A Tele-Cognitive Rehabilitation System Using LabVIEW

Anna Lisa Mangia 1, Elena Borelli 2, Angelo Cappello 3

1 Department of Electrical, Electronic and Information Engineering (DEI), Bologna University of Bologna
2 Health Sciences and Technologies - Interdepartmental Centre for Industrial Research (HST-ICIR), University of Bologna, Italy
3 annalisa.mangia2@unibo.it
2 elena.borelli@unibo.it
3 angelo.cappello@unibo.it

Abstract: Brain injury is one of the main causes of long-term disability, and its rehabilitation is a challenge to healthcare teams. This study developed a tele-rehabilitation system for the cognitive rehabilitation of persons with brain injury using LabVIEW, a high-level graphical programming environment. The system offers several cognitive rehabilitation exercises and allows patients' personal and clinical data and the results of the exercises performed by patients to be saved in an Access database. The system provides a remote connection between the database and the device suitable for rehabilitative training, allowing continuous monitoring of patients' performance.

Keywords: LabVIEW, Virtual Instrument (VI), Cognitive Rehabilitation, Tele-Therapy

I. INTRODUCTION

Brain injury can produce a variety of cognitive disturbances depending on the location of the lesion [1]. Current methods for cognitive rehabilitation are based on traditional paper-and-pencil tests. However, significant difficulties are encountered when these conventional methods are applied to cognitively impaired patients. First, many patients with both cognitive and physical impairment, cannot reach the hospital alone, and most families cannot afford the high cost of accompanying patients to the rehabilitation hospital several times a week for training or even stay in the hospital. Second, traditional paper-and-pencil tests are usually carried out in one-to-one mode, meaning one doctor can only coach one patient at a time to do the cognitive training. For a large number of patients, this method of cognitive rehabilitation is ineffective. Since cognitive rehabilitation is a far-flung process, computer-based technologies show outstanding advantages in assisting therapy, evaluating residual function quantitatively, storing rehabilitation results, and so on. In addition, doctors can assist patients to perform the computer-based rehabilitation training through an internet connection and check the training results, thus overcoming the problems arising with traditional therapy. The tele-therapy technology for cognitive disturbances offers good opportunities to satisfy the needs of an increasing number of patients [2] [3] [4]. For this reason, we developed software for tele-cognitive rehabilitation using LabVIEW, a high-level graphical programming environment [5]. This paper outlines the rehabilitation tests, the structure of the database connected to the application, and the LabVIEW-based remote connection between the database and the patient’s training workstation.
II. DESCRIPTION OF THE TELE-REHABILITATION SYSTEM

A. COGNITIVE REHABILITATION TRAINING
The tele-rehabilitation software contains several cognitive training programmes for the patients. The application for cognitive rehabilitation training is organized into four parts: (1) memory training, (2) visuo-spatial cognition training, (3) selection and classification training, and (4) cognitive phonology training. Rehabilitation exercises are characterized by adaptation of training difficulty to the performance of the patient, effective feedback and user-friendliness. Rendering scales and scores are also provided to improve the patients’ motivation. Furthermore, exercises are characterized by a random presentation of stimuli to avoid learning effects [6].

B. DATABASE ARCHITECTURE
The software allows the personal and clinical data of the patients to be inserted and stored in a database along with the exercise settings and patients’ scores. The relational database is based on Access. A relational database is a collection of data item tables formally described and organized according to a relational model. Data in a single table represent a relation and, in typical solutions, tables may have additionally defined relationships with each other [7]. Our database tables are: (1) Patient, containing patients’ personal data, (2) Medical Case, containing patients’ clinical data, (3) Training Exercise, containing the list of exercises executed by the patients with the setting parameters for each one, (4) Results and Score, containing the patients’ results for each exercise. A block diagram of the database relations is shown in Figure 1. Different medical cases can be associated with each patient, different training exercises with each medical case, and different results and scores with each training exercise. This allows the patient’s performance to be monitored in real time and the follow-up phases easily executed.

Figure 1. Database Block Diagram.

We used the Access Database because it allows a simple consultation independently of LabVIEW. We used the Database Connectivity Toolkit (DCT) to connect the database with LabVIEW. The DCT is a LabVIEW toolkit providing optimized Virtual Instruments (VI) for database access using ActiveX Data Objects (ADO) technology [8]. The system allows a remote connection between the database and the patient’s workstation executing the training.

C. DATABASE REMOTE CONNECTION
The database remote control uses the Client-Server model and the TPC/IP protocol. The server is the machine hosting the database at the rehabilitation centre, while the clients are the devices running the cognitive rehabilitation training software. To achieve remote connection, we used the LabVIEW VI Server functions. A VI Server is a set of functions that dynamically controls front panel objects, VIs, and the LabVIEW environment. With a VI Server, VIs and LabVIEW can also be loaded and run either on the same machine or across a network [9]. Our idea to achieve database remote control was to execute in the server machine all the VIs involved in database management, as shown in Figure 2. That occurs whenever information needs to be inserted in or retrieved from the database by the client device. We call the VI of the server involved in database management VIDM (VI Database Management).
In order to build the VI server application, both the TCP/IP protocol in LabVIEW and the client access to the server had to be enabled, setting the client’s IP. The following steps were completed to allow the database to communicate with the VI running on the client device for the insertion of personal data and test results in the database. The client VIs: (1) open a reference to the server instance through the function *Open Application Reference*, (2) open a reference to the VIDM through the function *Open VI Reference*, (3) call the VIDM through the function *Invoke by Reference Node*, specifying the information inserted in the client device we want to store in the database, (4) close the VIDM reference and the server reference through the function *Close Reference*. An example of the remote connection code for the registration of a patient is reported in Figure 3.

Figure 2. Schematization of the remote connection model.

Figure 3. Code of one client VI controlling the dynamic execution of a remote server VI.
III. Experiment and Result

To demonstrate the concept introduced in this paper, the system is organized into two main parts: (1) the cognitive rehabilitation training battery, and (2) the database storing patients’ personal and clinical data and the setting and results of the rehabilitation exercises performed by the patients. The exercise interfaces are interactive, motivating and easily adapted to individual patients’ performance. Some exercise interfaces are shown in Figure 4. The system allows a remote connection with the database. Figure 5 shows the software interface for the insertion of the Client and Server IPs.

The remote control of the application has many advantages. First of all, it uses a single database accessible from every outstation, in order to insert and retrieve patients’ data. This makes the application lighter and suitable for portable devices like smartphones or tablet pc. The remote control opens the possibility of “shared therapy” because the therapist monitors the training of different patients at the same time, increasing the total capability of the rehabilitation team. Our tele-cognitive rehabilitation model is home-based and tailor-made. As previously stated, people with brain injuries do not just have cognitive problems, but they may also suffer from physical impairment. Tele-cognitive rehabilitation methods provide greater flexibility during service delivery. The system allows users to stay at home and avoid spending a long time travelling to receive tailor-made face-to-face treatments.

Figure 4. Some examples of testing interfaces.
IV. CONCLUSION

This paper outlined a tele-therapy system for cognitive disturbances. The results obtained are promising since our system is safe and stable. However there are many ways to improve and integrate the system. Thanks to the modularity of the application, it will be simple and fast to complete the platform with new rehabilitation exercises. An application for portable devices like tablets or smartphones is also planned.

V. REFERENCE
