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Frangi, Alejandro F. (2014) Image-based Cerebrovascular Modeling for Advanced Diagnosis and Interventional Planning. In: USES 2014 - The University of Sheffield Engineering Symposium, 24 June 2014, The Octagon Centre, University of Sheffield.

10.15445/01022014.22

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Image-based Cerebrovascular Modeling for Advanced Diagnosis and Interventional Planning

Alejandro F. Frangi

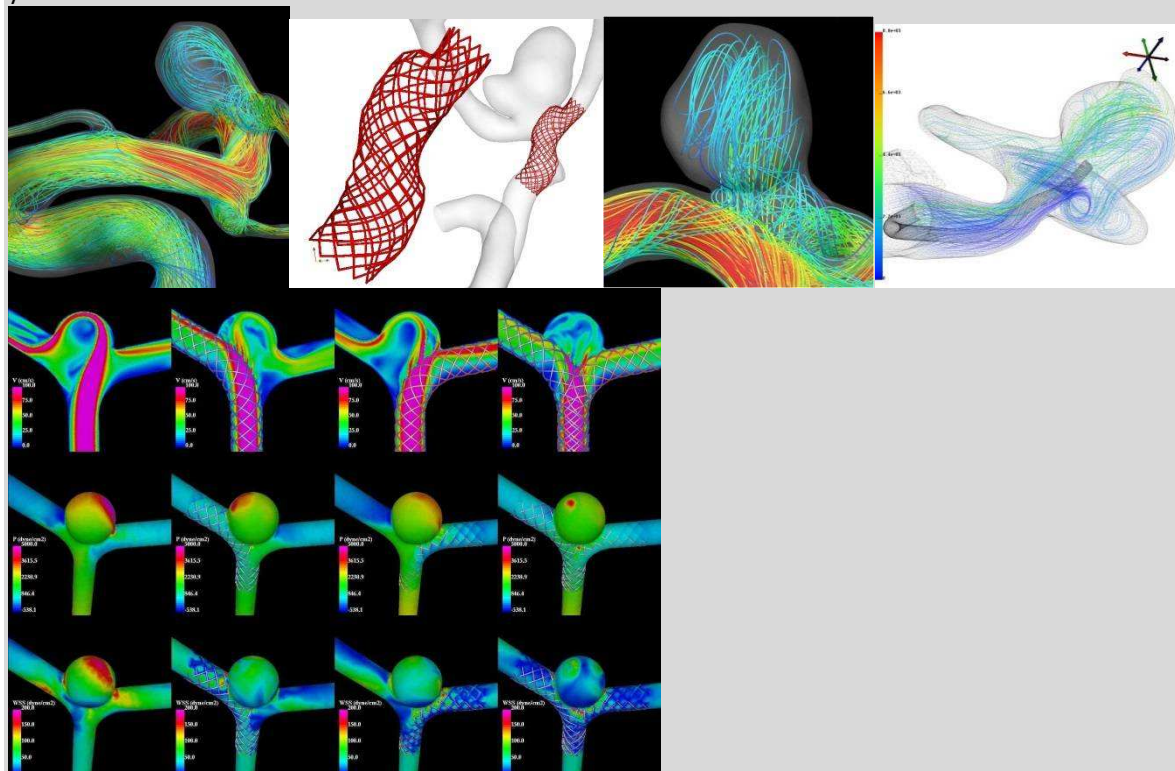
CISTIB Centre for Computational Imaging & Simulation Technologies in Biomedicine, INSIGNEO Institute for in silico Medicine

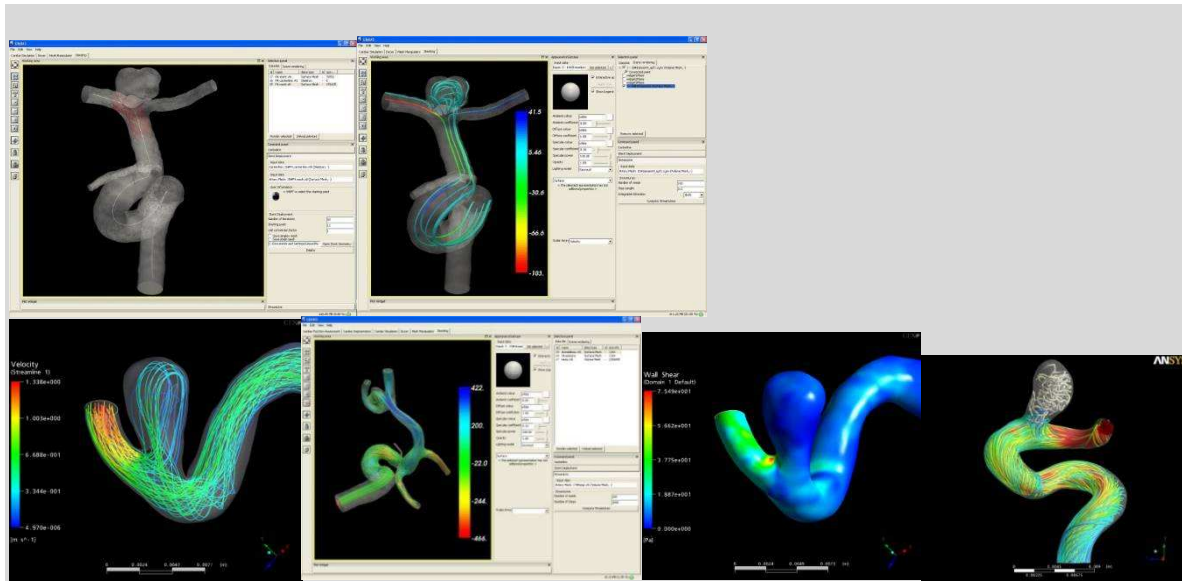
Abstract

Current technological progress in multidimensional and multimodal acquisition of biomedical data enables detailed investigation of the individual health status that should underpin improved patient diagnosis and treatment outcome. However, the abundance of biomedical information has not always been translated directly in improved healthcare. It rather increases the current information deluge and desperately calls for more holistic ways to analyse and assimilate patient data in an effective manner. The Virtual Physiological Human aims at developing the framework and tools that would ultimately enable such integrated investigation of the human body and rendering methods for personalized and predictive medicine.

This talk will focus on and illustrate two specific aspects: a) how the integration of biomedical imaging and sensing, signal and image computing and computational physiology are essential components in addressing this personalized, predictive and integrative healthcare challenge, and b) how such principles could be put at work to address specific clinical questions in the cardiovascular domain.

Finally, this lecture will also underline the important role of model validation as a key to translational success and how such validations span from technical validation of specific modelling components to clinical assessment of the effectiveness of the proposed tools. To conclude, the talk will outline some of the areas where current research efforts fall short in the VPH domain and that will possibly receive further investigation in the upcoming years.





Selected Overview Papers

1. Frangi AF, Hose DR, Hunter PJ, Ayache N, Brooks D. Guest Editorial: Special issue on Medical Imaging and Image Computing in Computational Physiology. *IEEE Trans Med Imaging*. 2013;32:1-7.
2. Hunter PJ, Chapman T, Coveney PV, de Bono B, Diaz V, Fenner J, Frangi AF, Harris P, Hose R, Kohl P, Lawford P, McCormack K, Mendes M, Omholt S, Quarteroni A, Shublaq N, Skar J, Stroetmann K, Tegner J, Thomas SR, Tollis I, Tsamardinos I, van Beek JHGM, Viceconti M. (2013) A vision and strategy for the VPH: 2012 Update. *Interface Focus*, 2013;3(2):20130004.
3. Villa-Uriol MC, Berti G, Marzo A, Hose DR, Chiarini A, Singh P, Penrose J, Schmidt JG, Pozo J, Frangi AF. @neurIST complex information processing toolchain for the integrated management of cerebral aneurysm. *J Roy Soc Interface*. 2011;308-319
4. Villa-Uriol MC, Larrabide I, Pozo JM, Kim M, Camara O, De Craene M, Zhang C, Geers AJ, Morales H, Bogunović H, Cardenes R, Frangi AF. Toward integrated management of cerebral aneurysms. *Philos Transact A Math Phys Eng Sci*. 2010;368:2961-2982
5. Larrabide I, Villa-Uriol MC, Cárdenes R, Barbarito V, Carotenuto L, Geers AJ, Morales HG, Pozo JM, Mazzeo MD, Bogunović H, Omedas P, Riccobene C, Macho JM, Frangi AF. AngioLab- a software tool for morphological analysis and endovascular treatment planning of intracranial aneurysms. *Comput Methods Programs Biomed*. 2012;108:806-819

Selected Original Contributions

1. Geers AJ, Morales HG, Larrabide I, Frangi AF (2014) Approximating hemodynamics of cerebral aneurysms with steady flow simulations, *J Biomech*, 2014;47(1):178-85.
2. Morales HG, Larrabide I, Geers AJ, Dai D, Kallmes DF, Frangi AF. (2013) Analysis and Quantification of Endovascular Coils Distribution inside Saccular Aneurysms Using Histological Images, *J Neuro Intervent Surg*, *J Neurointerv Surg*. 2013 Nov;5 Suppl 3:iii33-7.
3. Morales HG, Larrabide I, Geers AJ, Aguilar ML, Frangi AF (2013) Newtonian and Non-Newtonian Blood Flow in Coiled Cerebral Aneurysms, *J Biomech*, Sep 3;46(13):2158-64.
4. Larrabide I, Aguilar ML, Morales HG, Geers AJ, Kulczar S, Rüfenacht D, Frangi AF. Intra-aneurysmal pressure and flow changes induced by flow diverters: relation to aneurysm size and shape. *AJNR Am J Neuroradiol*, 2013 Apr;34(4):816-22.
5. Pozo JM, Villa-Uriol MC, Frangi AF. Efficient 3D geometric and Zernike moments computation from unstructured surface meshes. *IEEE Trans Pattern Anal Mach Intell*. 2011;33:471-484
6. Morales HG, Kim M, Villa-Uriol MC, Larrabide I, Vivas EE, Sola T, Guimaraens L, Frangi AF. How do coil configuration and packing density influence intra-aneurysmal hemodynamics? *AJNR Am J Neuroradiol*. 2011;32:1935-1941
7. Larrabide I, Villa-Uriol MC, Cardenes R, Pozo JM, Macho J, San Roman L, Blasco J, Vivas E, Marzo A, Hose DR, Frangi AF. Three-dimensional morphological analysis of intracranial aneurysms: A fully automated method for aneurysm sac isolation and quantification. *Med Phys*. 2011;38:2439-2449
8. Bernardini A, Larrabide I, Morales HG, Cito S, Pennati G, Petrini L, Frangi AF. Influence of different computational approaches for stent deployment on cerebral aneurysm haemodynamics. *Interface Focus*. 2011;1:338-348