Background

Hemodynamic parameters are the measurements of blood pressure, blood flow, and other factors that affect the circulation of blood in the body. Hemodynamic monitoring is used to assess the cardiovascular function and the response to interventions in critically ill or unstable patients. TAWSS, OSI, and HOLMES are hemodynamic parameters that are used to assess the risk of thrombosis and atherosclerosis in blood vessels. They are based on the wall shear stress (WSS), which is the frictional force exerted by the blood flow on the endothelial cells that line the vessel wall.

TAWSS:

TAWSS stands for time-averaged wall shear stress. It is the average value of the WSS over a cardiac cycle. It reflects the magnitude of the shear stress that the endothelium is exposed to. Low TAWSS values are associated with regions of disturbed flow and increased risk of thrombosis and atherosclerosis.

$$\mathrm{TAWSS} = \frac{1}{\mathrm{T}} \int_0^{\mathrm{T}} |\overrightarrow{\mathrm{wss}}| \mathrm{dt} \qquad (1)$$

OSI:

OSI stands for oscillatory shear index. It is a measure of the temporal variation of the WSS direction over a cardiac cycle. It ranges from 0 to 0.5, where 0 indicates a unidirectional flow and 0.5 indicates a fully reversing flow. High OSI values are associated with regions of oscillatory flow and increased risk of thrombosis and atherosclerosis.

$$\mathrm{OSI} = 0.5 \left(1 - \frac{\left| \frac{1}{\mathrm{T}} \int_0^{\mathrm{T}} \overrightarrow{\mathrm{wss}} \mathrm{dt} \right|}{\mathrm{TAWSS}} \right) \qquad (2)$$

HOLMES:

HOLMES stands for highly oscillatory low magnitude shear. It is a composite index that combines both the magnitude and the direction of the WSS. It is calculated by multiplying the TAWSS by (1 - OSI). It ranges from 0 to 1, where 0 indicates a low shear stress or a fully reversing flow, and 1 indicates a high shear stress or a unidirectional flow. Low HOLMES values are associated with regions of low and oscillatory flow and increased risk of thrombosis and atherosclerosis.

$$\mathrm{HOLMES} = \mathrm{TAWSS} \times (0.5 - \mathrm{OSI}) \qquad (3)$$

problem statement

These hemodynamic parameters are measurable, but are not easy to measure them accurately and non-invasively. There are different methods to measure or estimate TAWSS, OSI and HOLMES such as Computational fluid dynamics (CFD), 4D Flow MRI, Artificial intelligence (AI) and etc.

The CFD method has been used to check the condition of a coarctation patient, and to predict thrombosis and atherosclerosis in this patient, the accurate calculation of TAWSS, OSI, and HOLMES is of particular importance. In this situation, only the values of WSS at different nodes of the patient's aorta wall have been provided to us, and with these values, it is not possible to analyse and predict the state of thrombosis and atherosclerosis.

The available information includes 731 csv files, which correspond to each time step of the patient's cardiac cycle simulation, which is 0.731 seconds long.

Required results

You must provide a calculation method in MATLAB software that uses WSS values to calculate the required values of this research, which includes TAWSS, OSI and HOLMES.

In addition to providing the values, each assigned to a specific node, in a csv file, you are expected to produce a report that explains how your method and code work. Also, your code with .m or .txt extensions must be provided with the report and all these files should be uploaded in the form of a zip file in the relevant link.