User study flow visualization

Fluids, such as water, air and blood, play an important role in many fields, for example medicine.

Unlike solids, the shape of a fluid can change continuously. This means that every position within a fluid has its own direction and speed.

By visualizing the motion within a fluid we can gain more insight into the behavior of the fluid and how the fluid interacts with its environment.

Flow types

Laminar flow flows in parallel, in a tube the flow is parallel to the wall of the tube.

Turbulent flow is characterized by chaotic flow patterns resulting in for example vortices ("swirling" flow).

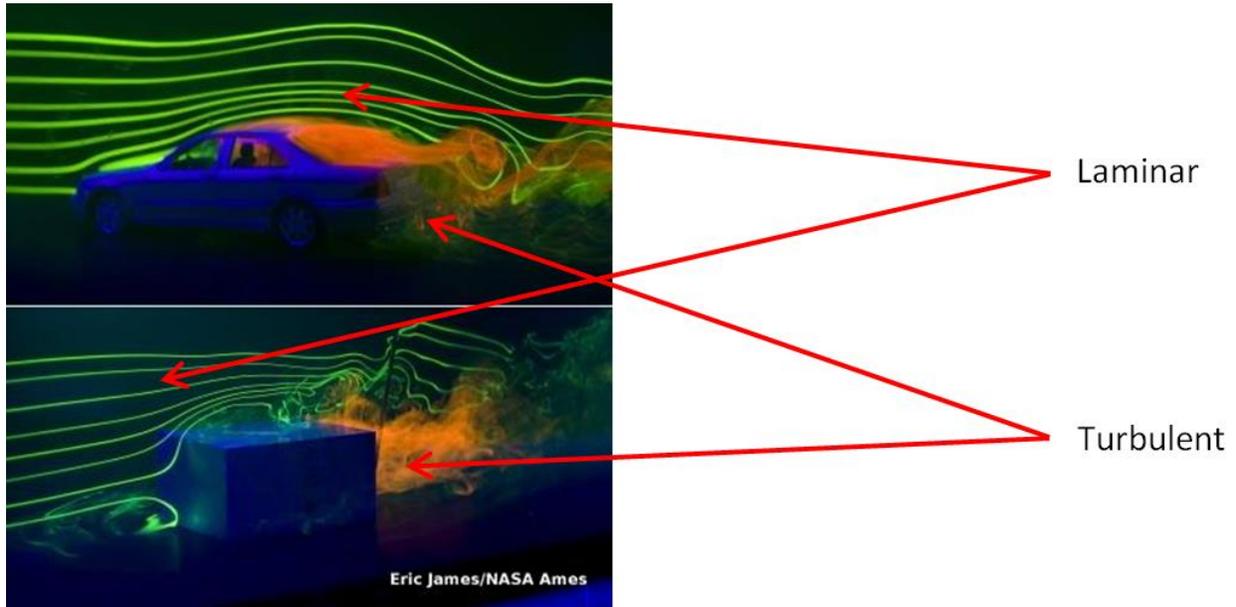A schematic of both flow types is shown by the image below
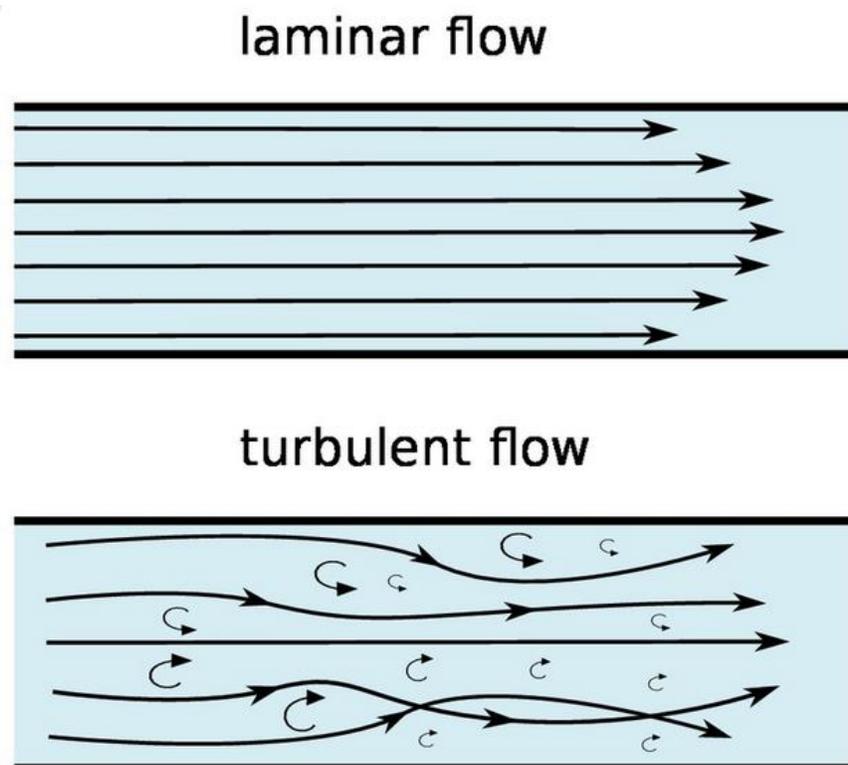
Flow visualization

The flow of a fluid can be visualized by injecting a contrast agent, such as smoke or ink.

These visualizations are called streak visualizations.

This results in images similar to physical experiments where smoke is used to examine the aerodynamics of a car:

Eric James/NASA Ames

Another technique used in physical experiments is to visualize the trajectory of a particle, for example a bubble.

These visualizations are called path visualizations, as they visualize the path of a particle.

The trajectory of bubbles and sparks are shown by the lines in the images below using an long camera exposure.
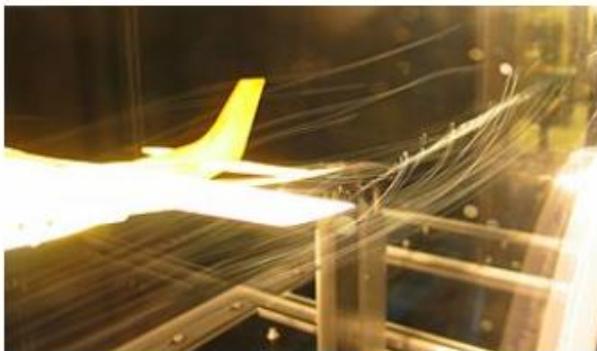
Data explanation

With PC-MRI the velocity field within a blood vessel can be measured, which then tells us the direction and speed of the flow within the vessel. The amount of turbulence found in the flow is often an indicator for the efficiency of the blood flow. For example, the number of vortices can be used to classify aneurysms and their risks [1].

Both the injection of a contrast agent and the trajectory of particles can be visualized for PC-MRI data using computer visualization and produces images similar to the images shown above.

[1] J.R. Cebral et al. - Characterization of Cerebral Aneurysms for Assessing Risk of Rupture By Using PatientSpecific Computational Hemodynamics Models, American Journal of Neuroradiology, 2005

User study

What is your profession

- (Medical) flow analysist
- Medical doctor or student
- Visualization/graphics researcher
- Other

Years of experience

—

Vortex counting

In this study either a path or streak visualization is shown.

The goal is to count over time the total number of vortices (swirls) in the data.

You can watch and pause the video as often as you need.

The color indicates the origin of the flow.

The following question was asked 6 times for a random data set and visualization method.

Example videos are included in the additional material.

Phase 6

How many vortices did you count in the video? *

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

How certain are you of your answer? *

	1	2	3	4	5	6	7	
Very uncertain	○	○	○	○	○	○	○	Very certain

The user study was concluded with the following question:

Which visualization type did you prefer for this task? *

	1	2	3	4	5	6	7	
Path visualization	○	○	○	○	○	○	○	Streak visualization