Touchscreens as Mediators for Social Human-Robot Interactions: A Focus Group Evaluation involving Diabetic Children

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Abstract. Social Human-Robot Interaction (sHRI) seeks to develop robotic agents capable of building and maintaining engaging social interactions with humans. One issue in attempting to do so is attempting to constrain a social interaction, for technical reasons, without impairing the potential social richness of such an interaction. In this paper a hardware setup is described, the Sandtray, to address this issue by acting as a mediator for interactions. Being centred around a touchscreen, it affords a number of interaction and technical advantages over both sHRI with no interaction mediator, and sHRI involving mediators consisting of real-world objects in a shared workspace. A focus group evaluation was conducted with diabetic children to explore the potential utility and enjoyability of this Sandtray setup in a medical domain involving child-robot interactions. Results demonstrate the broad utility of the touchscreen-mediator approach, providing support for the continued development and application of the Sandtray in this domain.

Keywords: Social Human-Robot Interaction; Interaction Mediator; Sandtray.

1 Introduction

Social Human-Robot Interaction (sHRI) is concerned with the development and study of systems and technologies that enable robots to interact with humans, with a focus on social behaviours: the goal is therefore typically oriented more towards companion robots than manufacturing robots. However, shortfalls in the current state of robot technology necessitates the constraining of a social interaction to a context (typically subject matter, with relevant actions) in which the robotic system can behave effectively (for example, in verbal interaction, this could be the restricted recognition of words from a subject-specific database). This is typically achieved by having the robot explicitly steer the social interaction towards the domain that it is able to act in: for example by asking questions for which there are a number of expected answers. However, it has been proposed that by imposing constraints on the interaction in this way, there is a detrimental effect on the degree to which the human behaves in a naturalistic manner [1] - thus reducing the overall effectiveness of the sHRI solution.

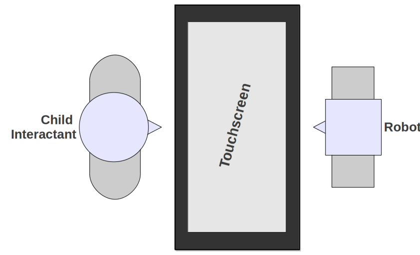

Fig. 1. Overview of Sandtray-mediated interactions (not to scale): the robot, an Aldebaran Nao, and child face each other over the touchscreen. This setup allows similar interaction affordances for both interactants without necessitating complex robot manipulation capabilities, whilst still providing a physical context for a multi-modal interaction.

There is thus a need to find an alternative means of constraining the interaction. A novel methodology has been proposed, which makes use of a touchscreen to provide a task context for a social human-robot interaction (figure 1) [2]. This paper seeks to discuss the inspirations and desire for such a new methodology in HRI, with touchscreen technology at the heart of the application, as has also been applied in a number of other studies, e.g. [3]. Touschscreens have been found to be particularly applicable to social activities involving children, e.g. [4], and so are an ideal candidate for the present research.

The present work is conducted in the context of child-robot interaction, specifically involving children with diabetes [5]. With such a target group, there are a number of aims in addition to those listed previously: there is a need to provide some educational content to help support the management of their condition (diet management, insulin calculations, etc), and the application has to be engaging enough so that the children remain interested (through ensuring a degree of entertainment for example). It is therefore important to gain the views not only of the medical professionals to verify the technical content, but also of the end users themselves. An evaluation is therefore also presented in this paper, to validate this manner of touchscreen usage in an sHRI context from the perspective of the children concerned.

2 The Sandtray

The Sandtray has been introduced as a means of facilitating social HRI by providing a context for the interaction [2]. When meeting for the first time, two people will typically interact on subject that is related to a common task or goal, or to a common context. For example, on meeting at a bus-stop, the topic of conversation may typically encompass the weather, or the increasing tardiness of the local public transport. The Sandtray enables such a context to be provided, but in a manner that can be controlled by altering the contents of the screen, rather than through prescriptive robot behaviour. In this section, the inspirations for such a device are provided, and a description is given of the system.

2.1 Inspirations

One of the inspirations informing the development of the Sandtray has been the sandplay methodology. Making use of an interaction medium such as a box of sand and some toy figure, this is a therapeutic application to allow a child to express themselves in a creative manner [6], emphasising a child-led interaction [7]. This principle of providing a structured means of engaging a child in interaction without inhibiting the *way* the child interacts forms the underlying inspiration for the Sandtray [2]. While other work has directly implemented the therapeutic principles of Sandplay in a virtual form [8], the present research is inspired by the role of the mediating device on general sHRI rather than the therapeutic application per se: the term 'Sandtray' is in this work just a label to describe this application to sHRI.

In terms of HRI, the Sandtray setup offers a number of advantages in practical terms. Specifically, two outstanding issues in the control of autonomous humanoid robots are perception and action. Neither of these issues are trivial, with specialist solutions being required for each type of robot, and frequently also for each task to be completed.

Firstly, regarding perception, object identification and recognition are problematic in complex environments, particularly when objects occlude one another. Furthermore, with the presence of only limited sensory apparatus on robots, successful recognition of one object often precludes attention being paid to other aspects, most notably the behaviour of the interacting human. Having a shared workspace between a robot and a human involving multiple objects with which they should jointly interact thus poses a number of practical sensing problems.

Secondly, regarding action, the manipulation capabilities of robots in the real world (i.e. away from the well-defined and constrained settings of automated processes) remains limited, currently lagging the desirable levels of performance. While a degree of manipulation of objects is achievable, this would typically only be possible for known objects, or objects with known physical characteristics (in some cases this would even include placement position and orientation). The interaction capabilities of robots with real objects in shared workspaces is thus limited.

It is therefore desirable if both of these issues could be circumvented, in order for the robot designers to be able to focus on the social interaction, rather than technical constraints. The use of a touchscreen enables such a circumvention, whilst maintaining the possibility of enabling a robot and human to maintain a shared workspace in which physical interaction is possible. For perception, the images displayed on the screen are known, both in terms of identity and position, thus obviating the need for complex vision processing algorithms for the robot. For action, fine-grained manipulation is not required given that the objects displayed are virtual: very course motor control is sufficient to create the illusion of physical interaction on the part of the robot. Indeed, given that virtual objects displayed on screen may be typically either just be selected or moved around, the interaction affordances for both human and robot are the same. Furthermore, the use of virtual objects (whilst still enabling a pseudo-physical interaction) provides another advantage in terms of empirical studies: the behaviour and properties of the virtual objects shown on the touchscreen can be manipulated in real-time, even whilst an interaction is ongoing, to an extent that is not possible using real-world objects. Examples of this include changing the maximum allowable drag speed of virtual objects, or changing the class of an object (see below) for instance.

2.2 Hardware and Functionality

The Sandtray setup is comprised of a capacitive touchscreen (27") embedded into a low table, such that the surface sits approximately 0.35m from the floor. It is designed for use on the floor, as a piece of furniture. A non-reactive black bezel approximately 15cm in width surrounds the touchscreen area on all four sides, which enables users to lean on the device and not the screen; an affordance that has been found to be particularly useful with children, as it provides them with physical support without interfering with the touchscreen itself.

The Sandtray is intended for use in the study on interactions between two parties, specifically one child and one robot, where they sit opposite each other with the touchscreen between them (figure 1). This arrangement enables the robot behaviour to be more clearly exhibited to the child, with an emphasis on collaborative rather than competitive interactions. Further children may be present during an interaction with the robot (with two children and one robot shown for example in figure 2).

Fig. 2. Application of the Sandtray to a study performed in a school (in this example two children and one robot). The ability to test the Sandtray platform and robot behaviours in environments with which the children are familiar facilitates naturalistic behaviour.

The robot is controlled using one of two options: remote control (named 'Wizard of Oz' or WoZ), where a human experimenter determines what the robot does and when, and an autonomous controller, which automatically generates robot behaviour (of the same types available to the WoZ control) and is reactive to certain human behaviours. The robot controller communicates over a wireless network with the programme that generates the images on the touchscreen (the 'game-engine', see below). With this organisation, information regarding the state of the images shown on the touchscreen (e.g. figure 3) can be passed directly to the robot controller (be it autonomous or under WoZ control), and vice versa (the robot controller can request that a certain image be moved on screen, and synchronise this with arm movements to simulate image dragging). In this way, the robot can be responsive to various on-screen events, and interact with the virtual objects on-screen.

Fig. 3. Example of the items shown on screen during a carbohydrate-content food sorting task on the Sandtray. An item has just been correctly categorised, resulting in visual (green 'tick' shown) and auditory feedback. A collaborative scoring system is shown (upper and lower right-hand side), with buttons for resetting the images (top) or loading a new set of images (bottom) on the left.

For the experiment described in the following section, a game-engine for a two category sorting task has been implemented. The goal of this task is to sort a set of food images displayed on the touchscreen into two categories: high carbohydrate content food, and low carbohydrate content food (the image sets used were validated by a nutritionist; see figure 3 for an example). When a food item is moved to a category location, both visual and auditory feedback is provided to indicate correctness/incorrectness. It is important to note that this task does not inherently provide any interaction structure (see Introduction): there is no turn-taking imposed, and it is possible for one of the interacting partners (be it robot or child) to complete the task alone without any involvement from the other party.

3 Focus Group Study

A focus group was conducted at the Science Museum of Milan involving children with diabetes and their parents, on various topics related to what role a robot could potentially play in the management of their condition. This study was conducted over a period of three subsequent weekends (termed 'sessions' below) in collaboration with the local diabetes association (a support network for children with diabetes and their families). A total of 22 children took part in these sessions (mean age: 9.82, s.d.: 1.82), having been living with diabetes (i.e. after diagnosis) for an average of 3.93 years (s.d.: 2.31 years).

Three activities were carried out during each of these sessions. Each of these activities were conducted in different areas of a single large room. Firstly, the children were given a presentation by one of the experimenters and a robot. This included some guessing games and robot dancing, which served to introduce the robot and its capabilities to the children. The second activity was a group brain-storming session in which the children were led through a discussion by an experimenter on the subject of how the robot could help them manage their condition in three locations: home, school, and in the hospital. After this discussion, the children filled out a short questionnaire on how they viewed the robot. Two of these questions were on the Sandtray, which are discussed below.

While this focus group activity was being conducted, the children were brought one by one to play with the robot and Sandtray (figure 4). The physical arrangement of the robot, child and Sandtray is as shown in figure 1. The robot was controlled using a WoZ scheme, i.e. its actions controlled by a remote human experimenter, such that the child thought that the robot was acting autonomously. As described in the previous section, the task of the interaction was to sort displayed examples of food into two categories: high or low carbohydrate content (an Italian version of the display shown in figure 3).

The purpose of this evaluation was two-fold. Firstly, since the sorting task in the Sandtray context was designed to be supportive of educational goals for diabetic children (namely carbohydrate content identification), the primary goal of this evaluation was to assess whether the children enjoyed the game with the robot: with enjoyment supporting engagement and thus learning, this is an important aspect for this application. Secondly, it provided an opportunity to demonstrate the technologies involved, and to assess the appropriateness of the setup for children in general.

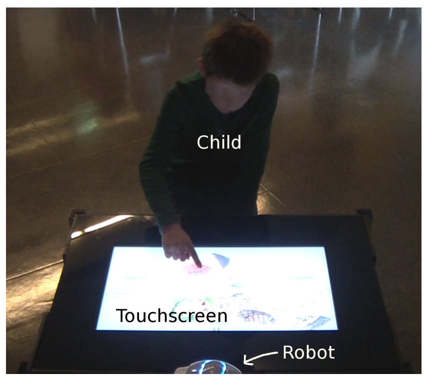

Fig. 4. Sandtray providing the context for a child-robot interaction during the focus group study.

The questionnaires were administered following the group session and the individual interactions with the Sandtray, and were completed individually by each of the children. There were two questions directly related to the Sandtray (translated from the original Italian): (1) "did you enjoy playing with the Sandtray (with the robot)?"; and (2) "do you think the Sandtray could be useful in various aspects of your life with diabetes?". In addition to this, free-text comments could be volunteered on any aspect of their experience in the focus group. The results of the two questions were very positive (figure 5). Furthermore, informal feedback from the parents present suggested that the type of interaction performed in with the Sandtray could be used to maintain their childrens' interest in diabetes related knowledge acquisition (in this case diet management), which a central goal in learning to manage their condition. Indeed, a number of parents queried whether such a game were currently available on tablet devices for use at home or school. While further qualitative and quantitative study remains necessary, these results provide preliminary support for the appropriateness of the Sandtray to this application domain.

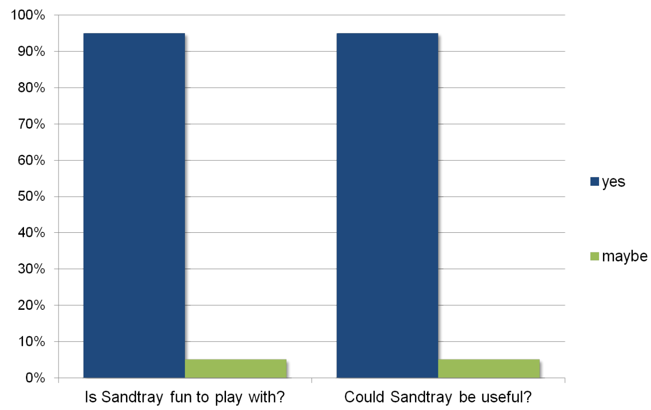

Fig. 5. Questionnaire responses regarding their perception of Sandtray from 22 diabetic children who took part in the focus group study. There were no negative responses recorded for either question. See text for details.

4 Discussion

The responses to the two Sandtray-specific questions asked of the child participants were overwhelmingly positive (figure 5). In support of these results, qualitative analysis of how the children played with the Sandtray setup (including robot) indicates that the children enjoyed engaging in the game. This could nevertheless be due to a novelty factor, since the children had not seen the robot prior to their visit to the focus group activity, rather than an intrinsic property of the robot/Sandtray. However, preliminary objective analysis conducted on the interactions themselves (from video recordings) have provided support for the hypothesis that the child sees the robot as a social agent in the context of the Sandtray [9], indicating that neither the touchscreen nor the robot take precedence in terms of attracting the attention of the child, despite a possible novelty effect.

Analysis of child-child interactions while using the Sandtray indicates that while the structure of the social interaction is not dictated by the task to be conducted on the Sandtray (the sorting task), the content of the interaction between the participants is constrained to the subject of the task [10]. In the context of social HRI this is a useful feature, as it enables the efforts of (for example) speech recognition and production to be focussed on the subject matter displayed rather than having to handle completely unconstrained subject matters. The related concept of using projected augmented reality tabletop systems has similarly found use in facilitating collaborative interactions, be they human-robot [11] or human-human [12]. In a broader context, this use of an interactive device in a mediating role provides content for the interaction without necessarily inhibiting the manner in which the participants interact [10], with touchscreens providing a set of additional advantages.

5 Conclusion

This paper has described the use of a large touchscreen setup, the Sandtray, to facilitate the development and evaluation of systems in social HRI. Inspired by principles from child therapy, this setup has been shown to provide a context for social interactions between a robot and a child. The touchscreen aspect is a central requirement: it eases the load on robot perception and manipulation, provides a set of interaction affordances common to both interaction partners, and provides a mediating environment that can be manipulated in real time according to the desired experimental conditions. It has been shown through user evaluation that this application of touchscreens to sHRI shows a great deal of promise - taking advantage of further advances in touchscreen technologies may yet yield further benefits in this promising application domain.

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References

1. Ros, R., Nalin, M., Wood, R., Baxter, P., Looiije, R., Demiris, Y., Belpaeme, T., Giusti, A., Pozzi, C.: Child-robot interaction in the wild : Advice to the aspiring experimenter. In: International Conference on Multimodal Interaction. (2011)
2. Baxter, P., Wood, R., Belpaeme, T.: A touchscreen-based "sandtray" to facilitate, mediate and contextualise human-robot social interaction. In: HRI12, ACM Press (2012) 105–106
3. Haring, M., Eichberg, J., Andre, E.: Studies on Grounding with Gaze and Pointing Gestures in Human-Robot-Interaction. In: ICSR 2012, Chengdu, China (2012) 378–387
4. Africano, D., Lundholm, P., Berg, S., Nilbrink, F., Lindbergh, K., Persson, A.: Designing tangible interfaces for childrens collaboration. In: CHI'2004. (2004) 853–868
5. Belpaeme, T., Baxter, P., Read, R., Wood, R., Cuayahuitl, H., Kiefer, B., Racioppa, S., Kruiff-Korbayova, I., Athanasopoulos, G., Enescu, V., Looije, R., Neerincx, M., Demiris, Y., Ros-Espinoza, R., Beck, A., Canamero, L., Hiolle, A., Lewis, M., Baroni, I., Nalin, M., Cosi, P., Paci, G., Tesser, F., Sommavilla, G., Humbert, R.: Multimodal child-robot interaction: Building social bonds. Journal of Human-Robot Interaction **1**(2) (2012) 33–53
6. Zhou, D.: A review of sandplay therapy. International Journal of Psychological Studies **1**(2) (2009) 69–72
7. Bradway, K.: Sandplay with children. Journal of Sandplay therapy **8**(2) (1999)
8. Hancock, M., ten Cate, T., Carpendale, S., Isenberg, T.: Supporting sandtray therapy on an interactive tabletop. In: CHI'2010, ACM Press (2010) 21–33
9. Baxter, P., Wood, R., Baroni, I., Kennedy, J., Nalin, M., Belpaeme, T.: Emergence of turn-taking in unstructured child-robot social interactions. In: HRI13, ACM Press (2013) 77–78
10. Kennedy, J., Baxter, P., Belpaeme, T.: Constraining content in mediated unstructured social interactions: Studies in the wild. In: AFFINE'13, IEEE Press (2013) accepted for publication
11. Okita, S.Y., Ng-Thow-Hing, V., Sarvadevabhatla, R.K.: Multimodal approach to affective human-robot interaction design with children. ACM Transactions on Interactive Intelligent Systems **1**(1) (Oct 2011) 1–29
12. Battocchi, A., Ben-Sasson, A., Esposito, G., Gal, E., Pianesi, F., Tomasini, D., Venuti, P., Weiss, P., Zancanaro, M.: Collaborative puzzle game: a tabletop interface for fostering collaborative skills in children with autism spectrum disorders. Journal of Assistive Technologies **4**(1) (2010) 4–13