VPH-Share: Patient-Centred Multi-scale Computational Workflows

Susheel Varma[1], Maria-Cruz Villa-Uriol[2], Pablo Lamata[3], Breanndan O'Nuallian[4], Enrico Schileo[5], John Fenner[1], Nic Smith[6], Rod Hose[1]

Introduction – Scientific discoveries in the natural sciences are increasingly data-driven and computationally intensive, providing unprecedented data analysis and scientific simulation opportunities. Scientific workflows are in essence executable descriptions of automatable scientific processes such as simulations or data processing and analyses. Workflows have direct implications for any underlying infrastructure, because the latter must be able to support the former through an interoperable framework. The framework should enable workflows to orchestrate and leverage distributed data stores for scientific analysis. This is seen as a necessary component for achieving an overarching VPH workspace for personalising clinically relevant multi-scale solutions using heterogeneous data.

This paper reports the emerging computational workflow developments within the VPH-Share project. Four flagship workflows are identified (@neurIST, euHeart, Virolab and VPHOP), including description of the underlying cloud infostructure developments that support these workflows.

Methods – To be useful to the VPH community, scientific models must be formulated, analysed and annotated for integration into a workflow. The workflows are designed to operate with a holistic representation (patient avatar) of all available patient data, which will be placed at the center of a workflow. A survey of clinical data available from medical institutions, and required by the workflows has been used to create cohesive but extensible patient avatar specification. Due to the heterogeneity, uncertainty and variability of these data items, techniques for the structured recognition of variation and uncertainty within the patient and model data are used to improve model prediction, but their efficacy is as yet unevaluated.

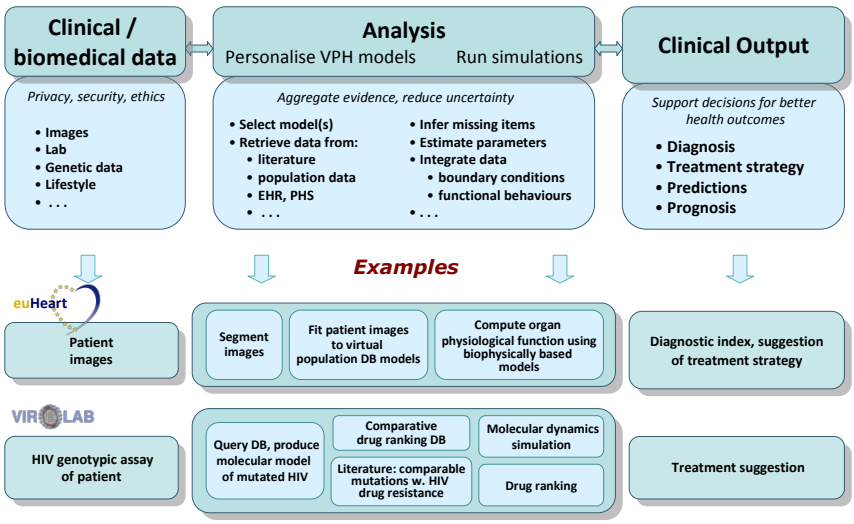

Figure 1: Components of a Generic VPH Workflow

[1] The University of Sheffield [2] Universitat Pompeu Fabra [3] University of Oxford [4] Universiteit van Amsterdam
[5] Istituto Ortopedico Rizzoli [6] King's College London

Each of the four 'flagship' workflows encompass a common strategy, see Figure **1**, simplifying a complex chain of events associated with normal and abnormal physiological processes within a single patient or a population. These functional simplifications are embodied as mathematical or computational descriptions that can be executed as an automatable sequence of steps in the form of a scientific workflow. Furthermore, VPH-Share plans to augment this process through secured access to anonymised patient data via cloud-based infrastructures, which also enables researchers to construct completely new workflows based on the modular components from existing workflows. Modularised examples of two of the four VPH-Share 'flagship' workflows are shown in Figure 2.

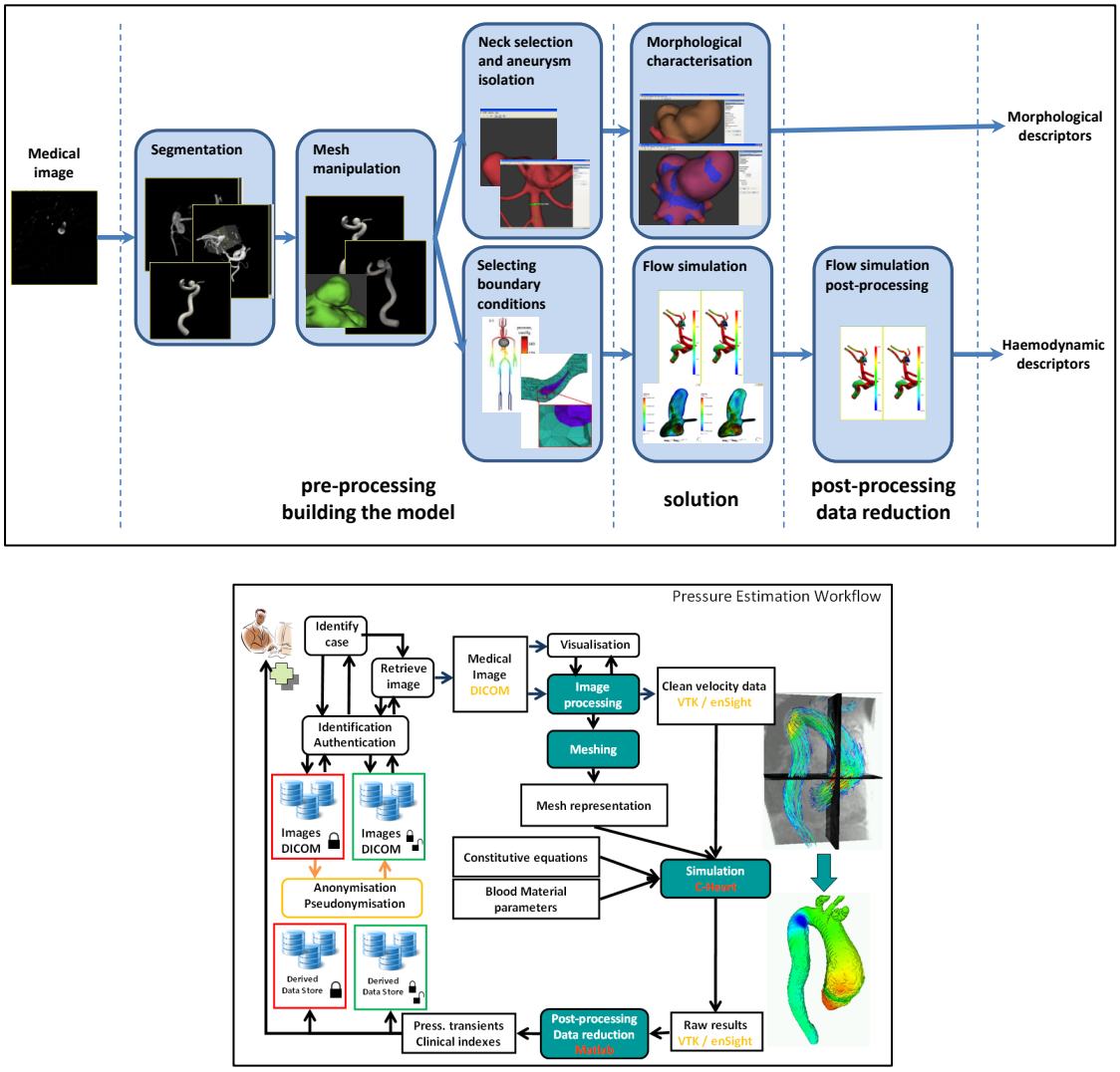

Figure 2: VPH-Share 'flagship' workflows (@neurIST, euHeart)

Progress – Over the past year, we have liaised with various research/clinical teams to capture the essence of their workflow practices. To further enhance the interoperability of these workflows, we have componentised every single step within the workflow into modular web services for integration into any workflow platform. To fully utilise the power of research workflows, we have also worked with clinical and semantic data teams from multiple institutions to design and construct a federated clinical data-warehousing platform to fully embody the concept of a patient avatar. We have also developed tools and techniques to mitigate the various issues of

heterogeneity, variability and uncertainty within the data to improve model prediction.

Automation of this process requires support from an infrastructure that integrates with all aspects of the clinical and research pathways. To this extent, within VPH-Share, we have developed a state-of-the-art cloud-based scientific workflow infrastructure prototype that is being configured to support the many aspect of the VPH workflows highlighted.

Discussion – Issues relating to workflow composition and execution within a cloud environment present many challenges, with the main ones being:

- Level of Abstraction
- Standards
- Information Management
- Provenance
- Interoperability

The key challenge for an infrastructure capable of supporting workflow development and execution in the context of VPH-Share, is a reliable and robust mechanism for interfacing the wealth of clinical data held within medical institutions with scientific research tools, models and workflows developed within research institutions.

Conclusion – VPH-Share project will provide the essential services, as well as the computational infrastructure, for the sharing of clinical and research data and tools, facilitating the construction and operation of new VPH workflows, and collaborations between the members of the VPH community. The four flagship workflows (from @neurIST, euHeart, VPHOP, Virolab) are providing existing data, tools and models to engage with the services developed by VPH-Share to drive the development of the infostructure, and pilot its applications. The project workflows aims are (1) to integrate information from disparate sources to build and to refine a personalised model to aid diagnosis and interventional planning; (2) to jointly develop multiscale models for the composition of new VPH workflows; and, (3) to facilitate collaborations within the VPH community.

Acknowledgments – The authors would like to thank the VPH-Share [1] (FP7-ICT-2009-6-269978) consortium partners for their inputs to the work presented in this paper. The authors are also deeply indebted to the VPH-NoE [2] (FP7-2007-IST-223920) and in particular the exemplar project EP8 for its valuable contributions to this paper.

References

[1] VPH-Share, Virtual Physiological Human: Sharing for Healthcare – A Research Environment. 2012 [Online] http://www.vph-share.eu

[2] The Virtual Physiological Human Network of Excellence. 2012 [Online] http://www.vph-noe.eu/