

# Encoding Flow Topologies



## A Common Language for Flows and Topological Flow Data Analysis

Prof. Takashi SAKAJO (Kyoto Univ.) Prof. Tomoo Yokoyama (Kyoto Univ. of Edu.)

### 1. Conventional Technology

There are not a few Flow Analysis Systems in the market but they have some limitations and disadvantages;

- Limited range of searchable flows
- Lack of accuracy
- Too difficult to realize automatic Image recognition
- Unavailable information extractions

### 2. Our Technology

What is Topological Flow Data Analysis (TFDA) ?

■ A brand-new methodology for data analysis from topology:

Unique letters, called COT (partially Cyclically Ordered rooted Tree) and word representations, are assigned to a large number of flow patterns. We also obtain some qualitative/quantitative information associated with letters. The letters are able to be used as basis for new data analysis innovation in wide variety of application field.

■ Easy characterization:

Even if you don't know the mathematical theory, you can make the characterization from flow data by understanding the mechanism of conversion rules. And software for automatic assignment of the characterization is now available.

What are the Advantages of TFDA?

■ "DNA information" of Flow can be Extracted:

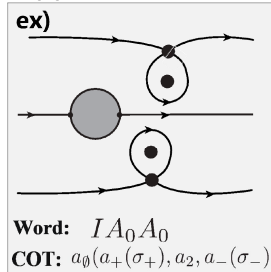
You can see each assigned letter represents a specific function.

■ Knowledge from the experience about flows can be Extracted:

Characteristic properties can be extracted by statistical processing of the letters.

■ Future predictions of flow patterns can be Available:

You will be able to predict in advance the possible changes of flows in future if you look at the letters without any exception.



### 3. Experiment: The lift acting on a wing

(a), (b) Consider a flow around an inclined flat wing in a uniform flow. It is starting to flow at  $t=0.0$ .

(c) In figure, word and COT representations are assigned to stream functions of the flows obtained by numerical simulation.

Numerical computation also yields the time-evolution of the lift-to-drag ratio acting on the flat plate.

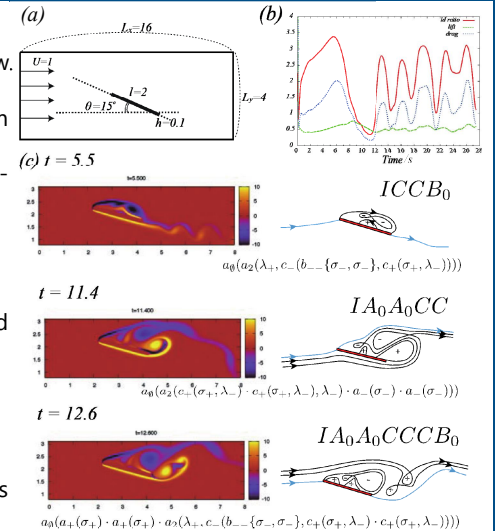
- The lift is maximal at  $t=5.5$  and  $t=12.6$ .
- It is minimal at  $t=11.4$ .

How should this calculation result relate to this consideration?

Using our technology, the streamline is extracted, and is assigned letters (in (c) right).

- There is the word sequence "CCB<sub>0</sub>" at  $t=5.5$  and  $t=12.6$ .
- There is no that at  $t=11.4$ .
- CCB<sub>0</sub>: The letter is a code for the existence of force enhancing vortex structure entrapped above the plate.

We can efficiently described situation by extracting patterns including "CCB<sub>0</sub>" for all data letters.



### 4. Applications

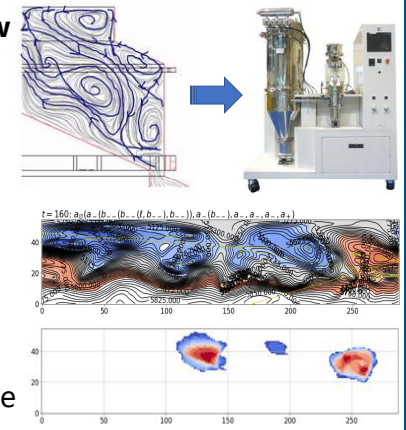
Any types of flow patters can be visualized in the flow field of medical engineering, environments and materials.

■ Design Optimization of Powder Jet Mill:

The design guidelines can be proposed from optimal device counting by streamline analysis for output of numerical calculations.

■ Judgment of extreme weather by weather maps:

By assigning a string of letters to a pattern of weather data to the weather map, the automatic judgement of extreme weather such as blocking phenomenon, can be available.



### 5. Patent Licensing Available

Patent No.: JP2019-139657, WO2014/041917(JP,US,EP,CN,IN,KR) WO2016/072515(JP,US,EP,IN), etc

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