VPH challenges: a solution to interactive visualisation of biomedical data

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1. Introduction

In recent years, various terms – the Virtual Physiological Human (VPH) [1], Integrative Biology, Physiome Research [2] – have been used to describe the trend in biomedical research towards the consideration of systemic processes. These phenomena are commonly observed in living organisms but cannot be explained within a single sub-system – they reflect, rather, systemic outcomes that result from the interaction of multiple sub-systems. In the past, when confronted by the complexity exhibited in biomedical problems, researchers have been forced to focus purely on single sub-systems, and the most common boundary separating these has been spatiotemporal scale. However, the many VPH projects that are concentrating on the study and simulation of biological systems at multiple scales will soon start to demand multiscale visualisation.

The Multiscale Spatiotemporal Visualisation (MSV) project [3] is, by the international cooperation of worldwide stakeholders in biomedical visualisation software development, implementing an open-source multiscale visualisation library as an extension to the Visualisation Toolkit (VTK) [4], ready to be incorporated by virtually any biomedical modelling software project.

During the first two years of the project, by combining the existing knowledge available in Europe and USA, four important results have been obtained and are summarised in this paper.

2. Exemplary problems data collection

In order to allow a better understanding of the needs of the VPH community in terms of multiscale visualisation, a survey was carried out of the data collected and available in the various projects currently running in Europe and the USA. This review allowed a number of challenges to be identified, and these will be addressed when designing and implementing the multiscale visualisation library [5]. The analysis also revealed that not all of the use cases are equally affected by the same challenges, which allowed a prioritisation of the challenges to be addressed, with the first being those most common in biomedical research: spatial multiscale data with gaps, management of out-of core data, and temporal data management.

Starting from the identified exemplary problems, a data collection has been set up representing as many of the different biomedical domains as possible (cardiological, musculo-skeletal, vascular, and many others), and including relevant data, which can be publicly released (as it is not affected by privacy issues) [6]. The data collection includes a description of the data with snapshots, an analysis of the multiscale challenges, and links to download the data. To give the exemplary problems higher visibility and accessibility, the data collection will be soon moved to the PhysiomeSpace data-sharing service [7].

The collected data are being used to validate the concrete implementation and within software applications, which will demonstrate the effectiveness of the approach proposed by MSV in the different biomedical domains.

3. Best practices

Relying on these exemplary problems, a survey has been conducted on the different forms that multiscale data may take, the common problems that need to be addressed, and the techniques that may be applied to deal with them.

For most applications, multiscale visualisation does not involve specific new techniques, but the complexity of the interaction does demand a unified and carefully planned approach. Currently it takes considerable research and programming effort to create a multiscale visualisation for an application, but with guidelines to provide a suitable infrastructure for design, and a software library that supports a range of multiscale methods, including the possibility to employ different methods at different scales within a single application, with each scale using the approach most appropriate to its needs, multiscale visualisation will become much more amenable to solution. A set of design guidelines building on previous best practice, to make multiscale visualisation more accessible to scientific researchers has been defined together with the essential characteristics that any biomedical multiscale visualisation application should have and the criteria that programmers should use to guide their development [8].

4. A shared vision

Thanks to a worldwide consultation among stakeholders and an extensive review of the state of the art within and outside the biomedical community, a formal definition of the multiscale visualisation problem has been produced and summarised in a public White Paper [9]. The exemplary data collection, together with a review of the state of the art of available visualization techniques, has been the basis for defining a taxonomy for multiscale visualization. It focuses on the multiscale visualization aspects with the objective of providing users of the MSV library with an overview of the most relevant techniques for multiscale visualization and interaction. As already mentioned, the data type and structure to be visualised are aspects as important as the techniques to be employed when designing an interactive visualization environment. Thus, data classification has been included in the multiscale visualization taxonomy, which has not been restricted only to the biomedical field. This taxonomy will help developers to grasp key techniques of visualization and domain users to understand how some visualization methods work so that they may choose the most appropriate form of visualization for their purposes.

5. Software library implementation

To address the challenges identified in a unified software solution, an open-source library is being implemented to address the interactive visualization of multiscale data. The library is being developed in C++ as an extension of VTK, and it has been designed to be as general as possible, providing a series of software elements that might be used later in other software development projects to add support to the multiscale visualization.

Analysis of the tools available in the biomedical and other domains has shown that the zoom-based approach, previously investigated during the EC-funded LHDL project [10] has proven to be very effective in many other domains, such as geography. Thus, MSV implements the click-and-zoom interaction paradigm: visual cues are provided for the positions of lower scale data with respect to the whole data, which leads to an intuitive interface for data navigation. MSV is also investigating the possibility of conveying meaningful information about the data represented through the icon/placeholder shapes and colours, with the aim of optimizing information transfer and user experience. In the future, we will also consider using placeholders for hyperlinks to provide extra information such as documentation, etc.

6. Conclusions

The first two years of the project have produced a clear and general vision on the interactive visualisation of biomedical data challenges and available solutions.

All results produced by the project are being publicly released to foster the growth of the community around this important topic in VPH research.

As already mentioned, the final year of the project will be devoted to a concrete software implementation, based on best practice, which will be made available to the worldwide research community under an open source licence at the end of 2012. At the same time, the MSV library components being developed will be used in the implementation of a range of prototypes on the exemplary problems collected, which will allow checks to be made on the efficacy of the proposed approach. In particular, two demonstrators are already at an advanced stage of development [11] and will be used to test further functionalities to be included in the MSV library.

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