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TOBI Interface A (TiA) – A Standardized Interface to Transmit Raw Biosignals

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Abstract. TOBI interface A (TiA) describes a standardized interface to transmit raw biosignals, supporting multirate and block-oriented transmission of different kinds of signals at the same time. To facilitate a distinction between those kinds of signals, so-called signal types are introduced. TiA is a single server, multiple client system, whereby clients can connect to the server at runtime. Meta information transfer between client and server is divided into a control- and data connection. The control communication is using TCP with XML messages, and data transmission is using UDP or TCP with a binary data stream.

Keywords: Biosignal acquisition, Interface, Standardization, Transmission, Brain-Computer Interface

1. Introduction

Many different BCI systems have been developed since the idea of a BCI in 1973 [Vidal 1973]. All BCIs have one similarity, they all deal with biosignals. Those biosignals again have similarities, they are divided into separate channels, are acquired with a specific sampling rate etc. In [Mason and Birch, 2003] a common structure of BCI systems was introduced. Here, the BCI "processing pipeline" is divided into different sections: (i) data acquisition, (ii) pre-processing, (iii) feature extraction, (iv) classification, and (v) application. These "modules" are all interconnected with individual interfaces. Today, various BCI systems are public or commercially available (BCI2000, xBCI, OpenVibe, BF++, rtsBCI, g.tec g.BCIsys), implemented in different languages (C++, Matlab,…) and often platform dependent. A result of such diversity is often incompatibility and similar work done twice. A waste of manpower and working hours is the final outcome. To cope with those issues, different TOBI interfaces labeled as TiA–TiD are developed and designed within the European ICT Programme Project TOBI (FP7-224631). Those interfaces should assist researchers to interconnect their systems or processing modules with other BCIs, independent of used programming languages and platforms. TiA provides a standardized and platform independent way to transmit raw biosignals from a server to multiple clients. A client-server architecture was chosen because a BCI can be seen as a pipeline like in Masons model.

2. Material and Methods

2.1. Signal Types

Various brain signals are used for BCI purposes. These days also combinations of different brain signals or other user-driven signals are combined forming so called hybrid BCIs. A main topic of TiA is an easy distinction between those signals. For this purpose so-called signal types have been introduced, shown in Table 1. Those signal types are used in a TiA specific data packet [Breitwieser et al., 2010] to transmit acquired signals and facilitate a subsequent distinction.

Table 1. *Selected signal types already defined in TiA (extension possible and desired)*

Flag	*Signal Type*	*Flag*	*Signal Type*	*Flag*	*Signal Type*	*Flag*	*Signal Type*
0x01	EEG	0x04	ECG	0x07	Button	0x10	NIRS
0x02	EMG	0x05	HR (heart rate)	0x08	Joystick	0x11	FMRI
0x03	EOG	0x06	BP (blood pressure)	0x09	Sensor	0x12	-

2.1. TiA Handshaking

To facilitate a proper communication between client and server a handshaking procedure using TCP was introduced as shown in Figure 1. During the initial handshaking meta information like the number of channels, channel labels etc. is transmitted over a separate control connection using XML messages. XML was chosen as it is an established standard and many well tested parsing tools are available. The client acquires its configuration concerning acquisition directly from the server. By this configuration errors are minimized. Afterwards, raw data is transmitted from the server to the client through a unidirectional TCP or UDP data connection using TiA data packets. Terminating the raw data stream is handled by a termination handshake using the available control connection. In case of a severe server error, data transmission is aborted. Implementing error messages to the client is scheduled.

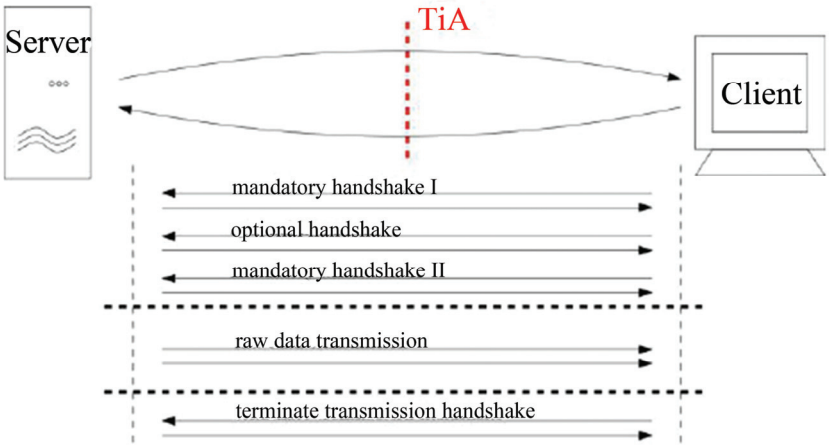

Figure 1. *A short illustration of the TiA handshaking process between an exemplary server and client.*

3. Results

A first version of TiA is already implemented using C++ in the TOBI signal server [Breitwieser et al, 2010] with clients in C++, for Matlab, Simulink and the iPod Touch. Tests of TiA were performed using the loopback interface (Core2Duo 6300, Debian Testing 64bit) and TCP data transmission. Transmission time of a data packet (values in µs): mean: 19 ±3; median: 16; min: 7; max: 2817) for a 10 kHz signal with 128 channels over 5min (3 million packets; packet size: 544byte). Transmission time over a 1GBit network connection with 100Hz packet rate and 250 channels (107.2 kB/s data rate) over 15min with 1MB/s additional artificial load: 0.21ms ± 0.05; median: 0.2ms; min: 0.05ms; max: 0.8ms. Variations with only 16 channels and no additional load showed no effects. TiA in combination with the signal server was also successfully tested in longtime runs (>12 hours).

4. Discussion

TiA is built to enhance corporation between BCI researchers or hardware manufacturers and facilitate BCI development in this way. By using TiA it is possible to build tools and components for BCI research and share them with other people on the field without worrying about compatibility issues. Implementing TiA makes a product easily accessible for people already using this interface.

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