Development of a University Guidance and Information Robot

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ABSTRACT

We are developing a social robot that will be deployed in a large, recently-built university building designed for learning and teaching. We outline the design process for this robot, which has included consultations with stakeholders including members of university services, students and other visitors to the building, as well as members of the "Reach Out" team who normally provide in-person support in the building. These consultations have resulted in a clear specification of the desired robot functionality, which will combine central helpdesk queries with local information about the building and the surrounding university campus. We outline the technical components that will be used to develop the robot system, and also describe how the success of the deployed robot will be evaluated.

CCS CONCEPTS

• **Human-centered computing** → Field Studies; • **Computer systems organization** → Robotics.

KEYWORDS

human-robot interaction, social robotics, robots in public spaces

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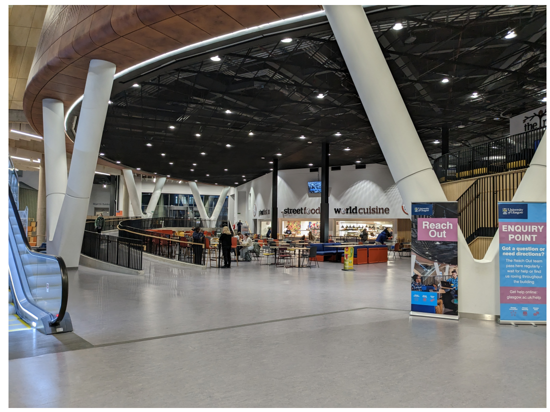

Figure 1: Level 1 of the James McCune Smith Learning Hub, with a 'Reach Out' help point seen on the right

1 INTRODUCTION

In large public buildings, it can often be difficult for visitors to find their way or to determine what resources are available. This sort of receptionist/guidance context is one of the most common deployment contexts for a social robot [16], both because it is one to which common social robots such as Furhat and Pepper are particularly suited, and also because it is a task which is sufficiently well-defined that a successful robot system can be developed to support it and prove useful when deployed.

We are developing a social robot with the goal of helping university students to navigate and interact with a large, recently-built learning and teaching building. The target building, the James McCune Smith Learning Hub at the University of Glasgow (Figure 1), has a capacity for over 2500 students and includes a number of large lecture theatres on many floors, as well as smaller bookable study spaces, computer labs, along with an open cafe/social space on the ground floor. The design of the building means that there is no dedicated reception desk; instead, members of a dedicated "Reach Out" student support team are deployed in the building throughout the day to help with any queries that might arise. Our goal is to develop a robot that can be deployed in the building to help answer questions similar to those that are given to the support team, providing an additional point of contact for students and other visitors. The robot is being developed as to be complementary to the "Reach Out" team, rather than as a separate entity, and has the potential to influence the development of a novel service delivery strategy for University Services.

To develop the specific details of the robot's appearance and behaviour, we have consulted with a range of stakeholders, including members of the University Services team who are responsible for front-line student support through the university, including in the context of the building; students and other visitors to the building; as well as members of the student support team who currently respond to in-person queries within the target building. These consultations have resulted in a clear specification of the desired services for the robot to support: Helpdesk queries, along with local information about the building and the wider campus. We are currently developing the robot system in response to these specifications, and will deploy it later in the academic year. In this paper, we provide a technical description of the overall system, and also outline how the success of the robot will be assessed.

2 RELATED WORK

Although much initial work on social robots was lab-based, in recent years, an increasing number of social robots have been deployed in public spaces [16, 23]. Many such deployments have made use of the well-known SoftBank Robotics Pepper robot, a 120cm tall humanoid

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robot equipped with 20 degrees of freedom, built-in microphone and speakers for natural-language interaction, as well as a range of visual and touch sensors to support embodied communication. Pepper's size and form factor were specifically designed for real-world social HRI [19], and it has been deployed in a wide range of contexts including shopping malls [6], museums [5], restaurants [26], libraries [17], and train stations [27]. User responses to robots in these locations have generally been positive, although often in practice, rich multimodal interactions can be difficult due to the technical challenges of audiovisual sensing in uncontrolled public spaces [e.g., 7]. Other robots have also been regularly used for public-space deployments: for example, recent deployment contexts for the Furhat robot have included as a barista [14], a receptionist [15], and in an airport [8]. In Japan, the Robovie robot has been successfully used for a series of shopping-mall deployments over several years [2, 9, 12, 24, 25].

Design practices such as co-design and user-centred design are becoming increasingly well-established in the HRI community [4]. These techniques balance the decision-making power between researchers and stakeholders, resulting in appropriate technology that also meets the needs of the target users [21]. Consulting as wide a range of stakeholders as possible is clearly necessary when developing the behaviour of a robot that is to be deployed in a public space [18]. Without this sort of consultation, there is a risk that robots will not be accepted by their users, or will not be used beyond the initial period of novelty [20, 23].

3 REQUIREMENTS ANALYSIS

To confirm that the building is an acceptable location for a robot to be deployed, and to develop the specific details of the system, we consulted a range of stakeholders: university services personnel, building users, and members of the existing on-site support team.

3.1 University Services Consultation

Initially, we consulted with members of the University Services team, whose overall goal is to support front-line academic activities and enhance the student experience, to confirm that they were supportive of the overall robot project. For this consultation, we had two main questions: one regarding the robot appearance and platform, and one regarding the overall use case of the robot. Regarding the robot platform, the team was presented with images of two possible humanoid robots for this project, Pepper and Furhat. In this consultation, Pepper was established as a clear favourite for the deployment; based on the images, descriptions of Furhat included 'creepy' and 'like a Girls World doll', while Pepper was seen to be a better choice for the desired use case. We note that Pepper is also by far the most common robot used in a wide range of real-world deployments, as outlined in Section 2.

Regarding the overall use case, the University Services members were keen to see the university's IT Helpdesk as the primary information source for the robot, as a way for them to evaluate new ways of providing assistance to members of the university and also the quality of the information. They often struggle to encourage people to search the Helpdesk themselves: the team does have a physical presence in the university library but they only staff it for 60% of the opening time. They felt that a social robot in the learning and teaching hub could be a useful way of to explore a different model of providing help out-of-hours and through a different channel.

3.2 End User Research

Once the University Services team had agreed to pursue the overall goal of developing a social robot, the next step was to carry out user research with students and staff within the learning and teaching building where the robot was to be deployed. Over a three hour period, Pepper was situated on the ground floor: at this point, no behaviour was implemented on the robot beyond the default 'aliveness' behaviours (face tracking, small hand movements), but it was felt that having the actual robot there would provide much more specific and useful information from the passers-by.

During the time that the robot was present, passing users were prompted to come interact with the robot and answer questions on their thoughts. We covered three main topics through informal conversation:

- What are your feelings towards Pepper?
- What tasks or information would you find useful from Pepper?
- Would you interact with Pepper?

Two researchers collected the data from 70 participants via written notes. The informal structure allowed us to ask follow up and in depth questions to more curious and engaged students. Many students described the robot using terms such as 'cute, friendly and approachable', while a few described Pepper as 'skynet' and that it was 'going to steal all my data'. For almost all participants, this was the first time they had ever seen a social robot, so their primary conceptions came solely for popular culture surrounding robots. It is interesting to note that most participants referred to the robot as 'he/him' without prompting. One student in particular was encouraged by the anonymity the system could provide: they worried that human staff would judge them for asking 'easy' questions whereas the robot would not. This would therefore encourage them to ask for help instead of waiting for a helpdesk response. Students also commented on how they believed that because data was coming from a robot it would give them confidence in the accuracy of the information. Overall, the positive reactions we got from the target users during this session confirmed that they would be interested with interacting with a social robot such as Pepper in a university context and felt that it could be a useful addition to the service provision within the building.

3.3 Shadowing the Support Team

As a final part of the requirements gathering, we were able to shadow members of the student support team within the learning and teaching hub for a three hour period during a teaching day. This proved a valuable insight into how students interact with the team, and vice versa. Before the observation session, we were provided with a baseline document on what queries they are required to resolve, but we found that students often asked questions that went outside these bounds. It became apparent that within the space there were a large amount of local knowledge questions, for example the location of toilets or help with the printers, and that it would be useful to cater for this despite it not being contained within wider knowledge bases. We also learned that the team members often have to be proactive with students; whilst this outside the scope of this project, it provides a good indication of where subsequent robot development could be focussed.

Again, two researchers were involved in this part of the research. Each was assigned to a different ambassador in order to maximise the range of queries experienced. We were able to observe across all locations in the building, as the roving model of the team reassigns ambassadors to a different set of floors every hour. Directions were the most common request on the ground floor of the building; this could be explained by a number of reasons such as the space being new building on campus and people have not had teaching there before, or that the building handles predominately first-year undergrad classes due to its large lecture theatres. It is noted that there could be influences on this, in that at the time of this study, the student mobile app still did not contain information about rooms in this building, unlike all the others on campus. On other floors of the building, technical support queries about facilities such as printers were also common.

3.4 Final Domain Specification

Based on these consultations with all relevant stakeholders, the robot system will work as follows. Using the Pepper robot as a platform, users will be able to access information contained in the Helpdesk, as required by the University Services stakeholders. In addition, we will incorporate all information required to respond to other commonly observed queries that go beyond the Helpdesk information, such as location information both within the building and across the university, as well as information about restaurants and other building facilities such as toilets and printers. The interaction will be speech-based and conversational, but constrained; we will not implement small talk or chit-chat into the robot system, as most stakeholders felt that the best use of the robot would be in a task-based design. The robot will be designed to be deployed at various locations throughout the building.

4 TECHNICAL DETAILS

Developing a robot to meet the final specification arising from the stakeholder consultation will require integrating a number of individual components onto the robot platform. Note that, as the solution will be deployed to represent the university, we will use a traditional rule-based pipeline to ensure responses are polite, meaningful, and appropriate. Although data-driven approaches to interaction such as ChatGPT are potentially more engaging, they also pose a real threat of generating content that is incorrect at best and potentially even offensive or dangerous [1].

4.1 Speech Recognition

Early in the end-user deployment, it became clear that Pepper's microphones and default Automated Speech Recognition (ASR) system were not capable of operating reliably in the large, open, ground-floor atrium that will be the robot's primary deployment location. On a similar project, to solve this issue, Pepper was placed inside an acoustic enclosure in a shopping-mall atrium [7]; however, this was not practical for the intended time-frame or deployment strategy for this robot. Instead, we will run the ASR system on a separate laptop, using an external beam microphone, which we expect to achieve acceptable ASR performance during deployment.

4.2 NLU and Dialogue Management

The core conversational component of the system will be implemented using the Rasa Open Source [22] library, a Python-based toolkit designed for developing and deploying chatbots. Rasa incorporates components for Natural Language Understanding (NLU) as well as response selection, meaning that the entirety of the chatbot can be built in the Rasa framework. External servers will be used to provide access to the information necessary to answer user queries: the Helpdesk information will be accessed via an API call, while the additional information will be loaded into databases which can be accessed when necessary to help users with location queries or other such information needs. The hypothese from the ASR system will be sent to Rasa as text as they are recognised, and the entirety of the chatbot process will operate based on those hypotheses.

4.3 Embodied Text-to-Speech

The output of the Rasa chatbot will consist primarily of plain-text utterances. Every utterance chosen by Rasa will be sent to Pepper via the built-in NaoQi SDK for realisation. Pepper will run text-to-speech on the selected output, and will also use its built-in ability to generate accompanying gestures where appropriate. The connection between Rasa and Pepper will be implemented using a similar model to that employed by Janeczko and Foster [11], who used custom web-based connectors to support the connection between a Rasa-based chatbot and a Pepper robot running the older NaoQi version which we will also need to use.

4.4 Other Considerations

As we plan to deploy Pepper in various locations across the building, properly giving directions will require that we explicitly encode the location of the robot, for example through an environment variable, so that directions are properly grounded. This additional information will aim to route the user to a common location, such as the lifts, following which properly grounded, static directions can be given. If the target location is on the same floor as the robot, this additional will be ignored. All directions will be routed via ramps and lifts so ensure our directions are accessible to all. If time permits, we will also explore using the Pepper tablet to display map directions in addition to giving the instructions verbally.

During deployment, Pepper will not be left unattended, so we plan to implement only rudimentary abuse prevention; it is unlikely any user would try to abuse the robot with staff within earshot. Pepper being closely supported will also allow any queries that are unresolved to be either resolved by staff, or a Helpdesk ticket created as would normally be carried out by the support team, and also allows the success of the robot to be directly assessed.

5 DEPLOYMENT AND EVALUATION PLANS

The robot will be evaluated via a field experiment, where the robot will be deployed between for one week between 9am-4pm in a range of locations across the learning and teaching building, such as at the various entrances and within small printing clusters. The times and locations have been chosen such as to expose the robot to the largest possible userbase. Users will be able to interact freely with the robot, but only information and recordings from participants who explicitly give consent will be used in the study. We will use both subjective and objective measures to test the success. Regarding subjective measures, while it would be ideal to use a full questionnaire such as SASSI [10] or RoSAS [3], the reality is that for short interactions or immediate queries such as "Where is Biology 1A", it is unlikely that we will be able to get the users to engage in a long evaluation session. For such users, we will use a short single-question post-interaction rating, similar to what was used in evaluations such as the Amazon Alexa Prize challenges [13]. For users who might approach the robot out of curiosity rather than with an urgent need, and who therefore might have more time to spare, we will invite them to carry out a more involved user questionnaire.

A number of objective measures will be gathered during the full deployment: this includes ASR confidence rates, number of clarification queries required, and overall resolution rate of user queries. As the robot will always be accompanied by a researcher, it should be possible to estimate the ASR word error rate and other similar measures by observing users actual behaviour and making notes. Due to the public nature of the deployment, it is unlikely we will be able to record user interactions.

In addition to the above measures, which will primarily be used to assess the robot from a research perspective, we will also work with the colleagues from University Services to measure the success of the robot from their perspective, in order to inform any further university-level decisions about other robot deployment plans or alternative service delivery mechanisms.

6 SUMMARY AND FURTHER WORK

We are developing a social robot that will be deployed in a large, newly-built university building alongside the existing in-person support team, to respond to queries from building visitors. Following consultation with a range of relevant stakeholders, we have established that the most suitable robot platform is the Pepper robot out of the hardware we have available, and that the target domain should combine Helpdesk queries with location and guidance information. Based on this domain specification, we have selected the appropriate technology to build the robot system and are currently developing and integrating the components. When the robot is ready, it will be deployed in a field experiment during early 2023, and a range of subjective and objective measures will be gathered; in addition, specific feedback will be gathered to help make future decisions about novel service delivery methods within the university.

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