Virtual Reality based Diagnosis System for Visuospatial Neglect

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Abstract: The diagnosis of Visuospatial neglect is generally conducted using paper based manual methods. The obtained results could be confused with sensory inattention pathology. In this paper we are presenting a new Virtual Reality based diagnosis method for patients suffering from Visuospatial neglect. For this purpose a Virtual Reality simulation called Farm Parade has been developed where the patient, after wearing a Virtual Reality headset, will be guided inside a road crossing a farm like environment where animals at both sides of the road will slowly move and generate sounds to encourage patients to look at them. The patient head motion will be then tracked to generate a graph showing his capacity to move his head and judge if he is suffering from Visuospatial neglect. The strength of the proposed system is the generation of numerical values relative to the amount of head's rotation which could be helpful for measuring precisely the degree of recovery.

1 INTRODUCTION

Visuospatial neglect is most commonly the results of stroke or cranial trauma. It affects up to 80% of patients in the acute stage (HeilmanKM, 1993)(Barat M, 2000)(PELISSIER J., 2005). It leads that the person forgets half of his body and mainly the side who is not relaying on during his daily life activities (Ogourtsova et al., 2018)(Li and Malhotra, 2015). Since most people are using their right side, most patients suffers from Visuospatial neglect on the left side of their body. This affects their daily life activities, in the way they cannot use their left hand or move normally their left feet. There are multiple approaches to diagnose patients suffering from Visuospatial neglect but most of them are manual. In addition, these approaches could lead to ambiguities those suffering from sensory inattention. In fact, both pathologies might coexist and patient might recover from one before the other (Li and Malhotra, 2015). Moreover, the classical tests could not give a precise measure of the recovery state of the patient. In the next section we will review popular methods used today to diagnosis Visuospatial neglect.

2 STATE OF ART

Visuospatial neglect diagnosis is mainly manual and paper based (Pedroli et al., 2015)(Bergegoc., 1995). This requires that patient sits in proper position and has the paper in a fixed position and center it within his body. This is not always an easy task especially for patients suffering from serious physical problem or those trying to cheat during the diagnosis by moving the paper to the normal side of their body to show that their fast recovery. Below examples of these tests.

2.1 Bisection Test

In the Bisection test, after sitting in proper position as described above, patient shall use a pen to mark the middle of each line. Patients suffering from Visuospatial neglect tend to not marking the line exactly on the middle. In addition they might not notice the presence of some line one affected side of their body.

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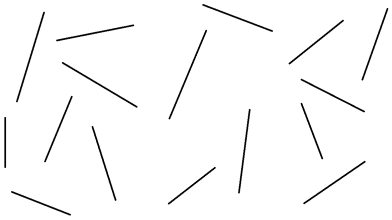


Figure 1: Bisection Test Example.

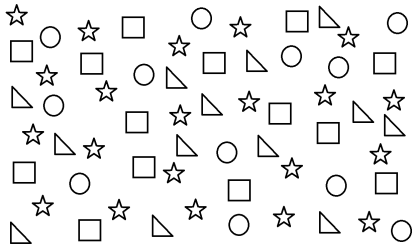


Figure 2: Cancellation Test Example.

2.2 Cancellation Test

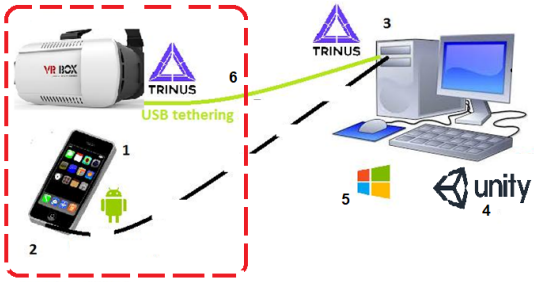
In the cancellation Test, after sitting in the proper position, the patient is required to mark a particular type of image and distinguish it from others. The exercise complexity could increase with higher number of images types and by decreasing their size. This is so far the most efficient test and patients suffering from Visuospatial neglect tend to mark pictures on the affected side of their body. A percentage of the recognized objects could be calculated after each test to track the patient progress.

2.3 Mobility Assessment Course

A work for Dynamic assessment of visual neglect was proposed by Antonia et al (Brink et al., 2018). In that work, the patient is moved through a corridor and has to find and report targets attached in the walls. This work is compared against classical tests and it presents sufficient reproducibility. In our proposed work, the walking through the corridor is replaced by a Virtual move along a road. The head tracking we have proposed allows us to precisely measure the amount of head's rotation which is a good indicator of the patient recovery.

3 THE PROPOSED SYSTEM

In the literature, Virtual reality was used to treat the problem of Visual neglect (Ogourtsova et al., 2018)(Tsirlin I, 2009)(Klinger E, 2008). A good review is presented in (Pedroli et al., 2015). In our work, we have chosen to develop an immersive content with head's interactivity in order to ensure embodiment and ownership. We consider that this constraint can help patient to be part of the simulation to ensure cerabral plasticity which is the first step to recovery. The sense of embodiment is well exposed in (F. Argelaguet, 2016).



1 Head's position detection

2 Sending head's position to the PC (unity)

3 Receinving head's position

4 rotate the scene according to head's position on PC

5 saving head's position for further processing

6 Sending live scene back to smartphone

Figure 3: Simulation setup.

A 3D simulation for capturing the angle of head's rotation is developed using Unity 3D. The 3D simulation is displayed in the computer's screen for the therapist to monitor the patient's behavior. The same content is displayed in a cardboard manner in the smartphone's screen inside the HMD. We used the Trinus VR software to ensure the communication between the PC (Unity plugin) and the smartphone. The same software (Trinus VR) is used to capture head's motion of the patient.

The communication between the Smartphone and the computer is ensured to be activated prior to the simulation. The test setup is presented in figure 3.

The functioning of our proposed system is summarized in the organigram in figure 4

In real time, the developed software's orientation of the patient, shifts the 3D content according to this orientation. The particular value of rotation along the Y-Axis is stored to assess the head's rotation to right and left (Y-Angle). Positive values of Y-Angle correspond to rotation into right whereas negative values correspond to rotation into left. The out performance of our system is the ability to measure precisely and in real-time:

- Rotation amount into right and left
- Maximum Y-Angle into right and left
- Angle density into right and left. This density is the measure of the surface (Y-Angle vs time) for positive values (right rotation corresponding

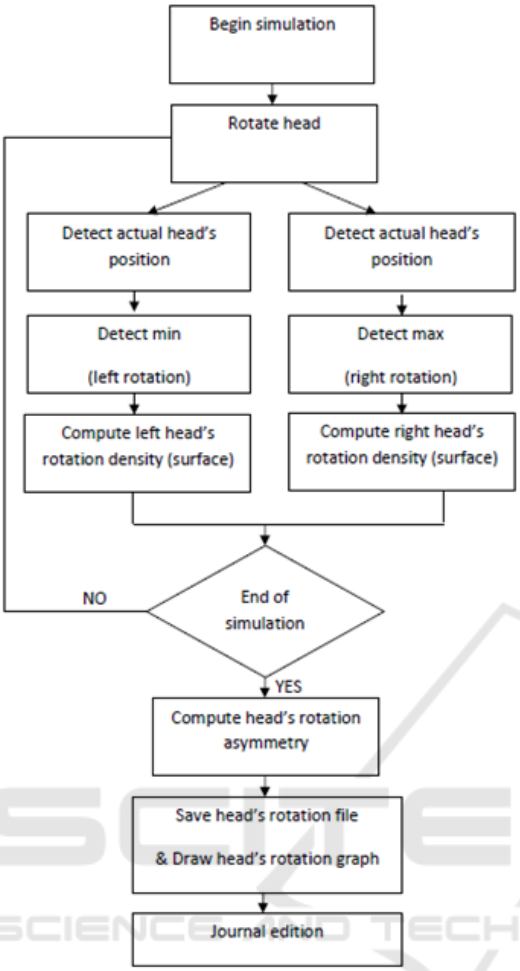


Figure 4: Simulation organigram.

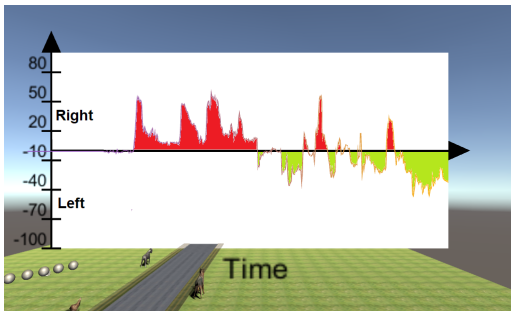


Figure 5: Density of right and left rotation.

to red surface in figure 5) and for negative values (left rotation corresponding to green surface in figure 5)

- Head's rotation asymmetry, given by equation 1. It corresponds to the percentage of left rotation against right rotation. Ideally, for a healthy participant, this amount should be 100 % for equal rotation to right and left.

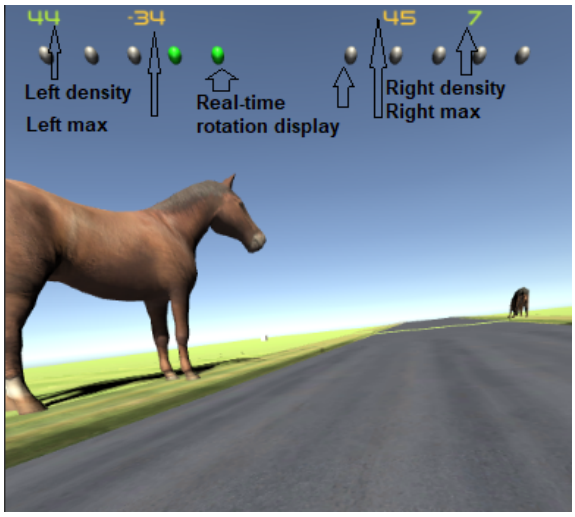


Figure 6: Simulation Farm Parade.

$$Asymmetry = \frac{\int_{begin}^{end} Angle_{left}(t)}{\int_{begin}^{end} Angle_{right}(t)} * 100 \qquad (1)$$

A the end of the 3D simulation, a graph of Y-Angle over time is displayed. An excel journal is also saved for further statistical processing.

We developed the following scenario for measuring head's rotation:

1. Simulation 1 - Farm Parade : This simulation consists on a navigation inside a farm with animals at the right and left sides. A patient suffering from visuospatial neglect could not move his head into the animals at his left side. This simulation could be considered as a simple evaluation tool (graph of head's position).

4 EXPERIMENTAL RESULTS

We have tested this new diagnosis method on seven patients at the department of physical medicine and rehabilitation of Sfax University Hospital. And the diagnosis method helped us identifying one patient suffering from Visuospatial neglect. The classical Visuospatial neglect tests are confirmed by our new method. In figure 7, corresponding to non visual neglect patient, we see that in the graph is roughly symmetric (equal surface for positive and negative values). The Asymmetry measure for this patient is 84 %. In figure 8, corresponding to visual neglect patient, we see that the graph is asymmetric (more surface for positive than negative values). The Asymmetry measure for this patient is 27 %.

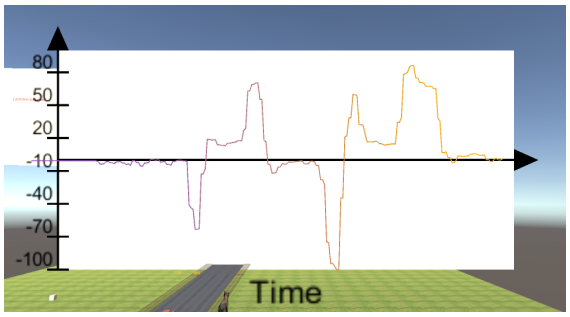


Figure 7: Non Visuospatial Neglect patient.

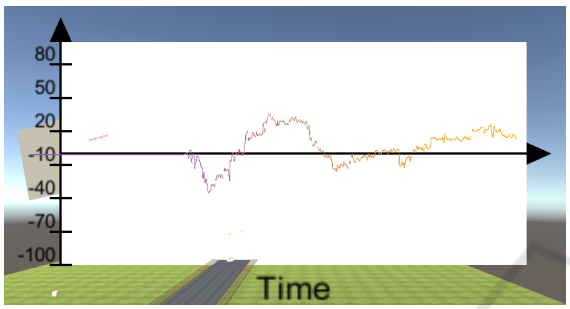


Figure 8: Visuospatial Neglect patient.

5 CONCLUSION

The proposed method is innovative, cheap and can be easily used in medical care centers. The obtained results are promising since Visuospatial neglect problem has been successfully identified. The strength of the proposed method is the ability to measure precisely the patient's head movement which is useful to assess the recovery state across sessions. The proposed system, while developing new scenarios, could be also used as a treatment for Visuospatial neglect since the patient is trained to turn his head which can help him to recover thanks to the neuroplasticity phenomenon. The proposed system will be tried for a larger group of patients to be validated. In the future we are planning to include hand's motion as a VR rehabilitation technique for other kinds of stroke induced disabilities.

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