THE BIO-FEEDBACK SYSTEMS DESIGN APPROACH AT THE "TOR VERGATA" UNIVERSITY

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The objective of this research was to realize an efficient and scalable C++ Bio-Feedback software framework that could be used in a wide range of pathological situations thus minimizing the time spent to build a completely new system.

One of the main problems encountered in the development of computer-based systems for handicapped people is that it is very difficult to optimize them in a wide range of situations. This generally occurs because every patient has residual capabilities that are specific to his condition and that make him in some way unique. Moreover, very often, different pathologies are treated using different approaches and tools: sometimes the processing power of a PC is required while in some others it is desirable for the whole system to be portable and lightweight. In any case it is necessary to try to use all of the usable biological signals such as EEG, EOG, EMG, voice, etc. simultaneously to maximize the overall "communication bandwidth". It must be noted that different approaches (e.g. EP, EEG, etc) could require targeting different platforms: the Microsoft Windows OS family for example (with the exception of Windows CE/Embedded) does not provide a Real-Time environment and several unpredictable delays (of the order of tenths of milliseconds) can be introduced at different stages. This is probably not a problem in EEG based applications, but it could be in EP ones. Moreover, in general, a Windows based solution could easily provide many features, such as text to speech capabilities, but, on the other side, it still does not allow to build wearable and cheap systems.

However, even if the nature of the utilized signals may vary among different pathological situations, the way in which a biofeedback system works is quite stereotyped: after the data have been acquired, there is a DSP pre-processing stage that performs some basic operations on the biological input signals, then a classification stage in which some features are extracted and manifested in some way to the user and eventually recognized as one of the subject voluntarily controlled activities, and, at the end, a stage in which a task can be executed. Finally it is very frequent that these systems provide different operating modalities such as training, testing, setup, and running.

This is a situation in which an object oriented programming approach reaches his best results: in our case it is possible to describe the operative flow that is common to all the biofeedback applications leaving to be defined only those aspects that are specific to the single implementation, such as the algorithms and the classification rules. Then, in a separate step, several systems can be realized just defining the points that are left unspecified.

It is important to notice that the proposed solution does not make any assumption on both the operating system and the hardware used. For this reason all the formats of the generated files were based on the XML technology (eXtensible Markup Language), that is portable across virtually any OS, and that also allows to extend the file format without loosing backward compatibility. This is a key issue when data files need to be shared across different laboratories or put on the Web.

This framework was used to develop three different BCI systems. Each of them was fully implemented using no more than 40 lines of C++ code. The same source code was compiled under the following operating systems: Windows 98/2000/XP (using Borland C++ Builder 5, Microsoft Visual C 6.0 and GCC 3.1), Windows CE 3.0 (using Microsoft Visual C++ for Embedded Visual Tools) and Linux (using GCC 3.1).

More details and resources can be found at http://www.luigibianchi.com/bci.htm