Model-Driven Interaction Design for Social Robots

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Abstract. Robotic software development frameworks lack a possibility to present, validate and generate qualitative complex human robot interactions and robot developers are mostly left with unclear informal project specifications. The development of a human-robot interaction is a complex task and involves different experts, for example, the need for human-robot interaction (HRI) specialists, who know about the psychological impact of the robot's movements during the interaction in order to design the best possible user experience. In this paper, we present a new project that aims to provide exactly this. Focusing on the interaction flow and movements of a robot for human-robot interactions we aim to provide a set of modelling languages for human-robot interaction which serves as a common, more formal, discussion point between the different stakeholders. This is a new project and the main topics of this publication are the scenario description, the analysis of the different stakeholders, our experience as robot application developers for our partner, as well as the future work we plan to achieve.

Keywords: robot, interaction, HRI, human-robot interaction, MDSD, software engineering

1 Introduction

Mobile robots are expected to provide all kinds of services for humans in various application scenarios and a dramatic increase of such service robot solutions is foreseen for the near future. However, in many of those scenarios the robots must be able to socially interact with people to respond appropriately to human behaviours and language, to learn and to collaborate with humans on human terms, as well as to act safely in the vicinity of humans. Social robotics aims to achieve this through development of social and communicative skills for physical robots and has become a very active research area in recent years [1, 2]. While many research results exist in single specific areas that contribute to social robotics and while novel mobile robotic platforms offer considerable functionalities for the realisation of social robots at a comparatively low price, the efficient programming of social robots for a target application is still a very challenging problem. Most often the interdisciplinary integration of the different functionalities such as speech processing, gesture detection, computer vision etc. is solved in an ad-hoc manner for very specific problems, where knowledge and assumptions about the robots software remain implicit. Additionally, human users show a wide range of possible

behaviours creating a high level of interaction uncertainty. Furthermore, social robots often have to be programmed together with domain experts for specific scenarios, these experts are most of the time not robotic experts. A promising approach for the programming of mobile robots in general is model-driven software development. Model-driven approaches are among the most prominent research topics in software engineering and hence several attempts of domain-specific modelling and languages are recently also proposed in robotics. However, many of these approaches do not support the aforementioned special aspects of social robots [3]. The goal of the project together with our partner is to deploy the Pepper robot in a museum environment where it will teach the visitor in an interactive and interesting way about Luxembourg city history. For the moment, we are working on this application using standard modelling tools and languages known from already established software engineering processes. Unfortunately, we quickly realised that they are not really suitable for the design of human robot interactions. The programming of a story telling robot, with all its movement possibilities is a challenging task, even more if the programmer is not in possession of a clear specification. In our lab, the responsible persons for the programming of our Pepper and NAO robots are mostly computer science students with no background in HRI or dialog creation. These are highly complex fields with their own experts. In our case, we consult social science researchers specialised in new technologies for this task. We believe that they have the necessary social experience to become HRI experts. These people however, do not necessarily possess the needed programming skills which makes the whole development process quite long and slow. For every assessment of the robot a meeting is held and the reactions of the robot are discussed and orally agreed upon. This solves the problem of the user friendly design of human-robot interaction, but does not solve the problem that the developer has, namely imprecise specifications of the application. Therefore, we argue that there is a real need for a set of domain-specific languages (DSL) which target the area of human-robot interaction.

In Section 2, we describe our project in detail, starting with the robot and its task inside the museum. In Section 3, we describe the problems encountered while developing robot applications. Here we also describe the different stakeholders that we consider important for the successful development of sophisticated social robot applications. In Section 4, we define the goals that we plan to achieve during the project's evolution. We shortly describe how we plan to tackle the aforementioned problems and conclude in the last section.

2 Project Description

In the project that we initiated together with our partner, the City of Luxembourg, the goal is to use a robot to provide an interactive learning experience to the visitors of the City History Museum. In a first step, the robot will be programmed to provide the visitors with detailed information about the museum's 360 degree panorama of an important place in the city centre. For this purpose we acquired the Pepper robot produced by Softbank Robotics [3]. We decided to use this robot, because Pepper is a human-shaped robot providing many different interaction possibilities and is among the most

[3] https://www.ald.softbankrobotics.com/en/cool-robots/pepper

prominent commercial robots available for a use-case like ours. We believe that a robot is the right tool for this purpose and in fact, several works analyse the social impact of physical embodiment on social presence of social robots in contrast to a virtual agent solution [4, 5].

In a first step we want to focus on a dialogue language based on state-based, frame-based and plan based techniques [8–10]. It is important to consider these 3 techniques, because they offer different levels of restrictions and complexity, which would allow the programming of a story telling robot as well as applications which allow for greater degrees of user initiative like, for example, an collaborative robots in industry. In a later step, we combine these interaction management methodologies with relevant movement animations inspired by robot control languages like, for example, DANCE [11]. These languages will be implemented inside a tool-chain for robot interaction design that we will provide. Our research will focus on the model-driven software engineering solutions for human-robot interactions, taking into account dialog management as well as robot control.

To develop our toolbox we work together with domain experts from the beginning. For the human-robot interaction we closely work together with researchers from the social science field, situated also at the University of Luxembourg. In future they are supposed to model, using our DSLs, the interactions that will later be programmed by the robot-developer or interpreted directly by the robot. We plan to develop multiple DSLs especially crafted for the dialogue between a robot and a human.

This work will support the design of interactions combining speech and related robot movement behaviours in a way that domain experts can easily understand, implement, or, in the case of the robot developer, transform to robot code. Our past experiences made it clear that designing a human-robot interaction is a difficult task which needs serious input from social experts. Furthermore, we found it very difficult to model and evaluate/discuss human-robot interactions before development due to the lack of suitable languages for this domain.

3 Problem Description & Stakeholders

Current development is done by defining what the robot will say and afterwards the robot's movements are implemented. These movements are selected by the robot developer ad-hoc. One of these behaviours, for example, could be the blinking of the robots eyes before expecting an answer from the user [7]. This basic eye blinking implementation was done by the robot developer without any formal specification and was then changed during meetings together with the social science researcher, who did not necessarily understand why such small programming tasks took such a great amount of time. This process can result in frustration and disappointment on both sides. In the optimal case, instead of focusing on the fine tuning of the robot's interaction, the developer could focus on more complex coding tasks. The fine tuning of the interaction should be left to the social science expert, who understands the complex impact that dialog, motion and emotions have in a human-robot interaction. The aforementioned problems are caused by both the knowledge and expectation gap of the different actors as well as the lack of DSLs which allow domain experts to model such complex multi-

modal robot dialogues. Such DSLs are important because not only would they speed up the programming process for the robot developer, but they could also allow the testing of robot behaviours in a simulator. Therefore, well designed tools and a well defined development process can, for example, be used by the robot developer to support his programming work. These DSLs will be developed in such a way that they raise the abstraction to such a level that they can be reused in project meetings as a common discussion point which is understood by all involved actors. Considering our scenario, we analyse the different stakeholders to be:

Client : We see the director of the museum as our client. She participates in the requirement elicitation at the beginning of the project. The produced interaction model will be evaluated, thereby we directly involve the museum director in the project and avoid miss-communication between employee and management level, which might happen because some employees' interests might differ from the museum's.
Museum Employee (Historian) : The employee responsible for this project is our main contact person. For the moment, this person is in charge of defining, together with our team, the objectives of the project. This is not a very effective way as the employee's goals might be different to the museum director's. Furthermore, often it is the case that this person, as well as the director, is a complete non-technical person which only knows robots from Sci-Fi movies and has ideas which are completely surrealistic. Among his participation during the requirement elicitation, the employee's main output should be the delivery of historical data.
Social Science Expert : Having knowledge about computer's, they do not necessarily have a robotic background so we need to explain the general capabilities of a robot and especially its interaction capabilities. This robot specification will be the same as for the other actors with the main difference that this person needs to look at a lower level of abstraction. He needs, for example, to know what lights on the robot can be controlled and what their constraints are.
Robot Developer : Robot developers have experience in the programming of complex robot applications and are usually not experts in social science or HRI. She is in charge of the requirement elicitation and manages the different stakeholders. During the implementation phase the developer should be supported by a clear specification of the robot's interaction model developed by the HRI expert. The whole development process should be iterative, based on the interaction models not by trial and error coding.

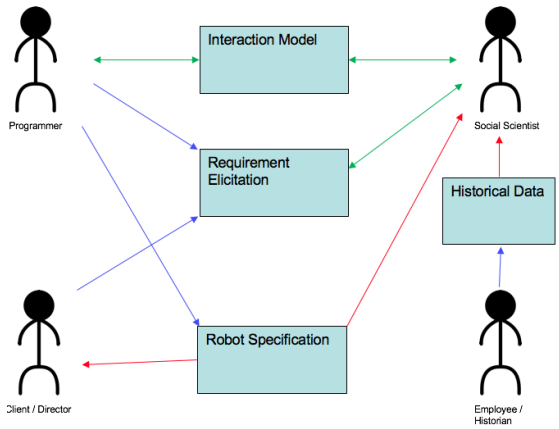

Fig. 1: Expected Inputs and Outputs of the different stakeholders of the project. The arrows represent **Output**, **Input** and **Input/Output**

4 Future Work

In our future work we develop a set of DSLs which allow the modelling of complex human-robot interactions on a higher level of abstraction. In the HRI field, user testing is important and there is a real need for a toolbox which enables fast modelling, development and testing of interactions for different kinds of robots. This toolbox can be used to rapidly develop different versions of a dialog and analyse user feedback to, for example, different dialog motions. Therefore, the final goal of our research is to propose a toolbox that allows HRI experts to design, implement and test complex human-robot interactions.

To achieve this, first we present a dialogue language based on state-based, frame-based and plan based techniques [8–10]. These 3 dialog management techniques offer different levels of restrictions and complexity, which allows the programming of any kind of human-robot dialog.

In a the next step, we combine these interaction management methodologies with relevant movement animations inspired by the robot control languages DANCE [11]. The challenge here is to synchronise dialogue and motion without raising the complexity of the modelling process.

The resulting models should also be usable in simulation environment which allows HRI experts to analyse and fine-tune robot interactions without the direct need of a physical robot, which is time consuming and not always at hand.

5 Conclusion

In this work, we described our project and analysed the different stakeholders. We talk about our experience as robot application developers and highlight the necessity of a set of DSLs which combine dialog and motion in robotics. Furthermore we gave an

outlook on our future works in this field, which we will be starting with the robot dialog language. To our knowledge this domain is not wildly explored and we want to say at this place that any comments or wishes from HRI experts are very welcome.

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