Towards Software Development
For Social Robotics Systems

Chong Sun, Jiongyan Zhang, Cong Liu, Barry Chew Bao King,
Yuwei Zhang, Matthew Galle, Maria Spichkova

RMIT University, Australia
{s3557753, s3589957, s3556054, s3584485, s3492095,
s3491364}@student.rmit.edu, maria.spichkova@rmit.edu.au

Abstract. In this paper we introduce the core results of the project on software development for social robotics systems. The usability of maintenance and control features is crucial for many kinds of systems, but in the case of social robotics we also have to take into account that (1) the humanoid robot physically interacts with humans, (2) the conversation with children might have different requirements in comparison to the conversation with adults. The results of our work were implement for the humanoid PAL REEM robot, but their core ideas can be applied for other types of humanoid robots. We developed a web-based solution that supports the management of robot-guided tours, provides recommendations for the users as well as allows for a visual analysis of the data on previous tours.

1 Introduction

Social robotics is an emerging research area. Over the last years there were many publications on application of robotics for healthcare and rehabilitation, household and service, healthcare and rehabilitation, companionship, etc., cf. [31]. The core function of social robots is assisting people through social interaction, in many cases involving also a physical interaction. A highly cited[1] paper of Feil-Seifer and Mataric [11] defines the concept of socially assistive robotics. Another highly cited[2] paper of Duffy [8] discusses the use of anthropomorphic paradigms to augment the functionality and behavioural characteristics of a robot use of human-like features for social interaction with people.

To understand the impact and capabilities of robots on the future of work, it is crucial to identify, observe and measure interactions between robots and humans, as well as to develop systems that support these observations and measurement. The focus of our project is on social robotics: analysis of interaction between humans and humanoid robots, as well as the corresponding support in the development and maintenance of humanoid robotics systems that are acting autonomously.

[1] 462 citations according to the Google Scholar, retrieved 20 December 2017
[2] 592 citations according to the Google Scholar, retrieved 20 December 2017
The work was conducted in collaboration with Commonwealth bank (CBA) under support of the Australian Technology Network (ATN). This project was a part of the ATN CBA Robotics Education and Research program, and continued our previous research on the topic of social robotics using a humanoid PAL REEM robot to conduct the experiments. The first project was dedicated to the development of a general framework for a REEM guided tour as well as its implementation for the REEM robot, cf. [6].

**Contributions:** The current project extends the developed framework by new features, such as (1) providing a web-based application for navigating the robot during the phase of collecting the spatial information, (2) creating and editing the tour files in a user-friendly manner, (3) providing recommendations for the users, as well as (4) allowing for a visual analysis of the data on previous tours. In this paper we present a solution that allows lab assistants to interact with the robotics system without having any technical knowledge about the system and can be operated by any exhibition, or lab staff member or social psychologist.

The project we present in this paper is a part of the RMIT University activities on enhancing learning experience by collaborative industrial projects [5,23,26,27,28]. The core results of our previous project on social robotics are presented in [6]. We focused on the Lab tours use case, where the robot takes guests on tours of our Innovation Labs and answers related questions. The framework presented in [6] is based on a formal framework for modelling and analysis of autonomous systems and their compositions [25], and can be applied to any kind of guided tours, as changing the application domain would mean changing only on the content of information provided about exhibits. In the project we present in this paper, we went further to extend the framework with web-based interface providing many useful features. While the old version with the voice commands is more human-oriented, the new web interface can be useful for a noisy environment. Thus, in some cases the spatial information for the tours has to be collected in noisy environments where the identification of voice commands can be difficult or even compromised. This might happen, for example, when the exhibition construction works are in progress, and waiting till all works are finished might lead to additional delays.

**Outline:** The rest of the paper is organised as follows. Section 2 presents related work. The architecture of the developed system as well as its core functionalities are introduced in Section 3. Section 4 summarises the paper and introduces directions of our future work.

## 2 Related Work

Duffy et al. [9] presented the concept of Social Robot Architecture, which integrates the key elements of agenthood and robotics in a coherent and systematic manner.

The ethical and social implications of robotics were discussed by Lin et al. in [10]. Young et al. [30] examined social-psychology concepts to apply them to the human-robot interaction.
Eyssel et al. [10] presented a case study where they analysed the effects of robot features (human-likeness and gender) and user characteristics on the human-robot interaction acceptance and psychological anthropomorphism. Salem et al. [21] analysed the effects of gesture on the perception of psychological anthropomorphism, by conducting a case study using the Honda humanoid robot. Trovato et al. [29] conducted a cross-cultural study on generation of culture-dependent facial expressions of humanoid robot. Sabanovic et al. [20] discussed the use of observational studies of human-robot social interaction in open-human-inhabited environments. Klein and Cook [13] analysed and compared the findings in the UK and Germany on robot-therapy with emotional robots as a treatment approach for people with cognitive impairments.

There were also a number of surveys and literature reviews on the related topics. A survey on social robots for long-term interaction was presented in [15]. A systematic review on application of social robotics in the Autism Spectrum Disorders treatment was presented in [19]. Cabibihan et al. [4] presented a survey on the roles and benefits of social robots in the therapy of children with autism.

Alemi et al. [1] examined the effect of robot assisted language learning on the anxiety level and attitude in English vocabulary acquisition amongst Iranian EFL junior high school students. The results demonstrated that application of social robotics in this context can increase learners’ engagement as well as satisfaction from the education process. Shimada et al. [22] used a social robot as a teaching assistant in a class for children’s collaborative learning, and concluded that a robot can increase children’s motivation of the class, but cannot increase their learning achievement.

Glas et al. [12] introduced a design framework enabling the development of social robotics applications by cross-disciplinary teams of programmers and interaction designers.

3 System Architecture and core features

The architecture of the proposed system is demonstrated in Figure 1. The core physical component of the system is the REEM robot on which the Robotics Operating System (ROS) is running to enable precise control from high-level programs. ROS provides services for Web-Ros communication, cf. Figure 2. ROS side can launch a service while the web-interface can call a service. In this project, we focused on the Tour and Motion Services.

Like in our previous project [6], our work was divided into two phases:

- Phase 1 was conducted in the RMIT University VXLab (Melbourne, Australia). The introduction to the VXLab facilities can be found in [2,3,24]. The web-based interface was developed using a simulated environment provided by a ROS robot software development framework.
- Phase 2 was conducted in the CBA Labs (Sydney, Australia). A number of experiments were conducted to apply the developed web-based interface to a real REEM robot and to simulate the scenario when an operator prepares
an exhibition/lab tour and executes it, both in simulated environment and on a real robot.

To develop the web-based interface, we applied React.js, an open-source JavaScript library. To execute the JavaScript code server-side we applied Node.js, an open-source JavaScript runtime environment. Node.js provided the management of dependencies to certain web packages that were required for certain features to be used such as UI elements and the ROS-bridge API.

ROS (Hydro Medusa) was used as the robot operating system that provides interfaces to the REEM robot’s sensors, motors, actuators and speakers, by utilising Python and C++ libraries. The robot gesture, movement and navigation functionalities relied on ROS libraries. The experiments were conducted under the Ubuntu 12.04 platform. The Gazebo simulator 2.2.3 was used as the simu-
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4. ARCHITECTURE

There is one physical component, which is CHIP, in our case. To run our code on CHIP, ROS code should be deployed on CHIP (server) first. Then, web-application can be set up on any devices connecting to CHIP by using the ROS Bridge. Structure can be seen from the graph above.

Fig. 2. System Communication

Simulation environment to test the capabilities of the robot. During simulation, the movements of the robot was portrayed through control of the RViz visualisation.

Converting text to speech was conducted using
- IBM Watson text-to-speech (TTS) service for the simulation, and
- on-board Acapela TTS for the experiments on the real robot.

In the simulation environment, TTS relied on generating wave files with Watson, then playing them back through any sound player. When deploying on the actual robot this process is handled by Acapela, a TTS engine from Acapela Group.

Figure 3 presents the control page, where the movements of the robot can be controlled by using the corresponding menu items. This provides the functionality necessary to create the lab tours: to navigate the robot, and to store the current locations of the robot.

Fig. 3. Navigation management
Figure 4 presents the management page to display all the existing tours and all the locations within each tour, as well as to manage them. We can edit the content of an existing tour (cf. Figure 5), add new tours, copy existing tours, search for particular tours or locations, etc.

![Tour Management](image)

**Fig. 4.** Tour Management

- **Add Tour** button will direct the screen to 'Add Tour' for user to create a new tour.
- **Copy Tour** button will direct the screen to 'Copy Tour' for user to make a copy of the tour and edit it.
- **Edit Tour** button will direct the screen to 'Edit Tour' for user to edit the locations and name, type of the tour.

![ChipHandler/web_modules/search-tours.jsx](image)

**Source Code File:** ChipHandler/web_modules/search-tours.jsx

**Description:** This is used for the 'search tours' function, while the user types in, the tour list will change according to the search value.

![Add Tour](image)

**6.1.2.2 Add Tour**

**Source Code File:**

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Moreover, user can either type in the description or upload a text file.

![ChipHandler/web_modules/scene_locations.jsx](image)

**Source Code File:** ChipHandler/web_modules/scene_locations.jsx

**Description:** This page will display all the existing locations. 'Add Location' button will direct the screen to 'Navigation' for user to create a new location. 'Copy Location' button will direct the screen to 'Copy Location' for user to make a copy of the existing Location and edit it. 'Edit Location' button will direct the screen to 'Edit Location' for user to edit the description for different levels.

![Location List](image)

- ocular
- ocular
- selfie station
- usability rooms

**Fig. 5.** Functionality to edit the content of a tour
Figure 6 demonstrates the functionality to edit the information on a location named *oculus*. The text within the description field will be a part of the speech within the guided tour: the text-to-speech module of the robot system will transform the text to the speech when the robot approaches the location.

**Fig. 6.** Functionality to edit the information on the *oculus* location

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**6.1.4 Statistics**

**6.1.4.1 Main Statistics**

**Source Code File:** ChipHandler/web_modules/scene-statistics.jsx

**Description:** This page will display the quantity of tours in recent 6 months, quantity of tours for different types, together with a table list all the information of every tour. When click the 'Detail' button, we app will move to 'Statistics Detail' to show the information for a specific tour.

**Screenshot:**

**6.1.5 Recommendation**

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**6.1.4.2 Statistics Detail**

**Source Code File:** ChipHandler/web_modules/tour-log-list.jsx

**Description:** This page will show the execution time of the tours and the log information.

**Screenshot:**

**Fig. 7.** Analysis of the data on the previous tours
Figure 7 presents the statistics on the tours within the previous 6 months, as well as the distribution of the tours by their types, both in tabular and graphical format. The users can also obtain more detailed information on a particular tour, cf. Figure 8.

**Fig. 8.** Analysis of the data on the tour *Zoo*

Figure 8 demonstrates how the developed system provides recommendations for the users based on the tour popularity. Customised recommendations, i.e., based on the customised parameters, are provided in a similar way.

To summarise, the developed web-based interface provides the following features:

- Navigate the robot,
- Store the current locations of the robot,
- Manage saved locations,
- Create a customised tour based on saved location,
- Embed speeches for a customised tour,
- Store information about a customised tour, such as the tour type, duration, etc.,
- Provide recommendations for the users, and
- Visual analyse the data on previous tours.
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6.1.5.1 Main Recommendation

Source Code File: ChipHandler/web_modules/scene-recommend.jsx

Description:
This page will display the top 10 popular tours and a table which lists the information of these tours. When click on one row the location will be displayed and user can execute the selected tour in this page. User can also execute advanced search by choose the type and duration, in order to find a more suitable tour.

Screenshot:

6.1.5.2 Advanced Recommendation

Source Code File: ChipHandler/web_modules/scene-recommend-top10.jsx

Fig. 9. Recommendations for the users based on the tour popularity

4 Discussion and Conclusions

In this paper, we presented the core results of the project on software development for social robotics systems: We developed a web-based solution that supports the management of robot-guided tours (including the collection of the spatial information for the tours within noisy environments), provides recommendations for the users as well as allows for a visual analysis of the data on previous tours. The results of our work were implement for the humanoid PAL REEM robot, but their core ideas can be applied for other types of humanoid robots.

We plan our future work on this project in three directions:
(1) to embed into the developed REEM framework the efficient testing methods, e.g. [17,18,14] as well as the model-based hazard and impact analysis methods [7],
(2) to apply the developed framework to another type of ROS-based robot, Baxter, hosted in the RMIT University VXLab, and
(3) to expand the developed guided tour features to involve game activities, as this would make the tours for children more entertaining and increase the children engagement.
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