Cognitive Neurorehabilitation based on Interactive Video Technology

J.M. Martínez-Moreno[a,b,1], J. Solana[a,b], R. Sánchez[c], S. González[d],
P. Sánchez-González [a,b], C. Gómez [c], M. Morell [c], C. Cáceres [a,b], T. Roig[c],
J.M. Tormos[c], E.J. Gómez [a,b]

[a] *Biomedical Engineering and Telemedicine Centre, ETSI Telecomunicación, Universidad Politécnica de Madrid, Spain*

[b] *Biomedical Research Networking Center in Bioengineering, Biomaterials and Nanomedicine (CIBER-BBN), Spain.*

[c] *Institut Guttmann Neurorehabilitation Hospital, Badalona, Spain.*

[d] *Lavinia Interactiva, Barcelona, Spain*

Abstract. Cognitive impairment is the main cause of disability in developed societies. New interactive technologies help therapists in neurorehabilitation in order to increase patients' autonomy and quality of life. This work proposes Interactive Video (IV) as a technology to develop cognitive rehabilitation tasks based on Activities of Daily Living (ADL). ADL cognitive task has been developed and integrated with eye-tracking technology for task interaction and patients' performance monitoring.

Keywords. Interactive video, neurorehabilitation environment, eye-tracking

Introduction

The use of new technologies in neurorehabilitation has led to higher intensity rehabilitation processes, extending therapies in an economically sustainable way. Interactive Video (IV) technology allows therapists to work with virtual environments that reproduce real situations. In this way, patients deal with Activities of the Daily Living (ADL) immersed within enhanced environments [1]. These rehabilitation exercises, which focus in re-learning lost functions, try to modulate the neural plasticity processes [2].

This research presents a system where a neurorehabilitation IV-based environment has been integrated with an eye-tracker device. Visual attention is used to both interact with the task and monitor patients' performance. While patients are interacting with the neurorehabilitation environment, their visual behavior is closely related with their cognitive state, which in turn mirrors the brain damage condition suffered by them [3][4]. Patients' gaze data can provide knowledge on their attention focus and their cognitive state, as well as on the validity of the rehabilitation tasks proposed [5].

[1] Corresponding Author: J.M. Martínez-Moreno. D-213, ETSI de Telecomunicación, Universidad Politécnica de Madrid, Av. Complutense 30, 28040, Madrid, Spain. Email: jmartinez@gbt.tfo.upm.es

1. Methods

IV refers to any video whose sequences and displayed information depend on the users' responses. Interactivity is provided by associating an interaction with any element which appears in the video scenes; the video flow is modified according to the way users interact with them.

IV effectiveness has been proved on teaching field, where interactive dynamic visualization allows users to adapt the processes to their individual cognitive skills [6] [7]. Moreover, some studies have proved that ADL observation treatment is a good rehabilitative approach in stroke patients [8]. This research is supported by the initial hypothesis which states IV as an appropriated technology to sustain personalized rehabilitation processes based on enhanced environments where real situations of daily living are reproduced in order to patients deal with them.

Eye-tracking technology is proposed to support and assess patient's performance. It is used to both interact and monitor the therapy session. Tobii 1750 is used as the eye-tracker device [9]. The system provides time-stamped data on the position (x,y) of the patient's gaze focus, the distance between device and patient or the patient's pupils diameter. More interestingly, parameters such as patient's gaze fixation areas and duration, as well as the instants when saccade movements occur, are obtained.

2. Results

In order to validate this new neurorehabilitation method using IV technology an ADL "buying bread" task was developed. An IV screenplay was designed by Guttmann Hospital neuropsychologists and recorded with amateur actors in outdoor and indoor real environments. The IV allows patients navigate through a series of scenes representing the different steps which they have to follow in order to reach a final goal, from sitting on the couch at home (initial state) to buying bread at the bakery (end state). Throughout the task, patients are required to make decisions: choosing the next step, answering questions or interacting with other characters.

Every single action in the task is under therapist control, who has previously adjusted the video scenes sequence to the cognitive capabilities required by the patient. Thus, all stimuli in the scenes may be preprogrammed by therapists in order to help the patient or even distract him/her from completing a task.

Afterwards Eye-Tracking technologies were integrated in the IV neurorehabilitation environment where patients deal with an ADL. Figure 1 shows the proposed integration schema for using eye-tracker's libraries from the IV web application.

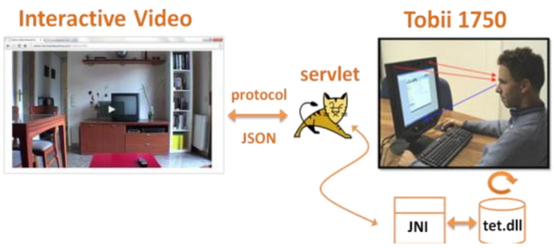

Figure 1. Neurorehabilitation environment schema

The eye-tracking system captures visual attention data while the patient is performing the activity. Tracking data are stored in both a global file and a set of individual files for each played video scene. Heat maps (Figure 2) can be obtained for every frame visually representing the areas where a patient pays more attention.

Figure 2 Heat maps generated by the environment

In addition, the environment is capable of detecting attention deficits when patients close their eyes or look away from the screen. The environment will respond to these situations showing new stimuli according to therapists' instructions, trying to retain/recover their attention.

3. Discussion

This research proposes IV as an appropriated technology to develop cognitive rehabilitation tasks based on activities of daily living. The ADL developed task has been integrated with Eye-Tracking technology within a real hospital neurorehabilitation environment, not only to adapt the task flow in order to hold patient's attention but also to extract useful information for therapies about how patient has performed his rehabilitation task.

A clinical trial is already designed and a further evaluation is in process to confirm the hypothesis that states the advantages and effectiveness on clinical routine of IV-based procedures for cognitive neurorehabilitation.

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