BIOSIGNAL PROCESSING ENVIRONMENT FOR AN EEG-BASED BRAIN-COMPUTER INTERFACE

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Biosignal Processing Environment

g.tec offers a complete biosignal processing platform under MATLAB which allows the fast and easy realization of an EEG-based brain-computer interface (BCI). This platform facilitates the multi-modal acquisition and analysis of biosignals such as EEG, ECoG, EMG, EOG and ECG. After amplification (g.BSamp) the signals are passed to a PC/notebook data acquisition system for visualization and storage. g.STIMunit controls experimental paradigms while g.RTsys performs the data acquisition and real-time parameter extraction and classification of the EEG.

The system provides algorithms for off-line analysis and allows integratation the same algorithms for real-time processing. A key feature is the rapid prototyping environment which enables fast and easy implementation of different processing algorithms and classification methods for optimal BCI performance. The system enables to achieve reliable results in an early stage of development and to perform rapid iterations of the design. The environment allows the integration of user-specific hardware and processing modules and gives access to MATLAB-Toolboxes to accelerate the BCI research and to encourage the creativity.

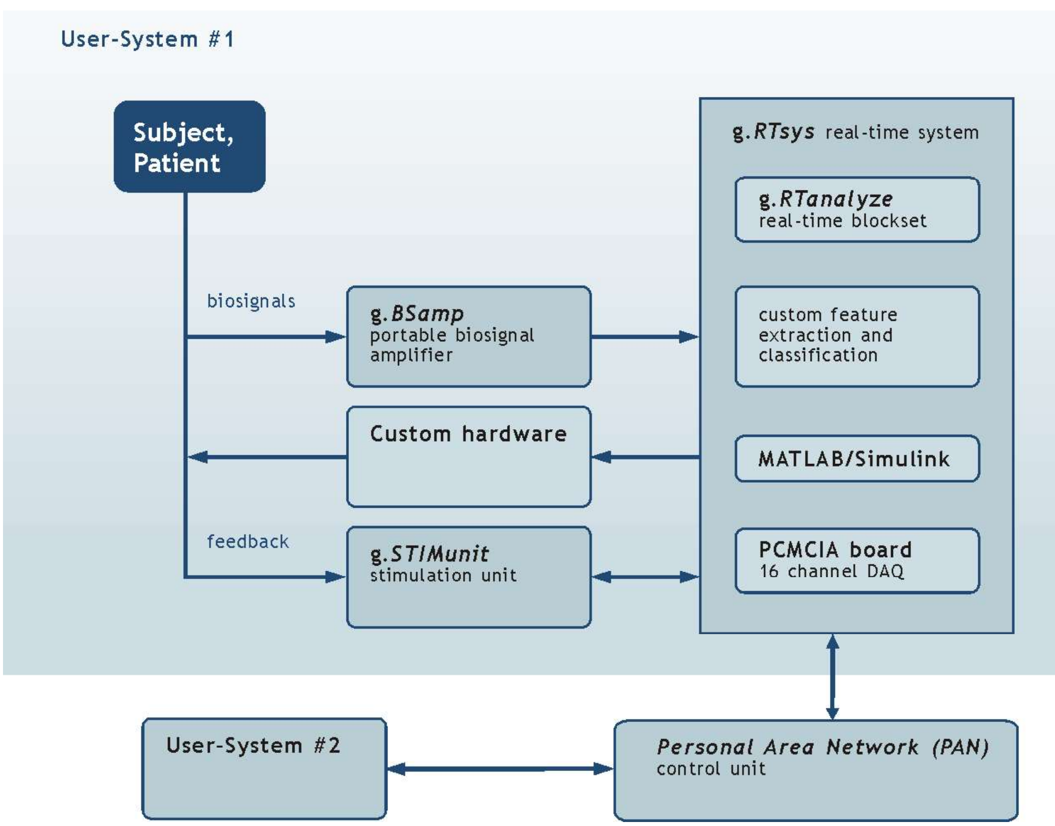

Figure 1: Hardware and software architecture of the portable BCI system.

To give BCI professionals the opportunity to acquire and analyse data of multiple patients/subjects a Personal Area Network gives access to a network of BCI systems (User-Systems #1, #2,...). A remote control unit allows to access multiple systems.

Development Process and Tests of the Brain-Computer Interface

Step1: Selection of parameter estimation and classification algorithms

The selection of the correct and best suited parameter estimation and classification algorithms is one of the most important tasks when setting up a new BCI system. Therefore, a specific algorithm selected from an EEG parameter estimation blockset can be plugged into the Simulink model as shown in Figure 2. In this case the brain-computer interface uses two bipolar EEG recordings (C3 and C4 of the international 10/20 system). Of each channel bandpower parameters are estimated and classified on-line with a linear-discriminant analysis. The classification result can be used to control, e.g., a cursor on the computer screen .

Step2: Implementation of the parameter estimation and classification algorithms with Simulink

Custom algorithms can easily be integrated in the analysis model.

Step3: Off-line simulations and tests of the Simulink block diagrams

Step4: Connection of the Simulink model to the real world

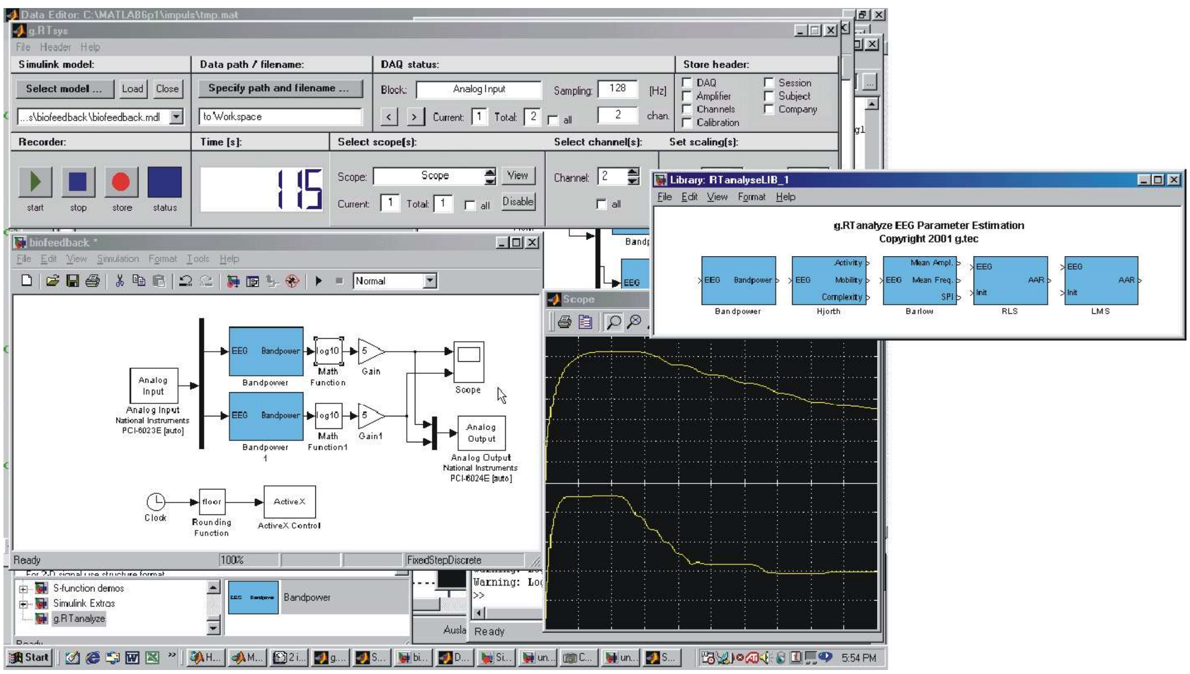

Figure 2: Real-time bandpower estimation of 2 EEG channels.

Step 5: Real-time code generation

Step 6: Development of an experimental paradigm under g.STIMunit

The brain-computer interface can be controlled by e.g. motor imagery of left/right hand movement. Therefore, a program converts a left hand imagination into a left movement of a horizontal bar on a computer screen and a right imagination into a right movement.

Step 7: Real-time tests

The BCI system was tested on about 150 subjects/patients [1, 2, 3, 4]. Three subjects reached a classification accuracy of 100 % [3].

Future developments

In order to make BCI systems accessible to patients it is necessary to minimise the size and the costs. g.tec is currently developing a Pocket-PC brain-computer interface consisting of an EEG-amplifier, and a Pocket-PC.

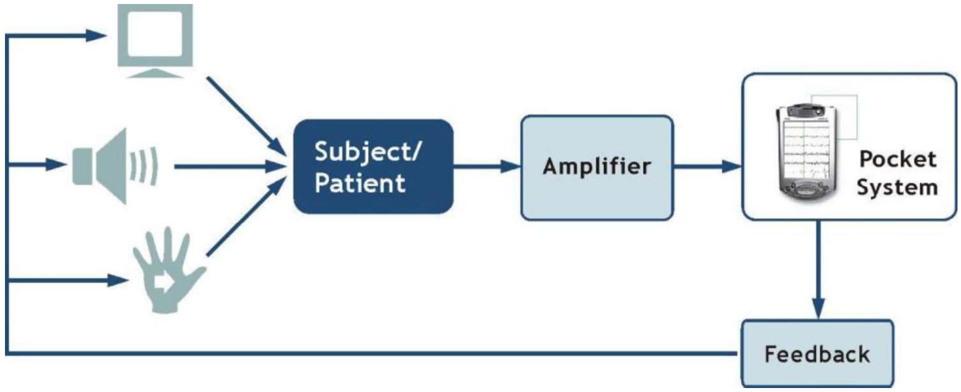

Figure 3: Pocket-PC BCI system.

The system is running Windows CE and allows the visualization, the quality check and storage of data. Parameters are extracted in real-time and are used for visual, auditory or tactile feedback to the patient/subject.

References

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[3] Pfurtscheller G, Neuper C, Guger C, Harkam W, Ramoser H, Schlogl A, Obermaier B, Pregenzer M.: “Current trends in Graz Brain-Computer Interface (BCI) research,” IEEE Trans Rehabil Eng., vol. 8, pp. 216-9, 2000.

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