

# Evaluating Virtual Embodiment with the ALEX Exoskeleton

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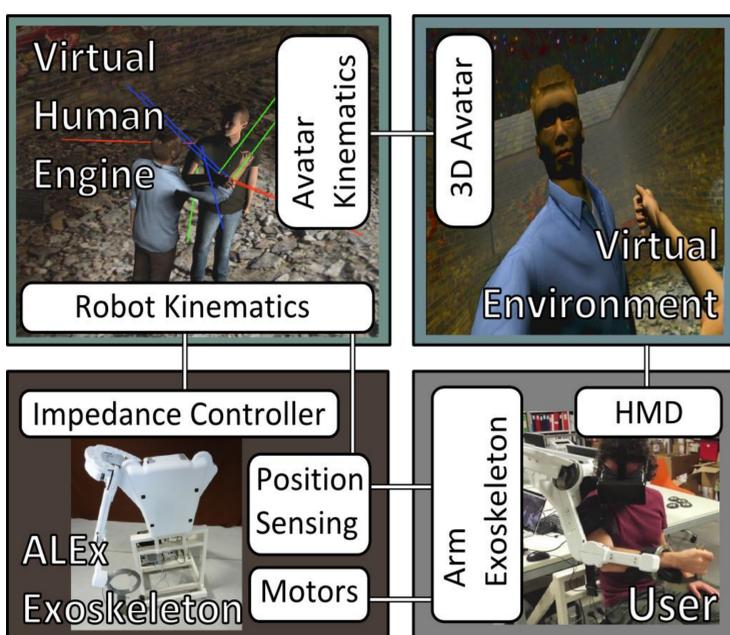
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## Introduction

**Embodiment of a virtual avatar** is a central topic of recent research in Virtual Reality: body awareness can be experimentally manipulated, allowing to investigate key questions involving body representation and ownership. In this work, embodiment in a virtual avatar with **haptic kinesthetic feedback** is achieved by means of a new **high-performance arm exoskeleton (ALEX)**.

## Proposed approach

The experimental setup is focused on the perception of danger and aggressive behavior through **physical interaction with another virtual human**. Virtual embodiment was measured through **participants' reaction** to the virtual experience.



**Visual feedback:** a city street scenario, comprising the body of the participant and of a virtual opponent, is rendered through an immersive Head Mounted Display (Oculus Rift) with tracking of the head and of the right arm (by the exoskeleton).

**Haptic feedback:** the physical interaction of the participant's arm in the virtual environment is simulated by **ALEX**: it is a high performance **arm exoskeleton**, designed and developed at PERCRO Laboratory. It features a wide workspace, light weight and intrinsic back-drivability.

**Virtual Human Engine:** integration of the visual and haptic feedbacks (including kinematics) was performed by a specific software module designed for physical embodiment through robotic interfaces.

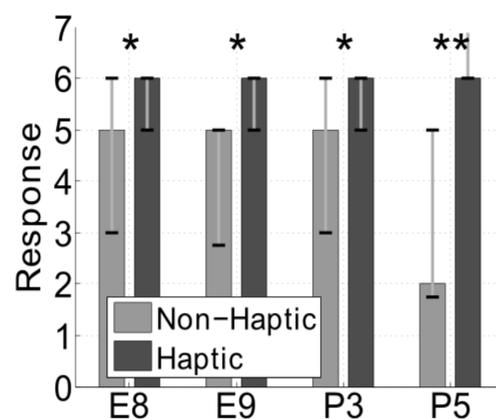
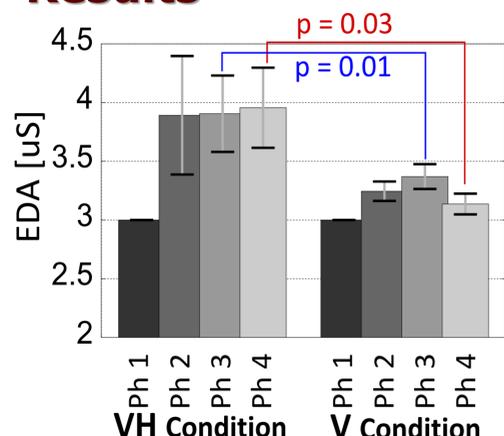
Video [http://y2u.be/3drtyM-mk\\_4](http://y2u.be/3drtyM-mk_4)

The experiment was performed in two conditions: with **Visual feedback (V)** and with **Visuo-Haptic feedback (VH)**. Each condition consisted of **4 phases**:

- Ph 1:** the participant **explores** the VE, looking his/her own virtual body and moving the arm in the real and virtual space.
- Ph 2:** the **opponent appears** in front of the participant, facing him/her.
- Ph 3:** the **opponent grasps** and **coercively moves** the arm of the participant (in VH, the real arm of the subject is moved by means of the ALEX exoskeleton).
- Ph 4:** the **opponent tries to hit** the participant (performed without haptic feedback)



## Results



16 subjects (8 female, 8 male) participated to the experiment. **Questionnaire** and **EDA (Electro Dermal Activity)** were used for evaluating the level of embodiment. Significant **higher** value of the **EDA** during **phases 3 and 4** for the **VH condition**, suggests higher emotional involvement of participants in VH. Results were confirmed by the significant responses to the questionnaire, whereas higher marks relate to higher level of embodiment.

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