

A real-time fMRI communication interface for Turbo-BrainVoyager 3.0 using the TBV 3.0 Plugin Interface

Michael Lührs¹, Charles Müller¹, and Johannes Bernarding¹

¹Department of Biometry and Medical Informatics, Otto von Guericke University Magdeburg, Magdeburg, Saxony-Anhalt, Germany

Introduction

Only few software for real-time fMRI are available [1, 2]. In principle, the new version 3.0 of TBV as well as the home-built software EfaViS include now extended functionalities for real time analysis, storage, and transmission of the data. This is realized by a new interface in the TBV that enables the access to the processed data for use with external software modules. However, no standardized transfer protocol is provided. Therefore, a bidirectional interface based on the public domain software and the TCP/IP protocol was implemented which features a flexible construction to transfer the data. Data transfer had to be completed within on repetition time (typically TR=2s). The results is provided as an additional module within the Module *Visualization and Data Postprocessing of Medical Data* (MedInfoGrid project, BMBF, 01/G07016A) and is provided to the TBV developers and users.

Methods

The plugin was implemented in the open source toolkit Qt [3] which provides a platform-independent C++ library with a well-established object-oriented structure. The simultaneous transfer of the received data to a third party had to be realized in a second thread as the real time data acquisition must not be interrupted. Thus, Qt is used for communication and for the required thread structure. To implement a standardized communication the interface was implemented using the TCP/IP protocol as a plugin where the functionality has a direct impact on the internal data flow of the source software system. Due to the wider distribution of the TBV software, we restrict ourselves to the description of the TBV application. After the real-time process has started, two functions are called by the TBV at each time step (before and after data processing) and the data transfer is executed. The data is send to the thread where they are transferred to the server. For the transfer only one connection is used, which allows an error detection and faster transmission of data, because the connection has not to be established at each time step. If the connection breaks, we try to establish a new connection to ensure the possibility to proceed with the real-time evaluation. To send all available data types provided by the TBV generic container classes of Qt were used. Such, it is possible to send multiple data from multiple regions of interests (ROIs). After completion of the real-time process a further function call controls that all data have been send and received. The TBV with plugin was tested with a Siemens 3 T MR Scanner (Trio, IDEA VA35). Data were acquired with an adapted EPI sequence including real-time export with Analyze or raw data format. In order to create the opportunity to receive multiple data from different TBV applications and to correlate in real time, a program was developed, which realizes an arbitrary number of connections to different applications. This tool serves as a basis for inter-operational experiments with multiple MR scanners. It also allows communication between different subjects in different MR scanners. For this as the next development step, a feedback to the subjects, which, for example can be realized by the software tool VRsense, will be returned.

Results

Two real time systems were successfully tested (EfaViS[1], TBV[2]). First, the software was successfully tested whether all data were sent correctly and within the repetition time of 2s. Subsequently, the framework was used for rtfMRI experiments where different cortical ROIs of the cortex were selected for navigating through VR scenes (figure 2). The averaged signal values of these ROIs were transmitted processed on-line. The transmission took less than one millisecond. All data were sent and received by the server without error. The data were also visualized in separate windows by a second module which also allows further data processing. An overview of the data flow is shown in figure 1. The Plug-In will be available for free in a beta version on <http://www.brainvoyager.com/>.

Conclusion

The plugin allowed transmitting all the data in real time and without errors from the sender software. The transfer was robust, fast, and user-friendly. Thus, the realized concept enables to use complex data structures provided by the TBV software for other third-party real time applications such as visualizing neurofeedback stimuli or providing magnetic resonance-based brain computer interfaces.

[1] Hänel et al., HBM 2011, [2] <http://www.brainvoyager.com>, [3] Thelin, J.: Foundations of QT Development. Springer, (2007).

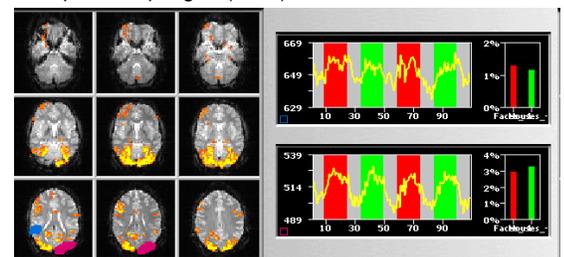
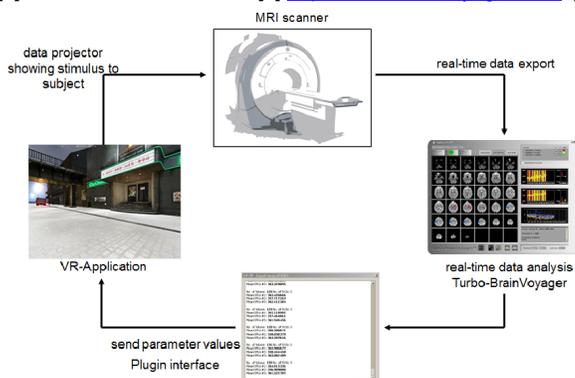


Figure 2: Visualization of the selected region of interest in the real time analysis Software Turbo-BrainVoyager. The right panel shows 2 activation curves extracted and transferred from the Regions of interest depicted in the left panel (blue and pink areas).

Figure 1: Overview of the data flow of the real time fMRI experiment serving as a brain computer interface. Depending on the activation level, the subject can navigate through the 3D virtual reality scene. Brain activation data were transferred from the TBV using the TCP/IP plugin.