1 Post-processing in VaMPy

This part of the Vascular Modeling Pypeline is dedicated to post-processing. The main purpose of the script `compute_hemodynamic_indices.py` is to compute hemodynamic indices such as the wall shear stress and oscillatory shear index, and can be executed by entering the following command:

```
$ python automatedPostProcessing/compute_hemodynamic_indices.py --case [PATH TO
    RESULTS]/Solutions
```

The main purpose of the script `compute_flow_and_simulation_metrics.py` is to compute simulation specific parameters, and common metrics within fluid dynamics, and can be executed by entering the following command:

```
$ python automatedPostProcessing/compute_flow_and_simulation_metrics.py --case [PATH
    TO RESULTS]/Solutions
```

2 Mathematical definitions of computed quantities

Table 1: Quantities of `compute_hemodynamic_indices.py`

Quantity	Abbreviation/Symbol	Definition	Unit
Wall shear stress	WSS, τ	$\mu\frac{\partial u}{\partial n}$	[Pa]
Time averaged wall shear stress	TAWSS	$\frac{1}{T}\int_0^T \lvert\tau\rvert\ dt$	[Pa]
Temporal wall shear stress gradient	TWSSG	$\frac{1}{T}\int_0^T \left\lvert\frac{\partial \tau}{\partial t}\right\rvert\ dt$	[Pa/s]
Oscillatory shear index	OSI	$\frac{1}{2}\left(1-\frac{\left\lvert\int_0^T \tau\, dt\right\rvert}{\int_0^T \lvert\tau\rvert\ dt}\right)$	[-]
Relative residence time	RRT	$\frac{1}{(1-2\cdot \mathrm{OSI})\cdot \mathrm{TAWSS}}$	[1/Pa]
Endothelial cell activation potential	ECAP	$\frac{\mathrm{OSI}}{\mathrm{TAWSS}}$	[1/Pa]

Table 2: Quantities of `compute_flow_and_simulation_metrics.py`

Quantity	Abbreviation/Symbol	Definition	Unit
Velocity	u	$u(x,y,z,t) = (u_x, u_y, u_z)$	[m/s]
Mean velocity	$\bar{u}, u_{\text{mean}}$	$\frac{1}{T}\int_0^T u\,dt$	[m/s]
Turbulent velocity	u'	$u - \bar{u}$	[m/s]
Kinematic viscosity	ν	$\frac{\mu}{\rho}$	[m^2/s]
Time interval	T	`User defined`	[s]
Time step	Δt	$\frac{T}{N}$	[s]
Characteristic edge length	$\Delta x, h$	`CellDiameter(mesh)`	[m]
Courant–Friedrichs–Lewy condition	CFL	$\lvert u\rvert \frac{\Delta t}{\Delta x}$	[-]
Rate of strain	S_{ij}	$\frac{1}{2}\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right)$	[1/s]
Turbulent rate of strain	s_{ij}	$\frac{1}{2}\left(\frac{\partial u'_i}{\partial x_j} + \frac{\partial u'_j}{\partial x_i}\right)$	[1/s]
Absolute rate of strain	Strain	$\sqrt{\langle S_{ij}, S_{ij}\rangle}$	[1/s]
Dissipation	$\mathcal{E}$	$2\nu\langle S_{ij}, S_{ij}\rangle$	[m^2/s^3]
Turbulent dissipation	ε	$2\nu\langle s_{ij}, s_{ij}\rangle$	[m^2/s^3]
Kinetic energy	KE, E_k	$\frac{1}{2}\left(u_x^2 + u_y^2 + u_z^2\right)$	[m^2/s^2]
Turbulent kinetic energy	TKE, k	$\frac{1}{2}\left({u'_x}^2 + {u'_y}^2 + {u'_z}^2\right)$	[m^2/s^2]
Friction velocity	$u^\star, u_\tau$	$\sqrt{\nu S_{ij}}$	[m/s]
Generalized length scale	ℓ^+	$\frac{u^\star \Delta x}{\nu}$	[-]
Generalized time scale	t^+	$\frac{\nu}{u^{\star 2}}$	[s]
Kolmogorov length scale	η	$\left(\frac{\nu^3}{\varepsilon}\right)^{\frac{1}{4}}$	[m]
Kolmogorov time scale	τ_η	$\left(\frac{\nu}{\varepsilon}\right)^{\frac{1}{2}}$	[s]
Kolmogorov velocity scale	u_η	$(\varepsilon\nu)^{\frac{1}{4}}$	[m/s]