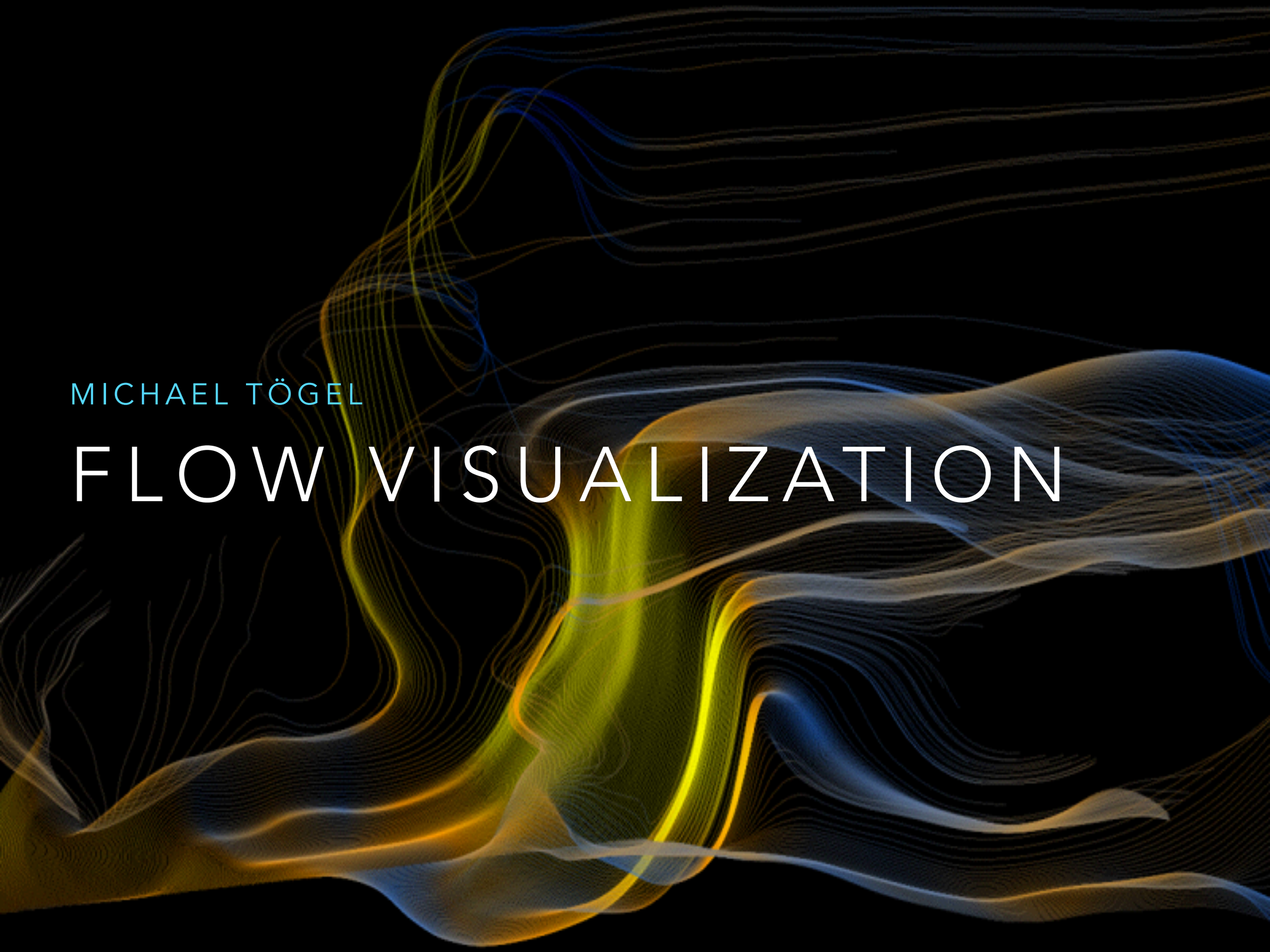
MICHAEL TÖGEL

FLOW VISUALIZATION



WHAT IS

FLOW VISUALIZATION?

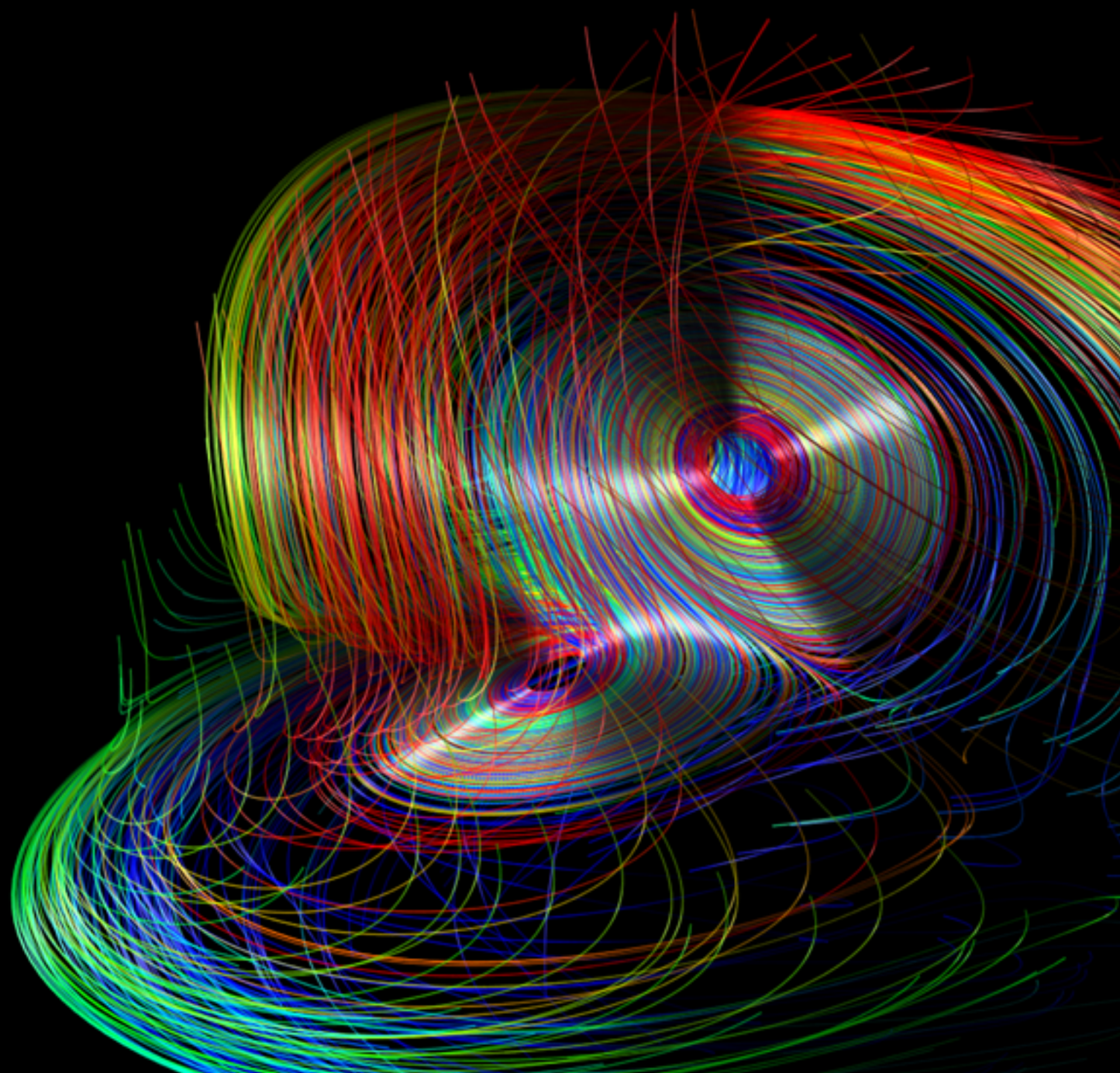
Used to make flow patterns visible

To get qualitative or quantitative information

http://www.fkfs.de/uploads/pics/kfz_bild_8-4-1_de_02.jpg

ABOUT FLOW VIS

- classic subfield of vis
- rich variety of applications
- automotive industry
- aerodynamics
- turbomachinery
- weather simulation
- medical visualization



The State of the Art in Flow Visualization: Dense and Texture-Based Techniques

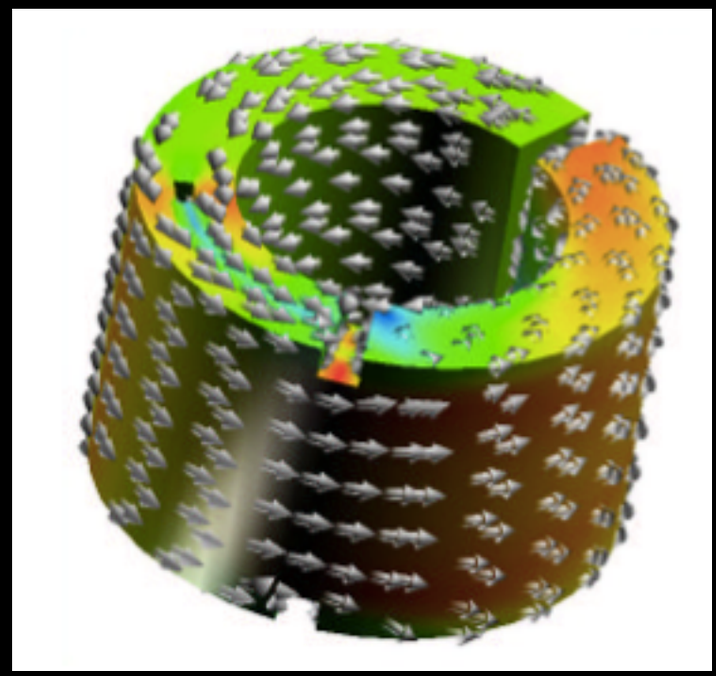
R. S. LARAMEE, H. HAUSER, H. DOLEISCH, B. VROLIJK, F. H. POST, D. WEISKOPF

www.winslam.com/rlaramee/star/index.html

DIFFERENT USERS...
...DIFFERENT APPROACHES

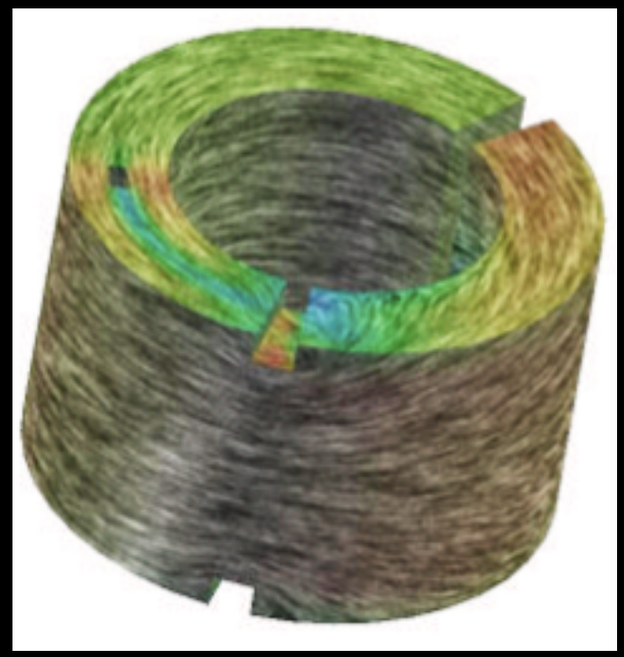
- Direct flow vis
- Dense, texture based flow vis
- Geometric flow vis
- Feature-based flow vis

DIRECT FLOW VIS



- „as direct as possible“
- Overall picture of the flow…
- … by„drawing arrows“ or color coding velocity
- Immediate investigation

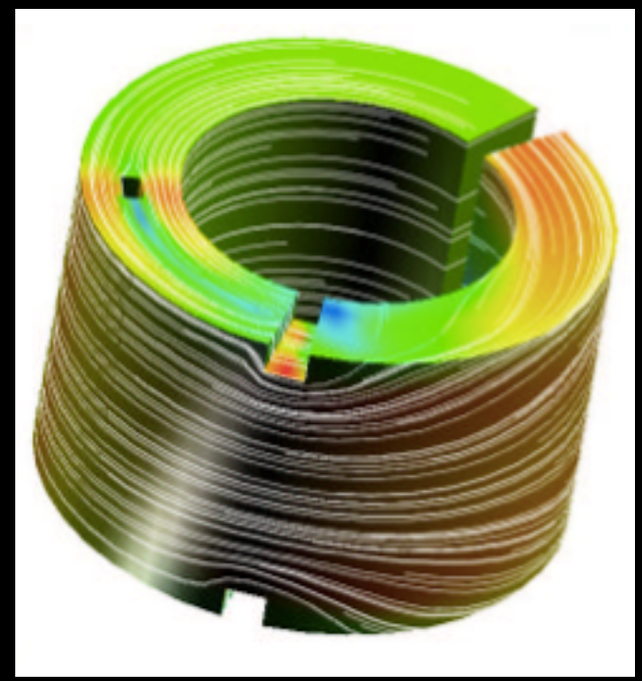
DENSE, TEXTURE BASED



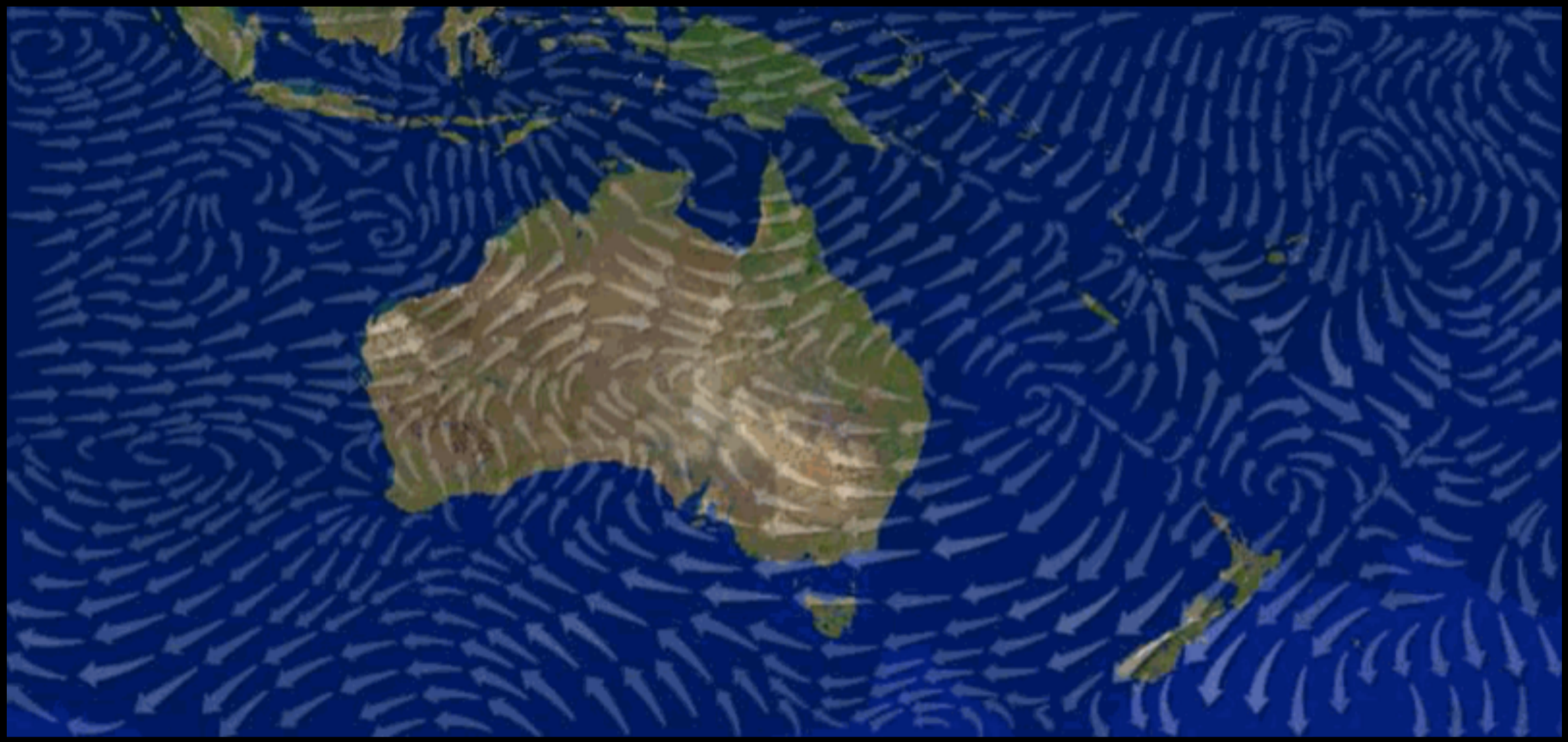
- Similar to direct flow
- Texture used to generate density
- Filtering of texture values

GEOMETRIC FLOW VIS

- Long term behavior of the flow
- Streamlines
- Streaklines
- Pathlines



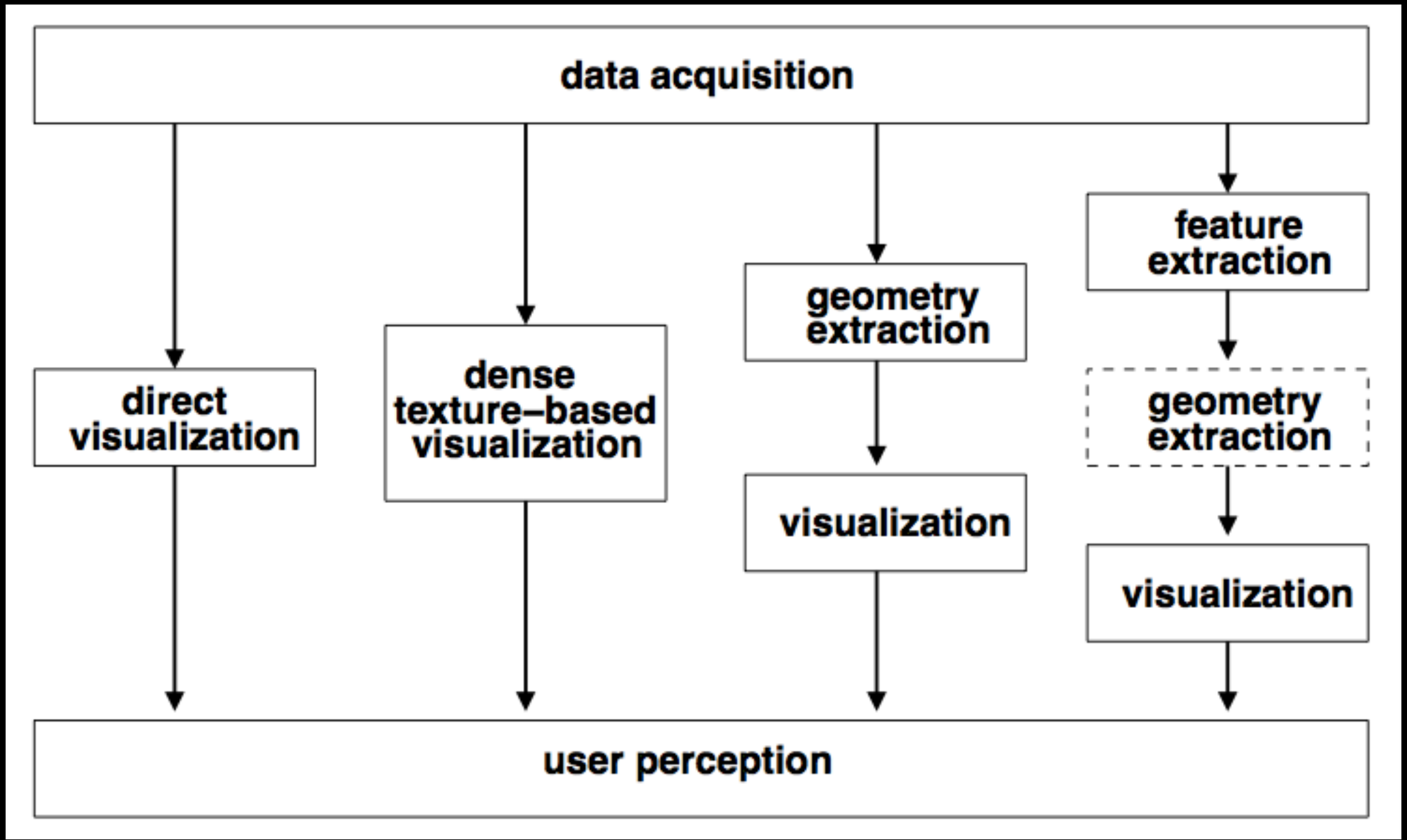
GEOMETRIC FLOW VIS



Arrows showing the wind direction and magnitude over Australia. The arrows are placed along streamlines.

From: *T. McLoughlin et al. / Over Two Decades of Integration-Based, Geometric Flow Visualization*

FLOW VIS TECHNIQUES



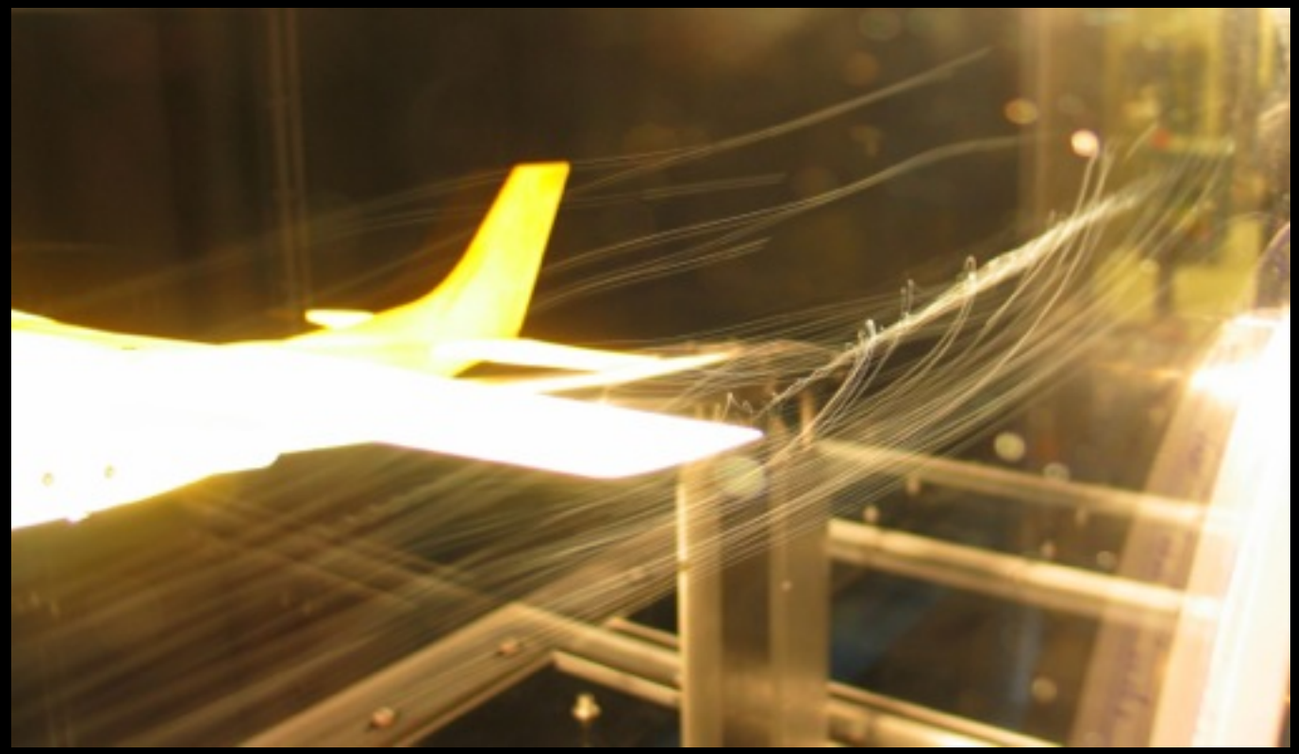
Direct Dense, Texture based Geometric Feature-based

FEATURE-BASED FLOW VIS

- First step: Abstraction / Extraction
  - important phenomena
    - topological information
- „Visualization of derived data"

DATA SOURCES

- flow simulation
- flow measurement
- analytic models of flows
  - dynamical systems
  - differential equations



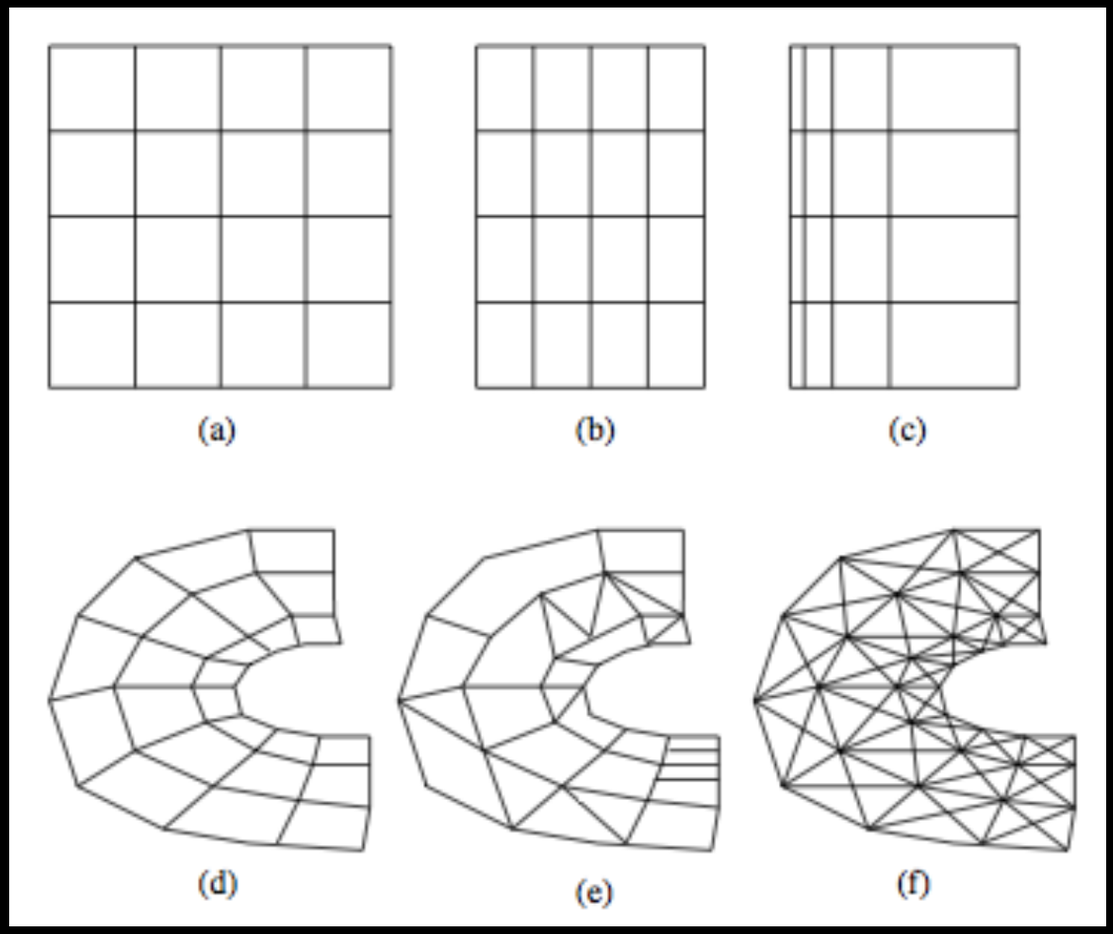
www.fkfs.de/uploads/pics/kfz_bild_8-4-1_de_02.jpg
http://upload.wikimedia.org/wikipedia/commons/c/cd/Cessna_182_model-wingtip-vortex.jpg

RECONSTRUCTION OF FLOW DATA

- Information given as vectors
- vector samples usually laid out across a grid
- We assume vector data is defined on grid nodes
- Different types of grids…

GRIDS

- Vector samples laid out across a certain grid
- (a) Cartesian
- (b) Regular
- (c) Rectilinear
- (d) Structured
- (e) Unstructured
- (f) Unstructured Triangular



DENSE AND TEXTURE BASED FLOW VIS

- Provide full spatial coverage of the vector field
- Different techniques:
  - Spot Noise Techniques
  - LIC (Line Integrated Convulution)
  - Texture advection & GPU-based

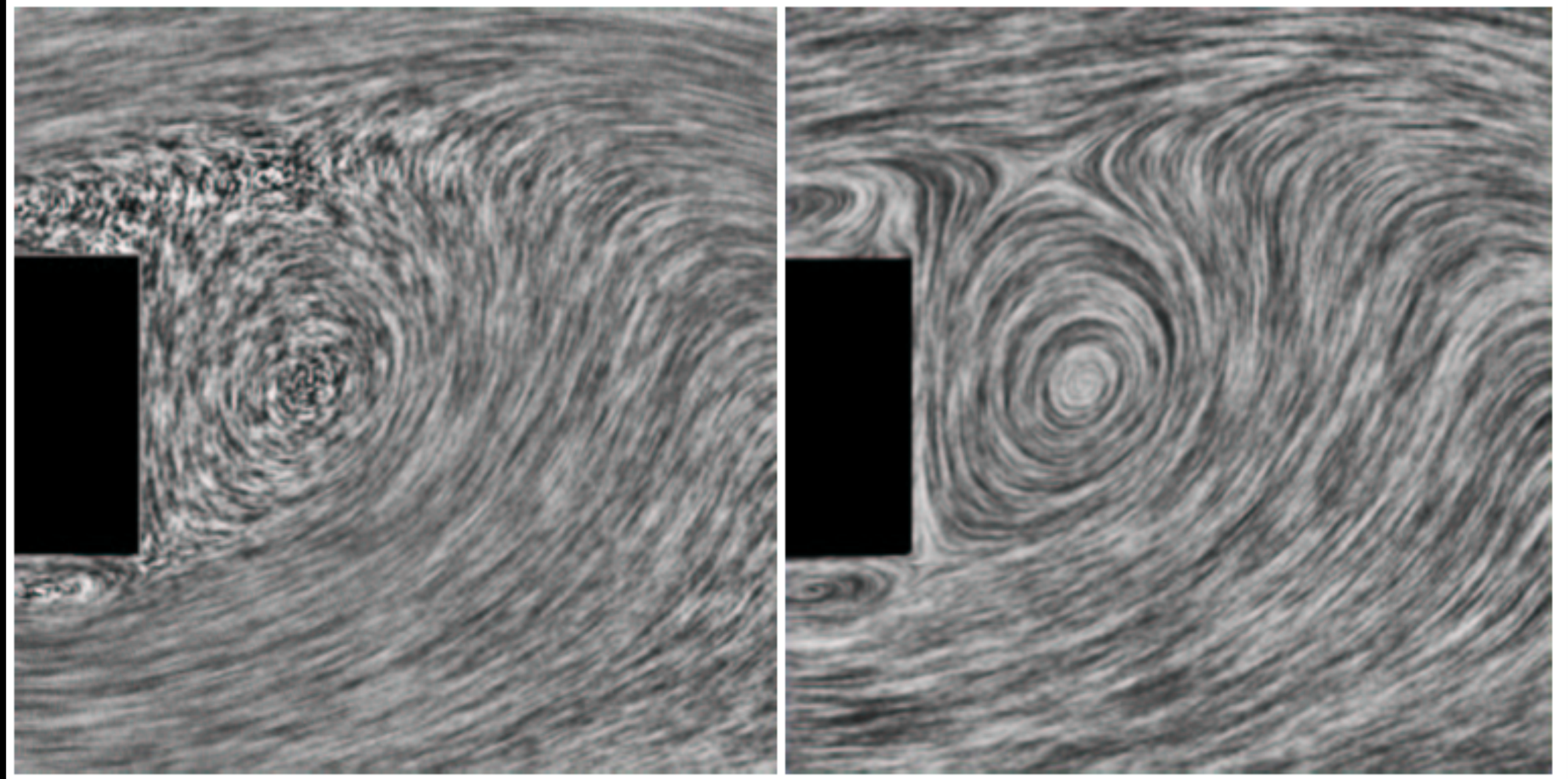
SPOT NOISE TECHNIQUES

- One of the first
- Introduced by Van Wijk
- Generates texture by distributing spots over domain
- Spot defined by:
  - intensity
  - scaling
  - position

LIC

- Introduced by Cabral and Leedom
- Inputs:
  - vector field on cartesian grid
  - white noise texture
- Pixels are correlated along the path of a streamline

SPOT NOISE VS. LIC

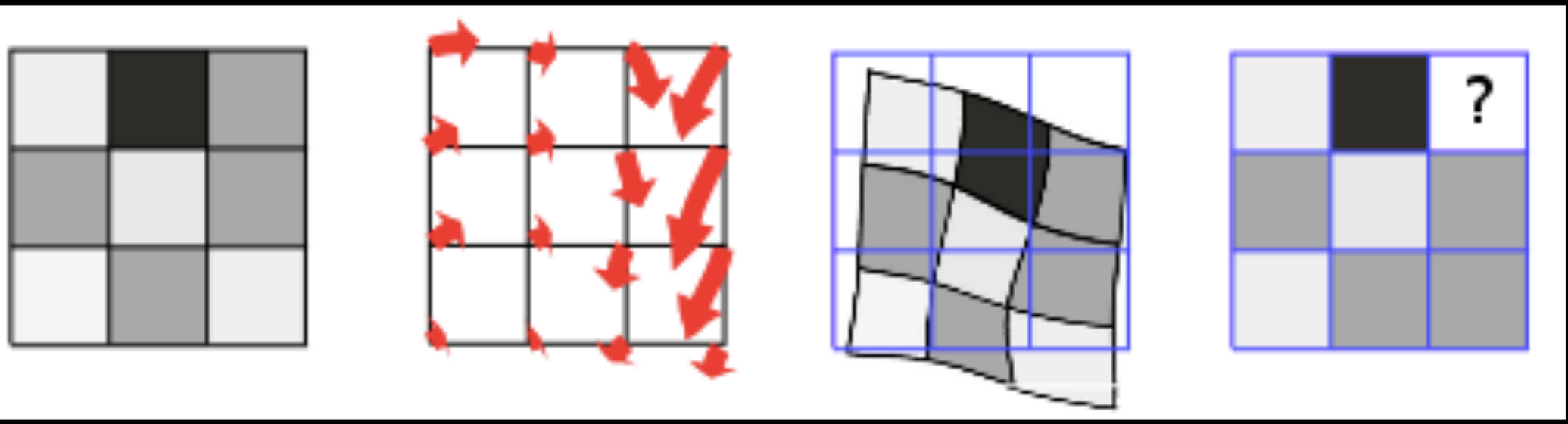


Visualization of a flow around a box
Spot Noise (left) against LIC (right)

TEXTURE ADVECTION AND GPU-BASED

- IBVF (by Van Wijk)
  - Tool: www.win.tue.nl/~vanwijk/ibfv/
- Core idea:
  - Create noise texture on a regular grid
  - Bend the grid according to the flow
- Produces a whole image in every step
- Almost realtime for 2D flow data

TEXTURE ADVECTION AND GPU-BASED



PRO'S

- Overview of current Flow Vis Techniques
- Easy to understand (even for beginners)
- Good graphical examples

CON'S

- Covered only theoretical how it's done
- No implementation examples*
- A few unexplained methods**

*Except for „Image Based Flow Visualization“: www.win.tue.nl/~vanwijk/ibvf

**For example: Data Sources - flow measurement: possible aquired through laser-based technology
But what are these laser-based technologies?

Over Two Decades of Integration-Based, Geometric Flow Visualization

T. MCLOUGHLIN, R. S. LARAMEE, R. PEIKERT,
F. H. POST, M. CHEN

www.cs.swan.ac.uk/~cstony/research/star/

PRO'S

- Concise introduction to flow vis research
- Very good graphical examples
- Overview of the solved and unsolved problems

CON'S

- Better overview in:
  - „The State of the Art in Flow Visualization“
- Covers only Geometric Flow Visualization