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SIGVIEWER AND SIGNALSERVER – OPEN SOURCE SOFTWARE PROJECTS FOR BIOSIGNAL ANALYSIS

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Abstract: *We have developed two open source biosignal processing applications used at both ends of the signal processing chain, namely the signal acquisition server SignalServer and the signal visualization and analysis application SigViewer. Both programs are cross-platform (that is, they run under Windows, Mac OS X, and Linux operating systems), free open source software, and licensed under the GNU General Public License (GPL). SignalServer records raw data from various data acquisition devices and sends the data over the network in a standardized format. SigViewer reads many different biosignal formats and visualizes the contained multi-channel time series data. In addition, SigViewer supports annotations via custom event markers.*

Keywords: *Biosignal analysis, signal acquisition, software, open source, GPL*

Introduction

Open source software has numerous advantages over proprietary applications, especially in the area of scientific research and development. For example, researchers can change and adapt the source code to fit their specific requirements. Existing software components can be reused, and bugs can be fixed in the source code by every user. Depending on the specific license used in a project, it is often required to make any changes to the source code available to the public again, using the same license as in the original program. Such licenses are called copyleft licences. The most prominent example for a copyleft license is the GNU General Public License (GPL).

We have developed two biosignal processing applications used at both ends of the signal processing workflow, namely the signal acquisition server SignalServer and the signal visualization and analysis application SigViewer. Both programs are cross-platform (that is, they run under Windows, Mac OS X, and Linux operating systems), free open source software, and licensed under the GNU GPL[1].

SignalServer

SignalServer (tools4bci.sourceforge.net/signalserver.html) is a program to record data from various sources such as biosignal amplifiers, data acquisition cards, joysticks, and mice [1]. A frequently updated list of supported devices, which includes devices such as g.USBamp, g.Mobilab, g.BSamp (g.tec medical engineering GmbH, Austria), and BrainVision BrainAmp (Brain Products GmbH, Germany), can be found on the project website. SignalServer provides an abstraction layer between hardware devices and programs receiving the recorded data. To this end, data is transmitted in a standardized format over the network via TCP/IP or UDP.

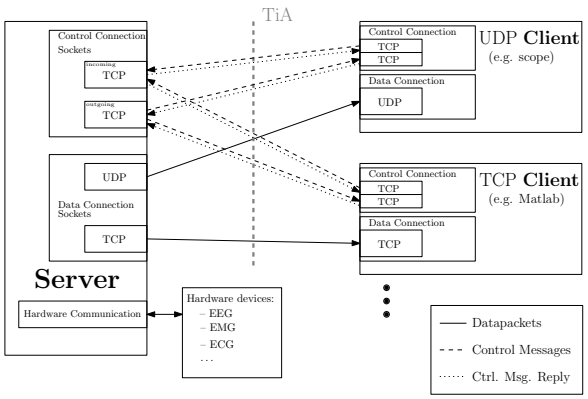

Figure 1: Concept of TiA communication between SignalServer (left) and clients (right).

SignalServer works (as the name suggests) as a server, and one or more clients can connect to this server to receive data. Communication between client and server adheres to the protocol defined in the "TOBI interface A" (TiA)[2], as provided by the TiA library (tools4bci.sourceforge.net/tia.html) [2]. Client and server communicate over a TCP/IP control connection, which uses plain text and XML messages inspired by HTTP. Data is sent over a another dedicated TCP/IP or UDP connection. Figure 1 illustrates the communication between SignalServer and clients.

The program is written in the standard C++ programming language and makes use of the Boost libraries[3]. Therefore, SignalServer runs under Windows, Mac OS X, and Linux platforms. However, since currently many hardware manufacturers provide only Windows drivers for their devices, SignalServer does not support data acquisition from some devices under non-Windows operating systems.

Extensive performance and stability tests have already been carried out [1]. The results showed that SignalServer has a low CPU load (depending on the signals, between 0–13 %),

[1] Note that SigServer is actually dual-licensed under the GPL and a commercial license.

[2] arxiv.org/abs/1103.4717

[3] www.boost.org

low memory footprint (again depending on the signals between 500 kB and 12 MB), and is stable over extended periods of time. The mean processing time is in the range of µs, and the typical network delay is around 0.1 ms.

Recently, SignalServer was extended to transmit only specific user-defined channels and/or downsample raw data to reduce network traffic and/or CPU load on the client side. Furthermore, SignalServer can save its data streams directly to GDF[4].

SigViewer

SigViewer (sigviewer.sourceforge.net) visualizes biosignal data streams such as EEG, EMG, EOG, ECG, and so on [3]. The application can load most biosignal formats provided by a library of the BioSig project [4], including .GDF, .EDF, .BDF, .CNT, .DAT (BCI2000), and .EEG (Brain Products GmbH, Germany). In addition to displaying data, SigViewer supports creating and saving annotations of arbitrary data chunks. These annotations can be used to mark segments in the data, for example to highlight artifacts in the EEG. Subsequent data analysis can then make use of these markers and exclude these segments from further processing.

In addition to visualizing data streams and annotations (see Figure 2 for a screenshot of the main window), SigViewer can also display associated meta information stored with the data files. Furthermore, SigViewer can compute and display the power spectrum and the mean time course averaged over selected epochs. The latter feature essentially isolates event-related potentials (ERPs).

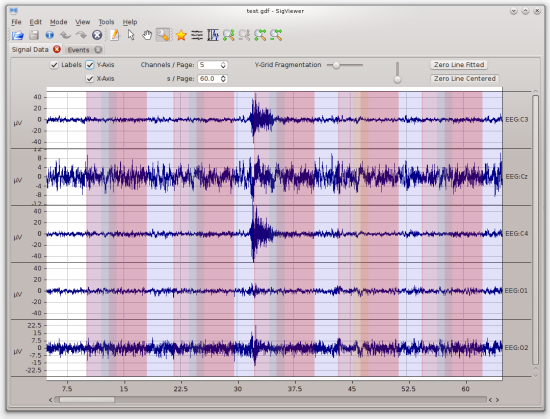

Figure 2: SigViewer's main window (running under Linux) showing five EEG channels with colored annotations and visualization options (above signals).

SigViewer is written in C++ and uses the cross-platform Qt 4 libraries[5]. Therefore, just like SignalServer, SigViewer also supports the three major operating systems mentioned above.

[4] arxiv.org/abs/cs.DB/0608052

[5] qt.digia.com

Discussion

Both applications, SignalServer and SigViewer, can be used in the signal processing workflow typical for biosignal processing, which consists of signal acquisition, signal processing, and signal visualization parts. While SignalServer unifies data streams from various harware devices by using TiA, SigViewer visualizes recorded data offline and offers numerous tools for signal analysis.

Both software projects are free and open source, and both programs are cross-platform. SignalServer is dual-licensed, so if the copyleft license cannot be used, a proprietary license is also available. Future work on SignalServer will include the integration of new hardware devices and the support of other interfaces used for (hybrid) brain-computer interfaces (BCIs) [2], such as event markers used in BCI experiments. These events, along with other metadata, can be stored directly in a GDF file, for example.

The list of devices supported by SignalServer will be continuously updated in the future. Other possible extensions include improved interoperability with other software platforms and support for other file formats for storing incoming data streams. SigViewer will receive new functionality as requested by the community. Possible major extensions include filtering of signals (high or low pass filters), computation of ERDS maps, and improved editing of metadata and event information.

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