ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

MASTER THESIS

Ensuring self-haptic Consistency for Immersive Amplified Embodiment

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"Thanks to my solid academic training, today I can write hundreds of words on virtually any topic without possessing a shred of information, which is how I got a good job in journalism."

Dave Barry

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Abstract

Computer Science Section
School of Coputer and Communication Sciences

MSc in Computer Science

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by Sidney BOVET

The Thesis Abstract is written here (and usually kept to just this page). The page is kept centered vertically so can expand into the blank space above the title too…

Acknowledgements

The acknowledgments and the people to thank go here…

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1 Introduction

Foreword: will cover multiple subjects from stroke rehabilitation to motion capture.

1.1 Stroke Rehabilitation

Explanation of what a stroke is and how to recover.

1.1.1 Motivation

Emphasis on the motivation being a key aspect of the rehabilitation process, with [ref].

1.2 Motion Caputre

The action of capturing one's movements and possibly altering it, be it in order to fit it onto an avatar of different moprphology or to change aid one reaching a target.

1.3 Pshychometrics

JND and other PM concepts.

2 Related Work

2.1 Motion Capture and Inverse Kinematics

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2.1.1 Egocentric Coordinates

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2.2 Stroke Rehabilitation

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3 Implementation

In this chapter we describe how we adapted the preexisting motion capture software in order to obtain the desired distorted behaviour.

3.1 Distortion model

As briefly mentioned in chapter 2, we are taking advantage of the Egocentric Coordinate formalism in order to introduce our distortion model. Formally, we modify every relative displacement vectors $\vec{v}_i$ such that:

$$\vec{v}_i := f(\vec{v}_i, \gamma) \tag{3.1}$$

And f is defined as:

$$f(\vec{v}, \gamma) = \hat{v} * ||\vec{v}|| * 4^{\gamma} \tag{3.2}$$

Where $\vec{v}$ is a vector, $\hat{v}$ is its normalized counterpart, and $\gamma \in \mathbb{R}$. The 4^{γ} is here for readability purpose: when $\gamma = 0.5$ the distortion makes each vector

Other Functions

Before resolving to use a simple linear function for our experimentation process, we tried out different functions that we think are of interest for further applications. Two of these functions are descibed here as a reference for further investigation.

Description and plots of the Power and Cosine functions.

3.2 Reachable Sphere

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4 Experiment

We are trying to estimate the limits of self attribution of a distorted movement and will do so by estimating the just noticeable difference (JND) in visual stimuli discrepency. This means estimating the just noticeable distortion made to the movement and hence the visual stimuli. The JND is estimated by using the adaptive staircase method introduced by [ref].

This method tries to estimate the JND by finding an upper and a lower bound for that value. These are found by changing the intensity of the distortion, based on whether the subject judged the last trial as distorted or not, and the JND is computed as the mean of the last few staircase turns (i.e. going from an increasing trend to a decreasing one or vice-versa). The dection judgment is gathered using a Yes/No prompt called the detection question : "Did the movements you saw exactly correspond to the movements you performed?"

4.1 Just Noticeable Difference

The JND will be measured in term of γ, the strength of the distortion. In general, if $\gamma = -0.5$ the subjects are hindered by having to travel 50% more than the distance between the targets, whereas if $\gamma = 0.5$ the movement will be amplified and the required motion will be reduced by 50%.

Due to the nature of the Egocentric Coordinates and how the distortion is applied (respectively detailed in chapters 2 and 3), this will not exactly be a metric of the difference in the distance that the subjects have to cover in order to reach the target, such as the metric used by [ref to Henrique]. It however gives a good understanding of the strength and the effect of the applied distortion.

4.2 Hypothesis

The hypothesis we have for the experiment is the following:

H1 The absolute value of the JND will be higher when the distortion is positive.

4.3 Equipment and Software

The HMD used for this experiment is the Oculus Rift in its first consumer version, with a resolution of 0 x 0 pixels per eye and a refresh rate of 90 Hz. Some more words on head and body tracking, with references to Eray's paper [ref].

4.4 Experiment design

We manipulate two factors: the sign of the distortion (positive or negative), respectively yielding a helped and hindered movement, and the starting position of the task (chest of leg). See chapter 3 for a complete overview of the concept of distortion and its sign.

We consider the starting position as a factor because of the nature of the distortion, which causes horizontal movements to be slightly more distorted. This is due to the proximity of many chest-located reference points as opposed to only four leg segments, thus having the sum of all relative displacement vectors diverting the hand position in the forward direction.

4.4.1 Task

While the whole set of IK goals will be distorted during the experiment, we will be focusing on the dominant hand movement. The task is performed in a seated position in order to avoid any unnecessary movement of the lower limbs, and has the subjects reach three successive target, one of which is in the air in front of them, and the two others are located at various locations on their skin. The reaching task is performed with the directing hand, and the subjects are instructed to keep their other hand at their side.

The first target T1 to be displayed is one on the skin and requires the subjects to perform a self-contact in order to activate it. After a random time between 200 and 300 ms, the target activates. The position of the air target T2 is then computed such that the subjects have to move a predefined distance $d = 50$ cm between T1 and T2, as well as between T2 and T3 once the air target is reached. This is achieved by computing the intersection between the two spheres of radius d centered on T1 and T3, and chosing the topmost position. A more detailed explanation of how this is achieved can be found in chapter 3.

One experiment run consists of a reaching task, followed by the detection question. Based on the answer to this question, the experiment software modifies the distortion as follows:

`"Yes"`   The discrepancy is increased.

`"No" and` $\gamma \neq 0$ The discrepancy is decreased.

`"No" and` $\gamma = 0$ The parameter is not changed, given that this would invert the sign of the distortion.

The amount of each increment or decrement is dynamic: it starts at 0.1 and is halved after the first staircase turn. That value is then kept for the rest of that staircase. The staicase is completed either when the subjects change direction 7 times or when they performed 20 trials in that staircase.

4.4.2 Procedure

The subjects are welcomed and introduced to the protocol described here, and then introduced to the tracking equipment. A characterization form is then filled in by the subjects during this first part of the experiment, with background questions regarding any previous VR experiment or experience with HMDs. They are then asked to remove their shoes and to wear the motion capture suit. A calibration is then performed as described by [ref to Eray's paper].

Before beginning the actual staircase trials, a familiarization phase takes place. The subjects briefly interact with the virtual environment without any distortion, so that they correctly embody the avatar and understand the question process.

More on the next steps later.

4.5 Subjects

A few physical limitations will be applied to filter the subjects of this experiment. They will be required to be right-handed for ease of software developement, and will need to be both smaller than 180cm and have an body mass index between 18 and 27. The latter is due to our motion capture equipment and especially the suit on which the markers are placed.

We also require that they have a normal or corrected to normal vision, and be fluent in both written and spoken english.

5 Results and Discussion

5.1 Main Section 1

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6 Conclusion

6.1 Main Section 1

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A Questionnaires

All the questions used will be displayed here.

A.1   Characterization

The characterization questionnaire

A.2   Redirection detection

The yes/no question

A.3   Embodiment

The embodiment questionnaire

B Results

Results will be fully shown here.

Bibliography

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