Providing Tablets as Collaborative-Task Workspace for Human-Robot Interaction

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***Abstract*— In a recent conference on assistive technology in special education and rehabilitation, over 54% of the sessions were directly or indirectly involved with tablets. Following the trend, many traditional assistive technologies are now transitioning into apps for smart devices. This paper discusses transforming a tablet into an HRI research platform where our robotic system engages the user in social interaction by learning how to operate a given app (task) from the user. The objective is to engage the robot within the context of the user's task by understanding the task's underlying rules and structures. An overview of the HRI toolkit is presented and a knowledge-based approach in modeling a task is discussed where previously learned cases are reused to solve a new problem.**

***Keywords*— collaborative HRI toolkit, tablet shared workspace, case-based reasoning, task learning**

I. Introduction: Tablet as an HRI Workspace

The intuitive interface, huge app market, and improved accessibility features accelerate the adaptation of tablets in education, vocation, rehabilitation, and independent living for individuals with disabilities [1]. If robots are capable of learning how to interact with a tablet and its wealthy collection of apps, they can better engage the users as motivators, playmates, and companions. This research presents a cognitive robotic system in conjunction with an Android toolkit that transforms a tablet into a shared workspace (Figure 1). Using a knowledge-based approach, the robot autonomously learns and engages in collaborative tasks by reusing previously learned cases. Though the scope of the interaction is restricted to a tablet platform, no *a priori* task information or structure is given to the system, thereby facilitating naturalistic interaction such as human demonstrating the task to the robot.

Smartphones and tablets have become a popular platform for user interface, usability, and accessibility studies. HaptiMap project provides a toolkit for researchers and app developers to use these smart devices as a human-computer interaction research platform [2]. The project's focus is on how to merge multimodal feedbacks to augment or replace visual information by providing various tools for combining, decomposing, and interpreting sensor and location feedbacks. In this paper, we present a novel HRI toolkit for sharing the tablet screen as a workspace between a human and his or her robot partner.

This work engages the robot within the context of the participant's task by understanding the task's underlying rules and objectives. The participants either teach or learn a task through demonstration on the tablet as if they would do with other human partners. In achieving naturalistic social interaction, the uncertainty of environmental perception, including the recognition of humans' social cues, always poses a difficult challenge. The tablet platform reduces such uncertainty since the touchscreen provides quantified sensor data on gestural behavior of the user. The two dimensional surface of the tablet also simplifies robot-control problem to a great degree, thereby reducing unnatural manipulation and errors that interfere with the interaction. The developmental environment and already available apps on the market facilitate the process of designing and implementing a task with controllable modalities. Such benefits of deploying touchscreen-based medium for studying interactions between a human and robot are also discussed in [3]. In their work, a simple task is presented on the screen that could potentially initiate a conversation or generate other social interactions.

This work was supported in part by the National Science Foundation under Award Number IIS-0705130.

Figure 1. A cognitive robotic system is coupled with an Android toolkit that transforms a tablet into a shared workspace for engaging and learning a task during human-robot collaboration.

II. Collaborative HRI Toolkit

The HRI toolkit is implemented on an Android 4.0.3 platform and is composed of a task-learning module, knowledge manager, task framework, sensor manager, context handler, and a server that communicates with the physical robot.

A. Physically Embodied Interaction: The Robot

Studies conducted with physically embodied interactions report that the presence of a physical robot produces deeper engagement when compared to telepresence robots or an on-screen simulation [4]. As a social mediator, the child-like humanoid Kaspar has shown potential in encouraging autistic children to participate in an imitation play [5]. The authors also mention how robots generate a high degree of motivation and engagement in participants, including those who were unwilling to interact with human therapists. This research focuses on implementing a task-learning behavior on a robotic platform where the robot observes and interprets human motions, deduces the underlying objective, generates an appropriate task behavior, and engages with its human partner by taking turns accomplishing a goal, thereby motivating and stimulating the social behavior of the participant. The scope of the task is defined as apps on the tablet, which involves virtual object manipulations such as pressing buttons and dragging objects.

B. Modeling and building task knowledge

Our previous method of modeling children's play behavior [6] is reapplied to recognize statistical patterns of events taking place on the tablet, such as dragging objects in a certain trajectory or placing an object relative to others like stacking, aligning, and inserting. These object manipulation behaviors are coupled with object features and event handlers (button press, icon flip, etc.) to form a case and a knowledge base. The robot receives event activity from the tablet and creates its behavior through vision processing and a motion and speech generator.

Case-based reasoning (CBR) is a human memory and cognition methodology that solves new problems based on the solutions of similar past problems. By comparing the current task to some past task cases stored in memory, the best solution is retrieved and adapted to the current task. This process allows the system to bypass a long complicated decision process. One of the issues associated with CBR is that the complexity of retrieving data from a database increases exponentially depending on the size of the database. Therefore, efforts have been made to maintain database size under threshold by re-building the database for each new task and grouping cases by task context. Also, low-dimensional feature descriptors have been proposed to reduce data size. The first phase of CBR is acquiring knowledge, i.e., training the database. During this phase, the system observes a play task performed by the participant and generates a case (problem-solution pair) for each turn, which is then saved in the database. In the second phase when a new problem is introduced, the most similar past problem and its solution are retrieved from the knowledge base. The distance between the two problems is computed as the sum of weighted distances between each feature descriptor. The weight coefficients are assigned to provide factor information of the task objective. Next is the reuse step where the retrieved solution is compared to the current task. Using the distance function, a new solution is generated that adapts to the current scene. During the last phase, the new problem-solution pair is revised and retained in the database. Using double-thresholding variables, the new case is discarded, saved in the database, or prompted for user input (Figure 2).

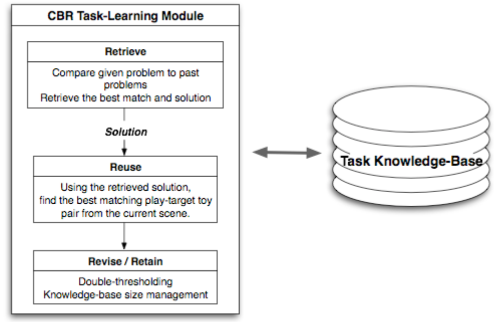

Figure 2. The robot uses case-based reasoning to store in memory the learned task behaviors demonstrated by the human.

III. CONCLUSION

While studying the apps used during therapy sessions or in special education classrooms, we noticed that these apps were carefully designed to increase exposure to given tasks by repeating similar, but slightly different sequence of tasks [7]. In real life, parents may lack knowledge, time, or patience to provide such interaction. Trained therapists, on the other hand, can provide quality sessions, but are burdened by cost and are often time limited. Social robots, in this regard, are becoming a suitable candidate for providing such uniform and repetitive exposure to interactive tasks. Since The context of social interaction is an infinitely large space, so this research proposes a novel HRI domain by restricting the interaction scene to a tablet. The focus of this research is not in how accurately the robot could solve a task, but equipping the robot with the learning ability to engage the participant to practice social behaviors. Even when the robot fails to understand and execute the task properly, it might motivate the participant to give the robot better instruction or demonstration. Future work will focus on designing user experiments that addresses these hypotheses and improving the social interaction modalities of the robot and the toolkit.

REFERENCES

[1] A. Fernandez-Lopez, M. Rodriguez-Fortiz, M. Rodriguez-Almendros, M. Martinez-Segura, "Mobile learning technology based on ios devices to support students with special education needs," *Computers & Education,* 2012.

[2] C. Magnusson, K. Tollmar, S. Brewster, T. Sarjakoski, T. Sarjakoski, and S. Roselier, "Exploring future challenges for haptic, audio and visual interfaces for mobile maps and location based services," in *Proceedings of the 2nd International Workshop on Location and the Web.* ACM, 2009, p. 8.

[3] P. Baxter, R. Wood, and T. Belpaeme, "A touchscreen-based sandtray to facilitate, mediate and contextualise human-robot social interaction," in *Human-Robot Interaction (HRI), 2012 7th ACM/IEEE International Conference on.* IEEE, 2012, pp. 105-106.

[4] J. Wainer, D. Feil-Seifer, D. Shell, and M. Mataric, "Embodiment and human-robot interaction: A task-based perspective," in *Robot and Human interactive Communication, 2007. RO-MAN 2007. The 16th IEEE International Symposium on.* IEEE, 2007, pp. 872-877.

[5] B. Robins, K. Dautenhahn, and P. Dickerson, "From isolation to communication: a case study evaluation of robot assisted play for children with autism with a minimally expressive humanoid robot," *Proc. Second Inter. Conf. Advances in CHI, ACHI'09.,* 2009.

[6] H. W. Park and A. Howard, "Case-based reasoning for planning turn-taking strategy with a therapeutic robot playmate," in *Biomedical Robotics and Biomechatronics (BioRob), 2010 3rd IEEE RAS and EMBS Interna- tional Conference on,* Sept. 2010, pp. 40-45.

[7] N.Shah, "Special education pupils find learning tool in ipad applications." *Education Week,* vol. 30, no. 22, pp. 1–16, 2011.