15th International Symposium on Computer Methods in Biomechanics and Biomedical Engineering
and
3rd Conference on Imaging and Visualization
CMBBE 2018
P. R. Fernandes and J. M. Tavares (Editors)

Abstract ID-182

INNOVATIVE FLOW VISUALIZATION OF 4D FLOWS IN INTRACRANIAL ANEURYSMS

Gabor Janiga

University of Magdeburg ''Otto von Guericke'', Germany
janiga@ovgu.de

Keywords: Intracranial aneurysms, Computational fluid dynamics (CFD), Phase-Contrast Magnetic Resonance Imaging (PC-MRI), Proper orthogonal decomposition (POD), Flow visualization

Summary: Intracranial aneurysms are balloon-type dilatations of the diseased brain arteries. It is believed that the hemodynamics play a paramount role in the development of this disease, including the growing process as well as the aneurysm rupture.
Patient-specific computational fluid dynamics (CFD) is a well-established tool to investigate the time-dependent three-dimensional (1D+3D) blood flows, but also Phase-Contrast Magnetic Resonance Imaging (PC-MRI) measurements produce 4D flow velocity vectors.
The simple and meaningful representation of such information is challenging. Standard visualization techniques – such as velocity vectors, 2D contour plots, iso-surfaces or streamlines – can be used to depict a given time snapshot or the temporal mean information. Furthermore, animation can be used to portray the temporal changes. However, the perception of the entire information is not easy. This is particularly true for non-experts in flow visualization, e.g., for physicians.
Proper orthogonal decomposition (POD) is a mathematical tool to analyze complex spatial-temporal information. It can be efficiently used to separate the main primary flow from underlying secondary and tertiary flow structures. This POD technique is applied in the present work for 4D blood flows in an intracranial aneurysm obtained by PC-MRI measurements and CFD simulations.
Innovative techniques that can be used to represent and combine the primary and the secondary flow will be presented at the conference. This leads to a faster and easier perception for non-experts in flow visualization and reduces the need for unsteady flow animations.

References:

[1] Abdelsamie, A., Janiga, G. and Thévenin, D., Spectral entropy as a flow state indicator. Int. J. Heat Fluid Flow 68, (2017) 102-113.
[2] Berg, P., Stucht, D., Janiga, G., Beuing, O., Speck, O. and Thévenin, D., Cerebral blood flow in a healthy circle of Willis and two intracranial aneurysms: Computational Fluid Dynamics versus 4D Phase-Contrast Magnetic Resonance Imaging. J. Biomech. Eng. 136(4), (2014) 041003/1-9.