WizUs

November 20, 2020

Socially-Driven Robots to Support Human-Human Interactions

WizUs

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- Host institution: **University of the West of England, Bristol Robotics Laboratory**
- Duration: **60 months** (5 years)

Abstract

AI is already part of our daily life, and robots are increasingly part of our everyday lives, supporting our ageing society, and assisting teachers in classrooms. In this context, how to ensure 'by-design' that these social robots have a positive social impact? This question is the backbone of the WizUs research project, and our specific objective is that, within 5 years, we create a socially-intelligent and responsible robot, that (1) will have recognised social utility, and (2) will see long-term acceptance by its users.

We formulate two main hypotheses: (1) this objective can only be achieved if the robot is socially-driven: the robot's behaviours must be driven by the intention to support positive human-human interactions. How this general principle translates into specific guidelines and algorithms – while taking into account the principles of a responsible AI – is a central contribution of the WizUs project.

(2) Long-term acceptance requires genuine involvement of the end-users at every step of the design process. To this end, WizUs introduces a novel methodology involving 'public-in-the-loop' machine learning: the large scale participation of end-users, over extended periods of time, to teach the robot how to become a good and responsible social helper.

WizUs tests these two hypotheses with an ambitious work programme. It includes basic research and conceptual framing; extensive, beyond-state-of-art, technical developments; and an ambitious experimental programme, with a combined two years of field deployment of social robots in public spaces.

WizUs opens a unique window into the positive role social robots can play in our future societies; it will provide a lasting legacy, paving the way forward for a better understanding of the design of socially-intelligent

robots that are socially useful and acceptable in the long-term.

Case for support (9 pages)

seven on the scientific case and two on the non-technical aspects (i.e. to cover the non-scientific elements of the assessment criteria) of your application.

Case for support

Long-term vision and ground-breaking nature of the project

Over the 5 years of the 'WizUs' project, I will design and deliver a ground-breaking embodied AI for socially intelligent robots, with long-term social utility and demonstrated acceptance in the field.

This breakthrough is made possible by a combination of novel methodologies and the principled integration of complex socio-cognitive capabilities:

- **crowd-sourced social interaction patterns;**
- **'public-in-the-loop' machine learning;**
- **a novel spatio-temporal and social model of the robot's environment;**
- **novel, non-repetitive, social behaviour production based on generative neural networks;**
- **and finally, an integrative cognitive architecture, driven by long-term social goals.**

In addition, I will deliver the conceptual and ethical framework required to further support the public debate and policy making process around social robots, and concretely demonstrate lifescale applications of these robots in two, one-year-long deployments in high impact, social environments.

Closely aligned with the EPSRC Delivery Plan priorities (see *National Importance* section), WizUs creates a unique opportunity to establish myself a key leader in Intelligent Social Robotics, as well as asserting the UK's worldwide leadership in AI and robotics.

Novely, context, timeliness, relevance

The service and companion robots that we are set to interact with in the coming years are being designed and built today in labs and startups all over the world. Indeed, we already envision close and long-term human-robot interactions in a range of sensitive domains like education, elderly care and health care. Critically, we as a society, need to develop in parallel the underpinning principles that will ensure the future roles of social robots are collectively defined, in a responsible and ethical manner – in particular in the context their interactions with vulnerable populations.

Progressing this question requires real-world evidence. However, because autonomous social robots lie at the forward edge of science and engineering, the real-world, long-term deployments required to gather such evidence are extremely rare. As a consequence, we currently have limited insights into the factors that determine the utility and acceptability of social robots.

WizUs approaches this important and timely question in a **novel and ambitious** manner: the project will define and implement **a vision of AI and social robotics that places the human at the centre of these emerging technologies, to foster novel social dynamics that are acceptable and beneficial to society**.I propose to create a **state-of-the-art autonomous social robot** that not only learns social behaviours **with and from** the public and end-users, but is also **co-designed from the ground-up to be acceptable, responsible and useful** to the humans it will serve.

Ambition, adventure, transformative aspects

This research is ground-breaking: **I will lead a team that, within 5 years, will design, implement and demonstrate the AI engine of a socially-intelligent robot. My aim is to create, sustain and better understand the dynamics of responsible long-term social human-robot interactions, in order to build a robot that (1) has an effective social utility, and (2) will see long-term acceptance by its end-users**.

The WizUs project is **ambitious**: I will bring together two emerging AI paradigms (teleological architectures and human-in-the-loop machine learning); I will integrate them into a state-of-the-art cognitive architecture for autonomous social robots, relying on multidisciplinary approaches where relevant (eg. creating a body language with a choreographer and novel expressive sounds with a sound specialist); I will engage in a unique, large-scale, 'public-in-the-loop' participatory design process that will transform how we think about public engagement with technology design; finally, I will deploy this co-designed autonomous robot in two, real-world, highly social settings, for long periods of time.

Combining scientific ambition, engineering ambition and methodological ambition, the WizUs project will set a high bar for excellence, which leads to a fourth ambition: establishing myself as one of the key leaders in social robotics. Surprisingly few groups worldwide have achieved full autonomy for a complex social robot. While I have done so (see *Résumé for Researcher*), the fellowship will enable me to further assert myself as one of the leaders in Human-Robot Interaction (HRI) – and reaffirm the UK's preemience in socially intelligent AI.

Methodology and approach to achieve impact

The overall aim of the WizUs project to **create, sustain and better understand the dynamics of responsible, long–term social human–robot interactions** translates into three key research questions:

RQ1: What are the public expectations with respect to the role of social robots, and how can we collectively design principles ensuring safe, beneficial, socially acceptable robots?

RQ2: What AI is required to sustain long-term engagement between end-users and a robot? In particular, how can AI provide a robot with an understanding of its own social environment and create behaviours that are not repetitive or overly predictable?

RQ3: What new ethical questions are raised by long-term social interaction with an artificial agent, and in particular, how to balance autonomy of the robot with behaviour transparency and human oversight?

From these questions we derive five objectives:

O1: conceptual framing What should motivate the robot to step in and attempt to help? What social norms are applicable to the robot behaviours? I will investigate the basic principles of responsible social interactions, that must form the foundations of a socially useful robot, accepted and used in the long run. Using user-centred design and participatory design methodologies, I will identify the determinants and parameters of a responsible social intervention, performed by a socially-driven robot, and formalise them in guidelines. This objective aims at addressing RQ1, and is realised in WP1. **rephrase to clarify the objective and follow the same structure'To...' as the other 2 objectives**

O2: real–time social modeling To create the novel cognitive capability of artificial *social situation assessment* and enabe the robot to represent real-time social dynamics in its environment, I will significantly extend and integrate the current state-of-art in spatio-temporal modeling (so-called *situation assessment*) with my recent research in social state modeling. This objective contributes to RQ2, and is investigated in WP2.

O3: congruent social behaviours production To create a novel way of producing non-repetitive, socially-congruent, expressive motions using the state of the art in generative neural networks, combined with data acquired from an expert choreographer. This will be integrated with novel *sound landscapes* to create a beyond-state-of-art, non-verbal (yet highly expressive) action and communication system for the robot. This objective also contributes to RQ2 and is the focus of WP3.

O4: embodied AI breakthrough To create robot behaviours that are perceived as purposeful and intentional (long-term goals), while being shaped by a user-created and user-controlled action policy. I will integrate long-term social goals, arising from the interaction principles of **O1**, with the social modeling capability of **O2** and the behaviours production of **O3** into a principled, goal-driven cognitive architecture. The breakthrough will come from combining these long-term social goals with bottom-up action policies, designed and learnt from the end-users using human-in-the-loop reinforcement learning.

I will specifically test the following two hypotheses: first, that long-term social goals, if suitably co-designed with the public and stakeholders and properly integrated into the robot as a *social teleology*, will create the perception that the robot is intentional and purposeful. This will in turn elicit sustained engagement from its human users.

Second, I will test the hypothesis that human-in-the-loop machine learning can be used to ensure an additional layer of human oversight and a level of behavioural transparency. Human-in-the-loop reinforcement learning – as implemented in the SPARC approach that I have developed and already used in complex social environments[1 2 3] – relies on an end-user 'teacher'. This teacher initially fully controls the robot (via teleoperation) while it learns the action policy, and then progressively relinquishes control up to a point where the robot is effectively autonomous. As I previsouly argued[2], this approach leads to increased control and ownership of the system, and as a result, increased trust on the part of end-users.

[1] Senft et al. 2017 (10.1016/j.patrec.2017.03.015). [2] Senft et al. 2019 (10.1126/scirobotics.aat1186). [3] Winkle et al. 2020 (10.15607/RSS.2020.XVI.059).

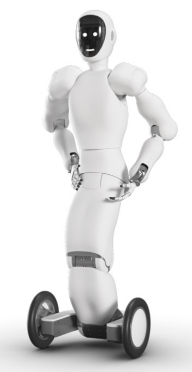
This addresses RQ2 and RQ3; however, it also raises one additional question: how to *arbitrate* between a top-down action policy arising from the long-term goals and the bottom-up action policy learnt from the end-users? This question leads to objective **O4'**: To design a policy arbitration mechanism that preserves the robot's long-term intentional behaviour while effectively guaranteeing human control, ownership and oversight. **O4** and **O4'** are addressed in WP4.

O5: ambitious field research Finally, the last objective of the WizUs project is to demonstrate the effectiveness of my approach in complex, real-world conditions. This means deploying the WizUs robots in existing social eco-systems that are sufficiently complex and open to explore novel social interactions. My objective is also to show that this real-world deployment can be successfully driven by the 'end-to-end' involvement of all the end-users and stakeholders: from defining the robot's role, from the different perspective of each end-user, to actually designing and 'teaching' the robot what to do. This is the focus of WP5.

Together, these five objectives build a coherent and realistic pathway towards addressing the overall aim of WizUs: creating, sustaining and better understanding the dynamics of responsible long-term social human-robot interactions.

Experimental approach

My experimental approach has two phases. First, I will co-design and co-construct the robot's social role and behaviours through large-scale public engagement. For a whole year, I will deploy the WizUs robot within the Open City Lab of Bristol Science Centre *WeTheCurious*, relinquishing its control to the visitors themselves. Tasked with remotely operating the robot to assist fellow visitors, a researcher will accompany them in 'inventing by doing' a new grammar of social interactions to develop answers to the questions: what does it mean for a robot to help? How to do so in the dynamic, messy, environment of a science centre? What are acceptable behaviours? Can we see new social norms emerge? At the end of this experiment, we expect 1000s of people to have experienced – and co-designed – how robots should interact with humans in a positive, helpful way. Each of these experiences will contribute to uncovering and designing the basic principles of social interaction for robots. This work is the focus of WP1.



While most of the interactions in the science centre will be short-lived, a follow-on, long term (one year) experiment will take place in one of Bristol's Special Education Needs (SEN) school where I currently run pilots, helping 250+ children with psycho-social impairments (autism) to develop their social skills and to engage into playful social activities: telling stories, triggering group activities with other children, providing additional social presence. Similar to the science museum experiment, the robot behaviours will be co-designed with, and learnt from the end-users themselves: teachers, parents, and as much as possible, the children themselves.

Importantly, WizUs focuses specifically on the AI engine of the robot: I will use an existing robotic platform (Halodi's EVE, pictured on the left) and develop and train the algorithms required to achieve autonomy and responsible, long-term social utility. Indeed, after an initial training period, the robot will be autonomous: while the users will be provided with tools to override the robot's decisions at any time (via both an app and touch sensors on the robot itself), it will otherwise move and act on its own, without the need for constant supervision.

Overview of the work programme

Figure 2.1 gives an overview of the project work packages and their interrelations. Experimental fieldwork, which plays a central role in the project, appears in the centre of the figure.

WP1: Framing robot-supported human-human interaction

WP1 aims at establishing the conceptual and ethical framework around the idea of *robot-supported human-human interactions*. It does so by co-creating patterns of interaction and norms with the general public, using a unique combination of ethnographic observations and 'crowd-sourced' interaction patterns.

Main outcomes: A theoretical framework for thinking about the role of social robots and guidelines to inform policies for this (including ethical implications); a set of operational and co-created interaction principles; a large dataset of social human-robot interactions

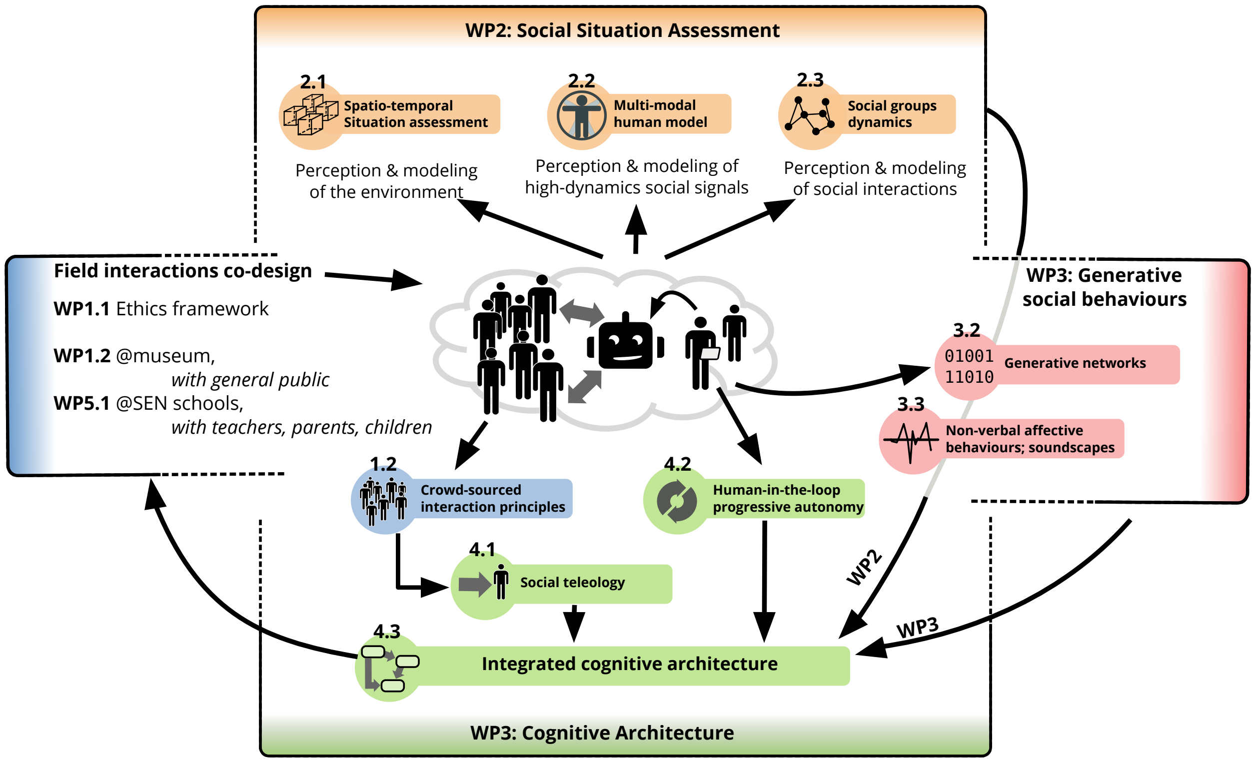


Figure 2.1: Overview of the work packages and tasks, and tasks inter-relations.

Timeframe: Y1–Y3; one senior post-doctoral research assistant (PD1) with background in the sociology of technology.

T1.1 – Conceptual framing and ethics of robot-supported social interactions
The first task in WP1 is to research and define the conceptual framework around questions like: what role should social robots have? Where to set the boundaries of artificial social interactions? What do 'ethical-by-design' and 'responsible-by-design' mean in the context of social human-robot interactions?

Each of the field experiments (T1.2, T5.1. T5.2) will both *build on* and *feed into* the framework developed in this task. In addition, four two-day workshops with the WizUs Ethics Advisory Board, spread over the duration of the project, will act as milestones for ethics review.

T1.2 – Crowd-sourced patterns of robot-supported social interactions The conceptual framework identified in T1.1 is translated into a set of *interaction design principles* and *determinants* that will together form a set of requirements and objectives for the socio-cognitive capabilities and architecture developed in WP2 and WP4.

In order to anchor T1.2 in the reality and complexity of human social interactions and involve the public in the design of these patterns and norms, I will embed one WizUs robot in the Bristol Science Centre WeTheCurious for a whole year (Y2). With the help of a researcher (PDRA), the visitors will be guided in tele-operating the robot to assist other visitors, and, by doing so, co-design what defines a good robot helper. This will generate the quantitative and qualitative data to inform questions like 'what role for the robot?', 'when to intervene?' and 'what are effective and acceptable social influence techniques?'. It will also be a unique example of crowd-sourcing at a large scale, with the general public, the design of the interactions with social robots. The generated dataset will also be used as a data source in WP2 and WP3.

Specific resources The Bristol Science Centre is fully committed to the project. They will include WizUs in its official programme of activities, and provide in-kind training for the WizUs researcher based at the centre.

WP2: Real-world Social Situation Assessment

In WP2, the project addresses the key scientific and technical prerequisites to effectively deliver WP4's cognitive architecture: namely, the perception and modeling of the spatio-temporal and social environment of the robot. This includes spatial characteristics (proxemics; group dynamics; complex, dynamic attentional mechanisms); psycho-social determinants (social roles and hierarchies; social groups; mental modelling; anthropomorphic ascriptions), and temporal characteristics (effects of novelty; dynamics of anthropomorphism and mental ascriptions; group dynamics). I have investigated many of these socio-cognitive capabilities in isolation (Table 2.1), and this WP is about *integrating* them into a coherent perceptual subsystem, significantly extending the state of the art[4,5].

Main outcomes: A complete pipeline for spatio-temporal and social situation assessment, built as open-source ROS nodes and able to map in real time the physical and social environment of the robot.

Timeframe: Y1–Y4; one post-doctoral research assistat (PD2) in social signal processing/machine learning/cognitive modelling expertise.

T2.1 – Hybrid situation assessment and knowledge representation This task builds the foundational spatio-temporal and symbolic perception and representation system for the robot. It will integrate the state of the art in spatio-temporal situation assessment that I have previously developed[67], drawing on recent advances in data-driven semantic labelling (for instance, using 4D convolution nets like MinkowskiNet[8]), and a symbolic knowledge base (like my own ontology-based one[9]) in order to create a coherent system of representations for the cognitive architecture of the robot.

T2.2 – Multi-modal human model This task focuses on the processing and modelling of social signals, extending existing techniques both model-based[10,11] and data-driven[12]. This task goes beyond the state of the art by looking specifically at resolving highly dynamical signals (like gaze saccades and micro facial expressions). Required datasets will be drawn from my previous work[13], as well as from the project experiments (T1.2, T5.1, T5.2).

T2.3 – Interaction and group dynamics Building on T2.2, T2.3 investigates the automatic understanding and modelling of group-level social interactions[14], including f-formations[15], sociograms[16], and inter-personal affordances[17]. This task builds on literature on social dynamics analysis (eg[18,19,20]) to apply it to real-time social assessment by a robot, which is itself embedded in the interaction.

T2.4 – Integrated model of the social environment The integration of the social cues from T2.2 and T2.3 results in a socio-cognitive model of the social environment of the robot, which will effectively extend the representation capabilities of T2.1 to the social sphere. The result of T2.4 is an AI module that implements a full social assessment pipeline, from social signal perception to higher-level socio-cognitive constructs. T2.4 also includes a focused experimental programme (based on the protocols designed by Frith and Happé[21], which I introduce in[22]) to demonstrate in isolation the resulting socio-cognitive capabilities.

WP3: Generative social behaviours

Mirroring WP2's focus on understanding the social interactions, WP3 addresses the question of social behaviour *production*: how to create natural, non-repetitive behaviours, engaging end-users over a sustained period of time. The robot behaviours will be exclusively non-verbal (non-verbal utterances, gaze, joint attention, facial expressions and expressive motions), and will include soundscapes as a novel, non-verbal interaction modality.

Main outcomes: A new method to automatically design complex and non-repetitive social behaviours, with a focus on non-verbal communication; research on soundscapes as a novel non-verbal modality for human-robot interaction.

Timeframe: Y2–Y5; one post-doctoral research assistant (PD3) in machine learning/learning from demonstration.

T3.1 – Behavioural baseline T3.1 establishes a baseline for behaviour generation, by surveying and implementing the current state of the art (behaviours library, activity switching[23]). This baseline will enable early in-situ experimental deployments, while also providing a comparison point for T3.2.

T3.2 – Generative neural network for social behaviour production WizUs aims to significantly advance the state of the art in this regard, by combining two recent techniques: (1) generative neural networks for

[4] Lemaignan et al. 2017 (10.1016/j.artint.2016.07.002). [5] Baxter et al. 2016 (10.1109/HRI.2016.7451865). [6] Lemaignan et al. 2018 (10.1109/IROS.2018.8594094). [7] Sallami et al. 2019 (10.1109/IROS40897.2019.8968106). [8] Choy et al. 2019 (10.1109/CVPR.2019.00319). [9] Lemaignan et al. 2010 (10.1109/IROS.2010.5649547). [10] Gunes and Schüller 2017 (10.1017/9781316676202.016). [11] Lemaignan et al. 2016 (10.1109/HRI.2016.7451747). [12] Bartlett et al. 2019 (10.3389/frobt.2019.00049). [13] Lemaignan et al. Oct. 2018 (10.1371/journal.pone.0205999). [14] Tapus et al. 2019. [15] Marshall et al. 2011. [16] Garcıa-Magariño et al. 2016. [17] Pandey and Alami 2013. [18] Durantin et al. June 2017 (10.3389/frobt.2017.00024). [19] Jermann et al. 2009. [20] Martinez-Maldonado et al. 2019. [21] Frith and Happé 1994. [22] Lemaignan and Dillenbourg 2015. [23] Coninx et al. 2016.

affective robot motion generation[24,25] (with training data created with an expert choreographer); (2) interactive machine learning in high-dimensional input/output spaces, where I have achieved with my students promising results for generating complex social behaviours[2,3] that fully involve the end-users[26]. Modulating (1) with the learnt features of (2), I will target a breakthrough in generating robots' social behaviours: the generation of non-repetitive, socially congruent and transparent social behaviours (including gestures but also gazing behaviours and facial expressions).

T3.3 – Non-verbal behaviours and robot soundscape In task T3.3, we introduce a novel non-verbal interaction modality for robots, based on soundscapes. Soundscapes involve creating a sound environment that reflects a particular situation; they have also been shown to be an effective intervention technique in the context of special needs interventions[27]. The soundscapes that I will create are 'owned' by the robot, which can manipulate them itself, for example to create an approachable, non-threatening, non-judgmental, social interaction context, or make the interaction a trusted physical and emotional safe-space for the user.

Specific resource: these soundscapes will be co-designed with Dr. Dave Meckin, an expert on sound design for vulnerable children, and a staff member at the host institution.

WP4: Goal-driven socio-cognitive architecture

In WP4, I will design a novel socio-cognitive architecture for social robots and implement it on the Halodi EVE robot. WP4 will integrate the modeling capabilities and behaviour production developed in WP2 and WP3, with a dual action policy – one driven by a social teleology (an artificial intrinsic motivation to act socially) and one learned through human-in-the-loop machine learning (Figure 2.2). This WP is high-risk/high-gain: while sustaining long-term engagement in a principled way remains a major scientific challenge in social robotics[28], the WP adopts a very novel approach to goal-driven socio-cognitive architectures. It has the potential to unlock long-term social engagement by endowing the robot with its own intentionality[29], while maintaining human oversight.

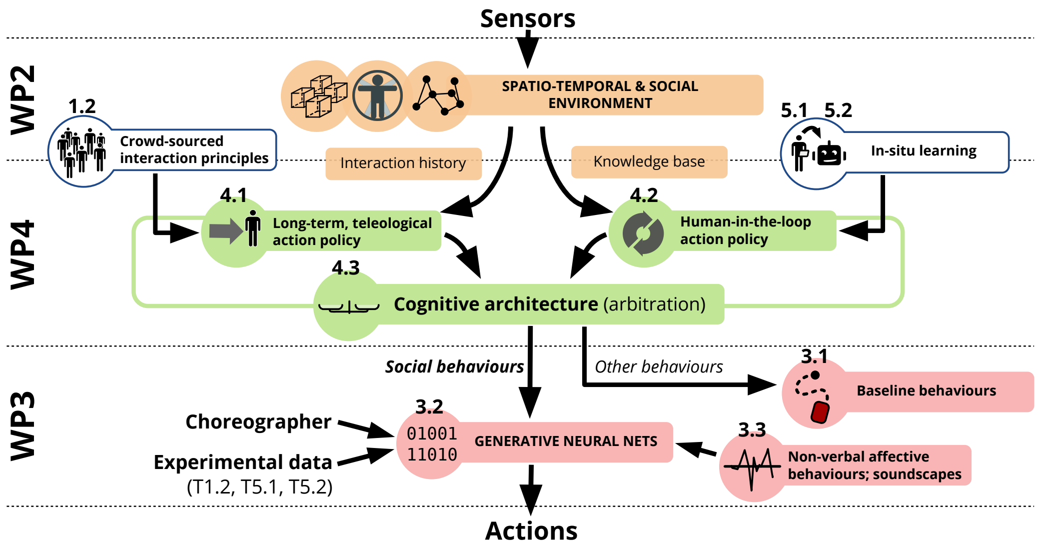


Figure 2.2: Overview of the AI engine implemented in WizUs.

Main outcomes: An integrated cognitive architecture for social robots, driven by both long-term social goals, and machine-learnt action policies; a reference open-source implementation, enabling long-term autonomy for the Halodi EVE robot.

Timeframe: Y1–Y5; one post-doctoral research assistant (PD4) in cognitive robotics; one PhD student (PHD1).

T4.1 – A social teleology for robots The idea of a *teleological* (ie goal-driven) robot architecture for social interaction is highly novel (existing literature on teleological robots only focuses on simple cognitive systems[30,31]). This task will design and implement such an architecture on the EVE robot. It first identifies *interaction principles* from the interaction patterns and determinants uncovered in T1.2; these are then mapped into

[24] Marmpena et al. 2019 (10.1109/ACII.2019.8925459). [25] Suguitan and Hoffman 2020 (10.1145/3319502.3374807). [26] Winkle et al. 2018 (10.1145/3171221.3171273). [27] Greher et al. 2010. [28] Hoffman May 2019. [29] Wiese et al. 2017. [30] Oudeyer et al. 2005. [31] Forestier and Oudeyer July 2017.

long-term interaction goals, capable of driving the robot actions over a period of time.

T4.2 – Learning from humans to achieve 'by-design' responsible & trustworthy AI Building on my recent results on human-in-the-loop social learning[1,2,3], this task implements the mechanics to allow human end-users to progressively teach the robot a domain-specific social policy. It also qualitatively researches how human-in-the-loop machine learning enables a more trustworthy AI system by involving end-users in the creation of the robot behaviours, resulting in *explainable* behaviours for the end-users.

T4.3 – Integrating a socially-driven architecture for long-term interaction Building on my previous work on cognitive architecture[4], this task brings together, in a principled manner, the perceptual (WP2) and behavioural (WP3) capabilities of the robot, as well as the social policies created in T4.1 and T4.2. T4.3 will specifically look at long term autonomy, including long-term social goals, cognitive redundancy and behavioural complexity.

T4.3 will also develop the arbitration mechanism that combines the robot's social teleology (T4.1) with the human-taught action policy (T4.2). This arbitration mechanism will build on research on reinforcement learning for experience transfer[32] that enables the re-assessment of a policy (here, our intrinsic motivation) based on previous experience (here, the human-taught policy).

WP5: Experimental programme: long-term deployments in sensitive social spaces

Finally, WP5 aims to convincingly demonstrate the importance and positive impact that socially-driven, socially-responsible robotics may have. The experimental work of WizUs will be organised around an ambitious long-term study, set in a complex, real-world environment, at a Special Educative Needs (SEN) school.

This environment also put the project in the unique position of actually delivering high societal impact: I anticipate 250+ SEN-educated children will directly benefit from the project, exploring how robots can have a net social utility while being accepted as an effective tool by field practitioners. This deployment will take place within the strict ethical framework established in T1.1.

Main outcomes: One long-term deployment of a social robot in a real-world, high impact environment, demonstrating long-term acceptance and social utility; large (anonymous) datasets of complex, real-world human-robot interactions.

Timeframe: Y3–Y5; one post-doctoral research assistant (PD4, shared with WP4).

T5.1 – A robot companion to support physical, mental and social well-being in SEN schools This task aims to demonstrate robot-supported social interventions within Bristol's network of SEN schools. During a one-year period (Y3), the robot will be based in schools, with interventions co-designed with the teachers, the parents and the students, both through preliminary focus groups and in-situ machine learning.**Add more/rephrase**

The envisioned interventions include: initiating group games; asking students about their well-being; co-teaching material with teachers; fostering interactions between the children.

Specific resources: The task will be supported by SEN researcher Dr. Nigel Newbutt, a staff member at the host institution, who has a long track record and on-going research partnerships with Bristol's special needs schools. I am currently collaborating with Dr. Newbutt on a pilot study which involve a non-autonomous (teleoperated) robot in the same SEN school.

T5.2 – is there a T5.2? Potentially add material from Robot4SEN proposal

Specific resources:

[32] Madden and Howley 2004.

Applicant and partnerships

Appropriateness of the track record

In addition to my strong academic track-record (presented in the Résumé section), I am in a unique position to deliver on the WizUs work plan. Beyond strong leadership, the breadth and depth of my interdisciplinary expertise in Human-Robot Interaction is academically recognised, as illustrated in Table 2.1.

I am also a technology expert, with major software and hardware contributions to the robotic community. As such, I have a clear grasp of the technical feasibility of the proposed work. I am also in the rare position of having substantial experience in designing and running full architectures for complex autonomous social robots[43].

Table 2.1: PI's domains of expertise relevant to the WizUs project

Psycho–social underpinnings of HRI	
human factors	anthropomorphismLemaignan et al. 2014, cognitive correlatesLemaignan et al. 2014, social influenceWinkle et al. 2019 (10.1109/HRI.2019.8673313)
trust, engagement, social presence	Flook et al. 2019 (10.1075/is.18067.flo)Lemaignan et al. 2015Fink et al. 2014Irfan et al. 2018 (10.1145/3173386.3173389)Wijnen et al. 2020 (10.1109/RO-MAN47096.2020.9223521)
theory of mind	perspective takingRos et al. 2010; Warnier et al. 2012, social mutual modellingLemaignan and Dillenbourg 2015; Dillenbourg et al. 2016 (10.1007/s11412-016-9235-5)
Social signal processing	
non-verbal behaviours	attentionLemaignan et al. 2016 (10.1109/HRI.2016.7451747), child-child datasetLemaignan et al. Oct. 2018 (10.1371/journal.pone.0205999), internal state decodingBartlett et al. 2019 (10.3389/frobt.2019.00049)
verbal interactions	speech recognitionKennedy et al. 2017 (10.1145/2909824.3020229), dialogue groundingLemaignan et al. 2011
Behaviour generation	
social behaviours	Lallée et al. 2011, verbal interactionsWallbridge et al. 2019 (10.3389/frobt.2019.00067); Wallbridge et al. 2019 (10.1109/HRI.2019.8673285), physical interactionsGharbi et al. 2013
interactive reinforcement learning	Senft et al. 2017 (10.1145/3029798.3038385); Senft et al. 2017 (10.1016/j.patrec.2017.03.015); Senft et al. 2019 (10.1126/scirobotics.aat1186); Winkle et al. 2020 (10.15607/RSS.2020.XVI.059)
Socio–cognitive architectures	
architecture design	Lemaignan et al. 2017 (10.1016/j.artint.2016.07.002); Baxter et al. 2016 (10.1109/HRI.2016.7451865); Lemaignan and Alami 2014; Lallée et al. 2012; Mallet et al. 2010
knowledge representation	ontologiesLemaignan et al. 2010 (10.1109/IROS.2010.5649547); Lemaignan and Alami 2013
spatio-temporal modelling	object detectionWallbridge et al. 2017, physics-aware situation assessmentLemaignan et al. 2018 (10.1109/IROS.2018.8594094)Sallami et al. 2019 (10.1109/IROS40897.2019.8968106)
Fieldwork in HRI	in classroomsHood et al. 2015; Lemaignan et al. 2016; Jacq et al. 2016 (10.1109/HRI.2016.7451758); Baxter et al. 2015; Kennedy et al. 2016; Senft et al. 2018, at homeMondada et al. 2015 (10.1007/978-3-319-23832-6_15)

National Importance

Guidelines EPSRC: see https://epsrc.ukri.org/funding/applicationprocess/preparing/includingnationalimportance/examplesnis/

WizUs addresses the questions of how to design socially assistive robots that are both effective autonomous social agent, and useful, acceptable and responsible vis-à-vis their end-users.

These questions are of prime societal importance, and WizUs closely aligns with the **EPSRC Delivery Plan *Connected Nation* and *Healthy Nation* priorities**. Specifically, the project investigates and will significantly advance the questions of Trustworthy autonomous AI, Multidisciplinary approaches to technology acceptability and Technology for the public good[33].

The project is also closely aligned with UKRI Healthcare Technology Grand Challenge: *Transforming Community Health and Care*[34] by significantly advancing our capabilities in term of socially assistive robotics.

More broadly, and as a multidisciplinary project, WizUs relates to several themes of the EPSRC portfolio. The main ones are: *Human–computer interaction* and *Social computing/interactions* within the *Digital Economy* theme, *Assistive technology* within the *Healthcare technology* theme, and *Artificial Intelligence* and *Robotics* within the Engineering theme.

From an academic perspective, the UK and the European Union currently enjoy a 2-3 years leadership on research and deployment of socially interactive robots (mainly built through the several large-scale European projects on that topic, which took place over the last decade). The UK did play a key role in several of these projects (eg FP6-Cogniron, FP7-CHRIS, FP7-STRANDS, FP7-Poeticon++), and has built a solid reputation. It is now critical that this expertise is maintained and further developed, as to ensure the future academic leadership of the UK.

In addition, WizUs would create the opportunity for the UK to establish itself at the forefront of the emerging research on the complex ethical questions arising from the development of social robots. Indeed, my research will significantly contribute to the pressing issues around Responsible AI applied to robotics: the creation of the High-level Expert Group on Artificial Intelligence by the European Union, and the subsequent release in 2019 of their *Ethics guidelines for trustworthy AI*, evidences the importance of framing and defining the adequate policies to enable and support the future development of a safe and trustworthy AI. It however does not address any of the emerging challenges raised by social robots.

My work will in effect pave the way for similar guidelines to be extended to social robotics, eg, *embodied, physical* AI. In line with the UK's strong societal values, the task T1.1, which continues throughout the project, will specifically address and frame the ethical underpinnings of social robots and deliver the guidelines that we need to inform our future policies on social robotics. Combined with beyond-state-of-the-art technological developments, **the WizUs research programme will make a major contribution in securing a safe and responsible digital future in the United Kingdom and beyond**.

Fellowship vision and Continued professional development

The fellowship vision is of combining elements of multidisciplinary fields (robotics, AI, ethics of technology, sociology, creative arts) to develop new methodologies and avenues of research in social robotics.

Research at the cross-roads of these interdiscplinary fields is very recent, and while higly important, not yet an established scientific domain for which funding would be more readily available. Indeed, an EPSRC Open Fellowship would be an ideal funding mechanism to effectively establish the field, and 5 years an appropriate time horizon to establish myself as a community leader, within the broader HRI community.

In term of professional development, I have identified the following development opportunities to gain the experience and skills that will enable my progression towards national and international leadership:

- **policy making** on social robotics
- **responsible design**
- **secondment in GAN/DL group**
- **...what else?**

In addition, and while I do have seven years of informal and formal line-management experience, my role until now has mostly been of team co-supervision, rather than team leadership. The fellowship, by gathering a team of five researchers, would offer an excellent opportunity for me to gain that team management experience. One experienced researcher at the host institution (Dr. Catherine Hobbs) has offered to provide additional mentoring to support this progression.

The project is ambitious, with an experimental programme that goes significantly beyond the state of the art. It will provide a lasting scientific and technical legacy, that extends well beyond the end of the fellowship. As

[33] EPSRC Delivery Plan 2019: https://epsrc.ukri.org/about/plans/dp2019/ [34] https://epsrc.ukri.org/research/ourportfolio/themes/healthcaretechnologies/strategy/grandchallenges/

a high-risk/high-gain project, WizUs will also be a powerful enabler: by the end of the fellowship, I will have established myself as a world-leader in the emerging field of socially-driven, responsible autonomous robots, significantly reinforcing the British and European capacity in this critical field for our digital future.

Early achievements track-record

→ **Will move to the Résumé**

Since I completed my joint PhD in Cognitive Robotics from the CNRS/LAAS (France) and the Technical University of Munich (Germany), for which I received the *Best PhD in Robotics 2012* award from French CNRS and the prized *Cumma Summa Laude* distinction in Germany, I have emerged as a leading authority in HRI.

Soon after my PhD, I created and successfully led for 2 years the HRI group within the AI for Learning CHILI Lab at EPFL (Switzerland), supervising in total 10 students, and establishing in a short timeframe CHILI as an internationally recognised centre in robotics for education. While my original training was in **symbolic cognition & AI for autonomous robotics**, my postdoctoral stay at the highly cross-disciplinary CHILI Lab gave me the opportunity to become an expert in **experimental sciences, socio-psychology and education sciences**.

I then engaged in basic research on artificial cognition during a **H2020 Marie Sklodovska-Curie Individual Fellowship**: over 2 years, I explored the underpinnings of artificial social cognition. I **contributed significantly to the framing of the emerging field of data-driven HRI**, also releasing of the PInSoRo open dataset (10.5281/zenodo.1043507), a **one-in-a-kind dataset of natural child-child and child-robot social interactions**.

My current role as a permanent **Associate Professor in Social Robotics and AI** at the Bristol Robotics Laboratory (BRL, largest co-located robotic lab in the UK) recognise my leadership. I am **in charge of defining and implementing the lab's research strategy in human-robot interactions**. I created the Embedded Cognition for Human-Robot Interactions (ECHOS) research group, that I now co-lead, supervising 15+ PhDs and post-docs. I also supervise the BRL's Connected Autonomous Vehicles research group (5 students and post-docs). Specifically, the ECHOS group covers most aspects of situated AI for human-robot interaction, **my role includes strategic planning of the group activities, scientific guidance, recruitment of staff and prospective students, and grant applications**.

My field of expertise covers **the socio-cognitive aspects of human-robot interaction, both from the perspective of the human cognition and the design and implementation of cognitive architectures for robots**. I have also focused a significant portion of my **experimental work on child-robot interactions in real-world educative settings**, exploring how robots can support teachers and therapists to develop engaging novel learning paradigms.

This expertise is recognised internationally: I have a substantial track record of academic outputs. Since 2008, I have authored or co-authored **75+ peer-reviewed publications** in international journals and conferences, leading to **2500+ citations**, h-index of 25, i10-index of 40 (source: Google Scholar).

I have established strong **peer recognition** in the field of human-robot interaction and cognitive robotics. For instance:

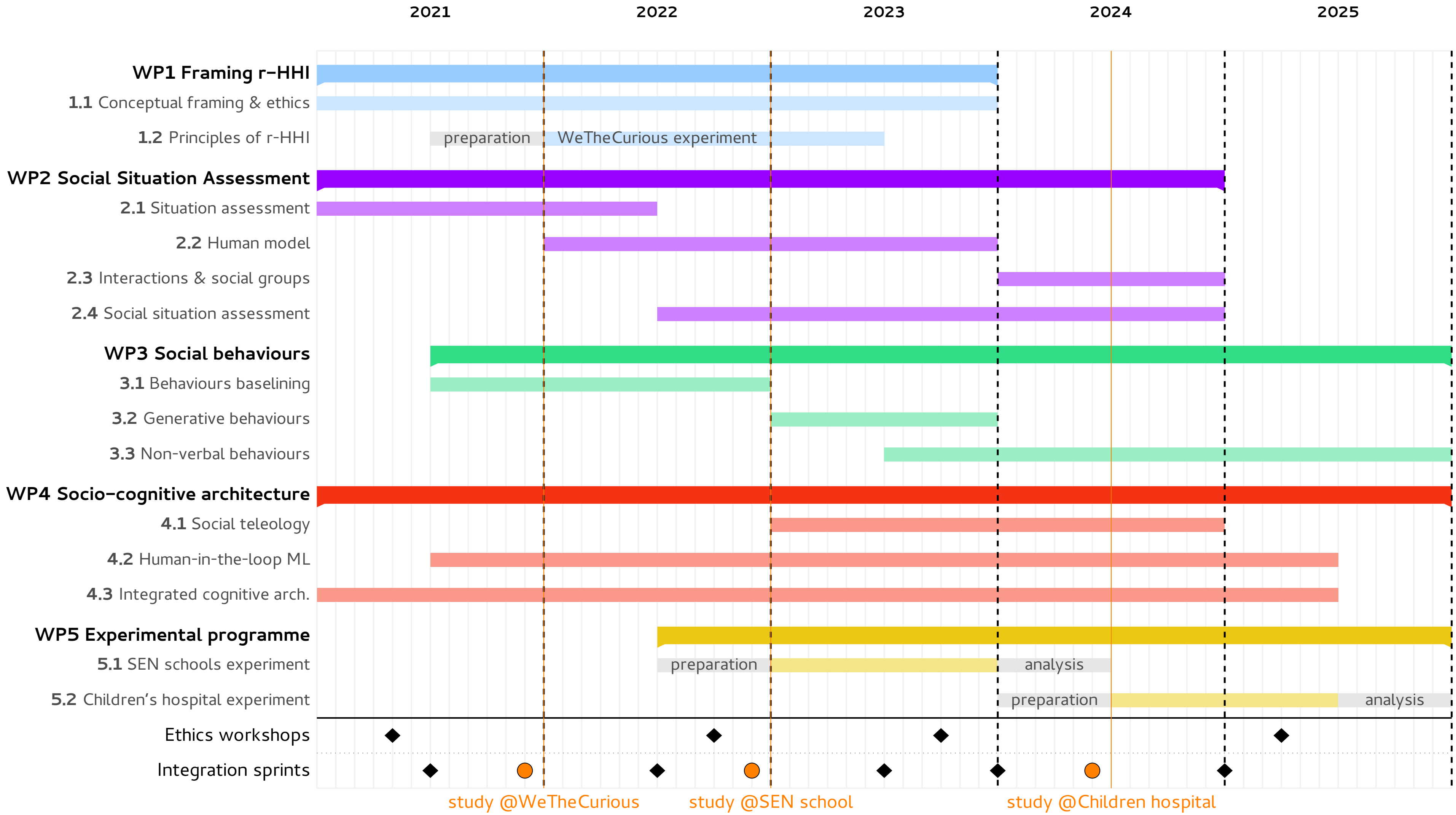
- invited to **high-profile editorial roles**: Programme Committee member of the HRI conference since 2015; editor of Frontiers In Robotics and AI journal; editor or Programme Committee member of several leading conferences in AI and Robotics (RSS, IROS, IJCAI, HAI, AAMAS);
- invited member of the UK EPSRC Associate Peer Review College; invited reviewer for the French, Dutch, Israeli research agencies;
- numerous **invited talks** at national and international symposiums and events (9 invited talks since Jan. 2018, including **keynotes** at the UK Robotics and Autonomous Systems 2019 conference, and at the 2018 AAAI Fall Symposium);
- **local chair for the high-profile, international HRI2020 conference** (700+ delegates);
- regularly invited to PhD defense committees (most recently at LAAS, France, Uni Bielefeld, Germany, and Uni Örebro, Sweden).

I **actively engage with policy makers, at national and European level**: for instance, over the past 2 years, I have been directly interacting (through participating to panels, visits and one-to-one discussions) with the EU Research Executive Agency (MSCA AI Cluster 2019); the UK minister for Business, Energy and Industrial Strategy Greg Clark; the UK minister for Universities, Science, Research and Innovation Chris Skidmore; the chair of the West of England authority Tim Bowles; the UK Research & Innovation Portfolio manager for Robotics Clara Morri.

I have a **strong track record of tech transfer**, through patenting (US patent US20190016213A1) and involvement in national and EU-level projects focused on tech-transfer (InnovateUK ROBOPILOT, CAPRI, CAV-Forth; EU Terrinet, SABRE).

Finally, I actively engage in **research communication**: my past research has been covered several times by mainstream international media, including press releases by Reuters, Press Association; TV coverage by the BBC, Sky News; radio interviews and broadcast. My academic website (academia.skadge.org) showcases this media coverage. I also maintain an active, science-focused, presence on the social media (Twitter handle: @skadge).

Work plan (1 page)


2021
2022
2023
2024
2025
WP1 Framing r–HHI
1.1 Conceptual framing & ethics
1.2 Principles of r-HHI
preparation
WeTheCurious experiment
WP2 Social Situation Assessment
2.1 Situation assessment
2.2 Human model
2.3 Interactions & social groups
2.4 Social situation assessment
WP3 Social behaviours
3.1 Behaviours baselining
3.2 Generative behaviours
3.3 Non-verbal behaviours
WP4 Socio–cognitive architecture
4.1 Social teleology
4.2 Human-in-the-loop ML
4.3 Integrated cognitive arch.
WP5 Experimental programme
5.1 SEN schools experiment
preparation
analysis
5.2 Children's hospital experiment
preparation
analysis
Ethics workshops
Integration sprints
study @WeTheCurious
study @SEN school
study @Children hospital

Host Organisation statement (2 pages)

Justification of resources (2 pages)

Guidelines EPSRC: You must be able to justify the planning and project management of the proposed research programme, including the management of any staff requested. You must be able to demonstrate that the resources requested in this application are justified and appropriate for delivering the proposed research. You should identify the main risks and put contingencies in place.

Justification of resources

Research team and PI commitment

Table 7.1 provides an overview of the time allocation per members of the team, over the course of the project.

	Y1	Y2	Y3	Y4	Y5	Total months
Séverin Lemaignan (PI)	0.6	0.6	0.6	0.6	0.6	36
PDRA 1 (WP1)	1	1	1			36
PDRA 2 (WP2)	1	1	1	1		48
PDRA 3 (WP3)		1	1	1	1	48
PDRA 4 (WP4, WP5)	1	1	1	1	1	60
PhD 1 (WP4, WP5)		1	1	1	0.5	42

Table 7.1: Full-time equivalent for the research team members

Team

PI Séverin Lemaignan will dedicate 60% (3 days/week) of his time to the project. This time will cover significant research time (about 2 days/week) as well as the supervision of the team and management of the project (1 day/week).

The rest of his time will be dedicate to other academic commitments within the Bristol Robotics Lab (including the on-going supervision of his other PhD students, supervision of MSc students, the supervision of the Human-Robot Interaction research group at BRL, lab-wide strategic engagement), as well as a small proportion of Master-level teaching in Human-Robot Interaction (about 5 days/term).

Each of the project work packages will have one lead researcher (post-doctoral research assistant, PDRA); the duration of each of the PDRAs' contracts roughly matches the duration of the corresponding work packages.

- WP1: I will appoint a PDRA (PD1) with a background in sociology of technology and science facilitation; the researcher will work for three year to frame the *robot–supported human–human interactions* paradigm, and lead the field work at the WeTheCurious science centre (to this end, the centre has committed to provide in-kind training in science communication to the researcher, enabling her/him to engage directly with the public);

- WP2: WP2 will be led by a PDRA (PD2) with a background in social signal processing and/or machine learning; the researcher will be appointed for 4 years; extensive collaboration with WP1's PDRA is expected to frame the social dynamics fostered by the robot;

- WP3: one PDRA (PD3, background in learning from demonstration and machine learning) will be in charge of developing the novel continuous robot behaviour generation method, and will be appointed for 4 years, starting on the second year;

- WP4: WP4 (the cognitive architecture) lays at the core of the project; the WP4 leader will be a senior PDRA in cognitive robotics (PD4), appointed for the whole 5 years to ensure continuity on this critical part; she/he will be responsible for the integration of the outputs of the other work packages; the same PDRA will also oversee (with the PI) the experimental work taking place in WP5.

The cost for the WP4 PhD student (PHD1) is **not requested**, as the host laboratory is part of the UK FARSCOPE Centre for Doctoral training, which will fund the student directly.

In addition, a small amount of budget is allocated to senior staff Dr. Dave Meckin (3 months FTE, support soundscape design, WP3.3) and Dr. Nigel Newbutt (4 months FTE, support the work in the SEN schools, WP5.1). I also have 3 month FTE of technician time allocated over the duration of the project to support specific technical developments on the robot.

Research equipment

I will purchase one Halodi EVEr3 robot (total £141,550) for the WizUs project. The EVEr3 robot is a recently developed service robot from the Finish Halodi company. The Equipment Business Case provides an extensive justification for this robot.

Travels

Travels and conference fees have been costed on the basis of one international conference per year and per person.

In addition, the budget include the costs of the four 2-days ethics workshops, that the three members of the ethics Advisory Board will be invited to join.

Subcontracting

The subcontracting amount covers: - the specific content creation and public communication costs, required to integrate the robot in the Bristol science centre WeTheCurious. - work with the choreographer from the RustySquid (http://www.rustysquid.org.uk/) company.

Open access

In line with the European requirements, all journal publications will made available under an Open Access license. On the basis of an average of 2 journal publications per annum, and an average processing fee of €1,200 per article, we request €12,000 to support Open Access costs. Note that conference publications do not always offer immediate open-access policies.

Other costs

The €5000 cost in section A.3 correspond to the project auditing.

Consumables include cloud computing resources, organisation of the ethics advisory board workshops, participant compensations.

Existing resources available to the researcher

The fellowship will take place at the Bristol Robotics Laboratory (BRL). The BRL is the largest co-located and most comprehensive advanced robotics research establishment in the UK. It is a joint venture between the University of the West of England and the University of Bristol. BRL has an international reputation as a leading research centre in advanced robotics research and has over 250 researchers working on a broad portfolio of topics, including HRI, collective robotics, neuro-inspired control, haptics, control systems, assistive robotics, soft robotics and biomedical systems. This multidisciplinary environment will directly benefit the project. BRL has many collaboration partnerships, both national and international, and is experienced in managing large multi-site projects. BRL has support from two embedded units specialising in business and enterprise, together with an incubator and successful track record of spin-outs.

The BRL also has a long track-record of designing and building new and original robots (from the BERT humanoid in the FP7 CHRIS project, to micro-robotics and surgical robots). WizUs will directly benefit of this expertise, which will ensure a feasible and realistic technical deployments of the WizUs robots. Dedicated technician time is allocated to this end.

The BRL also include a hardware incubator and is co-located with 70 start-ups and SMEs specialising in robotic hardware and mechatronics (Bristol's FutureSpace). This combination of excellent research and vast industry expertise on one site is unique in the UK, and is will play an instrumental role in providing opportunities beyond the project towards a strong pathway to impact, including further engagement with industrial partners and spin-off opportunities.

Other in–kind contributions

The Bristol science centre will provide in-kind training in science communication, as well as in-kind access to the centre facilities, for the duration of the study. The training (10 days in total) would have normally been billed £3,000 by the science centre.

Risks & mitigations

Resume for researcher (4 pages per CV)

CHECK GUIDANCE UPDATE BEFORE SUBMITTING

Résumé for Researcher

Pr. Séverin Lemaignan

ORCID: 0000-0002-3391-8876
Nationality: French
Date of birth: 17 Jan 1983 (37 years old)
academia.skadge.org – twitter.com/skadge

EDUCATION

2008 – 2012	**Joint German–French PhD in Cognitive Robotics** LAAS-CNRS, France / Technical University of Munich, Germany Supervisors: Pr. Rachid Alami, CNRS; Pr. Michael Beetz, TUM
2004 – 2005	**MSc Artificial Intelligence for Learning Technologies** University Paris V, France
2002 – 2002	**Joint German–French MSc of Engineering** Karlsruhe Institute of Technology, Germany / ENSAM ParisTech, France

CURRENT POSITION

2019 –	**Associate Professor in Social Robotics and Artificial Intelligence** Bristol Robotics Laboratory, University of the West of England, United Kingdom Supervision of the Human-Robot Interaction research group; Supervision of the Driverless Vehicle research group. Directly managing 20+ students and early career researchers.

PREVIOUS POSITIONS

2018 – 2019	**Senior Research Fellow in Robotics and AI** Bristol Robotics Laboratory, University of the West of England, United Kingdom
2017 – 2018	**Lecturer in Robotics** Plymouth University, Plymouth, United Kingdom
2015 – 2017	**EU Marie Skłodowska–Curie Post–doctoral fellow** Plymouth University, Plymouth, United Kingdom Development and Implementation of a Theory of Mind for robots
2013 – 2015	**Post–doctoral fellow** CHILI, EPFL, Lausanne, Switzerland Interaction with Robots in Learning Environments – Supervision of the robotic group
2012 – 2013	**Post–doctoral fellow** LAAS-CNRS, Toulouse, France Spatial and Temporal Reasoning for Cognitive Robotic Architectures
2006 – 2007	**Research Engineer** INRIA, Paris, France Development of semantic-aware control architectures for autonomous vehicles

FELLOWSHIPS AND AWARDS

2019	**UWE Vice Chancellor Accelerator Fellowship**
2015 – 2017	**EU Marie Skłodowska–Curie Individual Fellowship** Theory of Mind and social robotics Plymouth University, UK
HRI'2017	Best Paper award
HRI'2016	Best Paper award
AAAI'2015	Best Video award in Artificial Intelligence
HRI'2014	Best Late Breaking Report award
2012	**Best PhD in Robotics 2012** award, CNRS, France
2012	PhD with **High Distinction** ("Summa Cum Laude"), TU Munich
Ro–Man'2010	Best paper award

SUPERVISION OF GRADUATE STUDENTS AND POSTDOCTORAL FELLOWS

2018 – 2019 **2 post-docs**, **5 PhDs**, **4 MSc students**, Bristol Robotics Lab, UWE, UK
2015 – 2018 **3 PhDs**, Plymouth University, UK
2013 – 2015 **5 PhDs**, **5 MSc students**, EPFL, Switzerland
2012 – 2013 **2 MSc students**, LAAS-CNRS, France

TEACHING ACTIVITIES

2019 – **Associate Professor** (postgraduate; HRI), Bristol Robotics Lab, UWE, UK
2018 – 2019 **Senior Lecturer** (postgraduate; HRI), Bristol Robotics Lab, UWE, UK
2015 – 2018 **Lecturer** (undergraduate & postgraduate; robotics fundamentals, software engineering, human-robot interaction), Plymouth University, UK
2013 – 2015 **Teaching Assistant** (undergraduate; Visual Computing), EPFL, Switzerland
2008 – 2012 **Teaching Assistant** (undergraduate; programming, databases, ontologies), INSA Toulouse, France

ORGANISATION OF SCIENTIFIC MEETINGS

2020 **ACM/IEEE Human-Robot Interaction conference**, 700+ participants, local chair, Cambridge, UK
2017 **ACM/IEEE Human-Robot Interaction conference**, 400+ participants, alt.HRI chair, Vienna, AT
2016 **2nd Intl. workshop on Cognitive Architecture for Social HRI**, 45 participants, programme chair, Christchurch, NZ
2014 **Intl. workshop on Simulation for HRI**, 35 participants, programme chair, Bielefeld, DE
2012 **Intl. workshop on MORSE and its applications**, 30 participants, programme chair, Toulouse, FR
2009 **Cognitive Sciences' Young Researchers Conference**, 150 participants, steering committee, Toulouse, FR

INSTITUTIONAL RESPONSIBILITIES

2019 – Associate Professor, Faculty of Technology and Environment, UWE, UK
2019 – Head of the Outreach cluster, Faculty of Technology and Environment, UWE, UK
2019 PhD defense committee, University of Bielefeld, DE
2019 PhD defense committee, University of Örebro, SE
2018 – HRI module co-lead, MSc level, University of the West of England, UK
2017 – 2018 Module leader, Robotics fundamentals (undergraduate level), University of Plymouth, UK

EDITORIAL ACTIVITIES

2018 – Editorial board of *Frontiers in AI and Robotics*
2015 – Member of the IEEE/ACM HRI Programme Committee
2019 – Member of the Robotics, Science and System (RSS) Programme Committee
2017 – 2019 Member of the IEEE IROS Programme Committee
2017 – 2018 Member of the IJCAI Programme Committee
2017 – 2018 Member of the HAI Programme Committee

Project Partner Letters of Support

Length unlimited

Need ones for:

- WeTheCurious
- SEN school

Equipment business case

2 pages

Only required if equipment above £138000 incl VAT.

Guidance: https://epsrc.ukri.org/research/facilities/equipment/process/researchgrants/

Equipment Business Case

Guidelines EPSRC: This section must follow the structure presented here: https://epsrc.ukri.org/research/facilities/equipment/process/researchgrants/

PI name: Séverin Lemaignan

Host Institution: University of the West of England

Item: Two mobile social robots with intrisic safety for close interaction with humans. The HALODI EVEr3 is sucha platform.

Vendor: HALODI (the manufacturer of the robot)

Description: Briefly describe the item of equipment and its primary functions. Please explain how the specifications of the instrument make it different from other similar equipment available for use.

The key features that are necessary for the project are:

1. an intrinsically safe platform, suitable for operation in close contact with humans, including children
2. advanced social features, including an expressive face with mobile eyes
3. a agile mobile platform, suitable for (potentially crowded) human environments

Looking specifically at human-sized mobile manipulators with advanced social features, the choice of robotic platforms is in effect limited. Table 12.1 compares the two leading mobile social robots available on the market today (PAL TiaGo and SoftBank Pepper), along with the IIT R1 platform developed by the Italian Institute of Technology and the HALODI EVEr3. The Fetch Mobile Manipulator has been omitted, as it is functionally similar to TiaGo.

Note that, even though IIT would offer early access to the its platform, the IIT R1 robot is not yet officially available for purchase. As such, the platform can be considered to be a prototype and might face teething issues.

Table 12.1: Comparison of the HALODI EVEr3 with IIT R1, PAL TiaGo and Softbank Pepper. EVEr3 has been chosen for WizUs for being the only mobile dual manipulator with good navigation and advanced social interaction capabilities.

	HALODI EVEr3	PAL TiaGo	Softbank Pepper	IIT R1
Social features	Expressive face;	Poor (non-expressive head)	Expressive, yet fixed, face; limited gaze; approachable	Expressive face Lehmann et al. 2016; artificial skin for touch-based interactions; approachable
Perception	Good (SotA RGB-D; 7-mic array)	Medium (RGB-D camera; laser scanner; no microphone)	Medium (RGB-D; simple mic array; poor laser scanner)	Good (RGB-D; simple mic array; laser scanner)
Navigation	Good (high agility due to Segway-like self-balancing; lack of laser scanner might impair floor-level obstacle detection)	Good (however, limited agility due to large footprint)	Poor (weak localisation capabilities)	Good (high agility due to Segway-like self-balancing)
Safety	Good (smaller footprint; safe arms with torque control; dynamic stability)	Medium (heavy robot; large footprint; non-compliant arm)	Medium (smaller footprint; safe arms; limited stability)	Good (smaller footprint; safe arms; dynamic stability)
Manipulation capabilities	Good (dexterous hand; dual arm; 6kg payload)	Medium (non-anthropomorphic gripper; single arm)	Limited (poor gripper with low payload; dual arm)	Good (anthropomorphic gripper; pressure sensors; dual arm; 1.5kg payload)
Suitability for care environments	Good (designed for such domain, smaller footprint, easy to clean)	Poor (relatively large, difficult to clear)	Good (smaller footprint, easy to clean)	Good (smaller footprint, easy to clean)

Cost:

Guidelines EPSRC: Please set out the expected cost of the item(s) of equipment in pounds sterling (inclusive of VAT) and list any associated maintenance or support costs. Less expensive items of equipment that are intrinsically associated with the equipment may also be requested. Funding for maintenance of the equipment or for implementing or managing any sharing mechanisms can also be requested. In order to assist EPSRC's financial planning, please state clearly the anticipated funds that would be requested from EPSRC (in other words cost after the deduction of any contributions) making a clear distinction between cost of equipment item(s) and the cost of any associated resources. Please describe the timescales associated with procurement of the equipment and when you anticipate you will spend any capital provision made.

The maintenance costs include annual maintenance and on-site support and service.

Item	Quantity	Unit Cost	Total cost
EVEr3 robot	1	*£124,530*	£124,530
EVEr3-HA1 hands	2	*£8,510*	£17,020
Total (excl. maintenance)			**£141,550**
Maintenance	(per year)	£11,520	

The full cost of the robot and hands (£141,550) is requested from the EPSRC at the start of the project. The robot's production lead time is about 4 months. Taking into account the procurement time, we anticipate that the maintenance costs will only have to be paid for a total duration of 4.5 years (paid on a yearly basis).

Usage:

Guidelines EPSRC: Indicate the proportion of equipment time that will be available for use by the group managing the equipment, other groups at the same institution, and researchers at other institutions. Indicate how additional users of the equipment will be identified and how all users will be prioritised. Information should be provided on the anticipated demand, indicating the likely main users and where they will be based. You should describe how you plan to interact and/or collaborate with key groups or shared facilities in your research area. Note that it is acceptable for the equipment to be used entirely by one research group although this would need to be very carefully justified. EPSRC are looking to maximise the usage of equipment for high quality research, not necessarily share it as widely as possible.

Due to the nature of the project (in-the-wild deployement of the robot over extended periods of time), the robot will be exclusively used by the project.

At the end of the project, we anticipate that the robot will naturally fold into the numerous human-robot and assistive robotics activities taking place at the Bristol Robotics Lab. As the Halodi EVEr3 robot belongs to the latest generation of social robots (alongside the IIT R1, for example), it will also contribute to the replacement of the ageing Pepper and TiaGo robots currently extensively used in the laboratory.

Support:

Guidelines EPSRC: Please indicate how the item of equipment will be supported and maintained for the duration of any current or proposed research funding including any costs that would be recouped through charging.

In addition to the maintenance contract that will provide operational support over the course of the project, the Bristol Robotics Lab has a large technical team with long and extensive experience in supporting a wide range of robots. Dedicated technician time (3 months) is costed in the project, for specific technical developments or liaising with the Halodi company.

Strategic Case:

Guidelines EPSRC: Please describe the research enabled by the equipment and/or the value added to existing research programmes. Indicate which of the EPSRC's strategic priorities are met by the research enabled by this equipment. Describe how these priorities are met. Explain how the purchase of this item of equipment will compliment or enhance regional and/or national research capability. If an exists for the type of equipment requested, please explain how this item relates to the roadmap.

Ensuring Maximum Value:

Explain how the requested equipment will fit with other items of equipment, infrastructure and people support already at your university. Please indicate how the requested item(s) fits the strategy of your department and institution.

Contribution from Other Sources:

Guidelines EPSRC: Please describe here what contributions to the cost, operation or maintenance of the item of equipment will be found from other sources.

Alternatives:

Guidelines EPSRC: In the case that the proposal for equipment is not supported, describe the alternative options for using existing equipment of different specification or at other locations.

Current-generation social robots (like PAL TiaGo or Softbank Pepper, both available at the host institution) might be explored as alternatives. The PI (and the laboratory) have very extensive experience with both these robots.

Both these robots are generally suitable for deployements in real-world human environments (even though PAL TiaGo would require specific safety measures as its arm is not compliant, and therefore potentially dangerous).

However, they are not considered agile social platform: Softbank Pepper is known to have poor navigation performances; they feature a dated set of sensors and limited on-board processing capabilitiesN; nither TiaGo nor Pepper have non-verbal social features that are powerful enough to deliver the WizUs project. Critically, they both lack the abilities to show facial expressions or simulated gazing behaviours. Because the EVEr3 robot features a programmable display in place of the head, we will have full freedom to create complex non-verbal facial expressions.

Besides, EVEr3 has been designed from the ground-up to be used in care environments (in particular, hospital), and is made of materials that can easily be cleaned up/disinfected. This is of critical importance for the deployment in the hospital, or more generally in a post-COVID environment.

Equipment quote

Length unlimited

Proposal cover letter (no page limit)

The cover letter can be used to highlight any important information to EPSRC, this must include the priority area you are applying to.

This attachment type is not seen by reviewers or panel members.