IMT Atlantique
Bretagne-Pays de la Loire
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Thesis REACT: Physical Interactions Models of Companion Robots

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1 Thesis domain

Robotics used for assistance to frail people draws nowadays a considerable interest in the domain of e-health thanks to the extended range of applications that it offers, together with the scientific and technological challenges that it brings forth. While the first generation of robots was conceived for the execution of repetitive and specific industrial tasks, the new generation introduces robots as artificial companions with cognitive and interactive skills allowing them to operate in open worlds. In particular, assistive service robots aim at helping people with disabilities due to age or sickness, to improve their independence et well-being at the long-term, while continuing to live within their social circle, instead of retirement institutions that tend to become increasingly costly and less available.

In order to integrate a robot within living spaces, it has to be able to physically interact with its environment. We distinguish the interactions allowing for a robot to operate in its environment, such as stairs traversal and delivery/retrieval of objects. Given the diversity in forms and the robot sensing limits, a probabilistic approach with respect to the behaviour of the robot is required in terms of its interaction. This in turn should be based on the definition of probabilistic models able to capture the variance as well as the novelty, allowing for a robot to generalise its actions, or otherwise, retract.

In this context, we propose in this thesis to study the introduction of new personal assistance services, by the definition and deployment of probabilistic models of physical interaction, between the robot and its environment. These models will serve two objectives: (1) render the operation of the robot more reliable from the user perspective and (ii) homogenise a given service across heterogeneous robots. The research to pursue in this context amounts to associating the actions of the robot with its effects on the environment, where the least controllable effects of an interaction are treated stochastically. The identification of these effects should finally allow to delimit the steps composing a robot service and to fine-tune the most controllable via the application of machine learning.

2 Workplan

We are interested in use cases involving a robot that is destined to offer a set of assistance services that we consider primordial for its integration with a living space and aside humans with disabilities. The international competition RoboCup@Home (http://www.robocupathome.org) and its proposed scenarios could be used as references in order to concentrate on such services. This selection will be based on the hypothesis that basic functionalities of the robot such as localisation, obstacle avoidance or arm motion planning are available and reliable. This is already the case for the robots that will serve as platforms of experimentation in the research team hosting the thesis, thanks to their integration with ROS. (Robot Operating System[1]).

On the basis of the study of the state-of-the-art with respect to services/skills of the assistance robot, the point that the thesis will subsequently address concerns the hypotheses behind the sensor observations that are obtained during a given physical interaction and the state to estimate. For example, probabilistic models of the system state (arm, mobile robotic base and environment state) should be assumed which will in turn affect the methods that can be used (Bayesian, Kalman, etc). The dimensionality of the state to estimate that will depend on the complexity of the task to accomplish might pose a challenge. This is a point to be studied during the thesis and could be alleviated by an adaptation of the deterministic physical interaction model (i.e. kinematic and physical simulation) or with a better control of the conditions of the interaction scenario, in order to reduce the state dimensionality.

The envisioned contributions of the thesis include a better understanding of the problems related to the physical interaction of the robot with its environment via the study and the formalisation of criteria of performance, that take into account the stochastic as well as the probabilistic aspects of the interaction [2]. Conventional approaches are often based on abstractions/oversimplifications of the environment, while in reality the robot might confront situations that are significantly more complex. Models allowing to estimate the interaction of a mobile robot for the task of stairs traversal have been proposed [6] and a more general study was conducted in [5]. The recent study in the domain of manipulation [1] seems to reveal common notions between the domains, e.g. the compliance (conformity) of the interaction, configuration sampling and environment representation.

The work plan of the thesis extends in the 3-year period to a sequence of steps that aim to: (i) Identify the challenges to be faced with respect to the state-of-the-art and to the application requirements for an assistive robot, (ii) study the capacities of the robotic platform that will be necessary for the realisation of the chosen task and identify their limits, (iii) propose and develop new models of physical interaction based on machine learning, that will anticipate and adapt to novelty.

On this basis, there appears to exist a convergence of approaches from dif-

[1] `http://www.ros.org/`

ferent domains of physical interaction that are worth exploring and extending. The thesis aims to improve the state-of-the-art by firstly combining a stochastic model of physical interaction together with a deterministic model and secondly by residing on methods of novelty detection [8] that would allow the discovery of new examples of interaction, and exploit methods of artificial curiosity [3] to adapt and to learn the novelties. By introducing a measure of novelty, it could weigh the model of physical interaction in a way that would privilege that stochastic or deterministic nature of the interaction, depending on the degree of novelty. Some examples demonstrating the use of novelty in the discrimination of 3D shapes or the socially-compliant robot navigation were the object of the works [4] and [7].

3 Thesis perimeter

Funding REACT thesis is a project of 3 years that is jointly funded by the Bretagne Region (50%) and Brest Metropole (50%), in the context of the recently inaugurated Chair M@D (Maintien en Domicile)[2].

The employment contract in the context of the thesis prescribes the remuneration, full social security coverage as well as funding allowing the participation to conferences, seminars, etc.

Localization The hosting facility for the thesis is the IMT Atlantique Bretagne-Pays de la Loire (Brest campus), a public institute of superior education (postgraduate) and research, that accredits Master diplomas to engineers up to Doctoral degree. IMT Atlantique is ranked among the top 10 in France (group A+) of engineering schools in 2018 (L'Étudiant[3]). Brest is similarly ranked in 2018 among the best cities in France in terms of life and work quality [4].

Lab The IHSEV research team specialises in information and communication technologies for assistance to people, combining skills from informatics and robotics: domotics protocols, embedded systems, service robotics, robotic learning et interactive TV. It collaborates with medical personnel, ergonomists, sociologists. IHSEV disposes state-of-the-art robotic equipment (mobile robots (TurtleBot2 and variants), humanoids (Pepper, RB-1, Poppy), robotic arms (Kinova), etc), offering an attractive working environment for hosting research activities of international visibility.

[2] https://bit.ly/2s3aDGu
[3] https://bit.ly/2J4tfjE
[4] https://bit.ly/2BAEpIO

4 Candidate profile

General: Holder of (or near graduation) of a postgraduate diploma, Master of research or engineer diploma in the domains of Computer Science, Robotics, Mechatronics or associated field. Fluency in English is required, a spirit of collaboration and of initiative in the face of technological challenges.

Theoretical skills: Experience in one or more of the following domains: *Machine learning, motion planning, control, robot kinematics, computer vision.*

Technical skills: Experience in one more or more of the following technologies/tools: *Robot Operating System (ROS), Object-oriented programming Python/C++, scientific computing tools (Scikit, numpy, OpenCV, PCL), 3D simulation (Gazebo), Blender.*

The interested candidates should provide the following:

- CV
- Motivation letter

and optionally, letters of recommendation.

References

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