ARCHITECTURES OF A PC AND POCKET PC BASED BCI SYSTEM

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SUMMARY: EEG-based brain computer interface systems have different demands depending on the application area. A PC based system allows the flexible design of feature extraction, classification methods and experimental paradigms. The key advantage of a Pocket PC based approach is its very small dimension and fully battery supply. Hence a truly mobile BCI system e.g. mounted on a wheelchair can be realized.

INTRODUCTION

EEG based brain computer interface (BCI) systems can be used for people with disabilities to improve their quality of life. Applications of BCI systems comprise the restoration of movements, communication and environmental control [1]. General used parameters to quantify the performance of BCI systems are the accuracy and speed. Furthermore, a BCI approach should ensure that the user learn to control the system within a few training sessions. The level of control should be stable after initial learning and even improving in time [1, 3]. BCI systems must also be able to operate without expert oversight. Family members must be able to help in operation of the BCI system on a daily basis. Therefore, the systems must be robust and easy to use. System appearance and how the users look like while using the device are also important issues when realizing the BCI system.

BCI systems have been successfully realized based on different EEG phenomena: (i) oscillatory EEG components in the mu and beta range, (ii) slow cortical potentials and (iii) evoked potentials. Depending on the BCI concept and control strategy different electrode montages are used for measuring EEG. Thereafter, feature extraction and classification is performed to get a reliable control signal. After some training session the BCI accuracy enhances to a certain degree, meaning the BCI system and the subject have adapted to each other for a better general system performance [1].

For this described scenario it is necessary to have a very flexible and easy extendable system architecture. It must be possible to use multiple EEG electrodes, to use and compare different feature extraction and classification methods and to develop different applications [1,2,4]. However, for the general usage outside the research lab new key features must additionally be realized: the BCI system must be as small as possible and very easy to use. Therefore, both a flexible research system and an embedded Pocket PC system are discussed.

SYSTEMS

A Laboratory System
Figure 1 shows the PC/notebook based BCI system.

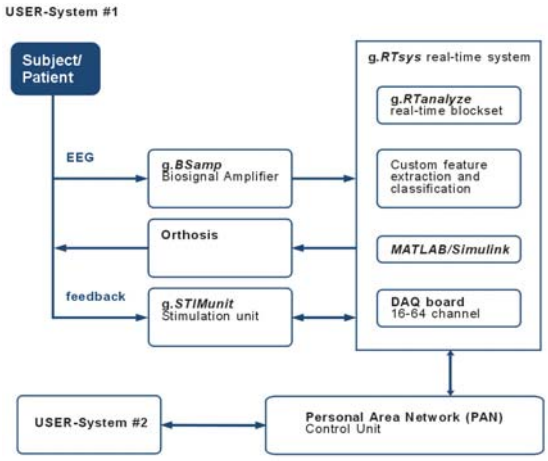

Figure 1: PC/notebook based BCI system

The subject is connected via EEG electrodes to a biosignal amplifier. A data acquisition board (DAQ board) performs the analog to digital conversion with a user selectable sampling rate. In order to control all hardware parameters, it is important to have a powerful software package that also includes the driver for the DAQ-boards. It is also important to choose a programming language that enables an easy setup or adaptation of the programs for the experimental paradigm, data acquisition and analysis. For this purpose, MATLAB, in combination with the signal flow oriented Simulink Toolbox, was chosen. Simulink is used for the real-time calculation of different parameters, which describe the current state of the EEG (g.RTanalyze). MATLAB handles the data acquisition, timing and presentation of the experimental paradigm. Thus, the system can be programmed graphically and it is also running in real-time under Windows [2].

Digital and analog outputs allow controlling external devices such as a hand orthosis or a stimulation unit to present different paradigms to the subject and enhance the BCI performance with feedback of the classification result. A personal area network is used to remotely control the BCI

system for operation control, algorithm updates as well as BCI data transfer [2].

The modular system described above is well suited for experimental purposes in a laboratory. Such a system configuration can be used for the realization of a language supporting system where the patient can select letters or words on the display of the notebook. But for assistive applications like a TV channel selection or a wheelchair mounted language supporting program, where the patient can also select letters or words, an embedded system including the processor board and DAQ board without mechanical disks and extra display is more suitable.
Size, robustness, ease, and convenience of use are major considerations for assistive communication devices. The hardware must be fully portable, supplied by a battery and cheap [3].

Figure 2: Pocket PC BCI system components.

B Mobile System
For the embedded BCI a standard IPAQ Pocket PC from HP is used as portable host and is connected via a serial cable to an embedded target computer system g.MOBIlab (see Figure 2 and 3). The serial interface has a data transfer rate of 115 kBaud. The embedded system consists of a µC operating at 12 MHz to optimize the power consumption. A 16 Bit analog to digital converter (ADC) samples 8 analog channels with 256 Hz each. The module is equipped with 4 EEG channels, 2 ECG channels and 2 analog inputs for external sensors. Two digital inputs and 2 digital outputs allow controlling external devices. Two AA batteries power the embedded system. The Pocket PC operating system is Pocket PC 2003 and the BCI system was programmed in Embedded Visual C++. The integrated Wireless LAN (WLAN) module of the Pocket PC can be used for wireless data transmission. Data are stored on the internal 64 MByte storage or streamed to a Compact Flash card (512 MByte) for later analysis.

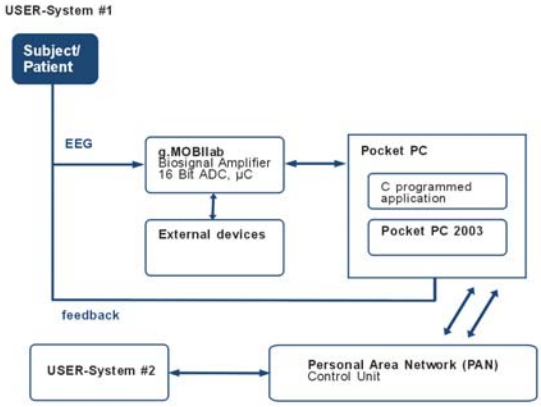

Figure 3: Pocket PC based BCI system

DISCUSSION

The PC based BCI system allows a very flexible design of BCI experiments concerning electrode configuration, utilized algorithms and applications. The rapid prototyping environment speeds up the development cycle significantly.
On the other hand the embedded BCI with its compact dimension allows the usage of the BCI outside the research lab for patient training and (as Pocket PC CPUs are getting more and more powerful) also for many sophisticated applications. The system can be mounted easily on a wheelchair or beside the bed and is fully battery powered. A big advantage is that the Pocket PC BCI operates immediately after switching it on without booting of the operating system.
Both systems have standard digital I/Os for communication with the external world but can also use a network connection. The Pocket PC is equipped with a Wireless LAN or Bluetooth interface for wireless operation.

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