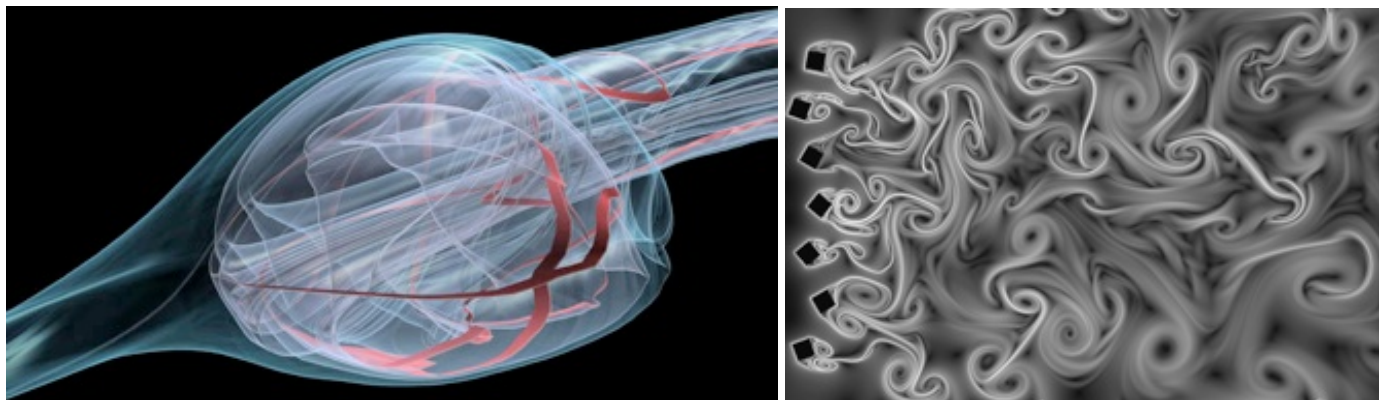


CS53000 - Spring 2021

Programming Assignment 4 - Vector Field Visualization



Key Dates

Handed out: Monday, March 15, 2021

Due: Thursday, April 1, 2021 before 11:59:59 pm (NEW!)

Objective

The topic of this assignment is vector field / flow visualization. You will study a delta wing dataset and visualize the velocity information using vector field visualization techniques. Your task will be to show the major flow structures present in the dataset (primary and secondary vortices and recirculation bubble on each side of the wing). In addition, you will visualize the spatial relationship that exists between the velocity (vector) field and the pressure (scalar) field. Refer to the corresponding instructions below.

Task 1: Glyphs [20%]

Your first task consists in using cutting planes to probe the vector values. Specifically, you will create a plane orthogonal to the X axis of the volume (the main axis of the wing) and sample the velocity vector field on that plane. You will need to follow an approach similar to what is demonstrated in [ProbeCombustor.py](#) for that purpose. To represent individual vectors as arrows, you will use [vtkArrowSource](#) as the source of a [vtkGlyph3D](#) filter. Use 3 plane at 3 different locations along the X axis (with normal pointing along the X direction) to capture the structures mentioned above. Show the delta wing geometry in each image for context (the corresponding geometry is provided as [vtkUnstructuredGrid](#) in a separate file).

Deliverables: Create an executable named `three_planes.py` that contains the (*hardcoded*) information needed to visualize the vector glyphs on the 3 planes that you have selected. Your executable should receive the *names of two files* from the command line, namely the CFD file containing the vector field information and the file containing the geometry of the delta wing.

```
> python three_planes.py <vfem.vtu> <wing.vtu>
```

Report: Explain in the report how you selected the planes used in your implementation and comment on the properties of the flow that you can discern in your visualization. Include pictures showing *each cutting plane*

individually (along with the associated glyphs) as well as other images showing all planes and the wing together.

Task 2: Streamlines, Stream Tubes and Stream Surfaces [40%]

Task 1 should provide you with a general sense of the location of interesting structures in the flow volume. Your second task now consists in using streamlines, stream tubes and stream surfaces as demonstrated in [officeTubes.py](#) and [streamSurface.py](#) to show how the flow swirls around the vortices present in the data.

Deliverables: You will construct 3 visualizations for this task.

- A first executable showing a large number (between 50 and 200) of *streamlines*.
- A second executable showing a small number of *stream tubes*
- A third executable showing a *stream surface* seeded along an appropriately chosen line segment (aka rake).

In each case, the seeding locations and the other parameters of the technique must be hardcoded in your program. You must choose parameter values that produce good quality results and capture the behavior of the flow around the vortices on each side of the wing. Note that each visualization should represent the velocity magnitude using color coding and the corresponding color scale should be provided for reference. Show the delta wing geometry in each image for context.

```
> streamlines <vfem.vtu> <wing.vtu>
> streamtubes <vfem.vtu> <wing.vtu>
> streamsurfaces <vfem.vtu> <wing.vtu>
```

Report: Explain in the report how the seeding locations were chosen for each of these three techniques and how they relate to the observations made in [Task 1](#).

Task 3: Combining Scalar and Vector Visualization [20%]

The scalar and vector information available for this dataset provide two complementary perspectives on the properties of the flow. For the third task of this assignment, you will combine isosurfaces of pressure with streamlines to visualize the relationship between the streamlines' geometry and the shape of the isosurfaces. Create visualizations in which the streamline seeds and the isovalues of the isosurface are chosen in such a way as to best illustrate the correlation between the two kinds of object.

Deliverables: Create an executable named `combined.py` that produces a visualization of the CFD dataset, combining isosurfaces of the pressure scalar field, streamlines of the velocity vector field, and geometry of the delta wing. The various parameters needed to create the visualization must be hardcoded in the program. Your executable should receive from the command line the names of the files needed to create the visualization: velocity and pressure dataset (in the same file), and wing geometry description.

```
> python combined.py <vfem.vtu> <wing.vtu>
```

Report: Describe in the report the things you tried before arriving at the proposed solution and explain why your final selection is a good one. Show the delta wing geometry in each image for context.

Task 4: Analysis [20%]

Considering your results in [Task 1](#) and [Task 2](#) of the assignment, comment on the effectiveness of the resulting visualizations for your understanding of this dataset. What were the pros and cons of each technique? Comment on the results you were able to achieve in [Task 3](#) by integrating isosurfacing and vector visualization. Did you find this combination beneficial? Provide a justified answer to each of these questions in the report.

Data Sets

The CFD dataset used in this project is available as a (fairly) large [vtkUnstructuredGrid](#). The information available corresponds to the velocity (vector field) and the pressure (a scalar field). A separate file describing the geometry of the delta wing is also available (also a [vtkUnstructuredGrid](#)). Note that the CFD simulation that produced this dataset used adaptive mesh refinement, which explains the vast discrepancies that exist between the resolution of the mesh next to the wing and further away from it.

- **3D Flow:** Velocity (vector field), and Pressure (scalar field) in **double** precision ([vfem.vtu](#), 170 MB)
- **Wing geometry** ([wing.vtu](#), 1.0 MB)

Submission

Submit your solution for this project on Brightspace before **April 1, 2021 at 11:59 pm**. Refer to the instructions below.

- Include all program files (**`three_planes.py`**, **`streamlines.py`**, **`streamtubes.py`**, **`streamsurfaces.py`**, **`combined.py`**) along with any other source code you may have.
- Include **high resolution sample images** showing results for each task.
- Include a report summarizing what you have done and answering all the questions asked. As always, the report should include high-resolution images.
- Include a **`README.txt`** file with execution instructions (optional).
- Include all files to be submitted in a single directory named **`<myLogin>_p4`**, where **`<myLogin>`** is your Purdue login.
- **Do not** include binary file
- **Do not** include data files
- **Do not** use absolute paths in your code

Use Brightspace for your submission.

Last modified Thu Mar 25 2021