Bio-fluid mechanics Exercise Part II

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January 2024

1 Code example: Single vessel

(2.1) Download the Python scripts from ILIAS. The code can be executed by running `python3 run_vesselsim.py`. But this will probably fail because some implementation details are missing. If it already fails due to an `ImportError`, make sure to install the dependencies: `python3 -m pip install numpy scipy`.

(2.2) To visualize the results, you will need `ParaView` available at `https://www.paraview.org/download/`. You can test if the visualization works by running `python3 pvdwriter.py`. This will write out some test mesh files. Open the file `test.pvd` in `ParaView`. In order to visualize the vessel, apply `Filters > Alphabetical > Cell To Point Data` and then `Filters > Alphabetical > Tube`. For the `Tube` filter select the field `R0` and then select `Vary Radius > By Absolute Scalar`. You can also set `Number of Sides` to something higher and disable `Capping`.

(2.3) Implement the functions `flux` (corresponds to $\boldsymbol{F}(\boldsymbol{U})$), `characteristic_variables` (corresponds to $\boldsymbol{W}(\boldsymbol{U})$), `primary_variables` (corresponds to $\boldsymbol{U}(\boldsymbol{W})$).

(2.4) Implement the function `W2_inflow`. At the inflow, we know the characteristic variable W_1 by using an upwind scheme. Moreover, we know the flow rate Q we want to prescribe. Use the transformation formula relating Q, W_1, and W_2. Use a Newton solver to solve for W_2.

Now you should be able to run the code. You can visualize with `ParaView`. (You can keep `ParaView` open and reload data with `F5`.) Vary the reflection coefficient R and observe the effect. You can also increase the domain length (ca. line 102) when constructing the mesh to better see the waves.

2 Code example (extra): Bifurcating vessels

(3.1) Complete the functions `solve_bifurcation` in the file `bifurcationsolver.py`.

(3.2) Change the variable `mesh` in `run_vesselsim.py` to `BifurcationMesh()`.

Now you should be able to run the code again. In `ParaView` you can use the `Select Cells` tool to select a cell on the centerline in any vessel. With the selection active use `Filters > Alphabetical > Plot Selection Over Time` to plot for example pressure or flow rate over time in the selected cell/cells.