STARR

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Flexible Feedback System for Home Self-Training

Renato BAPTISTA

Dr. Michel ANTUNES

Dr. Girum DEMISSE

Dr. Abdelrahman SHABAYEK

Dr. Djamila AOUADA

Prof. Dr. Björn OTTERSTEN

uni.lu
UNIVERSITÉ DU LUXEMBOURG

Interdisciplinary Centre for Security, Reliability and Trust
Signal Processing & Satellite Communications (SIGCOM) group

Outline

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1. Introduction
2. State of the art
3. Limitations
4. Proposed Approach
5. Experimental Results
6. Self-Trainer
7. STARR Application – Therapist and Patient

European Project STARR

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STARR - Decision **S**uppor**T** and self-m**A**nagement system for st**R**oke survivo**R**s

- **Goals:**
  - Reduce the **cost** of rehabilitation
  - Enable <u>rehabilitation at home</u>

- **<u>Challenges</u>**:
  - Design motion analysis system using small data
    - Limited number of patients
    - Data is destroyed due to legal and privacy issues
  - Design interpretable visual feedback for seamless user interactions

Introduction

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- Physical therapy for post-stroke patients
  - Supervision of a health professional
    - Helps to restore lost body functionalities
    - Helps to maintain daily life activities
- Role of the physiotherapist
  - **Explain** movements to be performed
  - **Advise** how to improve the performance
  - **Interrupt** the exercise in case of health related issues

State of the art

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- Motion Analysis
  - Combine exercises with video games
  - Emulate a physical therapy session
    - Detection, recognition, and analysis of specific motions
  - Assess how well people perform certain actions
    - Rehabilitation

- Feedback proposals
  - Improve an action being performed
    - **Per joint** analysis
    - Motion **constraints**

Limitations

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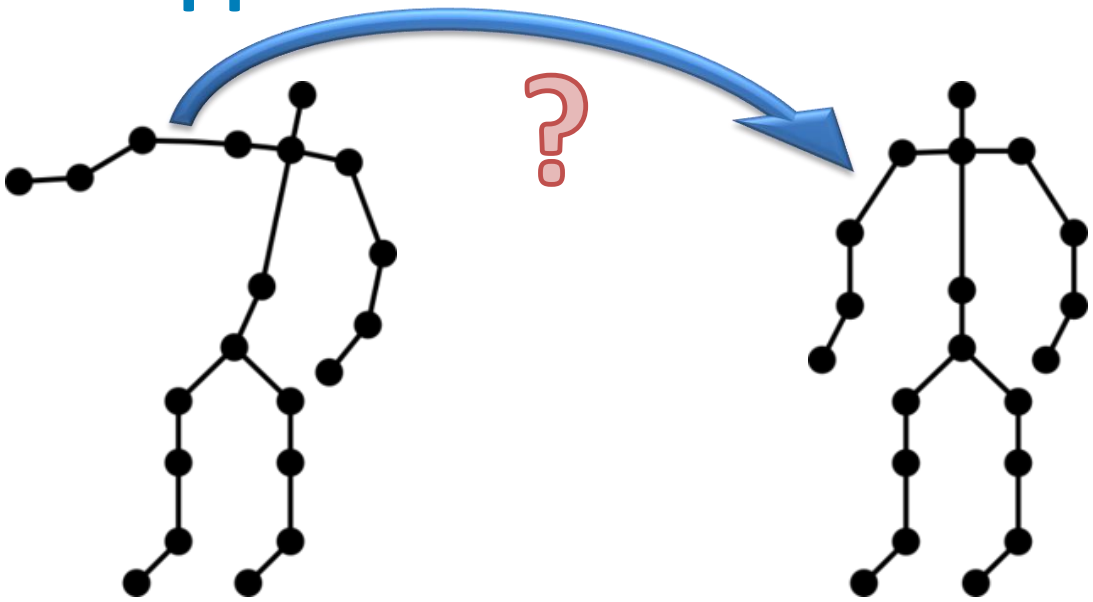
- Feedback is analyzed **per joint**
  - Complex set of instructions for suggesting a particular body-part motion (e.g. move arm up)

- Motion constraints are **action specific and manually defined**

Proposed Approach



How to **provide feedback** in the form of visual information?

- Proposed approach:
  - Feedback per **body-part**
  - Visual directive to achieve goal
- **Advantages**:
  - **Seamless** human-machine interaction
  - **Action-independent** feedback

Proposed Approach

Skeleton Processing

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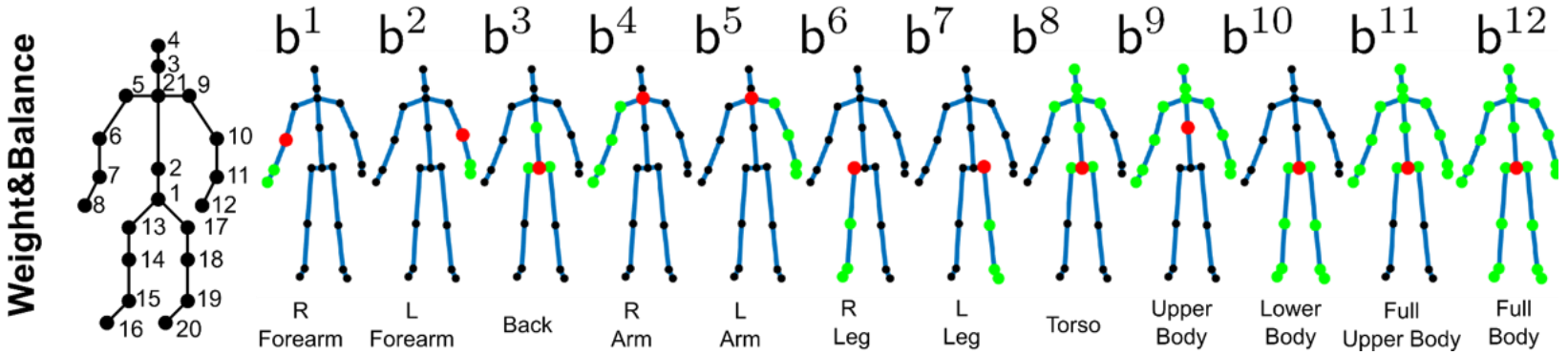
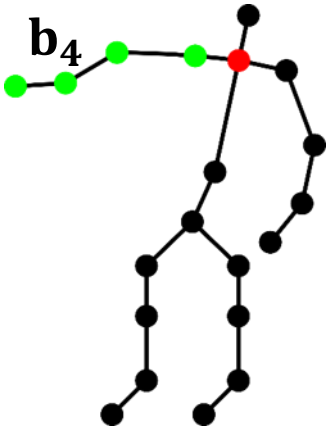
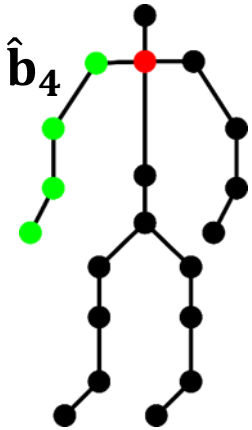
- Body-part representation



- Similarity between corresponding body-parts



Current pose S



Target pose $\hat{S}$

Score function

$$m^k = \sum_{j=1}^{n^k} ||\mathbf{b}_j^k - \hat{\mathbf{b}}_j^k||^2$$

Proposed Approach

Feedback Proposals

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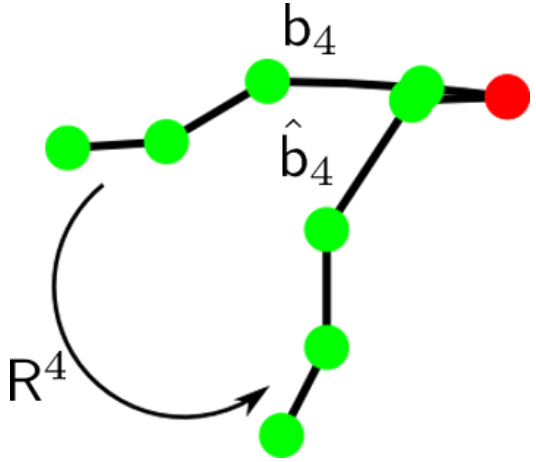
- Compute the rotation between ***current*** and ***target*** poses of a body-part such that the following is minimized

$$e^k(\mathrm{R}^k) = \sum_{j=1}^{n^k} ||\mathrm{R}^k \mathbf{b}_j^k - \hat{\mathbf{b}}_j^k||^2$$



- Generate a set of transformations

$$\mathcal{R} = \{\mathrm{R}_1, \ldots, \mathrm{R}_i, \ldots, \mathrm{R}_N\}$$

where $\mathrm{R}_i = \mathrm{R}^k$, such that:

- R_1 highest
- R_N lowest

impact in the human pose match

- Store body-part rotations maximizing the cost

$$c_i^k = m^k - e^k(\mathrm{R}^k)$$

Proposed Approach

Feedback Messages

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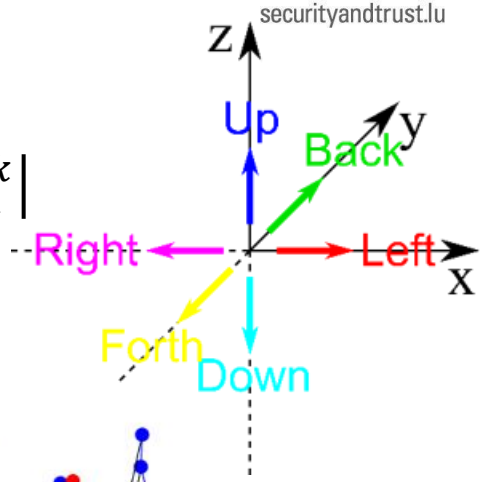
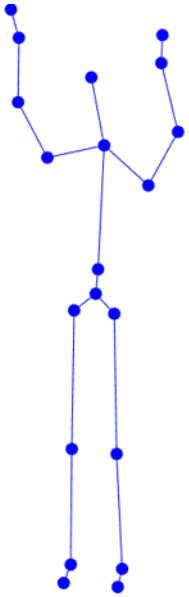
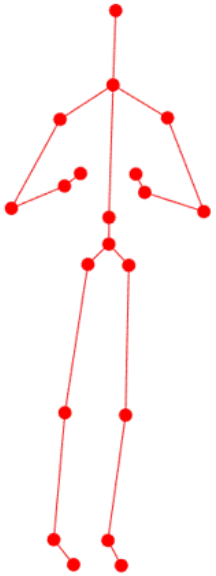
- Discretize feedback vector $\mathbf{f}^k = [f_x^k, f_y^k, f_z^k]$
  - Select the dimension *d* with highest magnitude $|f_d^k|$
- Show: *Body-part name + feedback direction*

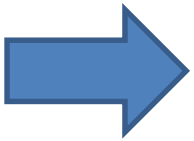


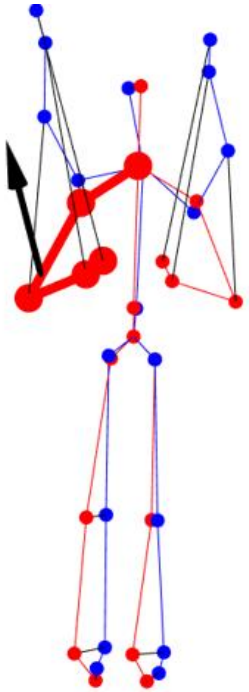


Target pose $\hat{S}$



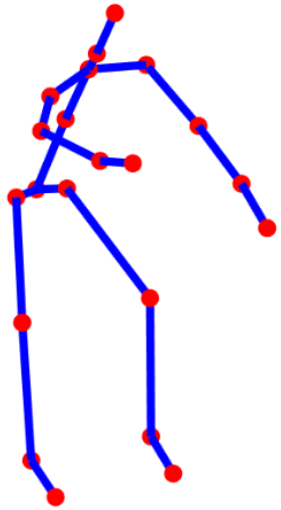
Current pose S





Move Right Arm Up

Experimental Results



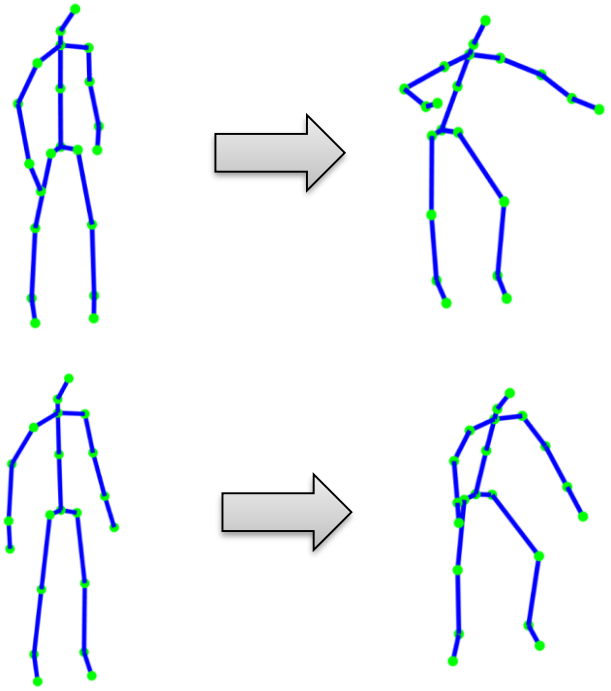
Template Pose

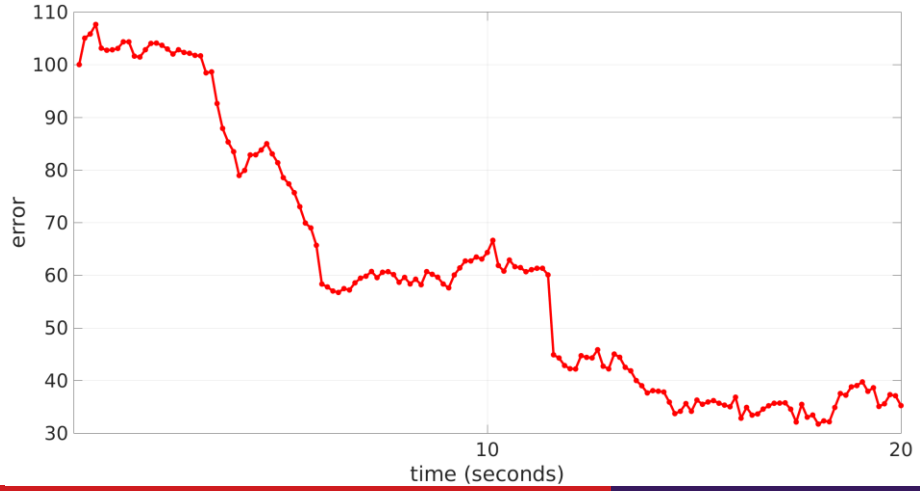
Subject 1

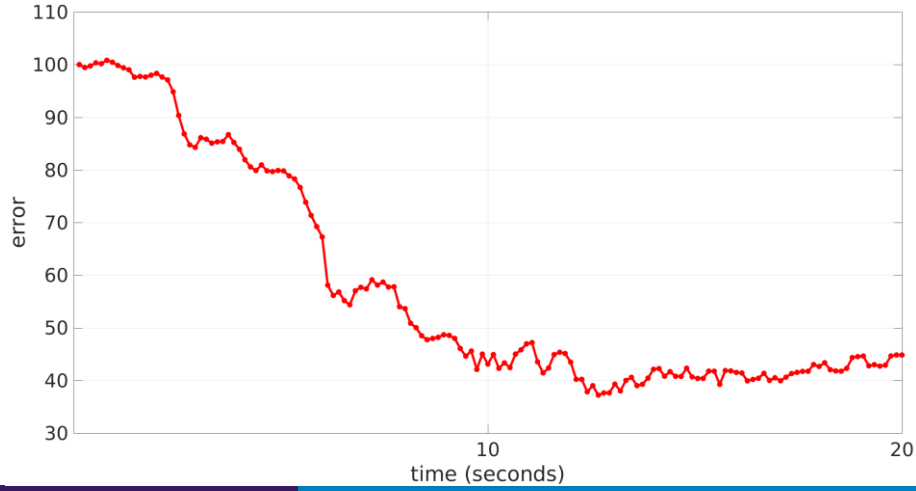
Subject 2

Initial

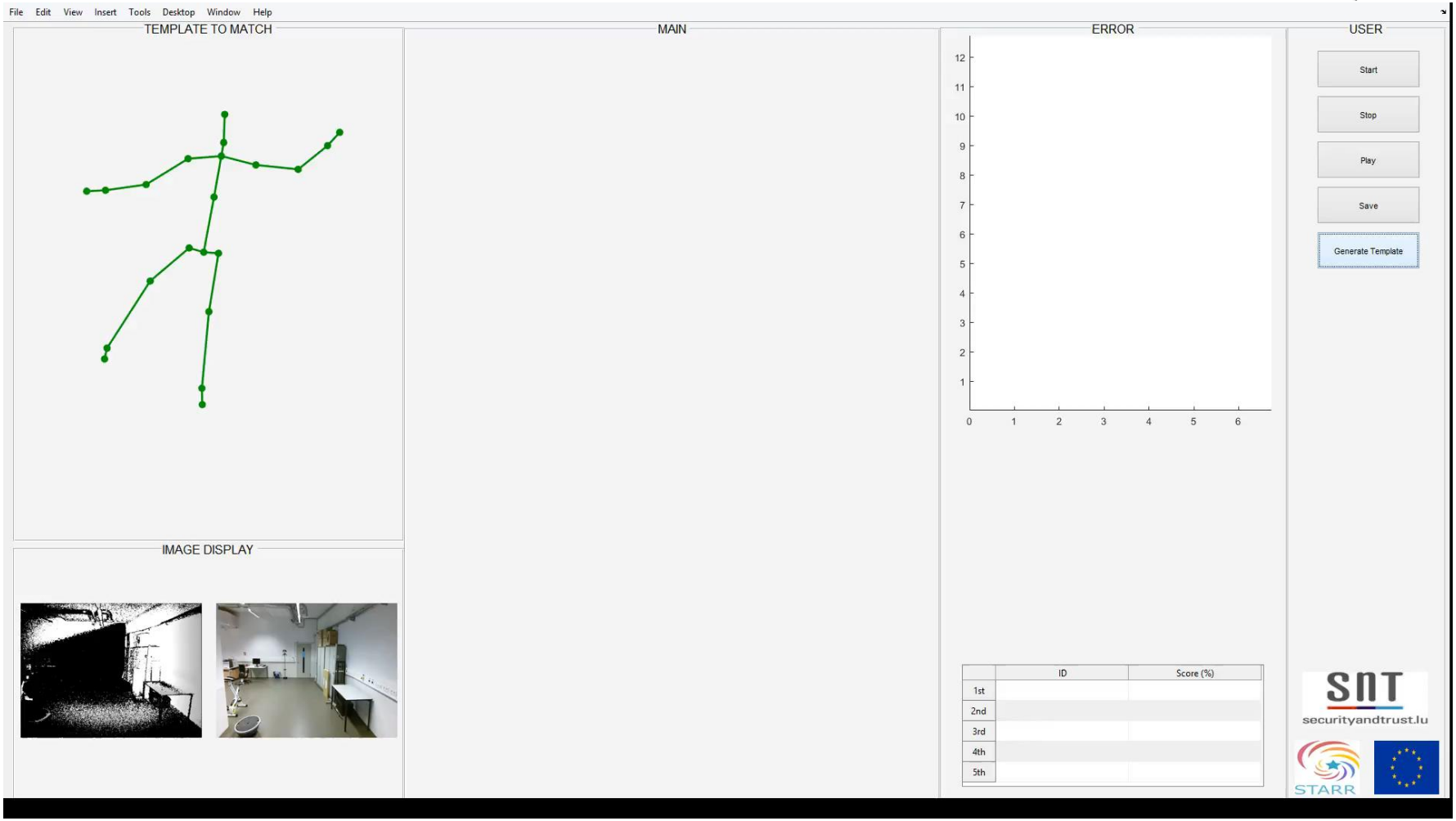
Final







Self-Trainer



- Interactive Demo
- Real-time feedback

Dissemination

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Antunes, M.; Baptista, R.; Demisse, G.; Aouada, D.; Ottersten, B.. "Visual and human-interpretable feedback for assisting physical activity". European Conference on Computer Vision (ECCV) Workshop on Assistive Computer Vision and Robotics Amsterdam, Netherlands (2016) - http://hdl.handle.net/10993/28312

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Papadopoulos, K.; Antunes, M.; Aouada, D.; Ottersten, B.. "*A Revisit of Action Detection using Improved Trajectories*". In IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Calgary, Canada (2018) - http://hdl.handle.net/10993/35012

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Thank you !

Renato BAPTISTA
renato.baptista@uni.lu