HemeWeb: Blood flow simulation in the cloud using docker

Steven Steven

Master of Science
School of Informatics
University of Edinburgh
2016

Acknowledgements

Many thanks to X Y Z

Declaration

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

(*Steven Steven*)

Table of Contents

1 Introduction **1**

1.1 Motivation 1

1.2 Objectives 1

1.3 Outline 1

2 Background **3**

2.1 Current HemeLB workflow 3

2.2 Cloud computing 4

2.3 Containerization Technology 4

2.4 Other High Performance Computing 4

Bibliography **5**

List of Figures

2.1 Current HemeLB workflow taken from Steven [2016] 4

Chapter 1

Introduction

Software are increasingly complex. Our everyday software are crammed with features that makes its usage difficult. To people without familiarity with the product, it will be a barrier of entry to use it even when it is really good for them.

This also ties in to the complexity of the research. Many of this softwares are developed as part of researches. Open science dictates that research should be reproducible or replicable for it to better validate the research. However, recent findings have shown that not many research in psychology or even computation are replicable easily.

1.1 Motivation

To study how blood flow in a given vessel, a fluid dynamic simulation software named HemeLB was originally developed by Mazzeo and Coveney [2008]. Currently, it is actively developed and used by researchers to help their study. For example, Itani et al. [2015] used HemeLB for automated ensemble simulation of blood flow for a range of exercise intensities, Bernabeu et al. [2015] used it for detecting difference of retinal hemodynamics with regards to diabetic retinopathy, and recently Franco et al. [2015, 2016] used it to understand branching pattern of blood vessel networks.

1.2 Objectives

1.3 Outline

I provide a brief introduction to the topic of this dissertation in this chapter. The rest of the chapters will be organized as follow:

- **Chapter 2**. I will provide background information that are necessary for readers to understand the concepts, technology and implementation that are done in this dissertation. HemeLB, containerization technology, cloud computing, High-Performance computing infrastructure, and other topics will be discussed in details in this chapter.
- **Chapter 3**. I will discuss the bulk of the work in this chapter. Implementation details and design of the proposed solutions will be provided and discussed in details.
- **Chapter 4**. Evaluation
- **Chapter 5**. Analysis
- **Chapter 6**. Future work

Chapter 2

Background

2.1 Current HemeLB workflow

Running a blood flow simulation using HemeLB currently consists of multiple steps. To understand how the proposed project can improve the current conditions, I will elaborate on how HemeLB workflow currently work.

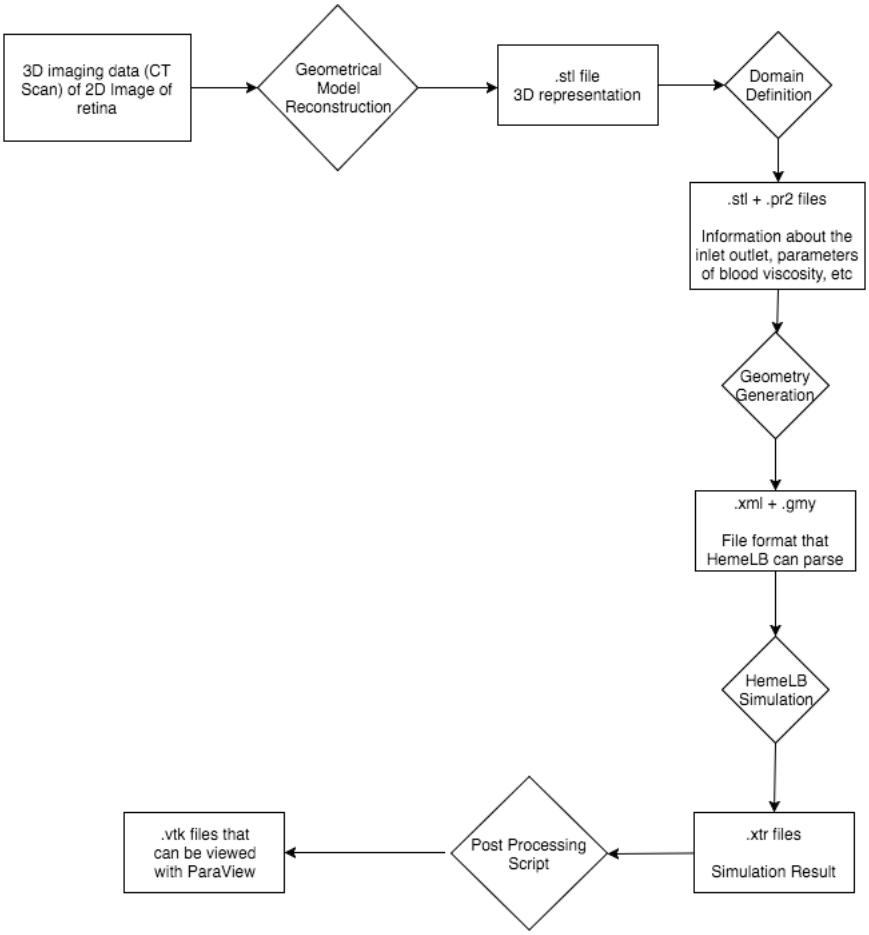

Figure 2.1: Current HemeLB workflow taken from Steven [2016]

2.2 Cloud computing

2.3 Containerization Technology

2.4 Other High Performance Computing

Bibliography

Bernabeu, M. O., Lu, Y., Lammer, J., Aiello, L. P., Coveney, P. V., and Sun, J. K. (2015). Characterization of parafoveal hemodynamics associated with diabetic retinopathy with adaptive optics scanning laser ophthalmoscopy and computational fluid dynamics. In *2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, pages 8070–8073. IEEE.

Franco, C. A., Jones, M. L., Bernabeu, M. O., Geudens, I., Mathivet, T., Rosa, A., Lopes, F. M., Lima, A. P., Ragab, A., Collins, R. T., et al. (2015). Dynamic endothelial cell rearrangements drive developmental vessel regression. *PLoS Biol*, 13(4):e1002125.

Franco, C. A., Jones, M. L., Bernabeu, M. O., Vion, A.-C., Barbacena, P., Fan, J., Mathivet, T., Fonseca, C. G., Ragab, A., Yamaguchi, T. P., et al. (2016). Non-canonical wnt signalling modulates the endothelial shear stress flow sensor in vascular remodelling. *Elife*, 5:e07727.

Itani, M. A., Schiller, U. D., Schmieschek, S., Hetherington, J., Bernabeu, M. O., Chandrashekar, H., Robertson, F., Coveney, P. V., and Groen, D. (2015). An automated multiscale ensemble simulation approach for vascular blood flow. *Journal of Computational Science*, 9:150–155.

Mazzeo, M. D. and Coveney, P. V. (2008). Hemelb: A high performance parallel lattice-boltzmann code for large scale fluid flow in complex geometries. *Computer Physics Communications*, 178(12):894–914.

Steven, S. (2016). Hemeweb: Container based high performance computing scenario in cloud infrastructure for hemelb. Informatics research proposal, University of Edinburgh.