Imprecise but Fun: Playful Interaction Using Electromyography

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Class: TP3

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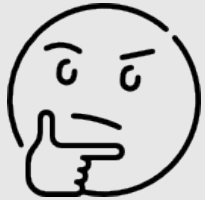
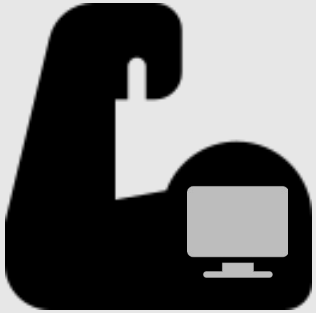
Motivation





Emergence of **Physiological** Input

Potential: **easy, intuitive** and **flexible playful** interaction

Exotic input modality

Introduction

- **Context**
  - **Physiological sensing**
  - Insight into **user's state of being**
  - Challenge (**hard**): **good robustness** and **effective deployment**
  - **Imprecise** readings as a limitation
  - Using Electromyography (EMG) to turn this **limitation** into a **feature**

What is Electromyography (EMG)?

EMG measures the **electrical activity** of **muscles**

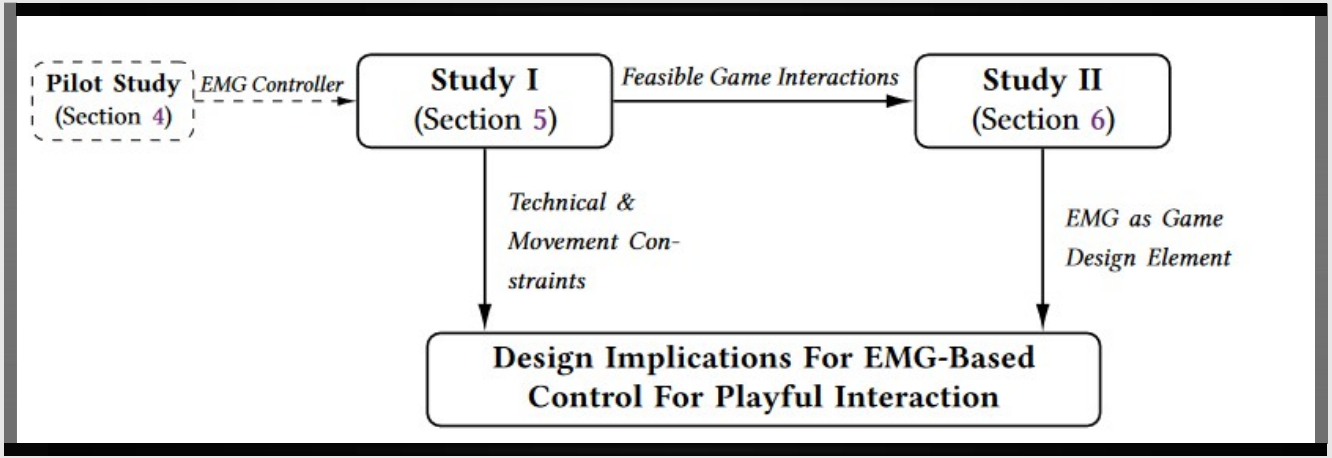
Computer system **control** with **muscles**

EMG

Placing electrodes on the skin **(sEMG)**
or
Inserting fine wire electrodes into the muscle **(EMG)**

Input modality for HCI.

Methodology



- **RQ1:**
- What are the **constraints** of EMG-based input for motor control?

- **RQ2:**
- How can we integrate EMG-based control as a **game design element**?

Pilot Study

“EMG-BASED INPUT FOR EXPLICIT CONTROL USING A LOW-COST CONTROLLER”

Basic Steering Task

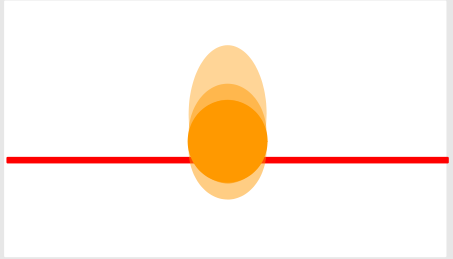
- Keep a ball in line
- **JOYSTICK** or **EMG**

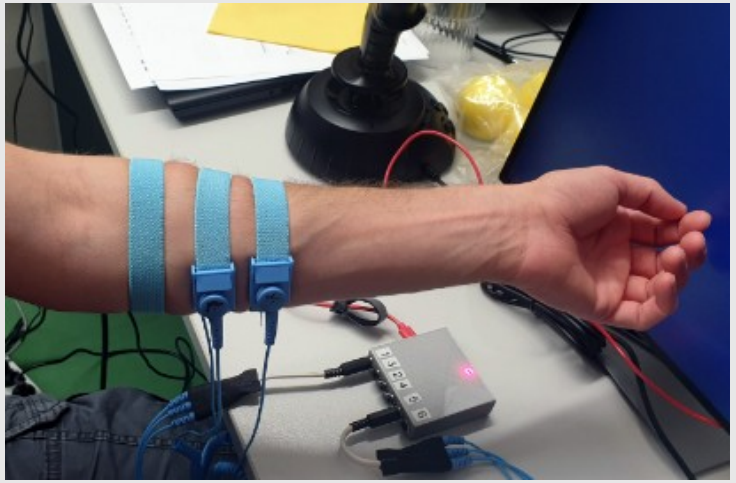
Participants

- 10 total (8 m, 2 f)
- Avg. Age = 26.9 y

Procedure

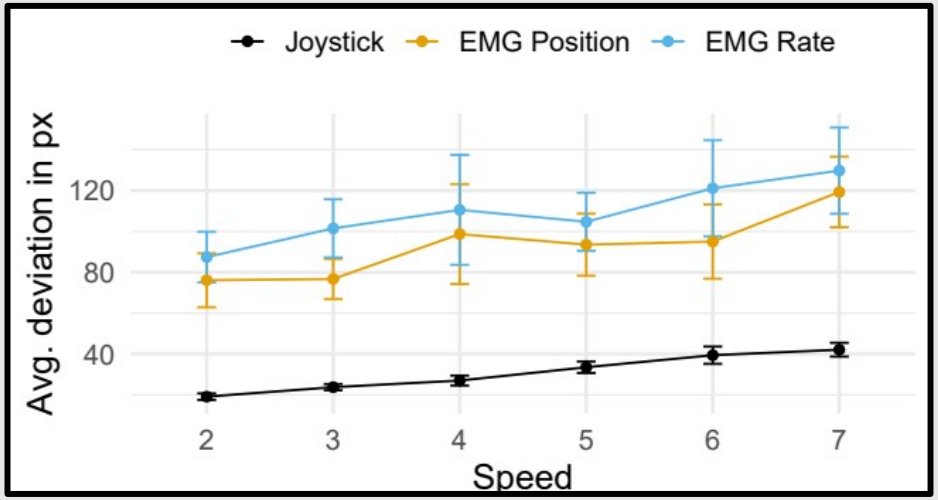
- Stimulus screen
- Strapped Electrodes
- Familiarize
- Repeat task for each control modality





Pilot Study - Results

- **Explicit control** with EMG is possible
- More **difficult**
- **Less** accurate

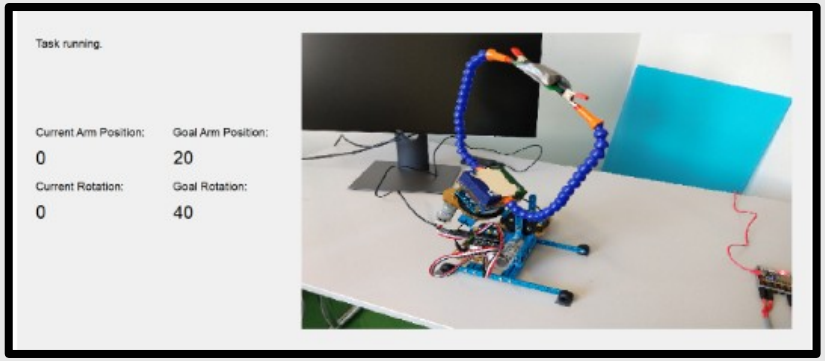


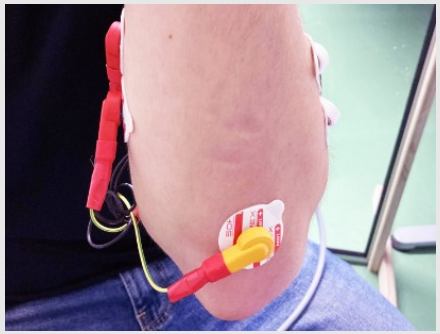
Linear mixed model

Study I

- **Task:** Soldering with **steerable third hand -** test **fine motor** control
  - **Conditions:** EMG, Pedal, Manual
  - **Subtasks:**
    - **Direct Control**
    - **Free Control**

- **12** participants (9 m, 3 f)
- Average age **27.5** years





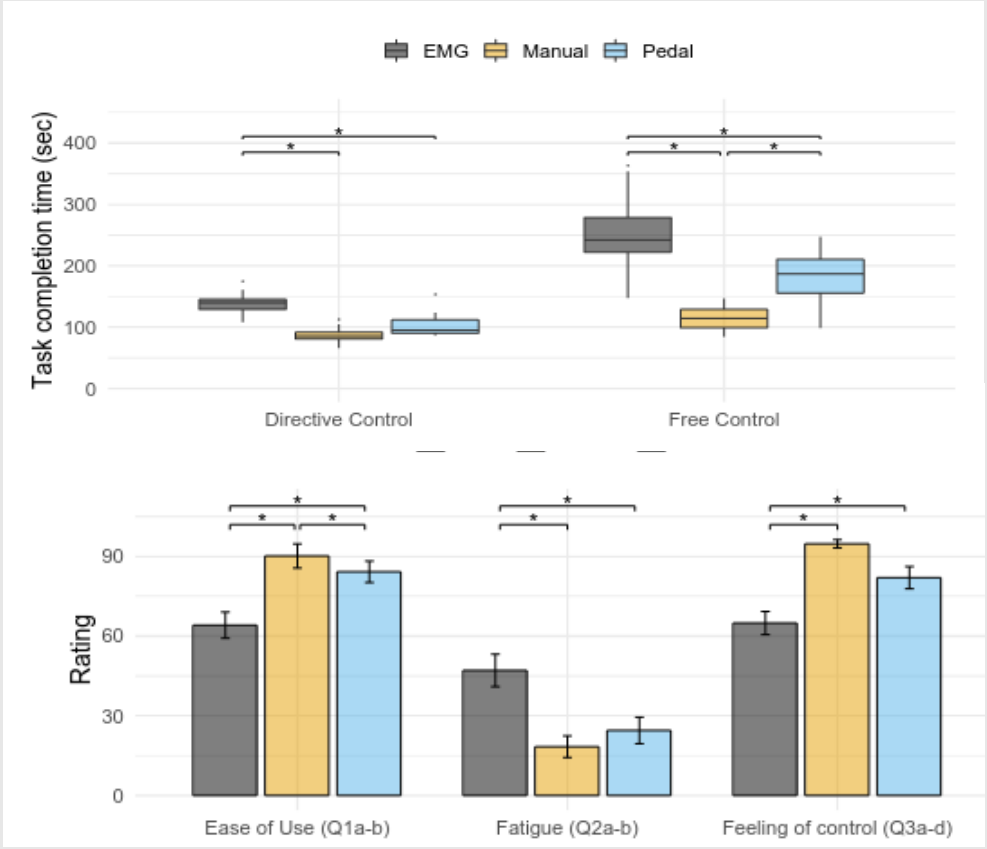
Study I - Results

- **Accuracy:** No difference

Usability and UX

- **Creepiness: Not** particularly **creepy**
- **Comfort: Not uncomfortable**

- **Refer to bottom graph**



Study II

“EMG-BASED INPUT IN GAME DESIGN - VROCKETBOOTS”

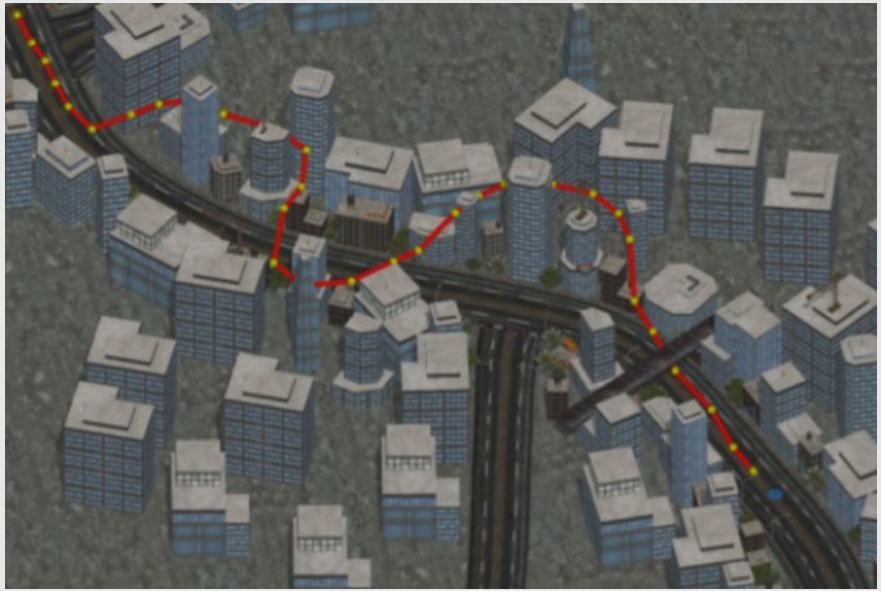
VR locomotion chosen:

- **Immersive potential**
- Direct **muscle input** as interaction with the **virtual world**
- **Naturally** engaging

VRocketBoots

Flight simulation game

- Follow a given **trajectory** (350 m, 34 rings)
- **Increase altitude** by **standing on toes**
  NOTE: (non-continuous thrust !!!)
- **Decrease altitude** on normal pose
- **EMG** vs **Controller**

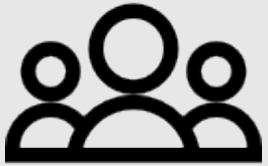


Why ?

- **Implicit control**
- **Playful** large environment **traversal**

- Nacke et al’s guidelines:
  - Direct **physio. input** -> **virtual** world **action**

Participants



Composition

- **University** recruitment
- 20 in total (14 m, 6 f)
- Average age: **26.3** years
- Standard deviation: 2.9 years

Experience

- **3D** apps - 75%
- **VR** - 40%
- No previous study participation

Procedure

Setup

- **Electrodes** attached only on **one leg** on the calves (gastrocnemius muscle)
- **EMG Calibrated** by performing **take-off gesture**
- **Time** to familiarize
  - Two flight ring **practice course**

Experiment

- **Perform flight**
- Short break
- Switch to **other condition** (EMG or Controller)

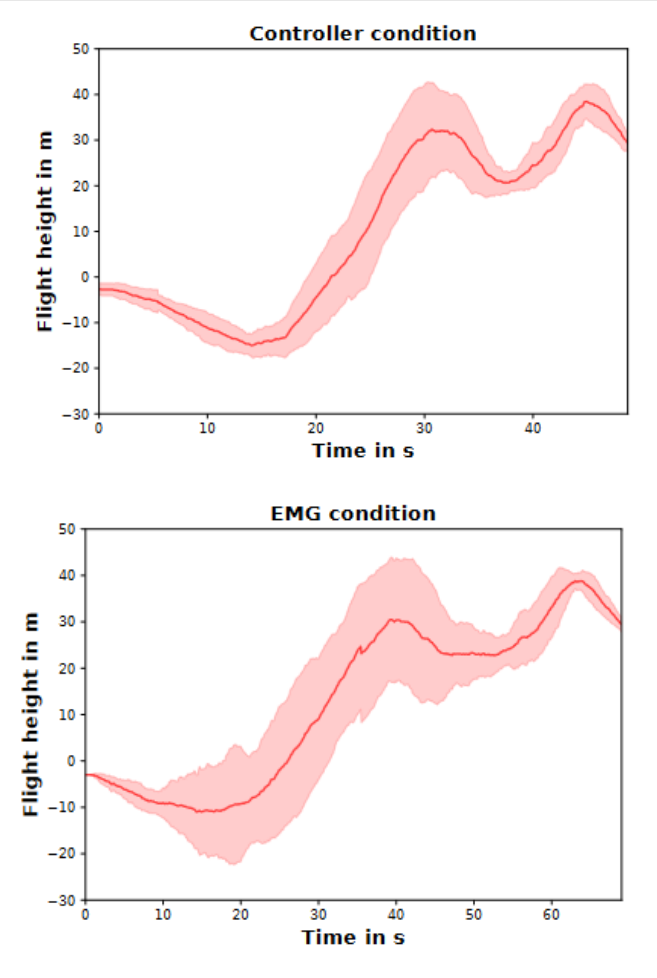
Results

Completion Time (average)

- **Controller**: 52.8 s
- **EMG:** 85.5 s

Flight Path Precision

- Red line - Mean
- Red corridor - Standard Deviation



Results - Interviews

Preference

- **70%** of participants **preferred EMG**
- **Challenging** and **immersive** nature

*"It was more **challenging** and **immersive**. A very different way of using controls, which made it more **fun**." (P3, m, 28y)*

Immersion

- Reported **EMG** as more **immersive**
- **Challenging** nature augmented **fun**

*"It felt more like a **workout**. It activates more parts of my body. But it became a **bit tiresome** in the end." (P9, m, 23y)*

Results - Interviews

Control

- **Imprecision**
- **Break** in the VR Illusion

*"It felt quite **natural** to fly upwards, but when going in different directions it **broke the illusion** a bit." (P20, m, 28y)*

User insight

- **Continuous movement** suggestion

*"If it was possible to make it into a **continuous** movement, then it would feel like **real life**." (P19, m, 25)*

Discussion

Imprecise but Fun

- **Bad** for accuracy and completion time (RQ1)
- **Challenging, playful** interaction through difficult muscle control (RQ2)

EMG as a Game Element

- **Large muscle** usage
- **Direct mapping** to game element
- Use fatigue with **great care**

Limitations

- **Fatigue**
- **Habituation**
- **Best** muscle groups remain an **open question**

Conclusion

EMG’s Imprecision

- **Challenging** and **engaging** game experiences

Suggestions for **EMG**-based game **design**

- Target **large muscles** and **coarse** movements
- Limit design to **coarse** movements
- Otherwise, **unintended EMG input** may break immersion

Bibliography & Credits

Bibliography

- M.A. Cavalcanti Garcia and T.M. M. Vieira, Surface electromyography: Why, when and how to use it, Rev Andal Med Deporte. 2011;4(1):17-28

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