Autonomous Socially Assistive Robotics in Pediatric Clinical Practice

by

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Autonomous Socially Assistive Robotics in Pediatric Clinical Practice

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1

Contents

2

1. **Introduction**
2. State of the Art
3. Objectives

Background & Scope

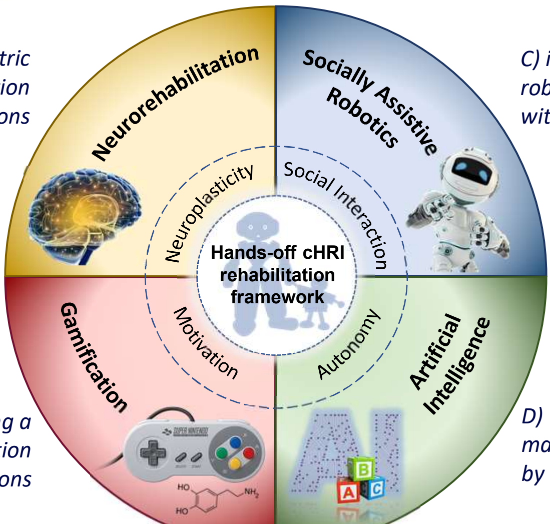
3

Foundations

Introduction > Foundations

A) Enhance pediatric neurorehabilitation interventions

B) by maintaining a prolonged motivation during sessions



C) in which a charming robot interacts socially with patients

D) whose decisions are made autonomously by itself

An interdisciplinary approach

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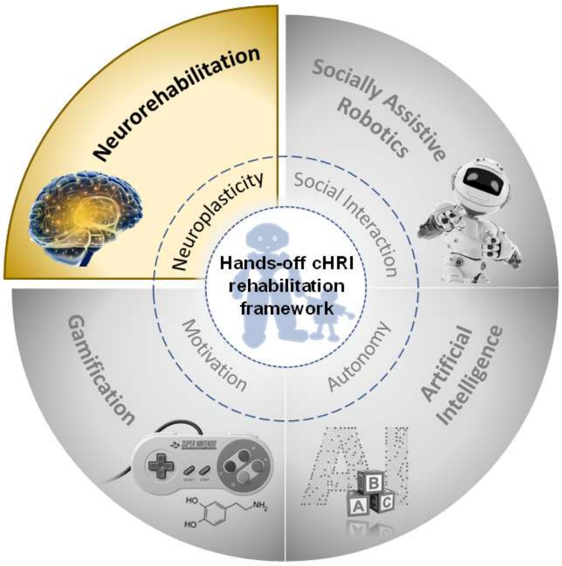
4

Neurorehabilitation

Introduction > Foundations > Neurorehabilitation



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5

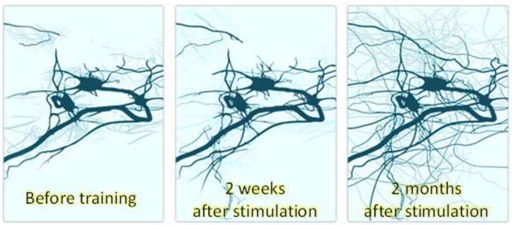
First Foundation: Neurorehabilitation

Introduction > Foundations > First Foundation: Neurorehabilitation

- *Infant Brain Damage* is a serious condition that happens after some complication during pregnancy or birth of the baby [Levine et al. 1984]
  - **Cerebral Palsy** and **Obstetric Brachial Plexus Palsy** → physical impairments
- In the first years of life, more psychomotor changes are experienced [Bijou 1976]:
  - ✓ Early diagnosis and intervention
  - ✓ Start the neurorehabilitation treatment as soon as possible
- Neuroplasticity → An **intense and continuous training** favors the establishment of new connections [Dobking 2004] [Leocani et al. 2006]
- Treatments are **prolonged over the children's life**

➢ Identified problem:

"These routine and repetitive exercises may lead to <u>demotivation</u> and loss of interest" [Calderita et al. 2014]



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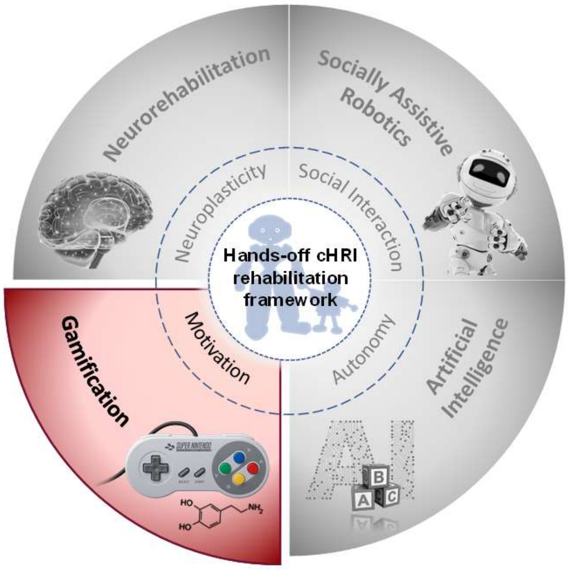
6

Gamification

Introduction > Foundations > Gamification



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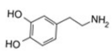
7

Second Foundation: Gamification

Introduction > Foundations > Second Foundation: Gamification

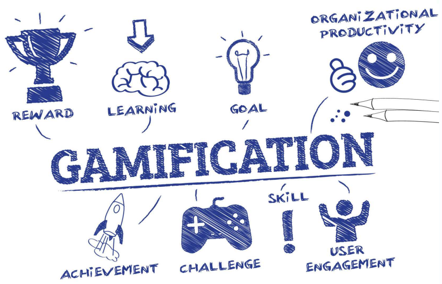
- Learning technique that implements game mechanisms in non-game contexts [Fleming et al. 2017]
- Towards a **playful perception, positive reinforcement and immersion** of the patient [Deterding et al. 2011]

  - ✓ Promotes **participation**
  - ✓ Improves **motivation, concentration and productivity**
  - ✓ Dopamine release **facilitates learning**



➢ Identified problem:

"A gamified therapy may not break communication barriers between the patient and the therapist"
[Dawe et al. 2019] [Karner et al. 1943]



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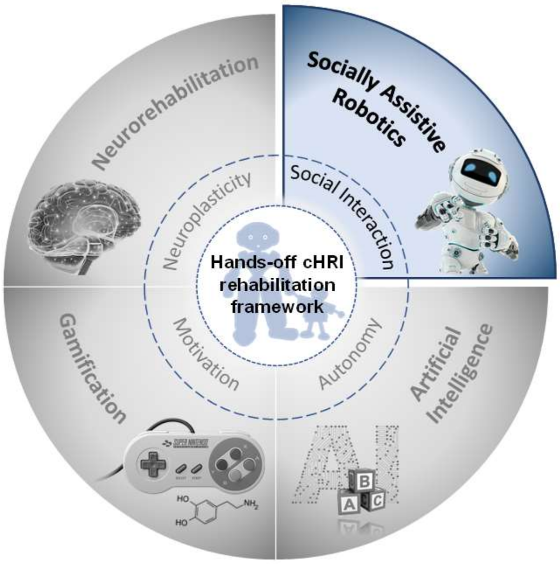
8

Socially Assistive Robotics (SAR)

Introduction > Foundations > Socially Assistive Robotics



Third Foundation: Socially Assistive Robotics (SAR)

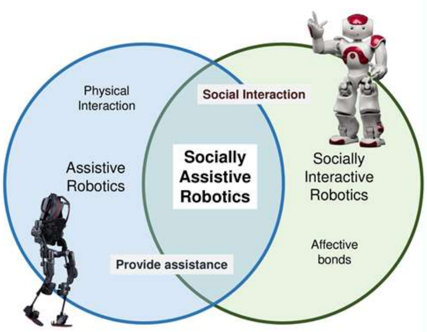
Introduction > Foundations > Third Foundation: Socially Assistive Robotics

- Provide assistance to human beings through **social interaction** [Feil-Seifer et al. 2005]
- **Stimulate better responses and a proactive behavior** from pediatric patients [Feil-Seifer et al. 2009] [Lee et al. 2012]

  - ✓ **Reduce significantly risk factors**
  - ✓ **Promote active training**
  - ✓ **Facilitate communication**

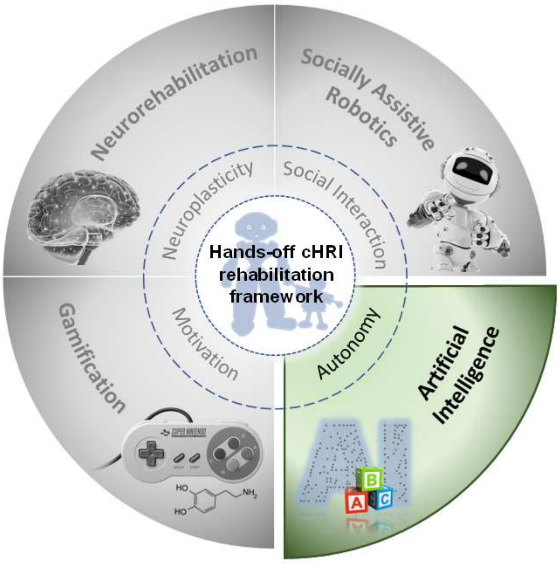
➢ Identified problem:

"The lack of autonomy can bring out the system limitations and teleoperated solutions do not provide any workload release of professionals"
[Belpaeme et al. 2013]



Artificial Intelligence

Introduction > Foundations > Artificial Intelligence



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11

Fourth Foundation: Artificial Intelligence

Introduction > Foundations > Fourth Foundation: Artificial Intelligence

- A SAR platform is considered ***autonomous*** when:
  - ✓ The interaction offered **does not require an external operator**
  - ✓ Self-explanatory**, easily deployable and configurable** for non-expert users

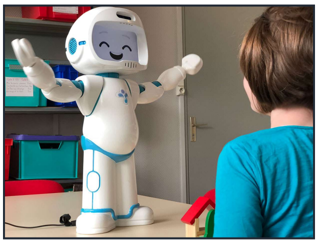
[Feil-Seifer et al. 2005]

- Key aspect → Task/Action selection
  - Model of the use case
  - Decision-making algorithm

➢ **Identified problem:**

"Changes in the model or use case still require expert knowledge of modeling"

[González et al. 2018]



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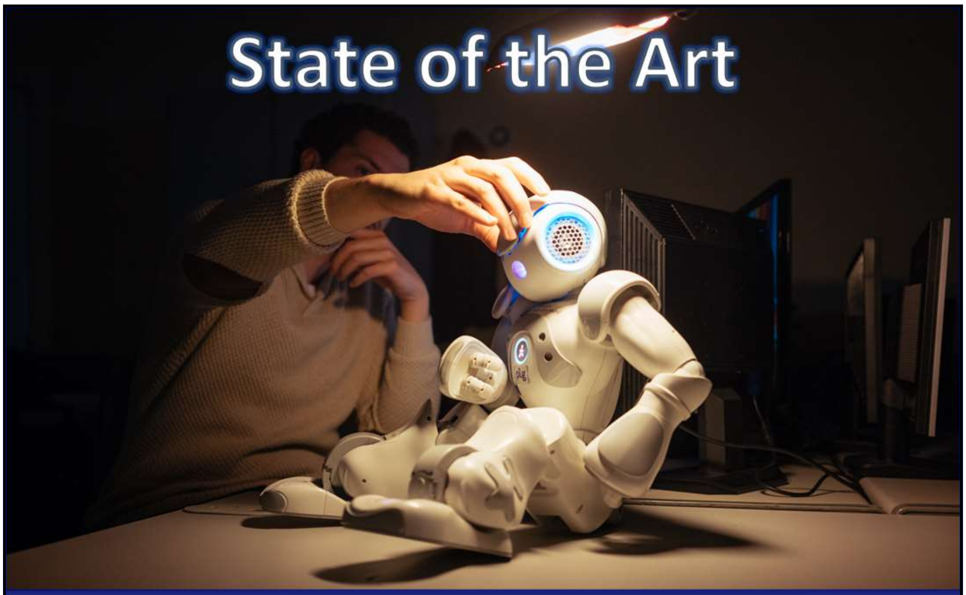
12



1. Introduction
2. **State of the Art**
3. Objectives

Background & Scope

13

Non-contact Rehabilitation Robotics

State of the Art > Non-contact Rehabilitation Robotics

- The area of robotic rehabilitation has historically been based on physical contact
  [Maciejasz et al. 2014]

Promoting social aspects

- Target individuals
  - **Pediatrics**: brain injury, autism, diabetes, education, hospitalization
    [Dawe et al. 2018]
  - **Adults**: post-stroke
    [Mataric et al. 2007]
  - **Elderly**: dementia, companion, active ageing
    [Fasola et al. 2013]

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14

SAR Rehabilitation in Pediatrics

State of the Art > SAR Rehabilitation in Pediatrics

Authors	Robot	Participant			Autonomy	Perception	Adaptation / Configuration	Long-term	Clinical Setting	Clinical Results	Gamified Sessions
		No.	Cond	Age							
[Brisben 2005]	Cosmobot	6	CP	4-10	✗	✓	✗	✓	✓	✗	✗
[Roberts 2012]	Manoi ATOI	20	TD	18-23	✓	✓	✓	✗	✗	✗	✗
[Rios R. 2013]	LEGO	1	CP	7	✗	✗	✗	✗	✗	✗	✗
[Suárez-M. 2013]	Ursus	6	CP OBPP	3-7	✗	✓	✗	✗	✓	✗	✗
[Kozyavkin 2014]	KineTron	6	CP	4-9	✗	✗	✗	✗	✓	✗	✗
[Malik 2014]	NAO	4	CP	5-14	✗	✗	✗	✓	✓	✗	✗
[Fridin 2014]	NAO	18	TD	4-8	✓	✓	✓	✗	✗	✗	✗
[Greczek 2014]	NAO	12	ASD	7-10	✓	✓	✓	✗	✗	✗	✗
[Adawiah 2015]	NAO	2	CP	5-14	✗	✗	✗	✗	✓	✗	✗
[Rodriguez-Lera, 2018]	QTRobot	4	TD	25-52	✓	✓	✓	✗	✗	✗	✗
[Carrillo 2018]	NAO	9	CP	-	✗	✗	✓	✓	✓	✗	✗

15

Autonomy in SAR

State of the Art > Autonomous Human-Robot Interaction

- Main HRI challenges to control the interaction:
  - **Execute the most appropriate action according to the state perceived**
  - **Long-term user adaptation**

  [Belpaeme et al. 2005]
- Robot control techniques

  Non-Autonomous
  - Scripted behavior [Kozyavkin 2014] [Malik 2014] [Adawiah 2015]
    - no unexpected events handling
  - Teleoperated [Brisben 2005] and Wizard of Oz [Suárez-M. 2013] [Carrillo 2018]
    - require human intervention

  Autonomous/Partially Autonomous
  - Subsymbolic representation [Baxter et al. 2013]
    - missing knowledge
  - Learning-based adaptation [Greczek 2014] [Fridin 2014]
    - many examples to converge
  - Symbolic representation based on state machines [Roberts 2012] [Rodriguez-Lera, 2018]
    - Costly to keep the coherency

16

Discussion

State of the Art > Discussion

- <u>SAR rehabilitation robotics is still in an early stage with a promising future</u>
- **Low level of autonomy** in most of the platforms
- **No** work explicitly applies **gamification and/or reward** techniques
- **Few experimental evidence**:
  - Small sample size
  - Few long-term studies
  - No clinical results
  - No implantations due to **lack of continuity**

17

Objectives

1. Introduction
2. State of the Art
3. **<u>Objectives</u>**

Background & Scope

18

Objectives

Introduction > Objectives

Main goal:

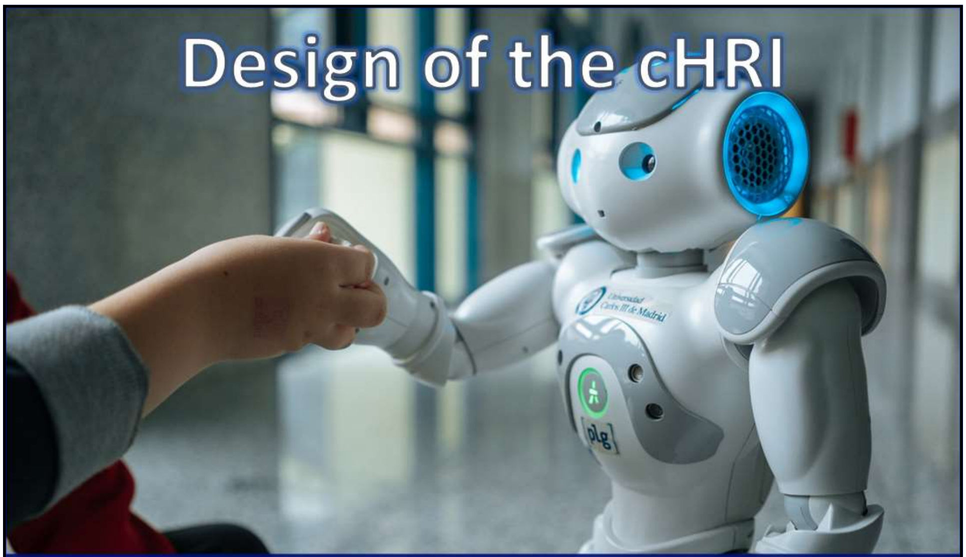
Design and evaluate child-robot interaction models and frameworks for non-contact rehabilitation to augment pediatric interventions

1. Design a **child-robot interaction framework for non-contact rehabilitation** that integrates the four foundations and all the previous fundamentals

Autonomy	Perception	Adaptation / Configuration	Long-term	Clinical Setting	Clinical Results	Gamified Sessions
✓	✓	✓	✓	✓	✓	✓

2. Development of **functional prototypes** intended to cover certain needs that are of interest to health professionals (user-centered methodology):
   - **I.** **<u>Pediatric physical rehabilitation</u> - NAOTherapist**
   - **II.** **<u>Infant motion encouragement</u> - IR Study at USC**
3. Evaluate the **feasibility of this framework in real healthcare scenarios with a significant sample of participants**

19



4. **<u>Design of the child-robot interaction</u>** (cHRI)

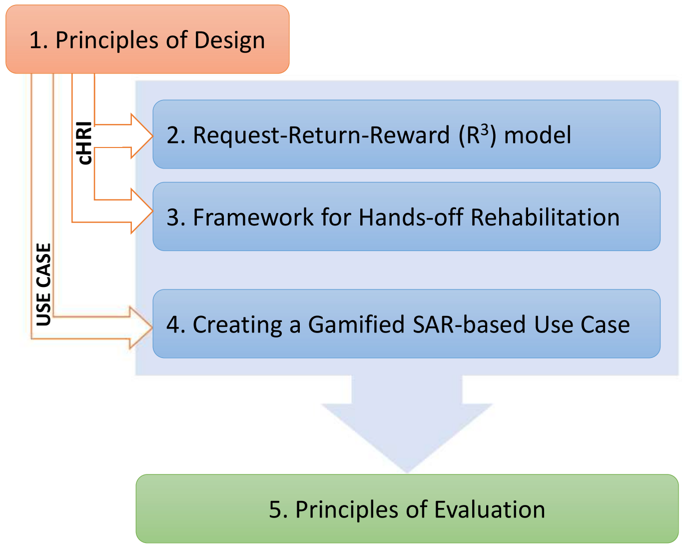
- Principles of Design
- cHRI Models and Framework
- Principles of Evaluation

Design Phase

20

Contributions to cHRI

Design of the cHRI > Outline



Principles of Design

Design of the cHRI > Principles of Design

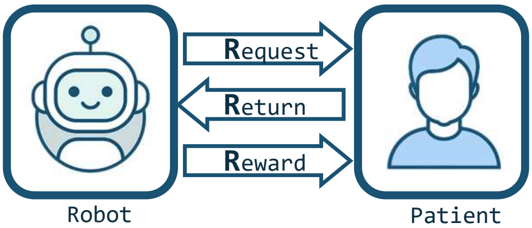
- Taxonomy of requirements to **conform to the clinical guidelines**
- Most of these principles arise from:
  - **Literature** [Fasola et al. 2013]
  - Interviews with **healthcare professionals**
  - **Personal experience**

1. Therapy requirements:
   - ✓ Goal-directed
   - ✓ Gradual and Balanced
   - ✓ Personalized
   - ✓ Constraint Induced
   - ✓ Game-like Tasks
2. Therapy execution:
   - ✓ Interactive
   - ✓ Supervised
   - ✓ Adaptive
   - ✓ Adequate Social Distance
3. Therapy engagement:
   - ✓ Attitude
   - ✓ Positively Reinforced
   - ✓ Promoting Bonding and Empathy

Request-Return-Reward (R^3) cHRI Model

Design of the cHRI > R^3 cHRI Model

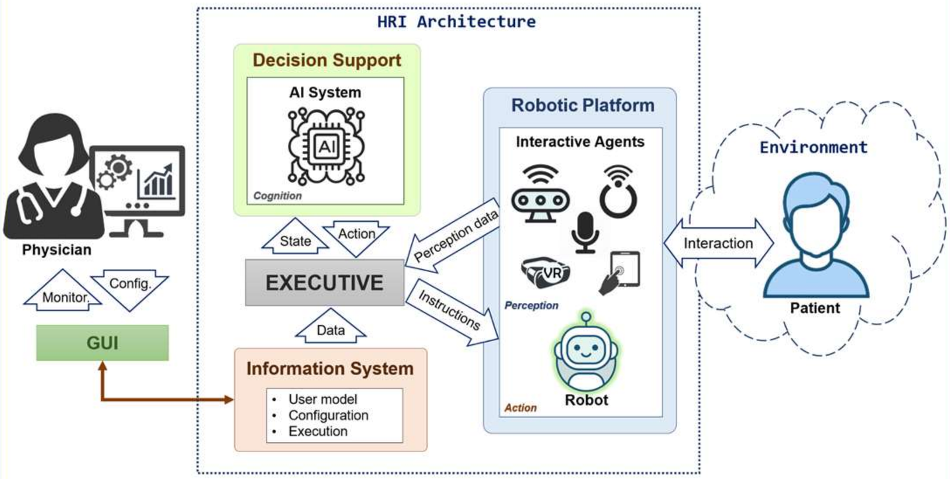
- Effort-based Reward training -> **50% more efficient** in solving a task [Bardi et al. 2013]
  - **Request** includes all those actions of the robot necessary for the patient to understand the task: verbally and non-verbally
  - **Return** relates to the perception capabilities to determine the correct achievement of the task
  - **Reward** reinforces the patient, so that the best rewards are a consequence of a great performance



23

General Framework for Hands-off Robotics Rehabilitation

Design of the cHRI > Framework for Hands-off Robotics Rehabilitation



24

Creating a Gamified SAR-based Use Case

Design of the cHRI > Applying Gamification to SAR

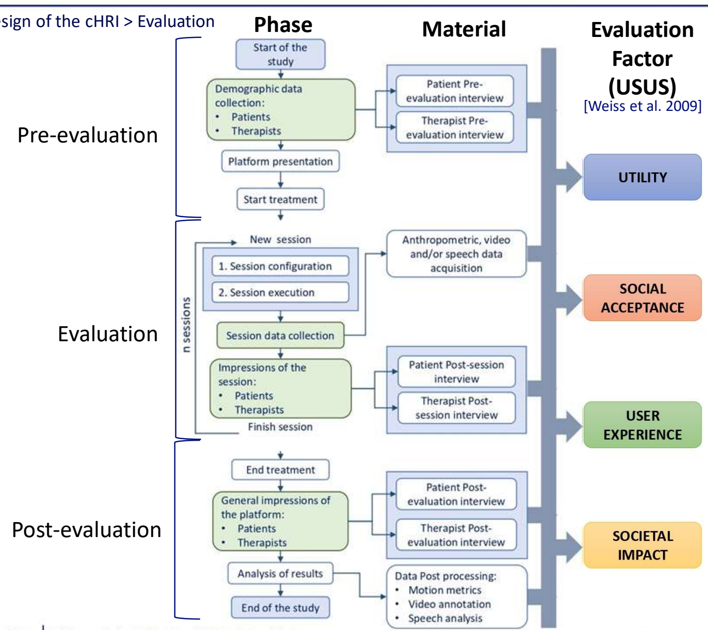
Aspect		
	Case diagnosis	ICP (Diparesis)
	Child's interests	Spaceships and heroes
	Child's achievement	Gain autonomy for eating
	Therapeutic goal	Improve range of mobility and handling
Game mechanics	**Game-like activities:**	
	▪ Little games	- Imitation game (proprioception and ROM) - Showing objects (handling)
	▪ Big games	Functional tasks "eating together"
	Immersion:	
	▪ Narrative	The robot comes from another planet and it crashed its spaceship
	▪ Role-play	The patient helps the "recovery" of the robot
	▪ Theatrical Prop	Background cloth with stars
	Instruments:	
	▪ Rewards	Dances, choreographies
	▪ Challenges	Quests proposed by the robot
	▪ Levels	Different difficulties
	▪ Score	Unlocks new behaviors

Ⓐ Design Phase

Ⓑ Implementation Phase

Principles of Evaluation

Design of the cHRI > Evaluation



- Interviews
- Questionnaires
- Discussion groups

Objective data:
- Session logs
- Motion metrics
- Video annotations

NAOTherapist Implementation

5. **Autonomous SAR for physical rehabilitation**
6. NAOTherapist Evaluation
   - Intensive Bimanual Therapy

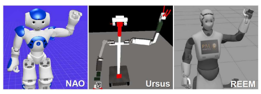
NAOTherapist

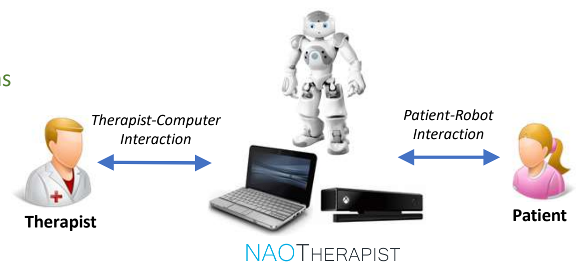
27

Autonomous SAR for Physical Rehabilitation: NAOTherapist

NAOTherapist > Introduction

- *NAOTherapist* is a cognitive robotic architecture to **develop hands-off rehabilitation sessions with a social robot** for patients with physical impairments
- Towards **novel motivational physical rehabilitation procedures**
- Address the decision making using **Automated Planning** [Ghallab et al. 2004]
- Adaptation using **rule-based expert knowledge**
  - ✓ Gamified sessions
  - ✓ Autonomous
  - ✓ Adaptative
  - ✓ Configurable by physicians
  - ✓ Easily Extensible
  - ✓ Hardware Independent





[González, Pulido and Fernández, 2017]
Published in Cognitive Systems Research

28

NAOTherapist Implementation

NAOTherapist > Outline

1. Model of Use Case
2. Interaction Flow of the Gamified Use Case

instance of

R^3 cHRI model

Gamified SAR-based Use Case

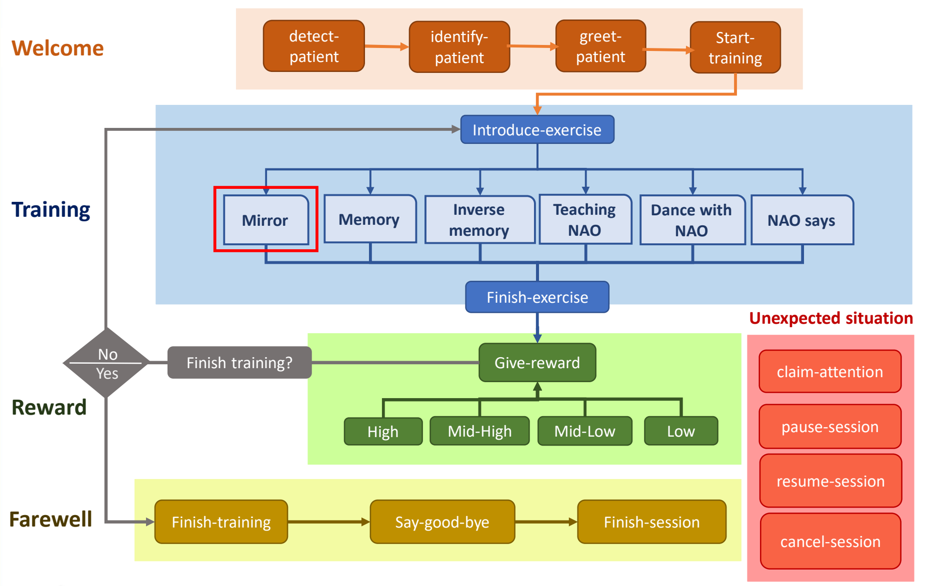
3. Cognitive Architecture: Decision Making
4. Perception: Motion Tracking
5. Graphical User Interface

instance of

Framework for Hands-off Rehabilitation

Model of Use Case

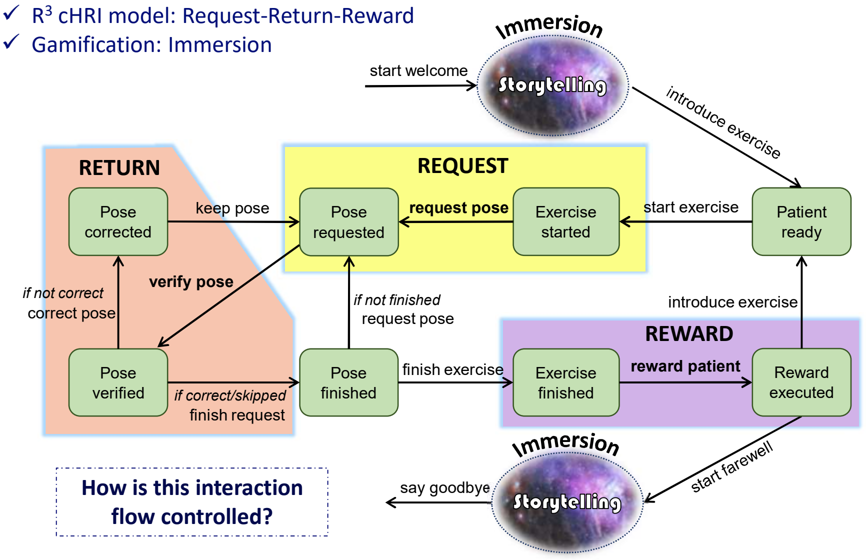
NAOTherapist > Automated Planning Model



Interaction Flow of Mirror Game

NAOTherapist > Use Case

- ✓ R[3] cHRI model: Request-Return-Reward
- ✓ Gamification: Immersion

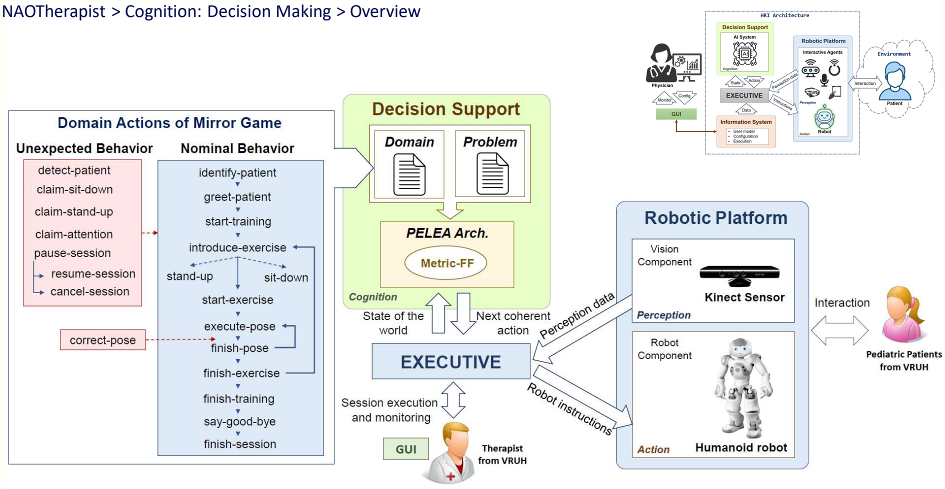


How is this interaction flow controlled?

31

Cognitive Architecture: Decision Making

NAOTherapist > Cognition: Decision Making > Overview



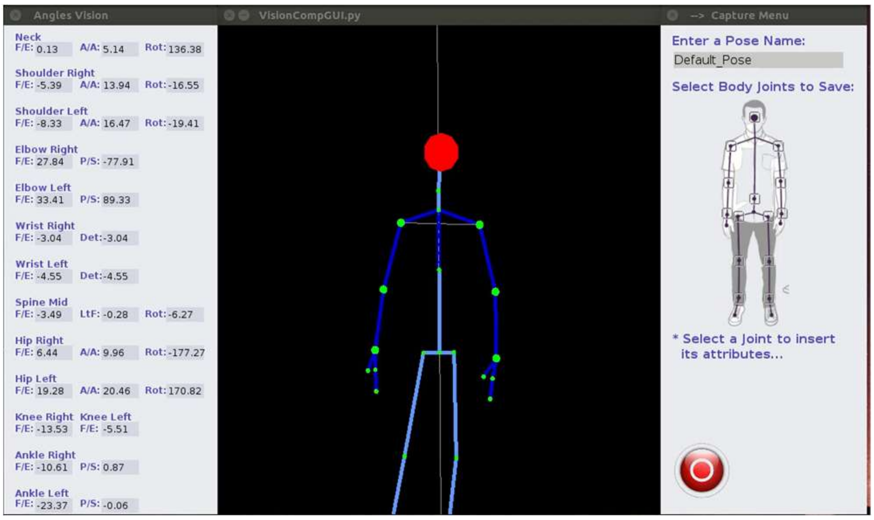
Decision support compares the **perceived state of the world with the expected one** and provides the **next coherent action**.

[González, Pulido and Fernández, 2017]
Published in Cognitive Systems Research

32

Perception: Motion Tracking

NAOTherapist > Perception: Motion Tracking



An anthropometric model of the patient in terms of range of mobility of each joint according to human beings

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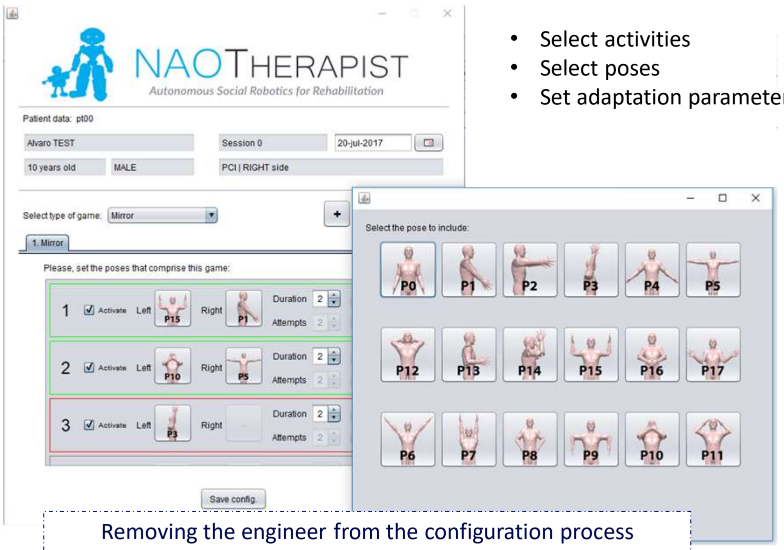
33

Graphical User Interface

NAOTherapist > GUI



- Select activities
- Select poses
- Set adaptation parameters

Removing the engineer from the configuration process

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34

5. Autonomous SAR for physical rehabilitation
6. **NAOTherapist Evaluation**
    - Intensive Bimanual Therapy

NAOTherapist

35

Chronology of Evaluation

NAOTherapist Evaluation > Chronology of Evaluation

			First Contact		Long term adherence	Intensive therapy
			1st Phase	2nd Phase	3rd Phase	4th Phase
			Oct 2014 – Feb 2015	Feb 2015	Nov 2015 - March 2016	July 2017
Characteristics	Evaluation	Clinical settings	✗	✓	✓	✓
		Participants	117	3	8	10
		Condition	TD	OBPP/CP	OBPP/CP	CP
		Sessions	1	1	12	11
		Frequency	-	-	weekly	daily
	System	Autonomy	✓	✓	✓	✓
		Perception	✓	✓	✓	✓
		Adaptation	✗	✗	✓	✓
		Configuration	✗	✗	✗	✓
		Gamification	✗	✗	✗	✓
	SAR-based Activities	Reward	✗	✗	✓	✓
		Mirror	✓	✓	✓	✓
		Memory	✗	✗	✓	✓
		NAO says	✗	✗	✗	✓
		Dance w NAO	✗	✗	✗	✓
		Teach me	✗	✗	✗	✓

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36

First Insights with Patients

NAOTherapist Evaluation > First insights with patients

5. Autonomous SAR for physical rehabilitation
6. **NAOTherapist Evaluation**
   - **Intensive Bimanual Therapy**

NAOTherapist

Ev. 3: Hand-Arm Bimanual Intensive Therapy (HABIT) Study

NAOTherapist Evaluation > Ev. 3: HABIT Study

- **First summer camp in Spain** that follows the HABIT methodology
  - 13/07 – 02/08: Monday to Saturday
  - 21 days, 5 hours/day
  - 10 patients with Infantile Cerebral Palsy
  - 1 or 2 expert volunteers for each patient
  - 10 consecutive sessions with NAOTherapist

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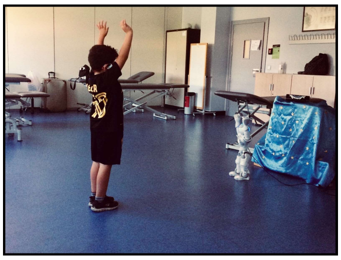


- **Objective**: **increase motivation and patient engagement** through varied game-like activities contributing to generate a playful environment

Dealing with the *novelty effect*

Ev. 3: 2-Step Session Procedure

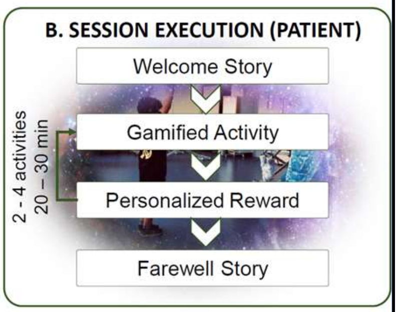
NAOTherapist Evaluation > Ev. 3: 2-Step Session Procedure

A. SESSION CONFIGURATION (THERAPIST)

1) Select the gamified rehabilitation activities:
   - Mirror
   - Memory
   - Inverse Memory
   - Nao says
   - Dance with me
   - Teach me

2) Adapt the activities to the patient

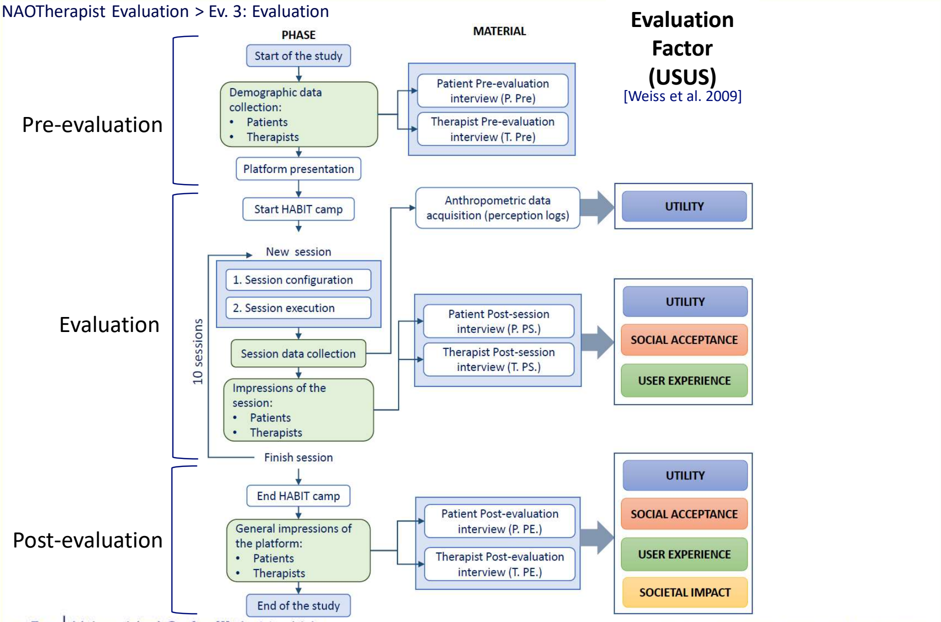
3) Execute the session and save it in patient's profile



No engineer was required during the study

Ev. 3: HABIT Evaluation Procedure

NAOTherapist Evaluation > Ev. 3: Evaluation



41

Ev 3: USUS Evaluation Indicators

NAOTherapist Evaluation > Ev 3: USUS Evaluation Indicators

Usability 0.0
- Effectiveness 0.0
- Efficiency 0.0
- Learnability 0.0
- Flexibility 0.0
- Robustness 0.0
- Utility 0.0

Social Acceptance 0.0
- Effort Expectancy 0.0
- Attitude towards using technology 0.0
- Self-Efficacy 0.0
- Attachment 0.0
- Reciprocity 0.0

User Experience 0.0
- Embodiment 0.0
- Emotion 0.0
- Human-oriented perception 0.0
- Feeling of security 0.0

Societal Impact 0.0
- Quality of life 0.0
- Working conditions 0.0

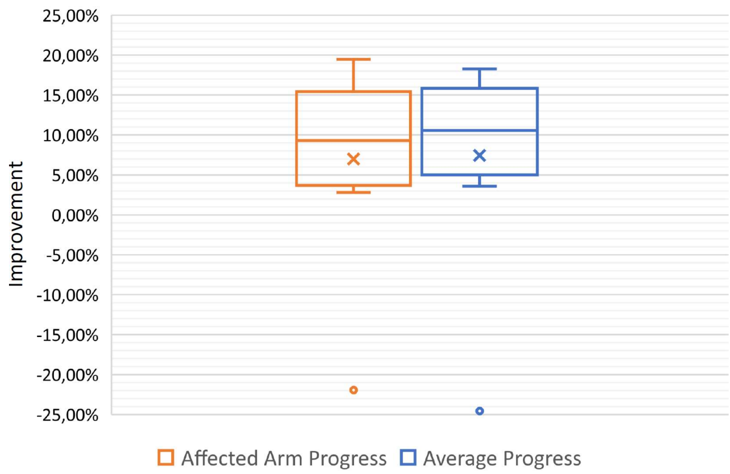
Objective: Evaluate each of the indicators with the administered materials

42

Ev. 3: Usability / Effectiveness

NAOTherapist Evaluation > Ev. 3: Usability / Effectiveness

Progress: comparing expected vs patient's pose (anthropometric model)



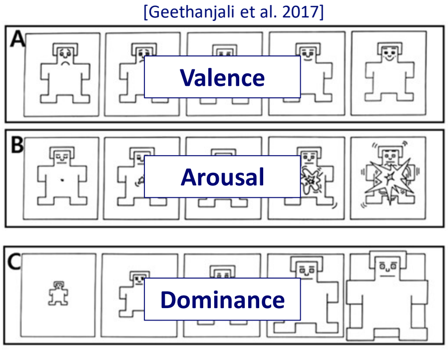
Most of the patients got a progress between 5% and 15%

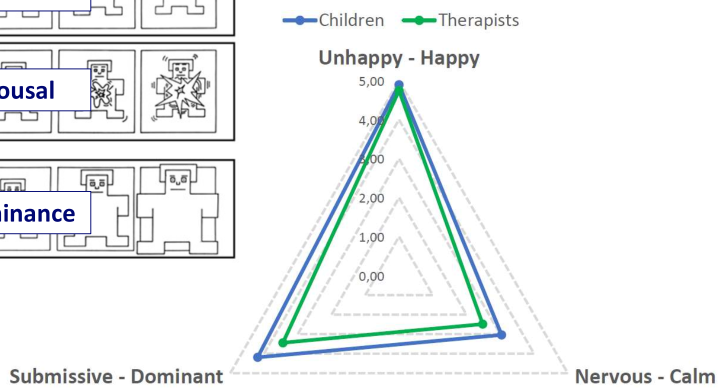
43

Ev. 3: User Experience / Emotion

NAOTherapist Evaluation > Ev. 3: User Experience / Emotion

SAM (Self-Assessment Manikin) scale
[Geethanjali et al. 2017]





Patients felt very happy, quite calm and with great control of the situation

44

Ev. 3: Results

NAOTherapist Evaluation > Ev. 3: Results & Discussion

Usability	3.8
Effectiveness	4.5
Efficiency	4.1
Learnability	4.1
Flexibility	3.7
Robustness	2.9
Utility	3.7

Social Acceptance	3.7
Effort Expectancy	3.8
Attitude towards using technology	4.5
Self-Efficacy	2.6
Attachment	4.7
Reciprocity	3.0

User Experience	4.1
Embodiment	4.9
Emotion	4.0
Human-oriented perception	3.7
Feeling of security	3.7

Societal Impact	4.0
Quality of life	4.1
Working conditions	3.9

45

Ev. 3: Enriching Experience

NAOTherapist Evaluation > Ev. 3: Enriching Experience

Ep 3. Intensive therapy	▪ First evaluation in intensive therapy Lesson learned: **"Every effort has its rewards"**

46

Evaluation Summary

NAOTherapist Evaluation > Evaluation Summary

244 children (21 patients)

429 sessions (206 clinical)

11 relatives

20 experts

3 clinical settings

11 publications

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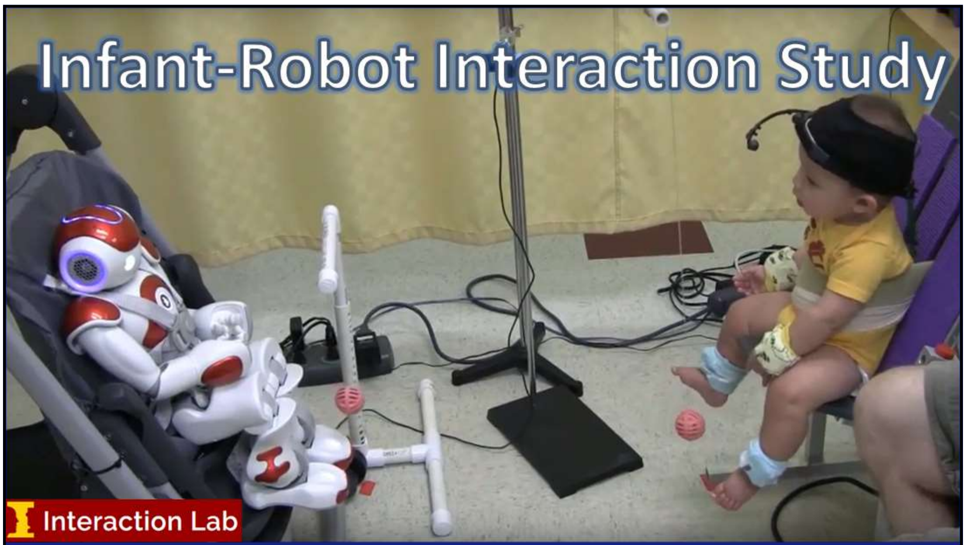
47



7. **Adaptation of Infant-Robot Interaction**
   - Fixed Threshold-based Approach
   - Adaptive RL-based Approach
   - Evaluation of Approaches

USC Viterbi School of Engineering Department of Computer Science

IR Interaction

48

IR Study: Motivation

IR Study > Motivation

- Early detection, prevention and intervention of possible developmental delays
- **Infant Motion encouragement promotes a typical and healthy development**

✓ Will they be able to mimic a goal-oriented task?
Principles of "Mirror Neurons"
  - "Kick the ball"

- Recruitment:
  - 12 participants ≈ 6 months

[Fitter, Funke, Pulido et al. 2019]
Published in IEEE Robotics & Automation Magazine

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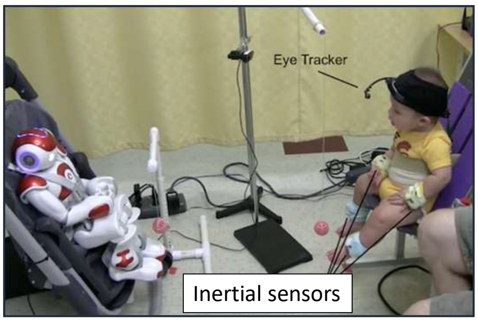
49

Study 1: Fixed Threshold-based Approach

IR Study > Study 1: Fixed Threshold-based Approach

- Evaluation setup:
  - Four inertial APDM sensors on both arms and legs
  - A NAO humanoid robot
  - Two suspended toy balls



- Session steps:
  1. Baseline (2 min)
  2. Demo (3 kicks)
  3. Contingency (8 min)
  4. Baseline (2 min)
- Metric: **right leg acceleration**
- <u>Reward activation threshold</u>: **set to 3.0 m/s²**

[Fitter, Funke, Pulido et al. 2019]
Published in IEEE Robotics & Automation Magazine

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50

First IR Study: Infant Response

IR Study > Infant Response

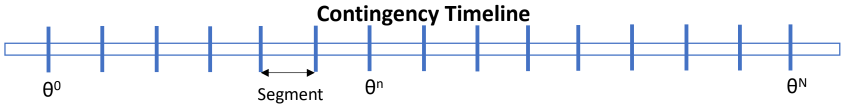
VIDEO

51

Study 2: Adaptive RL-based Approach

IR Study > Study 2: Adaptive RL-based Approach

- Objective: **implement adaptation methods** to improve SAR interaction
- Reinforcement Learning approach to adjust the level of difficulty (threshold)



- Reward activation threshold (θ): **adaptive after each segment**

Level of Difficulty:
- Low — Reward 1
- Mid-low — Reward 2
- Mid — Reward 3 +
- Mid-High — Reward 4 ++
- High — Reward 5 +++

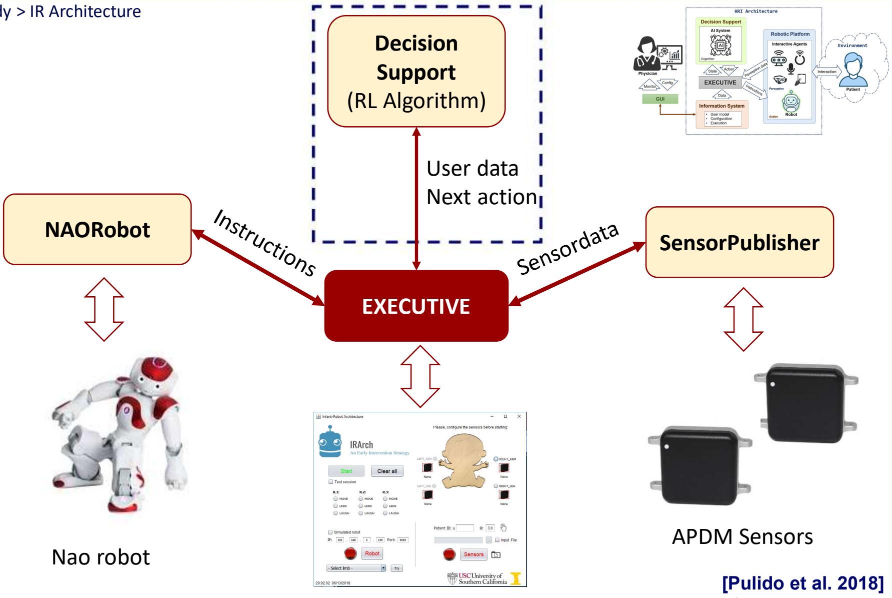
RL actions**: UP, STAY, DOWN**

Can the robot influence the baby's behavior so that s/he reaches **higher accelerations?**

52

IR Architecture

IR Study > IR Architecture



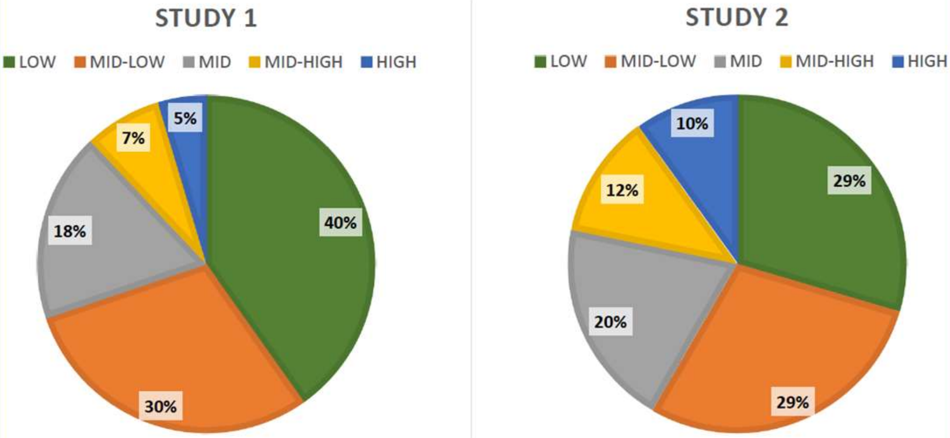
[Pulido et al. 2018]
Published in Workshop of Physical Agents

53

IR Study: Results

IR Study > Results

Same infants in both studies



The robot was able to encourage the infant to produce higher accelerations to get better rewards!

54

8. **Conclusions and Future Lines** **Closure**

55

Conclusions

- Main goal:

  The design and evaluation of child-robot interaction models and frameworks for non-contact rehabilitation to augment pediatric interventions

  - ✓ The system **conforms to the clinical guidelines**, complies with the mandatory objectives and is useful for health professionals
  - ✓ The interaction provided by **the robot guarantees an active engagement** improving the patient's experience
  - ✓ Integrating **mechanisms of gamification in therapy improves motivation** and, therefore, adherence to treatments
  - ✓ The **autonomy provided is so robust** that no engineer is required
  - ✓ SAR-based adaptation systems are able to **influence on the users' behaviors**

Robot	Participant			Autonomy	Perception	Adaptation / Configuration	Long-term	Clinical Setting	Clinical Results	Gamified sessions
	No.	Cond	Age							
NAOTherapist	> 200	CP OBPP TD	4-12	✓	✓	✓	✓	✓	✓	✓

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56

Future Lines

1. Improvements are projected around patient adaptation systems
2. Activity recognition
3. Facilitate the task of modeling new activities to health professionals
4. Extending the target population
5. Deepen the ethical and security aspects
6. Create a final product

57

Contributions: JCR Journal

2019

- **A Socially Assistive Robotic Platform for Upper-Limb Rehabilitation: A Longitudinal Study With Pediatric Patients:** JC. Pulido, C. Suarez-Mejias, JC. Gonzalez, A. Dueñas, P. Ferrand, M.E. Martinez, C. Echevarria, P. Infante-Cossio, C. Luis Parra and F. Fernandez. *IEEE Robotics & Automation Magazine (IEEE RAM)*, vol. 1, pp. 1-16, IEEE April 2019, **JCR 2017 impact 3.573 – Q1**, doi:10.1109/MRA.2019.2905231.
- **Socially Assistive Infant-Robot Interaction: Using Robots to Encourage Infant Leg-Motion Training:** N. Fitter, R. Funke, JC. Pulido, L. E Eisenman, W. Deng, M. R Rosales, N. Bradley, B. Sargent, B. Smith, M. J Mataric. *IEEE Robotics & Automation Magazine (IEEE RAM)*, vol. 1, pp. 1-16, IEEE April 2019, **JCR 2017 impact 3.573 – Q1**, doi:10.1109/MRA.2019.2905231. (USC)
- **Developing a Robot-Guided Interactive Simon Game for Physical and Cognitive Training:** Mısra Turp, José Carlos González, José Carlos Pulido and Fernando Fernández. *International Journal of Humanoid Robotics (IJHR)*, vol. 19(1), p. 195003, World Scientific, February 2019, **JCR 2017 impact 0.908 - Q4**, doi:10.1142/S0219843619500038.
- **Evaluating the Child–Robot Interaction of the NAOTherapist Platform in Pediatric Rehabilitation:** José Carlos Pulido, José Carlos González, Cristina Suárez-Mejías, Antonio Bandera, Pablo Bustos and Fernando Fernández. *International Journal of Social Robotics (IJSR)*, vol. 9(3), pp. 343–358, Springer, June 2017, **JCR 2017 impact 2.003 - Q3**, doi:10.1007/s12369-017-0402-2.

2017

- **A three-layer planning architecture for the autonomous control of rehabilitation therapies based on social robots:** José Carlos González, José Carlos Pulido and Fernando Fernández. *Cognitive Systems Research (CSR)*, vol. 43, pp. 232-249, Elsevier, June 2017, **JCR 2017 impact 1.425 - Q3**, doi:10.1016/j.cogsys.2016.09.003.

* USC symbol refers to the studies carried out during my international internship at the Interaction Lab of the University of Southern California.

58

Contributions: Conferences & Workshops

2018

- **Adaptation of the Difficulty Level in an Infant-Robot Movement Contingency Study:** José Carlos Pulido, Rebecca Funke, Javier García, Beth A. Smith and Maja Matarić, on the *3rd Iberian Robotics Conference, (ROBOT 2017), on in proceedings of the 19th Workshop of Physical Agents (WAF), pp. 70-83, Madrid (Spain), November 2018.* (USC)
- **Classifying Infant Motor Development using Day Long Movement Data from Wearable Sensors:** David Goodfellow, Ruoyu Zhi, Rebecca Funke, Jose Carlos Pulido, Maja J. Mataric, Beth A. Smith, on the 2018 KDD Workshop in Machine Learning in Healthcare and Medicine, London (UK), August 2018. (USC)

2017

- **Enhancing a Robotic Rehabilitation Model for Hand-Arm Bimanual Intensive Therapy:** Enrique García Estévez, Irene Díaz Portales, José Carlos Pulido, Raquel Fuentetaja and Fernando Fernandez, on the *3rd Iberian Robotics Conference, (ROBOT), Rehabilitation and Assistive Robotics special session*, Seville (Spain), November 2017.

2016

- **NAOTherapist: Autonomous Assistance of Physical Rehabilitation Therapies with a Social Humanoid Robot:** José Carlos Pulido, José Carlos González and Fernando Fernández, in proceedings of the International Workshop on Assistive & Rehabilitation Technology (IWART), pp. 15-16, Elche (Spain), December 2016.
- **Playing with Robots: An Interactive Simon Game**: Mısra Turp, José Carlos Pulido, José Carlos González, Fernando Fernández, in *proceedings of the Workshop on Social Robotics and Human-Robot Interaction (RSIM), CAEPIA 2015* Albacete (Spain), 2015.

2015

- **Therapy Monitoring and Patient Evaluation with Social Robots**: Alejandro Martín, José Carlos González, José Carlos Pulido, Ángel García-Olaya, Fernando Fernández and Cristina Suárez-Mejías, in *proceedings of the 3rd Workshop on ICTs for improving Patients Rehabilitation Research Techniques, REHAB 2015* Lisbon (Portugal), 2015.
- **Planning, Execution and Monitoring of Physical Rehabilitation Therapies with a Robotic Architecture**: José Carlos González, José Carlos Pulido, Fernando Fernández and Cristina Suárez-Mejías, in *proceedings of the 26th Medical Informatics Europe conference (MIE), Studies in Health Technology and Informatics*, vol. 210, pp. 339-343, Madrid (Spain), 2015.

2014

- **Goal-directed Generation of Exercise Sets for Upper-Limb Rehabilitation**: José Carlos Pulido, José Carlos González, Arturo González-Ferrer, Javier García, Fernando Fernández, Antonio Bandera, Pablo Bustos and Cristina Suárez, in *proceedings of the 5th Workshop on Knowledge Engineering for Planning and Scheduling (KEPS)*, ICAPS conference, pp. 38-45, Portsmouth (New Hampshire, USA), 2014.

* USC symbol refers to the studies carried out during my international internship at the Interaction Lab of the University of Southern California

Awards & Honors

- First prize in the VI edition of **"Implicados y Solidarios" de Bankinter**
- First prize in eHealth 2017: Best initiative in robotics
- Third national prize **Santander YUZZ** 2016

Current entrepreneurship programs:

CaixaImpulse innovation for society — Obra Social Fundación "la Caixa"

The COLLIDER — Mobile World Capital Barcelona

healthstart madrid — fundación para el conocimiento

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Computer Science and Engineering Department

Autonomous Socially Assistive Robotics in Pediatric Clinical Practice

José Carlos Pulido Pascual
Thesis advisors
Dr. Fernando Fernández Rebollo
Dra. Raquel Fuentetaja Pizán

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Planning and Learning Group

61