.

Current state-of-the-art instrumentation systems produce huge amounts of high-quality data with remarkable temporal and spatial resolution, comparable to numerical simulations.

The extraction of physical mechanisms from experimental data is very limited and far behind the capabilities of numerical methods and OPD closes the gap between experimental data and quantitative flow analysis. Decomposition methods are based on the idea of representing the fluid-system state by a state vector in state space. In the case of velocity data, it consists of properly ordered velocity components from all points in space, subjected to experimental investigation.

Oscillation Pattern Decomposition defines modes according to their stability properties; the most stable modes (meaning longer-lasting modes) are more important here.

The results of the analysis are sets of spatial modes. The OPD can be applied on time–resolved data only. It is based on stability analysis of the mean flow. Any fluctuation of the flow is then considered to be a kind of perturbation, which either can grow in time (if the flow is unstable), or decay (if the flow is stable).

Each OPD mode consists of a unique eigenmode and eigenvalue, both represented generally by complex numbers. The complex eigenmode represents a structure or pattern moving in space in a cyclic manner. The structure can be typically a wave or a travelling vortex propagating in space. The complex eigenvalue contains information on the cyclical phenomenon frequency and decay in time. This knowledge has a unique feature: it allows
The differences between POD and OPD

<table>
<thead>
<tr>
<th>POD</th>
<th>OPD</th>
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<tbody>
<tr>
<td>Coherent structures based on spatial (or temporal) correlation</td>
<td>Modal structures based on temporal linear evolution dynamics</td>
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<tr>
<td>Each POD mode may contain a broad mix of different frequencies</td>
<td>Each OPD mode has a single distinct frequency</td>
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<tr>
<td>Mixed frequencies leave phase information undefined</td>
<td>Phase information retained</td>
</tr>
<tr>
<td>No information about growth or decay</td>
<td>Modal growth/decay information retained</td>
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<tr>
<td>Ranking by energy content</td>
<td>Ranking by stability properties</td>
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Additional information

For additional information please contact your Dantec Dynamics representative.

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