Volume xx (200y), Number z, pp. 1–2

OpenWalnut: A New Tool for Multi-modal Visualization of the Human Brain

Sebastian Eichelbaum[1], Mathias Goldau[1,3], Stefan Philips[1,2], André Reichenbach[1], Ralph Schurade[2] and Alexander Wiebel[2]

[1] Abteilung für Bild- und Signalverarbeitung, Universität Leipzig, Germany
[2] Max-Planck-Institute for Human Cognitive and Brain Sciences, Germany
[3] Max-Planck-Institute for Neurological Research Cologne, Germany

1. Introduction

In the course of the ongoing research into neurological diseases and the function and anatomy of the brain, a large variety of examination techniques has evolved. The different techniques aim at findings for different research questions or different viewpoints of a single task. The following list names only a small selection of very common measurement modalities and parts of their application area.

computed tomography (CT) anatomical information using X-ray measurements
magnetic resonance imaging (MRI) anatomical information using magnetic resonance (esp. soft tissues)
diffusion weighted MRI (dwMRI) directed anatomical information for extraction of fiber approximations
functional MRI (fMRI) activity of brain areas indicated by the blood-oxygen-level dependence effect (BOLD)
electroencephalography (EEG) activation of certain brain areas indicated by electric fields

Considering the different applications, it is evident that for many research areas only a combination of these techniques can help answering the posed questions. To name only one example, the combination of dwMRI and fMRI with an anatomical context provided by T1 MRI images is very common. To be able to analyze the data measured by the different techniques, a tool that can efficiently visualize the different modalities simultaneously is needed. The software (called *OpenWalnut*) we will present in this poster aims at exactly this task. It does not only allow to display the different modalities together, but also provides tools to analyze their interdependence and relations.

In the following, we will describe the software's general architecture, its interactive multi-modal visualization capabilities and how these make it especially suitable for the task of multi-modal analysis of measurements of the human brain.

2. Data Flow Network

To achieve the challenging goal of combining multiple modalities and multiple approaches of analysis and visualization, OpenWalnut uses the idea of data flow networks internally to combine several algorithms and provide a processing flow. Each algorithm in OpenWalnut is called "Module" and can provide inputs and outputs, so called "connectors". This way, each module can define the kind of data it wants to process or provide to others. This allows the programmer of a new visualization or processing technique to concentrate on the technique itself. Even more interesting is the possibility to nest modules inside each other. This allows the user to combine modules, each having its own use-case, to even more complex modules without rewriting code. This kind of a "programming language", the combination of small building blocks to complex structures, allows OpenWalnut to be very generic and easily expandable.

As the complexity of module graphs can grow very fast, it yields a fast increasing barrier for the user. In contrast to other open source tools, like MeVisLab [mev] or SCIRun [SCI], OpenWalnut hides this complexity and is, therefore, also suitable for scientists who simply want to use visualization tools for their data but are not that familiar with the visualization details. SCIRun provides so-called *power apps* to hide the complexity of the data flow environment. These, and similar macros in MeVisLab are very helpful to provide GUIs for special tasks. However, they still have to be created with a script and the network in the background. OpenWalnut combines the best out of two worlds. On the one hand, it provides an easy to use graphical user interface, making it a plug-and-play visualization tool. On the other hand, it provides direct access to the data flow network. A simple, generic and yet powerful programming framework allows advanced users and computer scientist researchers to simply create algorithms or recombine existing ones to create advanced visualizations.

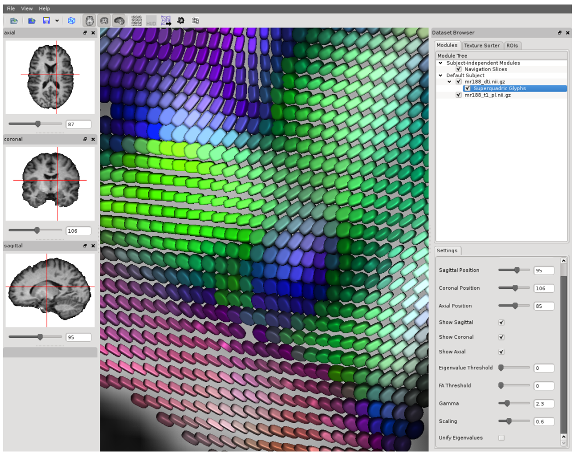

Figure 1: *OpenWalnut showing a diffusion tensor image with applied super-quadric glyphs [Kin04]. The GUI is kept simple and intuitive, so all the interactions with the dataset can be done in the "dataset browser" on the right-hand side.*

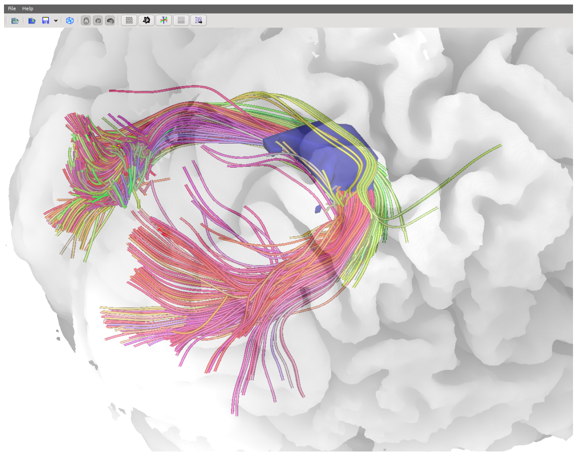

Figure 2: *Forceps occipitalis selected by a segmented part (blue) of the corresponding T1-weighted MRI image, which is used as a region of interest.*

3. Multi-modal Visualization

OpenWalnut is able to load a multitude of different image modalities in a variety of standard file formats (e.g. NIfTI, .fib and Vista). For all loadable modalities, a default module is available to provide a simple standard visualization of it, such as the common navigation slices as used by most neuroscientists for, e.g., T1/T2 images. Although, the standard visualization for each modality is useful, it does not always yield further insight into their relation to each other.

OpenWalnut's internal module-graph-structure allows data of different modalities to be combined in a very simple and uncomplicated way. For modules, it is equally simple to provide multiple kinds of data to other modules, such as intermediate calculation results, helping other algorithms to reuse them in their visualization. An example for this is the uncertainty field occurring in a fiber tracking algorithm, which can be used by other modules to take it into account during their calculations. The outputs of the modules can furthermore be used to define regions of interest, which select parts of other datasets. The possibilities of how modules can be combined to create new visualizations are nearly endless.

4. Interactivity

A main design goal of OpenWalnut was the strong focus on interactivity. The user is able to interactively select fiber-bundles, explore the dataset, manipulate the isovalue of iso-surfaces or to view tensor glyphs in real-time (Figure. 1), to mention only some of the possibilities. The module-graph-structure builds the foundation for this by propagating changes along the module graph and, therefore, allowing modules to instantly react to user interactions. A concrete example supporting this furthermore is the selection of fiber-bundles based on a segmented T1-weighted MRI image, allowing selection of bundles going through certain regions of the brain (Figure. 2).

5. Conclusion

OpenWalnut is a tool for multi-modal, medical visualization. Its universality allows it to be easily extended and used in any kind of application case. It is both, a tool for the scientific user and a powerful framework for the visualization researcher. OpenWalnut is licensed under the terms of the GNU Lesser General Public License. More information, documentation and downloads can be found on the project website `http://www.OpenWalnut.org`.

Acknowledgments

The authors are grateful for the advice, help and ideas of Gerik Scheuermann, Faisal Cheema, Christian Heine, Alfred Anwander, Thomas Knösche, Frank Zanow, Robin Ledig, Cornelius Müller and Mario Hlawitschka. This work was supported by the AIF (ZIM grant KF 2034701SS8).

References

[Kin04] KINDLMANN G.: Superquadric tensor glyphs. In *Proceedings of IEEE TCVG/EG Symposium on Visualization 2004* (May 2004), pp. 147–154. 2

[mev] MeVisLab - development environment for medical image processing and visualization. http://www.mevislab.de/. 1

[SCI] SCIRun: A scientific computing problem solving environment, scientific computing and imaging institute (SCI). http://www.scirun.org. 1