Visualization, DD2257

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Direct Vector Field Visualization

Direct or Elementary Methods

low level of abstraction

present all or most of the data

mapping is direct

no complex conversions

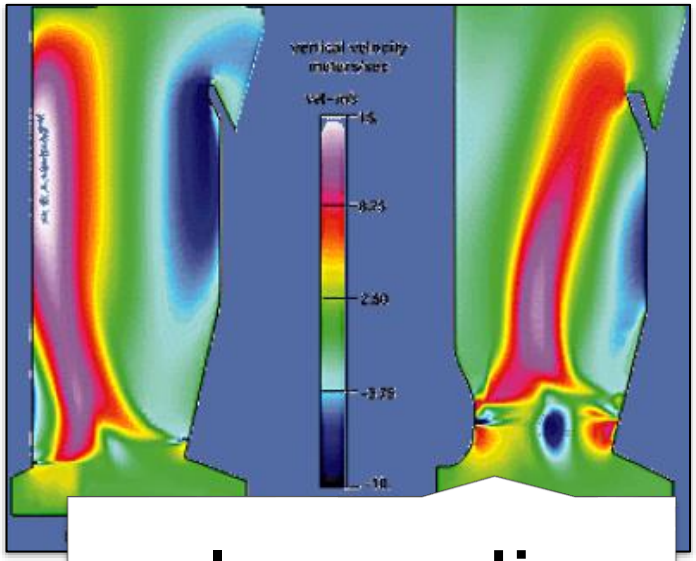
low cognitive effort

for reading local data

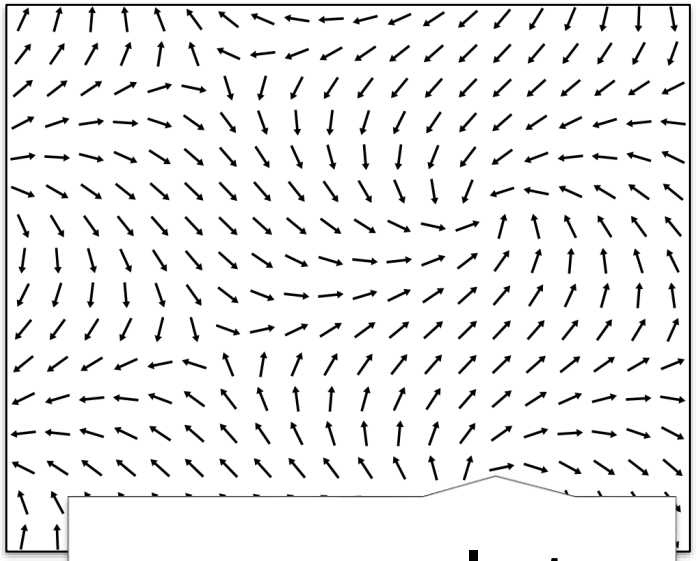
high cognitive effort

for understanding long-term behavior

very frequently used



color coding



arrow plots

Color Coding

extract scalar field

u, v, w-components, magnitude

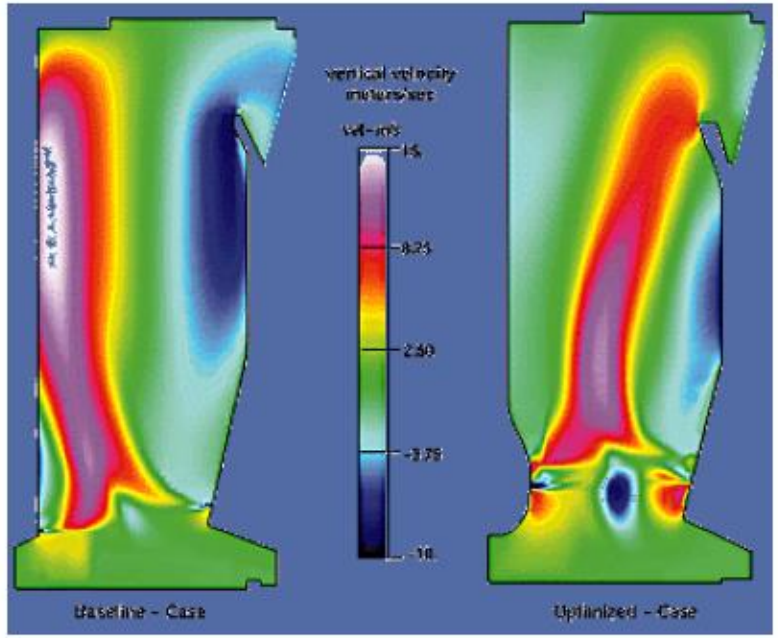
loss of information

apply methods from scalar field visualization

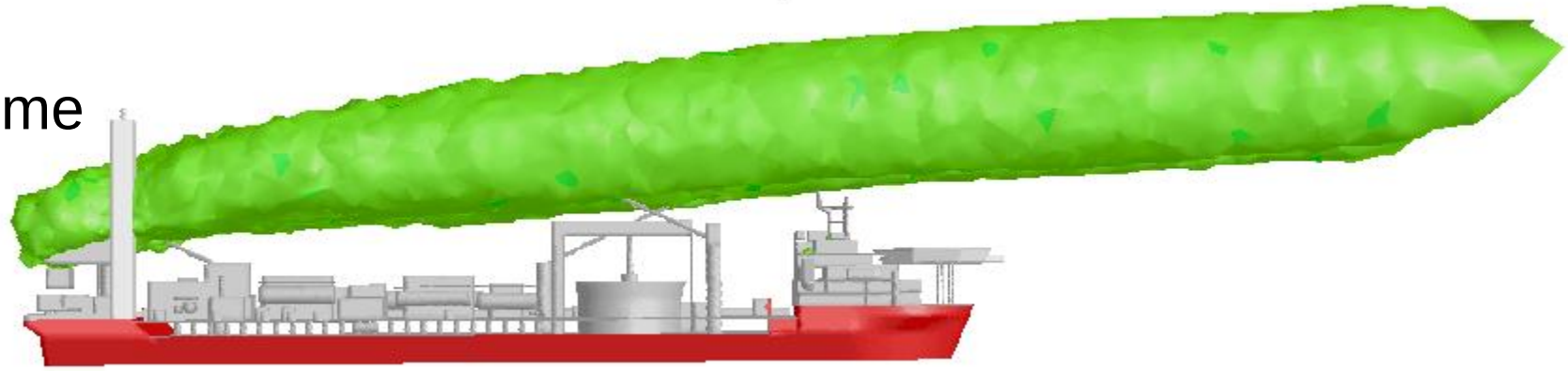
2D: color mapping

3D slices: color mapping

3D: isosurfaces, direct volume rendering

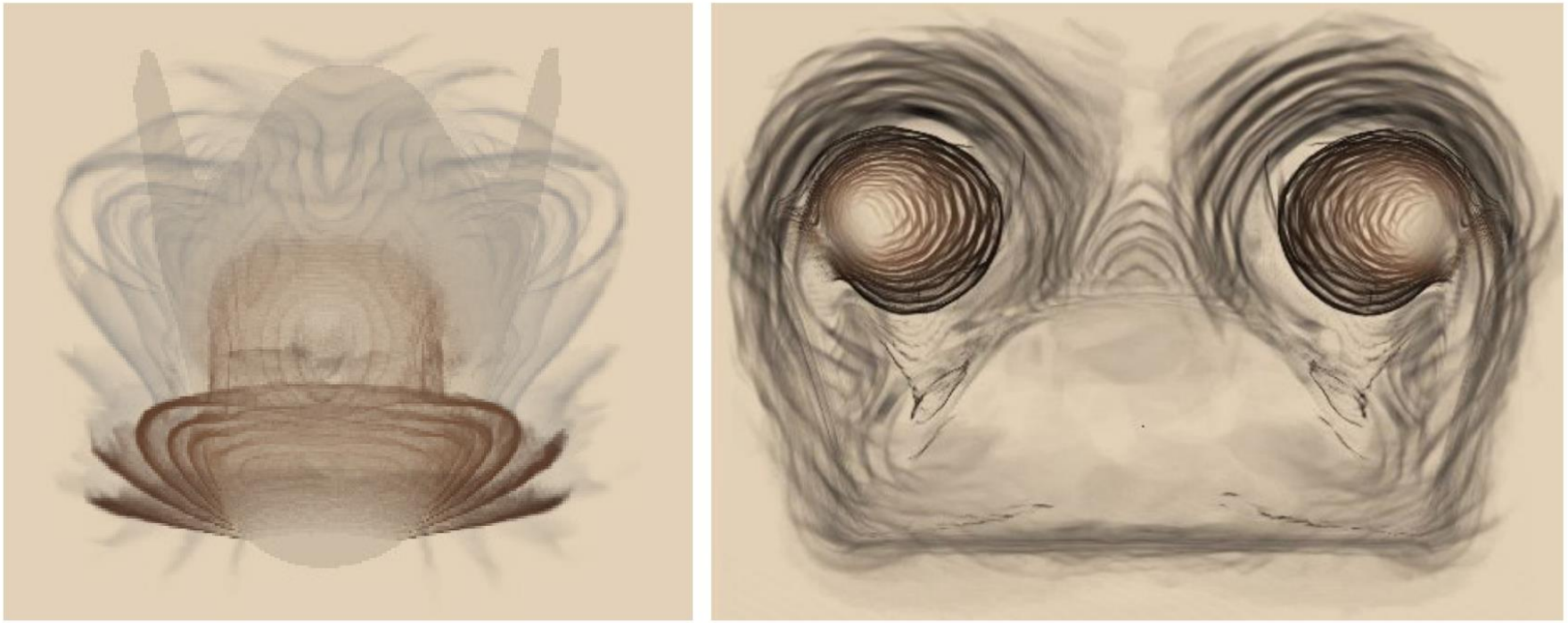


Vertical Velocity Distribution. The baseline condition illustrates the flow pattern expressing the vertical velocity components over the range front-10 to 15 m/s. The baseline case with only a single elevation of overfire air produces a high velocity flow channel attached to the front wall with an associated recirculation down the rear wall of the main combustor section. The optimized case includes a revised overfire air configured to centralize the vertical flow region. The peak vertical velocities and size of the recirculation zones are reduced in the optimized case.



images from www.fluent.com

Volume Illustration for Flow Visualization



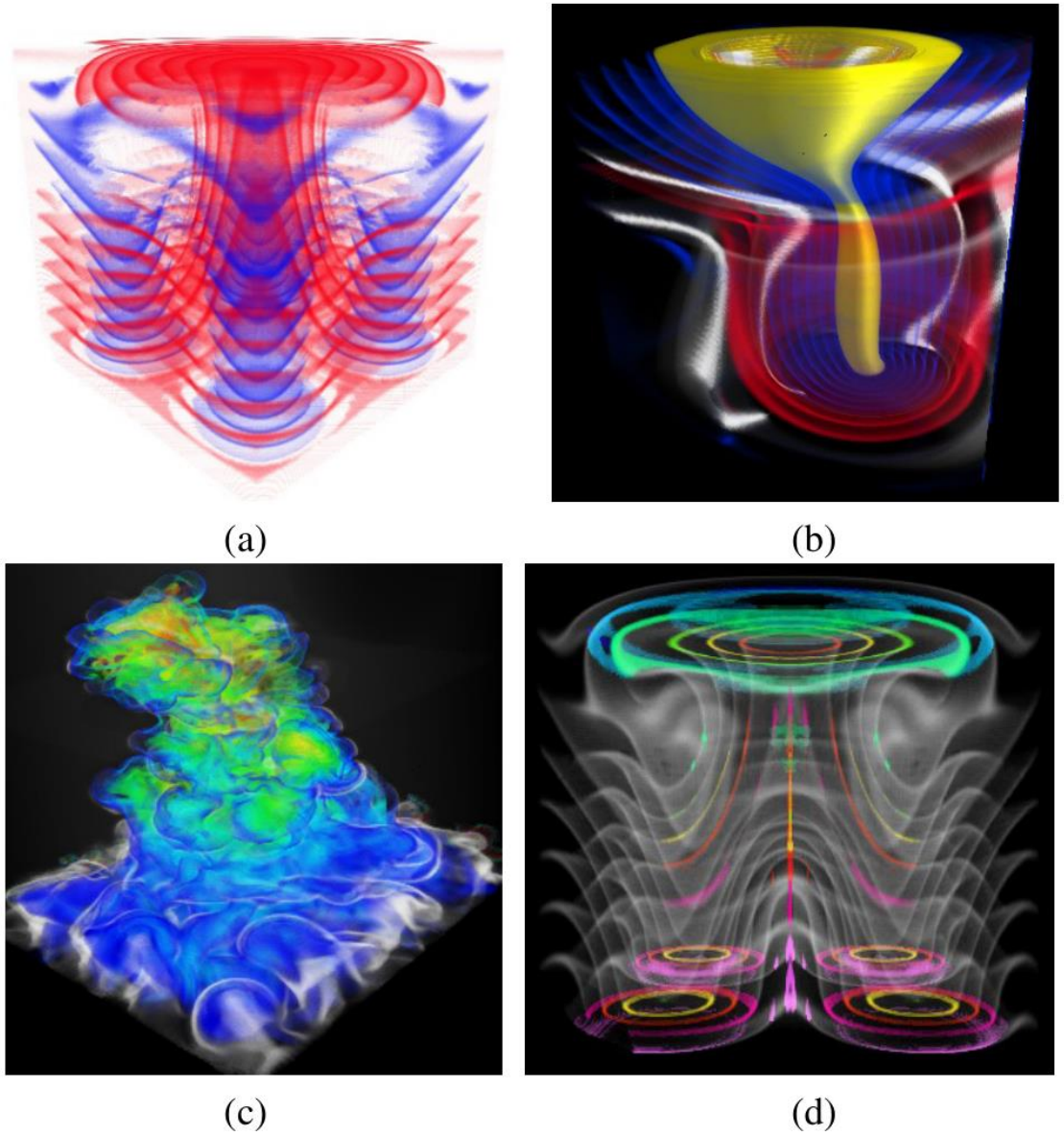
(a) (b)

Figure 3: Volume illustrations of flow around the X38 spacecraft. (a) is an illustration of density flow and shock around the bow, while (b) highlights the vortices created above the fins of the spacecraft.

images from Svakhine NA, Jang Y, Ebert D, Gaither K. Illustration and photography inspired visualization of flows and volumes. IEEE Visualization, 2005

Volume Illustration

Use of two-dimensional transfer function with the Laplacian operator and other flow quantities. (a) shows heat inflow (red) and outflow (blue). (b) shows all values of the Laplacian of velocity magnitude in the tornado dataset. (c) visualizes the cloud TKE using the Laplacian to highlight boundaries (white) and velocity for silhouetting. (d) highlights emerging flow structures in the convection dataset using banding of the second derivative magnitude of the temperature field.



images from Svakhine NA, Jang Y, Ebert D, Gaither K. Illustration and photography inspired visualization of flows and volumes. IEEE Visualization, 2005

Arrow Plots

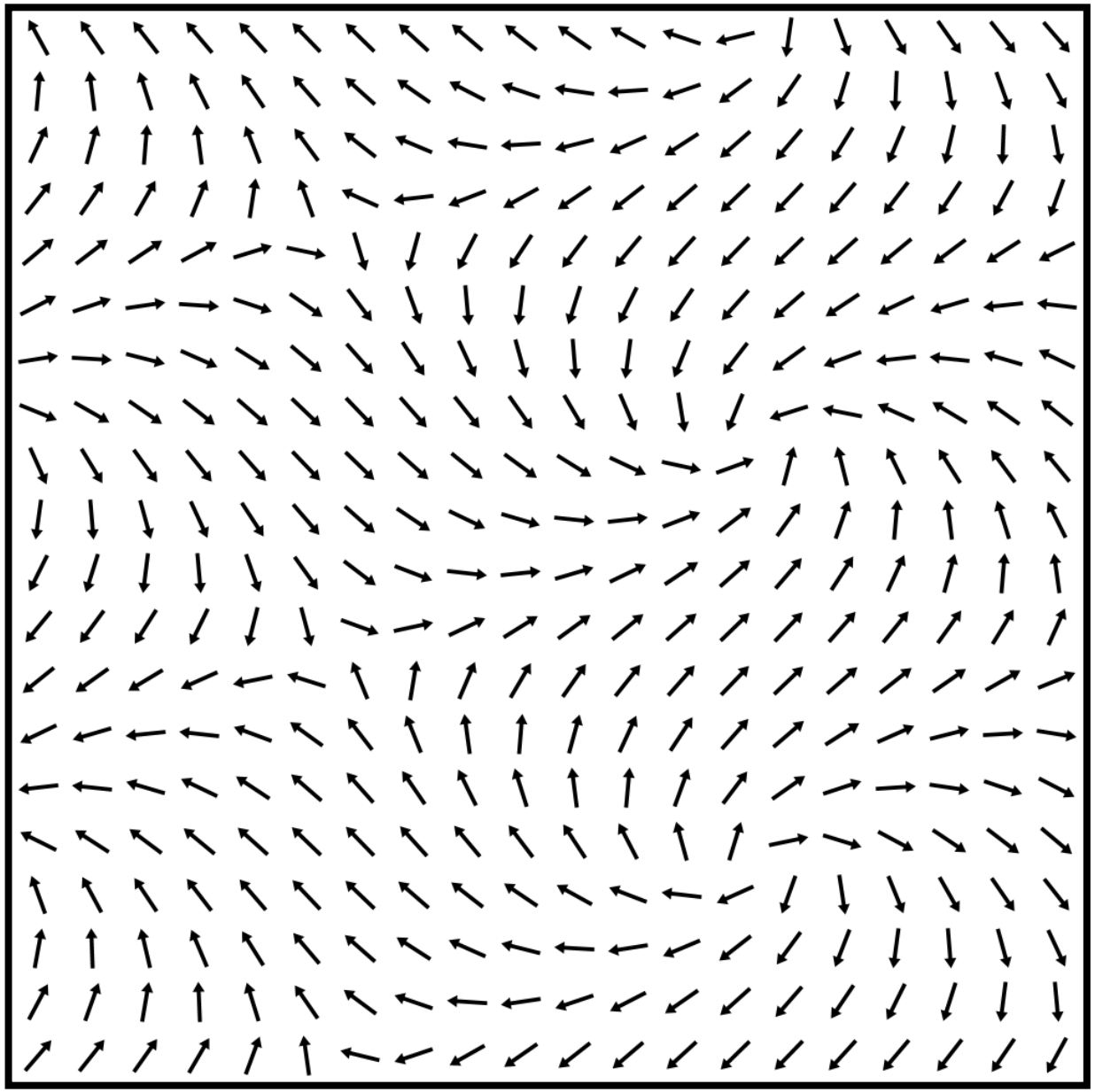
represent velocity as arrows at regular locations, e.g., place arrows at grid points

arrows: (scaled) unit length or encode magnitude

well-established for 2D

overloading possible

also called *hedgehog plots*



unit length arrows

Arrow Plots

represent velocity as arrows at regular locations, e.g., place arrows at grid points

arrows: (scaled) unit length or encode magnitude

well-established for 2D

overloading possible

also called *hedgehog plots*

original length arrows

Arrow Plots in 3D

occlusion problem

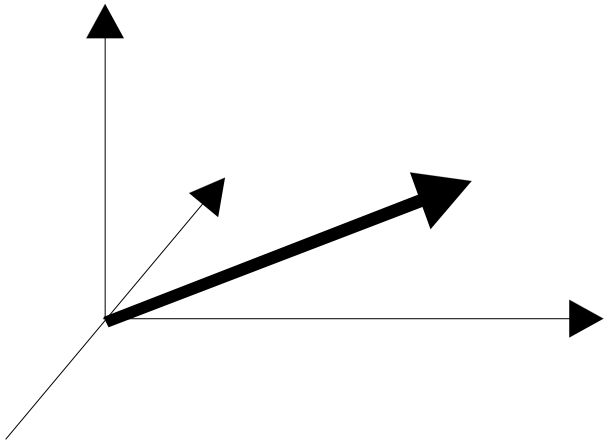
careful seeding

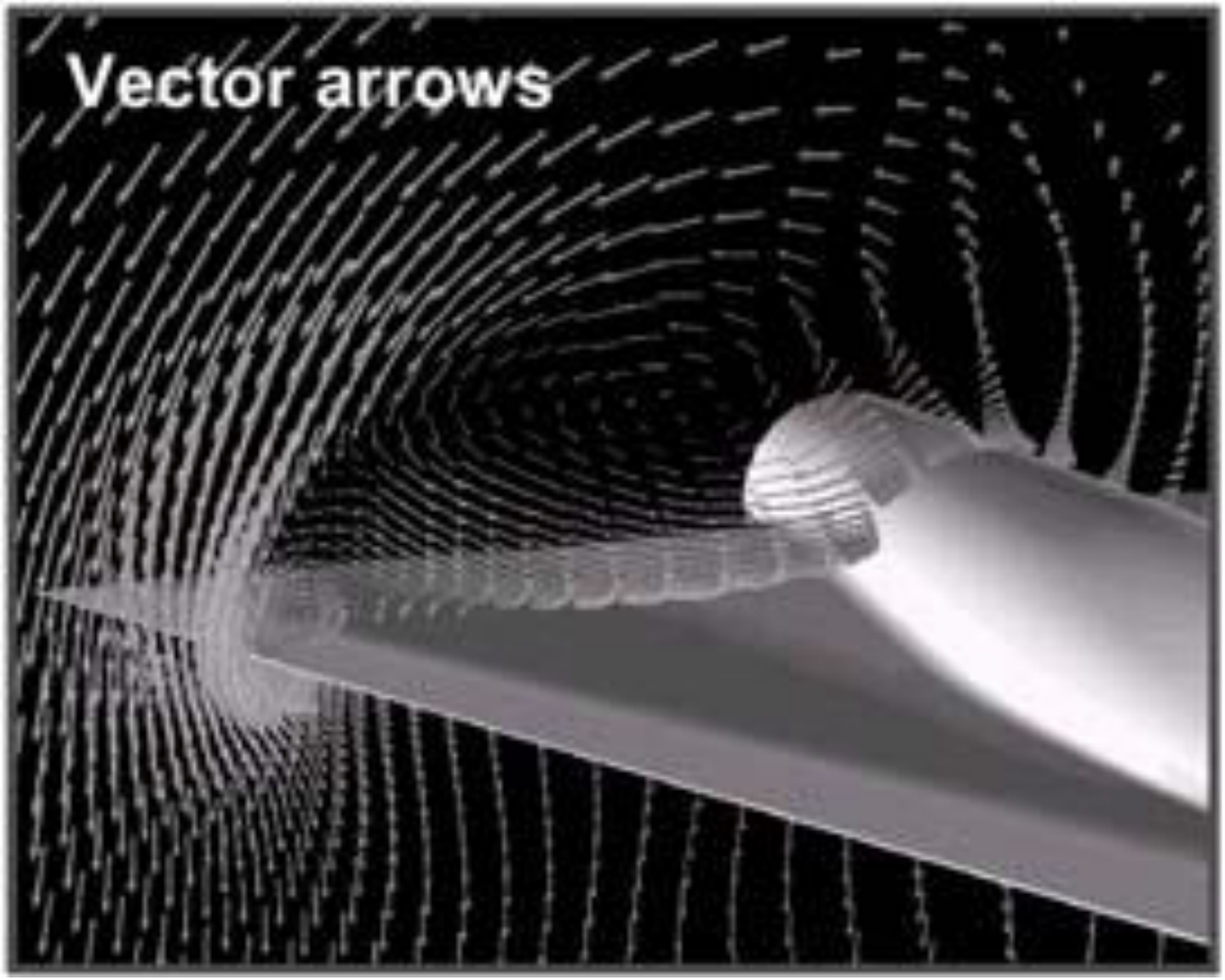
ambiguity problem

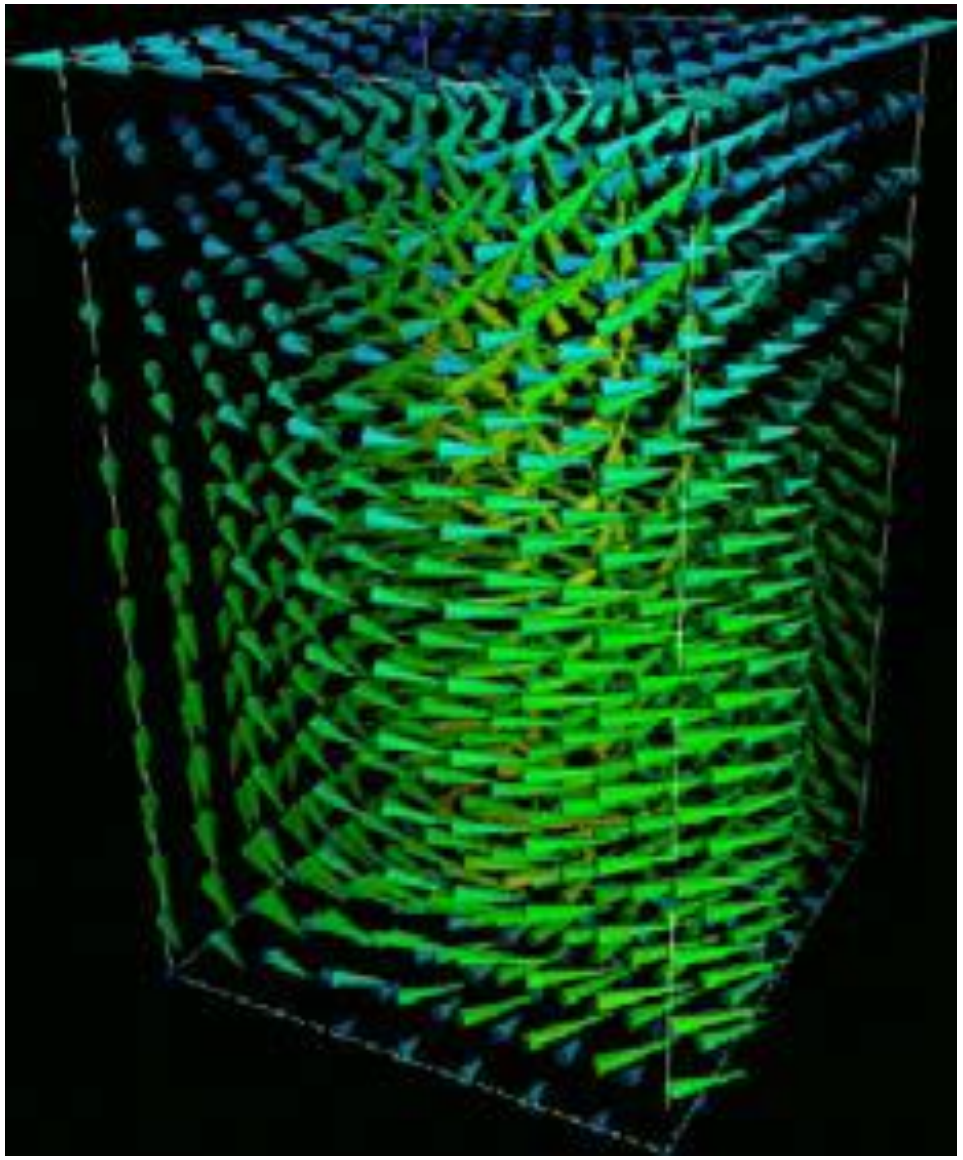
depth perception

better perception

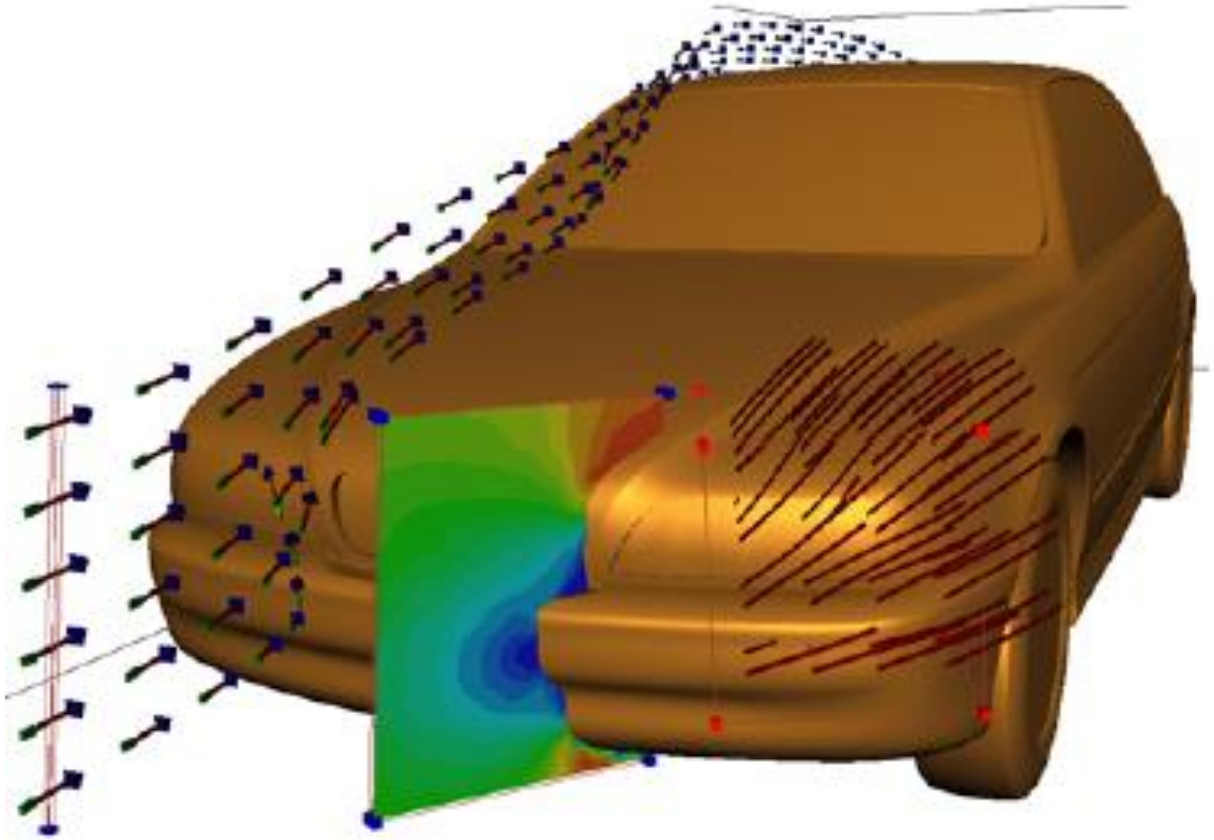
3D icons (cylinder + cone)




Vector arrows



3D Arrow Plots and Color Coding on Slices



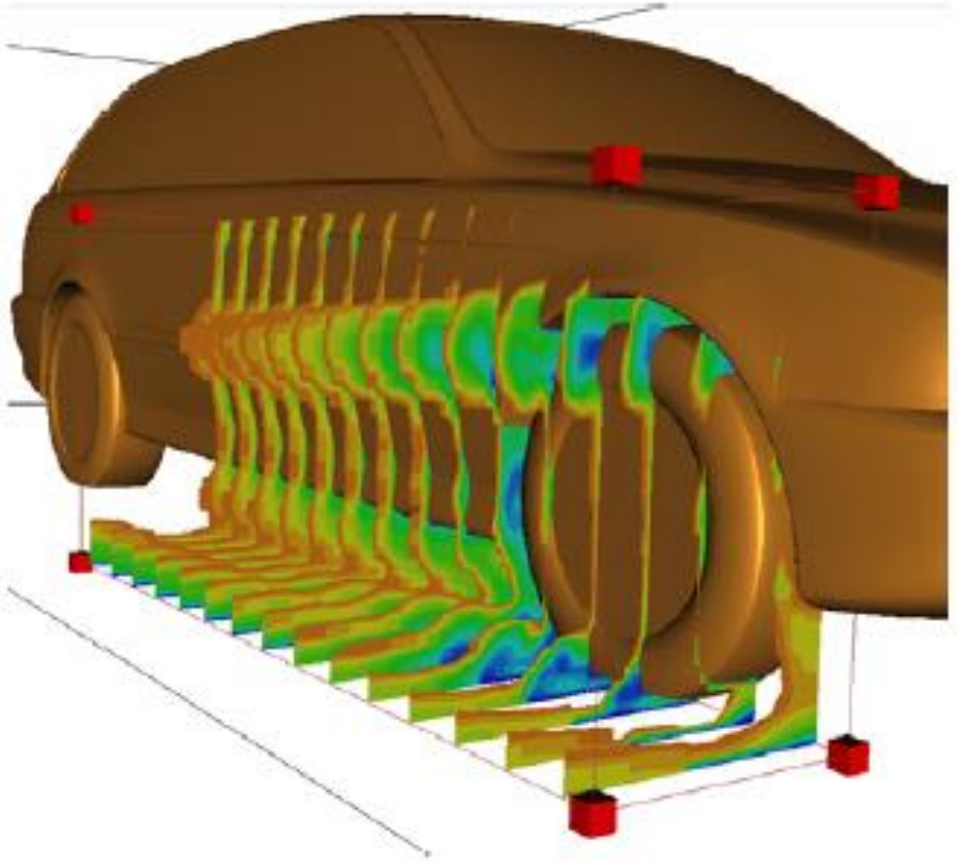


Figure 8: Freely movable slicing probe, using texture hardware to visualize the shape of a vortex.

images from Schulz et al 99

[Kirby et al 99]: show multiple variables of 2D flow data using a layering concept related to painting process of artists

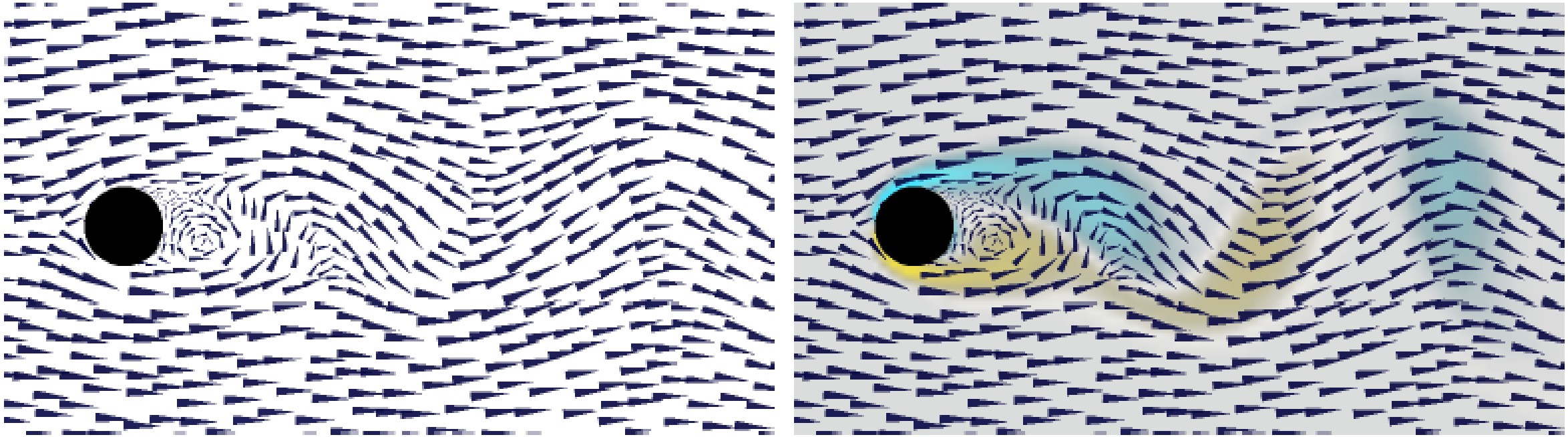
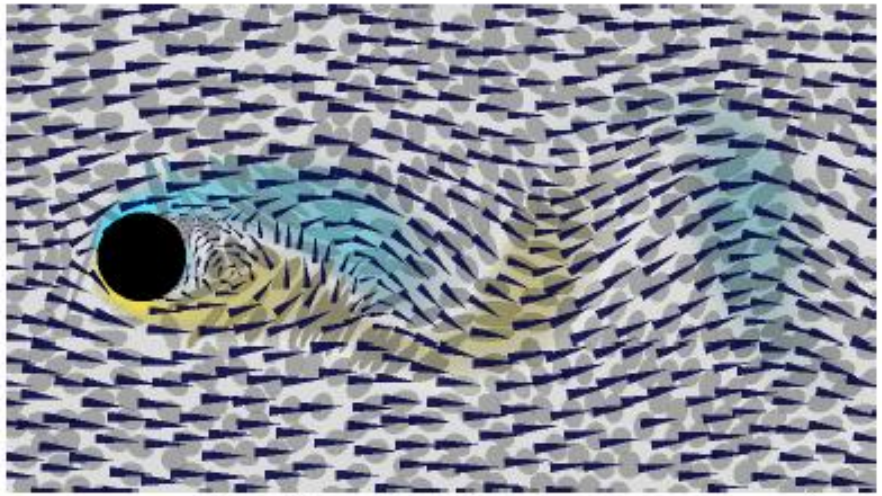
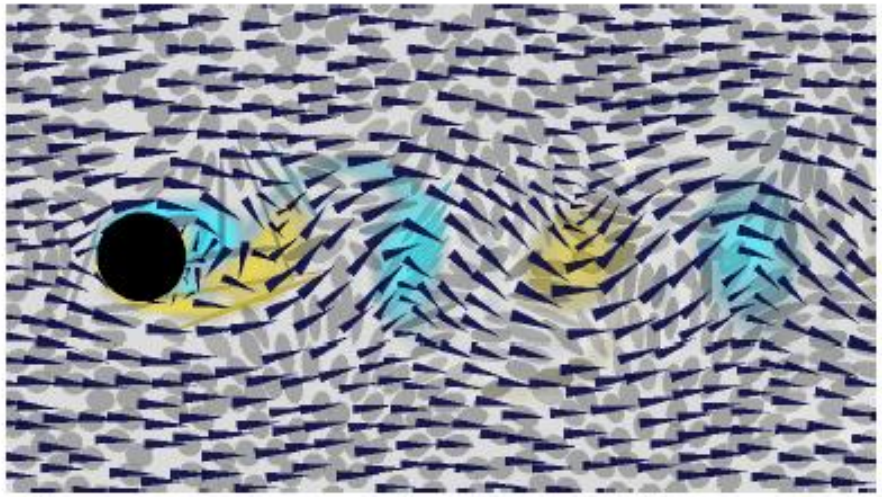


Figure 1: Typical visualization methods for 2D flow past a cylinder at Reynolds number 100. On the left, we show only the velocity field. On the right, we simultaneously show velocity and vorticity. Vorticity represents the rotational component of the flow. Clockwise vorticity is blue, counterclockwise yellow.

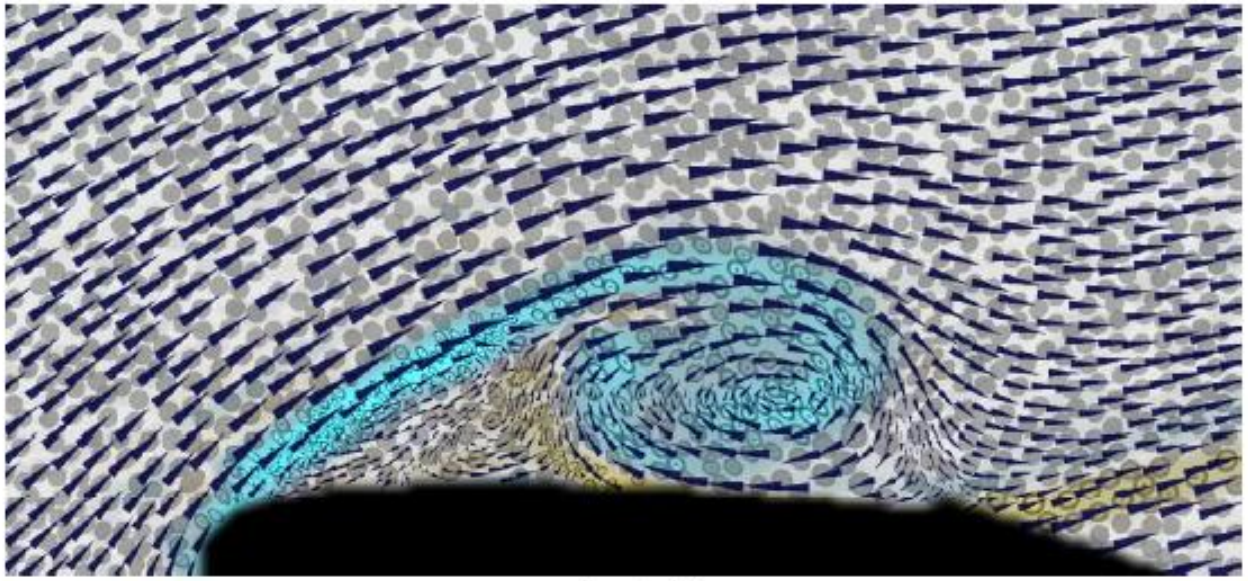


Reynolds number 100



simulated flow

Reynolds number 500



experimental flow

KEY

data	visualization
velocity	arrow direction
speed	arrow area
vorticity	underpainting/ellipse color (blue=cw, yellow=ccw), and ellipse texture contrast
rate of strain	log(ellipse radii)
divergence	ellipse area
shear	ellipse eccentricity

Summary

- low level of abstraction
- present all or most of the data
- Color Coding
  - scalar field visualization for specific aspects of the vector field
  - loss of information
- Arrow Plots
  - show vector as (scaled) arrow
  - very common in 2D or on 3D slices
  - perceptual issues, especially in 3D
- Combined methods