Model-Driven Interaction Design for Social Robots

Gary Cornelius[1], Nico Hochgeschwender[2], and Holger Voos[1]

[1] Interdisciplinary Centre for Security, Reliability and Trust, University of Luxembourg, Luxembourg
surname.name@uni.lu,
[2] Bonn-Rhein-Sieg University, Germany
surname.name@h-brs.de

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 should involve different experts, for example, the need for human-robot interaction (HRI) specialists, who know about the psychological impact of the robots 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 modelling language 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 stake holders, our experience as robot application developers for our partner, as well as the future work we plan to achieve.

Keywords: robot, interaction, mdsd, software engineering

1 Introduction

Mobile robots are expected to provide all kind 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 developed 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 before mentioned 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 realized that they are not really suitable for the design of human robot interactions. Even the programming of a story telling robot, with all it's movement possibilities is a challenging task if the programmer is not in possession of a clear dialog 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, not necessarily having a technological background. In our case, we consult social science researchers specialized 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 posses the needed programming skills related to robots which makes the whole development process quite long and slow as 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 specification of the application. Therefore, we argue that there is a real need for a DSL which targets exactly this area of robot interactions.

In section two, we describe our project in detail, starting with the robot and its task inside the museum. In section three, we describe the problems encountered while developing robot applications for our partner. Here we also describe the different stake holders that we consider important for the successful development of sophisticated social robot applications. In section four, we define the goals that we plan to achieve during the project's evolution. We shortly describe how we plan to tackle the before mentioned problems and conclude in the last section.

2 Project Description

In this 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 fist 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 human-shaped robot providing many different interaction possibilities and is among the most 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 Figure 1, we present a list of Pepper's sensors useful for human-robot interaction. For our first release we mainly focus on microphone, loudspeakers and the tablet. Combined with relevant movement animations we plan to deliver an interactive show to the visitor. The focus of our work is the interaction between Pepper and the public. Our main research will focus the model-driven software engineering solutions for human-robot interactions. This is why we first want focus on it's interaction capabilities and then, in future, Pepper will be roaming around the panorama area. The goal of the project is two-fold. On one hand, we need to provide an interesting use-case for Pepper inside the museum in order to make the visit of the museum an interesting experience. For this part, the human-robot interaction, we closely work together with researchers from the social science field situated also at the University of Luxembourg. They are in future supposed to model, using our DSLs, the interactions that will later be programmed by the robot-developer or interpreted directly by the robot. On the other hand we have our main research focus, the work on the software-engineering part. We plan to develop multiple DSLs especially crafted for the dialogue between a robot and a human. This work will support the design of an interaction, combining speech with tablet interaction and related robot movement behaviours in an 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 interactions before development due to the lack of languages especially suited for this domain.

3 Problem Description & Stake Holders

Current development is done by defining what the robot will say and afterwards we implement the robots movements, which are pre-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. This basic eye blinking

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

Fig. 1. Peppers Sensors: A list of the most useful sensors for human-robot interaction

implementation is done by the robot developer without any specification and is then iteratively changed during meetings together with the social science person. This is a tiring and boring process for the robot-developer, as he could be focusing on more complicated coding tasks and leave this fine tuning of the interaction to the social science people, who are experts in this field. The before mentioned problems are caused by both the knowledge 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, before the time costly implementation on the robot. In order to involve all the stake holders and use their maximum potential, there is a real need for a framework that supports the software development process of human-robot interactions. Furthermore, there is a need to analyse which tools are useful for which involved actor. Tools and a well defined development process can, for example, be used by the robot developer to support his programming work. The DSLs should be developed in such a way that they also allows to raise the abstraction to such a level that they can also be reused in project meetings as a common discussion basis which is understood by all the involved actors. Considering our scenario, we analyse the different stake-holders to be:

– **Client** : We see the director of the museum as our client. He evaluates the progress of the project together with the other members of the board. The assessment is done based on a board meeting that takes place twice a year. Our future plan is to directly involve the director on a regular basis, therefore he will be part of the requirement elicitation phase and will be provided a high level interaction model which reflects the decisions taken during the requirement elicitation. This interaction model will be evaluated before the time consuming development of the robot application, 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 interest might differ from the museum's.

Table 1. Expected Inputs and Outputs of the different stake holders of the project.

	Input	**Output**
Director	Robot Specification	Requirements Elicitation
Employee	Robot Specification	Requirements Elicitation Historical Data
Social Scientist	Requirements Elicitation Robot Specification Historical Data	Interaction Model
Robot Programmer	Interaction Model	Requirements Elicitation Robot Specification Robot Code

- **Employee** : 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.
- **HRI Expert** : Our team works together with people from the social science field with basic technology knowledge. Having knowledge about computer's, however, 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 than 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. He is in charge of the requirement elicitation and manages the different stake holders. During the implementation phase the developer should be supported by a clear specification of the robot's interaction dialogue designed by the HRI experts. The whole development process should be iterative, based on the interaction models not by trial and error coding.

4 Future Work

In our future work we will focus on the development of a set of DSLs. We start with a robot specification language. This language will provide high level abstractions of a robot's interactions capabilities for non expert users, but can also be used by experts in order to determine the robot's capabilities in detail. Looking at the robot specification in the most simplistic way, listing its sensors

and capabilities would already be a great start. Depending on the knowledge and interests of the person the models could provide higher or lower levels of abstraction. We will analyse in how far existing solutions can be modified for our needs, one existing specification language allows the robot developer to model a robot's perception capabilities.[6] Most important will be our work on the robot interaction modelling, which will build upon the robot specification language. We will develop a set of DSLs which allow the modelling of complex robot interactions on a higher abstraction level, such that this development can be done by HRI experts. In a first step, we will focus on the combination of audio interaction together with a set of predefined robot movement behaviours. This language will allow to specify a complete human robot interaction together with timing certain movements according to the talked text. If we achieve this the next logical step will be to provide a modelling language for the modelling of new behaviours. This way we can build our set of DSLs step by step together with HRI experts, such that it will actually be usable in reality, which is one of our main objectives. Our goal is it to use these models in a simulation environment which allows HRI experts to analyse and fine-tune robot interactions without the direct need of a physical robot, which is not always at hand.

5 Conclusion

In this work, we described our project and analysed the different stake holders. We talk about our experience as robot application developers and highlight the necessity of a set of DSLs designed for human-robot interactions. Furthermore we gave an outlook on our future works in this field, starting with the robot interaction specification and building up from there. To our knowledge this field is not explored yet and we want to say at this place that any comments or wishes from HRI experts are very welcome during this project.[3]

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