On The Quest of Trust Requirements for Socially Assistive Robots

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Agenda

- Introduction
- Objective
- Background
- NFR4TRUST
- Preliminary Validation/ Evaluation
- Conclusion

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Introduction

● Significant growth in interest in the development and use of robots that assist the human user, with an emphasis on social interaction

● Socially Assistive Robots (**SARs**) bring benefits in several applications mainly in their use by people with some limitation, be it physical, cognitive or social

  ○ Elderly care

  ○ Rehabilitation

  ○ Education

  ○ Etc.

Introduction

- Human-Robot Interaction (**HRI**) focuses on how humans and robots collaborate with each other and what role the robot plays in human life

- **Trust** has been widely discussed in the literature as a key element of a successful relationship

- Factors that help to promote human trust towards **SARs**

  - Social

  - Psychological

  - Spatial

  - Physical contact

Objective

- Investigate the factors that influencing human trust in robotic devices, specifically SARs, with the aim of developing a customized catalog of Non-Functional Requirements (NFRs) for Trust, tailored for Anthropomorphic-type SARs

- Target :
  - **Robot developers:** trust-related NFRs into their designs
  - **Adopters**: select suitable SARs based on trust requirements
  - **App developers**: NFRs considerations

Research questions

- **What are the main SARs Trust NFRs that need to be considered?**

- **Is the NFR Framework appropriate for modeling trust-related requirements in the context of Human-Robot Interaction?**

Background

Trust

- Trust is <mark>multidisciplinary</mark>

  o which leads to many different definitions, theories and metrics

- There are still <mark>few specific studies</mark> of **Trust** within the field of **HRI**

  o Most Trust Studies are in the field of Interpersonal and Automation

  o Human trust in automation and robots can be similar

- <mark>Trust</mark> and the perception of <mark>safety/security</mark> are directly <mark>intertwined</mark>, improving one means improving the other

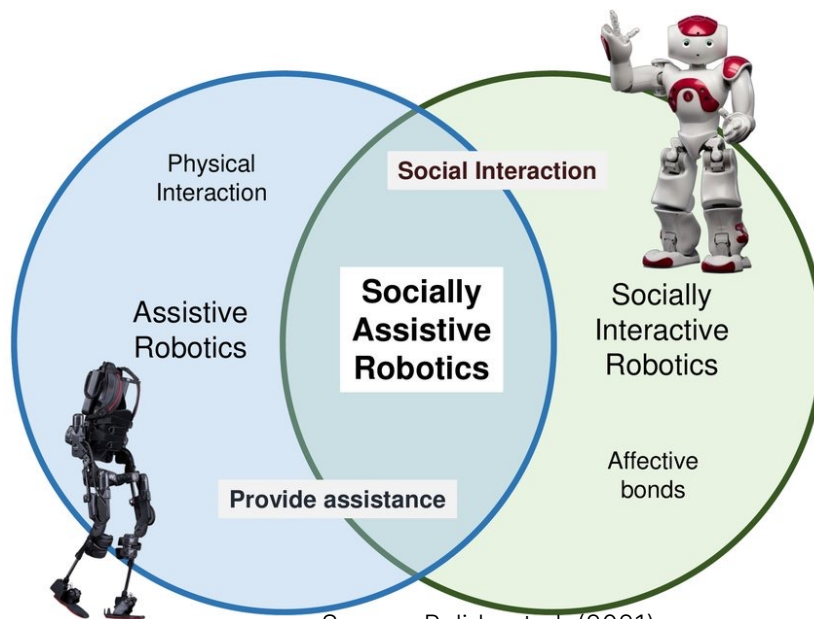 o Safety/Security must be taken into account when investigating trust factors

Trust Definition

- The belief that the user (==trustor==) has that the robot (==trustee==) will fulfil its expected functions in a ==predictable==, ==effective==, and ==safe== manner
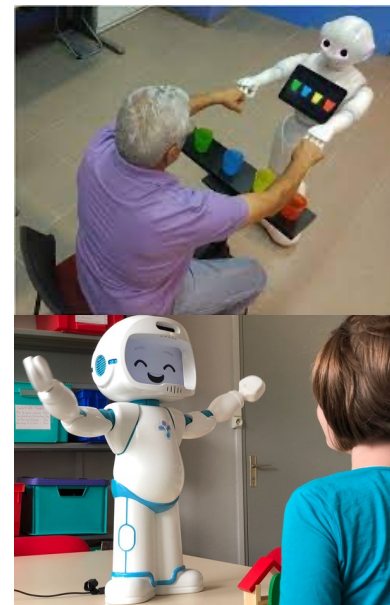
Socially Assistive Robots (SARs)

- Enables close and effective interactions that lead to measurable advancements in physical recovery, rehabilitation, learning, and various tasks [Feil-Seifer and Mataric (2005)]

Physical Interaction

Social Interaction

Assistive Robotics

Socially Assistive Robotics

Socially Interactive Robotics

Provide assistance

Affective bonds
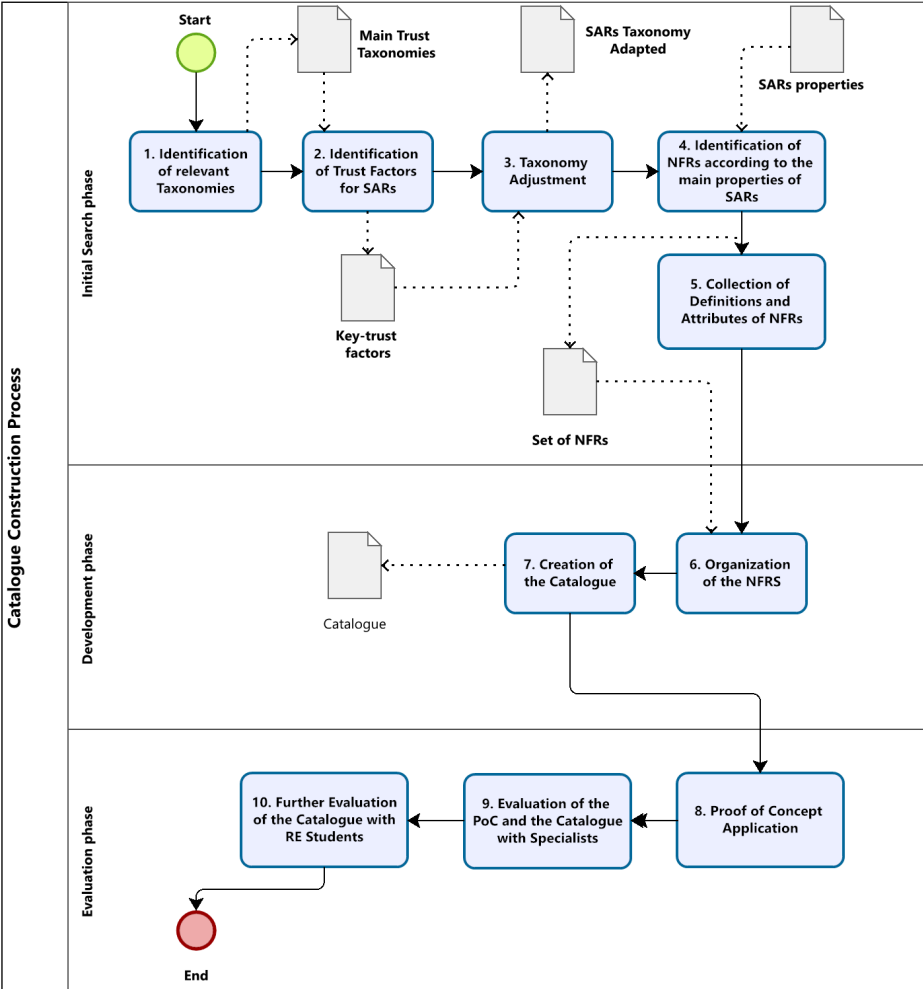
Source: Pulido et al. (2021)
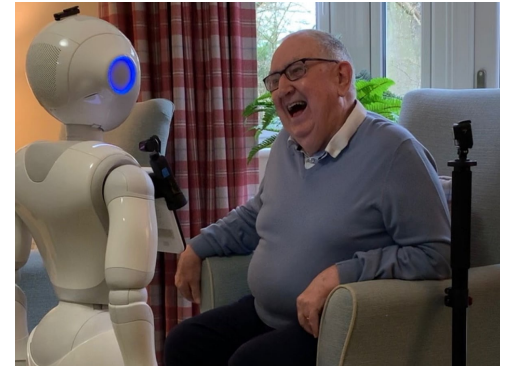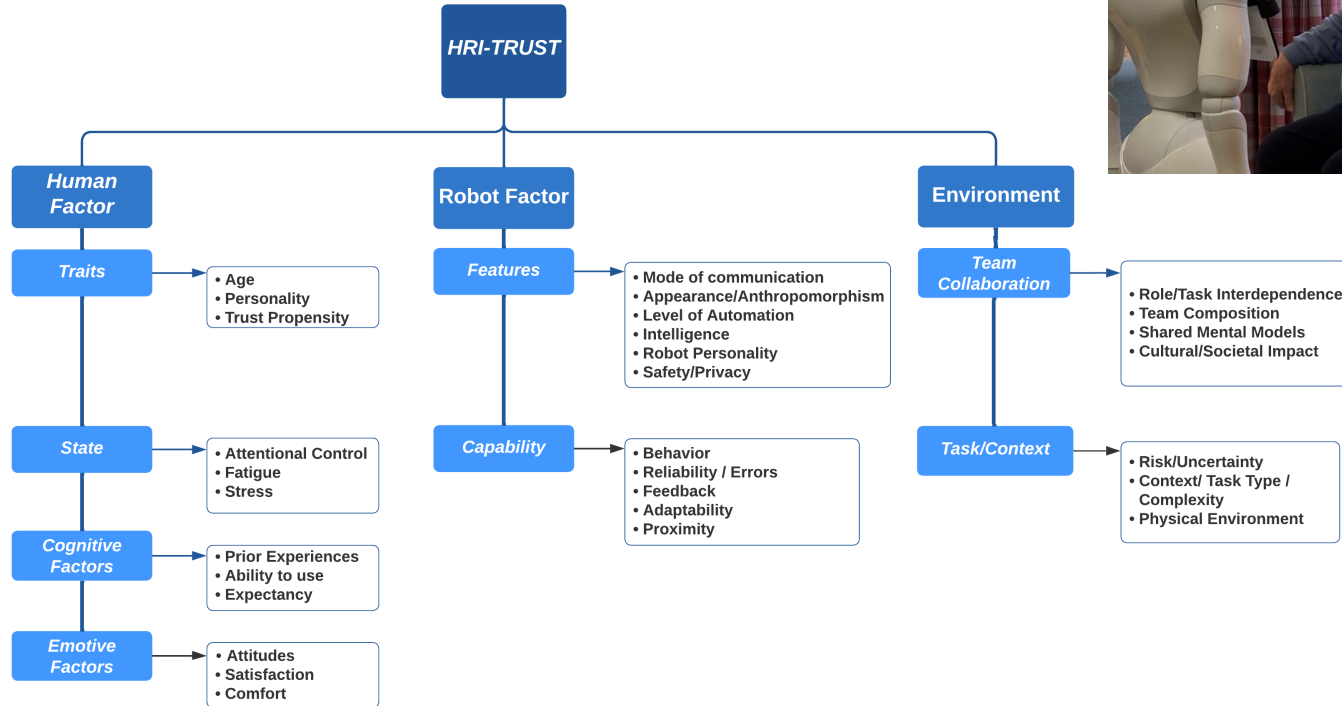
Non Functional Requirements (NFRs)

- NFRs have a relevant role during the development of SARs
- Requirements related to:
  - The social and psychological influence that the robot can exert in the interaction with the human
  - The types of physical contacts that can occur between the robot and humans
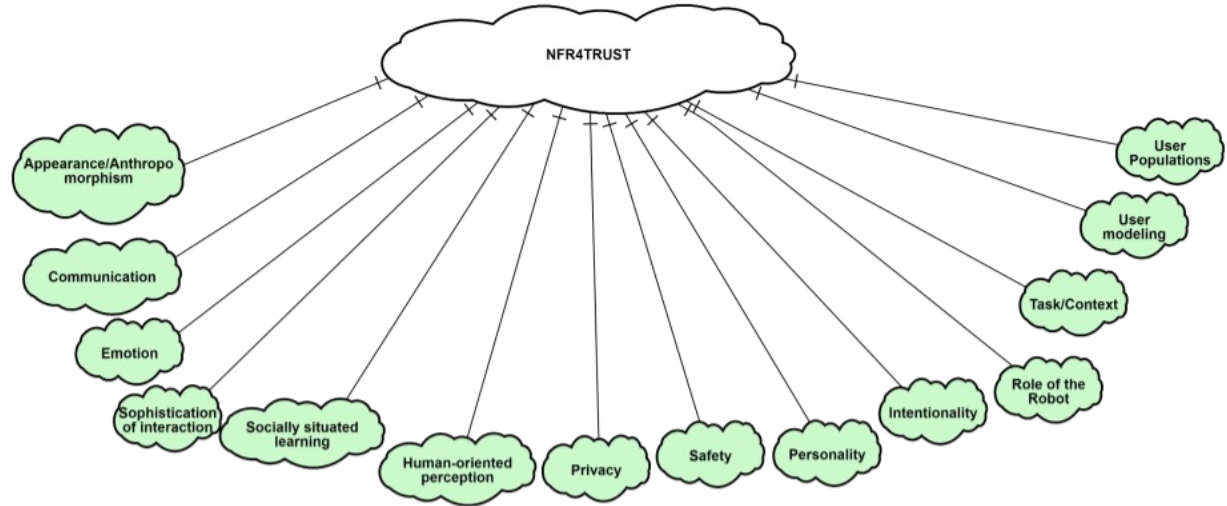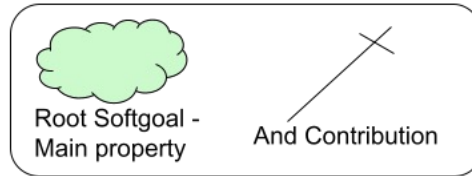
NFR4Trust Construction Process

Taxonomy

HRI-TRUST

Human Factor

Traits
→ • Age
• Personality
• Trust Propensity

State
→ • Attentional Control
• Fatigue
• Stress

Cognitive Factors
→ • Prior Experiences
• Ability to use
• Expectancy

Emotive Factors
→ • Attitudes
• Satisfaction
• Comfort

Robot Factor

Features
→ • Mode of communication
• Appearance/Anthropomorphism
• Level of Automation
• Intelligence
• Robot Personality
• Safety/Privacy

Capability
→ • Behavior
• Reliability / Errors
• Feedback
• Adaptability
• Proximity

Environment

Team Collaboration
→ • Role/Task Interdependence
• Team Composition
• Shared Mental Models
• Cultural/Societal Impact

Task/Context
→ • Risk/Uncertainty
• Context/ Task Type / Complexity
• Physical Environment

Trust Taxonomy in Human-Robot Interaction for Socially Assistive Robots

The Catalogue: 125 NFRs

Full catalog at: <u>Link</u>

Partial view of the SIG of the primary NFRs

Appearance/Anthropomorphism

Refinement of the Appearance/Anthropomorphism NFR

Appearance/Anthropomorphism
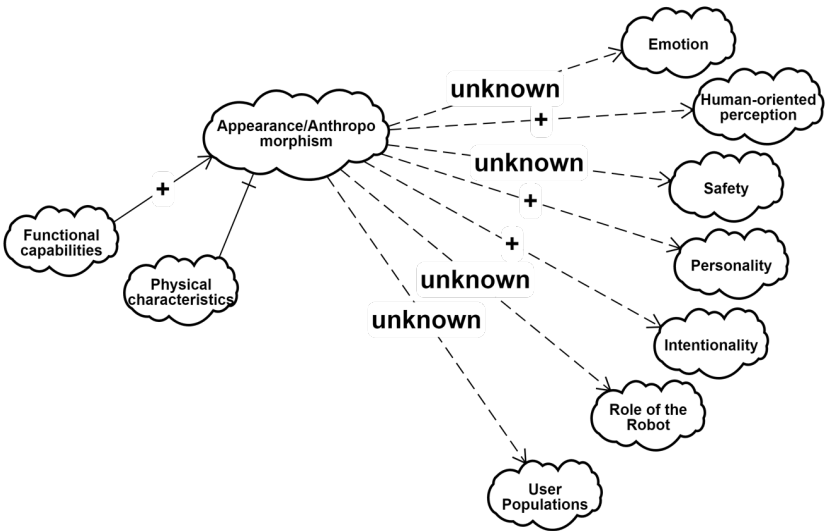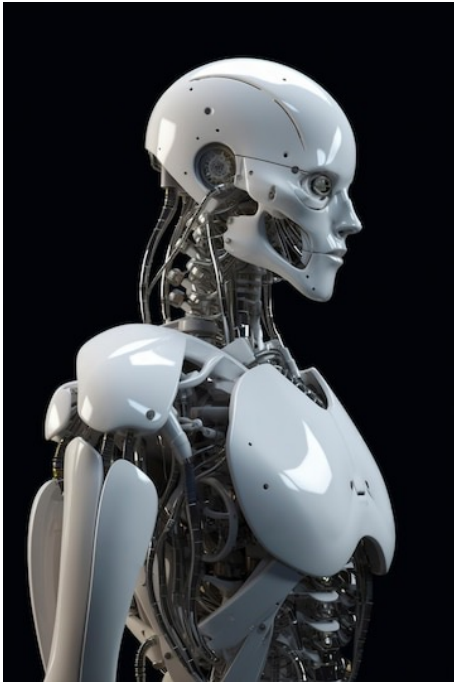
Contributions and correlations

Validation/Evaluation

- Proof of Concept (**PoC**):

  ○ Socially Assistive Robot (**NAO**) for upper limb motor rehabilitation.

- Interviews with **experts**

  ○ in the fields of SARs, Human-Robot Interaction, and the NFR framework

- Evaluation by **Requirements Engineers**

On the Use of Social Robots for Rehabilitation: The Case of NAO Physio

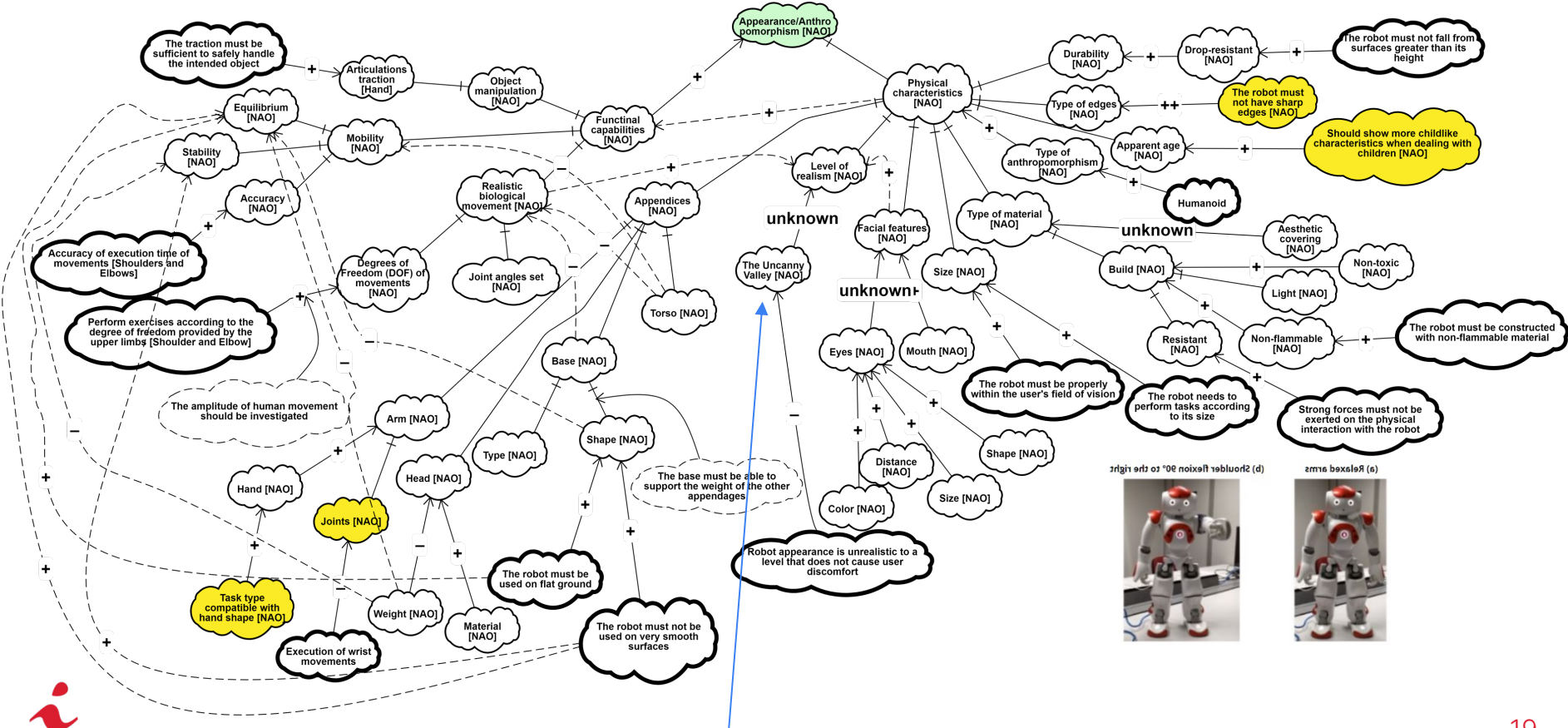Larissa Rodrigues da Costa ✉, Jaelson Castro, Cinthya Lins, Judith Kelner, Maria Lencastre & Óscar Pastor
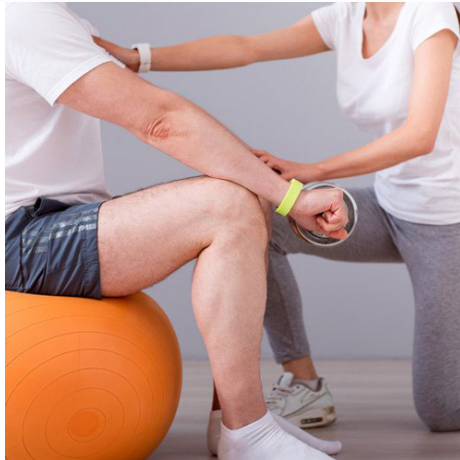
Upper Limb Rehabilitation

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# Proof-of-Concept: Appearance/Anthropomorphism
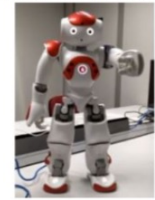
Na eerie or unsettling feeling that some people experience in response to not-quite-human figures like humanoid robots and lifelike computer-generated characters.

Catalogue Validation/Evaluation: Experts

- **Two experts interviewed:** Requirements Engineer (RE) with NFR Framework knowledge and HRI Engineer with Social Robots expertise. Interviews via videoconference, lasting around 1.5 hours each, recorded for future reference

- **RE expert evaluation:** Validate catalogue's applicability in real scenarios and check proposed SIG correctness

  - Demonstrated relevance of NFRs in SARs domain, feasibility of using catalogue in practical situations

  - RE expert approved NFR Framework use, including operationalization concept.

- **HRI expert evaluation** : Catalogue's usefulness for the design of SARs applications and its adoption for the developer of applications in this field.

  - Privacy identified as critical in Socially Assistive Robots, suggestions provided for improvement.

- Some suggestions from both experts incorporated into the catalogue
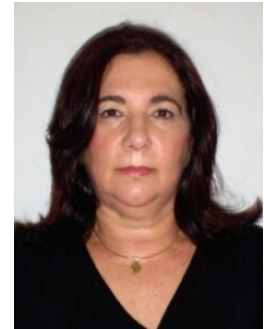
Catalogue Validation/Evaluation: Further Experts

- Revised catalogue led to a new round of interviews with three additional experts from Requirements Engineering and three from Human-Robot Interaction

- Conducted remotely via videoconference, customized for each expert's knowledge, lasting 1-2 hours and recorded for future analysis.

- Semi-structured interviews based on guidelines in [19]

- Interviews were flexible yet guided, combining structured questions and conversational exploration

Catalogue Validation/Evaluation: Further Experts

- Specialists from Requirements Engineering (RE) and Human-Robot Interaction (HRI) were interviewed, showing limited knowledge outside their expertise

- Trust importance for Social Robot acceptance recognized by all

- Participants' profiles assessed; knowledge gaps identified and presented concise research topics overview, focusing on areas of limited knowledge

Qualitative analysis

- Mapping requirements associated with robot awareness, conversational agents, and psychological factors in conversations

- Highlighting the significance of integrating empathy and addressing robot gender and cultural considerations in the catalogue.

- Managing catalogue complexity by organizing it with diverse levels of abstraction or views

- Evolution of the NFR Framework language to cover questions related to robot interaction

Qualitative analysis

- Presentation of properties in more textual formats or selectable aspects based on relevance

- Abstraction of decompositions for clarity

- Emphasizing the use of appropriate terminology as well as the necessity to better organize/structure the information to improve its usability for non-experts

Discussion of Results

- Subjective Perception

- Experience Level

- Comprehensive Evaluation is challenging

- NFR

  - Easy for RE Experts

  - Discrepancies in NFR Framework Knowledge (Different Views on the Notation)

- Dunning-Kruger Effect Possibility

  - Cognitive bias in which people with limited competence in a particular domain overestimate their abilities.

Assessment by Requirements Engineers

- **20** Participants
  - Remote Videoconferencing
  - Google Forms
- Proficient in NFR Framework
- Good **RE** Knowledge
- Little HRI, Trust, and related areas Knowledge
- **Accurate, relevant** and **effective**
- Some suggestions for **improvements**
  - later included in the catalogue

Related Works

TABLE. Comparison of related works on observed aspects

Works	Has Taxonomy?	It's about Trust?	It's about HRI?	It's about SARs?	Deals with Safety/Privacy in Trust?
Hancock, Peter A., et al. (2011) [20]	Yes	Yes	Yes	No	No
Schaefer, Kristin E. (2013) [21]	Yes	Yes	Yes	No	No
Schaefer, Kristin E., et al. (2016) [22]	Yes	Yes	No	No	No
Langer, Allison, et al. (2019) [23]	No	Yes	Yes	Yes	Yes
NFR4TRUST [25]	Yes	Yes	Yes	Yes	Yes

Related Works

TABLE. Comparison of related works on NFR catalogues

Works	Presents catalogues with the NFR Framework	It's about Trust?	It's about Trust in HRI?	It's about NFRs for SARs?
Cysneiros, L. M., do Prado Leite, J. C. S. (2020) [35]	Yes	Yes	No	No
Kwan, D., Cysneiros, L. M., do Prado Leite, J. C. S. (2021) [36]	Yes	Yes	No	No
Silva, R. A. D (2019) [37]	Yes	No	No	No
Quintanilla Portugal, Roxana Lisette. (2020) [38]	Yes	No	No	No
Sadi, Mahsa Hasani. (2020) [39]	Yes	No	No	No
NFR4TRUST [25]	Yes	Yes	Yes	Yes

Conclusions

- **Objective:** Identification, examination, and documentation of Non-Functional Requirements of Trust for Anthropomorphic-type Socially Assistive Robots

- **Research Questions:** Successfully addressed

  - **125** Trust NFRs that can be important for the design and selection of SARs as well as the development of their applications.

  - **14** primary trust requirements that play a critical role in establishing trust and ensuring the effective functioning of SARs

Conclusions

- **NFR Framework Notation:**

  - HRI Experts

    - Exploration of alternative **structuring** approaches needed for effective and accessible trust-related catalogues in HRI contexts.

  - RE Experts

   - Some disagreement on the notation

Future Work

- **Structure** the Trust Catalogue to better suit Human-Robot Interaction (HRI) contexts, ensuring accessibility and relevance

- **Guidance** on how engineers can effectively leverage the catalogue and apply its definitions and templates to real-world scenarios

- **More Experts** to include individuals with expertise in both **Human-Robot Interac**tion and **Requirements Engineering**,
  - Ensure a more comprehensive understanding of the subject matter

Future Work

- **New** trust **factors** based on ongoing research and real-world applications, expanding the catalogue's coverage

- **More SARs**, SAR **applications** beyond physical therapy to understand trust dynamics in different contexts.

- **Repository** for non-functional trust requirements, serving as a central hub for researchers and engineers
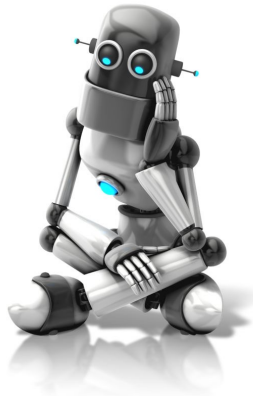
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