ViTAS gaming suite: Virtual Therapy Against Stroke

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***Abstract*— Stroke is the leading cause of disability in Western Society, and rehabilitation is a fundamental support to ensure the best possible recovery of stroke patients after acute disease. To support and enhance conventional therapies we have developed a virtual rehabilitation gaming suite called ViTAS. ViTAS replicates some of the tests performed in clinical contexts, thus making the integration between virtual and traditional rehabilitation completely straightforward. We have collected the opinion of 35 clinicians with different degree of experience, following a customized self-report questionnaire. The results showed high acceptance of clinicians to use ViTAS system in rehabilitation. We conclude that ViTAS could become an essential supplement to standard post-stroke rehabilitation protocols.**

I. INTRODUCTION

Stroke is the largest cause of disability in Western Society, since half of all stroke survivors have a disability [1]. Impaired motor function is one of the most common sequels after stroke, having a profound impact on the independence and quality of life of the affected individuals. In particular, stroke survivors with upper extremity (UE) functional limitations are particularly susceptible to problems in performing activities of daily living (ADLs) [2]. There is evidence that the application of rehabilitation protocols that promote the execution of hundreds of task-specific movements is a key factor to achieve reorganization of cortical maps after stroke [3]. However, conventional therapies may have practical limitations as being time consuming, resource intensive, dependent on patient adherence and limited in its availability depending on the geographical area. As a consequence, therapy intensity is often far from optimal for neuroplasticity [4]. One proposed method for optimizing the effects of stroke therapy is the use of virtual reality (VR) as rehabilitation supplement. VR is defined as a simulation of a real environment generated by computer in which, through a man-machine interface, the user interacts with certain elements inside a simulated scenario [5]. VR advantages rely on the possibility of determining task parameters based on subject specific requirements, offering realistic goals and challenges, obtaining precise performance measures, providing safe and ecologically valid environments and motivating patients over longer periods of time [6].

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Fig. 1. Images of the ViTAS gaming suite (from left to right and top to bottom): the ViTAS setup, virtual box and block test, stars cancellation test, pac-jump game. See text for more details.

The LeapMotion Controller (LMC, Leap Motion Inc., San Francisco, USA) is a human-computer interaction device not specifically developed for rehabilitation, but for hand gesture controlled user interfaces. The device is based on cost effective computer vision (CV) technologies and can measure simultaneously all the fingers from both hands, also modeling articulation joints. Compared to other CV sensors (such as the Microsoft Kinect used in [7]) LMC provides more accurate tracking of hands and fingers motions [8], and it is cheaper and less invasive than haptic and wearable devices. As shown Figure 1, the use of a LMC combined with a laptop or even a tablet could be ideal for using the ViTAS system at patient's home. Starting from recent works available in literature [9], [7], we have developed the ViTAS gaming suite, to simulate in a virtual environment the real test and exercises used during rehabilitation protocol. Compared to [9] we have introduced immersive 3D simulation of real rehabilitation exercises as originally proposed in [7] but with an improved hand gesture sensing. To evaluate the proposed system, we have asked 35 professionals and students of the rehabilitation field to answer a customized self-report questionnaire. In the following sections we will describe the proposed system, we will briefly discuss the obtained results and we will draw some conclusion and possible future works.

II. MATERIAL AND METHODS

A. ViTAS gaming suite

We developed the ViTAS using the Unity3D game engine and C# scripting language on a Microsoft Windows 8.1 laptop equipped with a Intel i7 processor, 8GB of RAM and an NVidia graphic card. Unity3D allows developers

to render real-time graphics and simulate physics. It also supports different input devices, such as the LMC used in our setup. We implemented different rehabilitation tests for stroke (see Figure 1): Box and Block [10], Star Cancellation [11] and Bilateral Arm Reaching Test (BART) [12]. We also added games to improve the user engagement and motivation. We strictly followed the specifications of each test to ensure an accurate virtual simulation of the real tests. Moreover the therapist could set different parameters of the simulation (i.e. dimensions of virtual objects, grasping tolerance, timings constraints) to adapt the difficulty level to the user conditions and rehabilitation goals. ViTAS saves statistics about timings, specific test events, hand and finger 3D positions in standard format compatible with widespread processing tools to enable the therapist to objectively monitor and report the user performance and tracking progress.

B. ViTAS usability and acceptance

To evaluate clinicians' opinion about the virtual reality system and its application in rehabilitation, all participants filled-in a customized self-report questionnaire consisted of 27 items divided in seven blocks: Use, UX, UI, Exercises, Satisfaction, Clinical use and Therapy. Use block contained questions related to systems usage complexity; UX block referred to systems User Experience; UI was related to User Interface Design; Exercises block evaluated tasks implementation; Satisfaction assessed how satisfied were the users with the system; Clinical Use block was related to the use of the system in clinical environments; and Therapy referred to system application as rehabilitation tool. This questionnaire was presented in the format of a five-points Likert scale and some checkboxes format questions. Participants had to report their agreement/disagreement and select some items with respect to a number of statements, and only one response per person was allowed and all participants were encouraged to comment and make suggestions on the system.

III. RESULTS AND DISCUSSION

Thirty five participants answered the questionnaire, 3 of them after trying it personally and 32 of them after seeing a video of it (available at `youtu.be/QiHEq-yxoQY`). The inclusion criteria were the following: 18 years of age; being a professional or a student in the rehabilitation field, free-will, cooperation and motivation to participate. The sample were mainly composed by occupational therapists (71%), followed by occupational therapists students (17.1%), and other rehabilitation specialty (physiotherapists, rehabilitation physicians and speech therapists). Results from the evaluation questionnaire are presented in Table I. Analyzing the answers we can deduce a positive acceptation of ViTAS software within clinical professionals. The large proportion of neutral answers in the Use block are coherent with the fact that most participants only knew the system by video. Moreover, the lack of positive feedback on the UI block indicates an aspect that needs to be addressed in future developments. Eventually, feedback from clinicians indicated the need of the implementation of goal-oriented tasks to train ADLs. Overall, the largely positive results obtained in the survey suggest high acceptance of the system by clinicians.

TABLE I
GROUPED RESULTS TO VITAS EVALUATION QUESTIONNAIRE.

Block	Positive Evaluation	Neutral Evaluation	Negative Evaluation
Use	66.1	25.9	8.1
UI	52.0	30.4	17.6
UX	86.8	11.8	1.5
Clinical Use	85.3	10.8	3.9
Exercises	82.5	16.5	0.9
Satisfaction	88.3	8.8	2.9
Therapy	82.7	13.8	3.5

IV. CONCLUSIONS

In this work we have described the ViTAS gaming suite, a virtual therapy system able to replicate the standard rehabilitation tests and exercises used in the post-stroke therapy. We have collected encouraging opinion from professionals and students of the rehabilitation field, that confirms the usefulness and effectiveness of the proposed system. Future work will focus on improving the user interface design to ease the use of the system, and to proceed with the clinical evaluation (clinical protocol already approved by ethical committee). Furthermore we will improve the data collection for the therapist and the automatic report generation about patient progress.

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