Beyond Actuated Tangibles: Introducing Robots to Interactive Tabletops

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TEI 2013, February 10-13, 2013, Barcelona, Spain
ACM

Abstract
Tangible user interfaces (TUIs) have been shown to support interaction on tabletops and interactive surfaces. We propose integrating robots as interactive partners in tabletop interfaces. We suggest a continuum of physical interfaces on interactive tabletops, starting from static tabletop TUIs, progressing to actuated TUIs and ending with small social tabletop robots that provide an engaging, partner-like interaction experience. In this report we motivate a vision of interactive robotic assistants and present our design of *Spidey*, a tabletop robot prototype. We conclude with findings from a focus group observation session reflecting on designing tabletop interaction mediated by touch, actuated TUIs, and social robots.

Keywords
Actuated tangible user interfaces, interactive tabletops and surfaces, social robots, robotic assistants.

ACM Classification Keywords
H.5.2. User Interfaces: Input devices and strategies.

Introduction

Digital tabletops introduced a complete paradigm shift in terms of interaction techniques [10]. As a virtual medium, tabletops present an engaging environment for the exploration of digital content, while as a physical medium they allow people to interact with the digital content via direct touch and tangible user interfaces (TUIs). Our long term vision is to expand the tabletop medium to include non-human users, and more specifically, physical tabletop robotic assistants (figure 1). While the concept of interaction with direct physical touch is becoming more commonplace with the availability of numerous touch devices, the use of interactive tangibles on digital tabletops and their social aspects is relatively new. Tabletop robots [5, 6] and interactive tangibles [3,7, 8, 9, 11, 14] have been introduced in the past, however in this work we propose moving beyond dynamic actuated TUIs on the tabletop, integrating robots that can present agency, and possibly become social interaction partners and assistants. This paper outlines our design approach and current preliminary prototype, and reflects on the possible effect tabletop robots may have on the user experience, examining their potential validity, usefulness and social aspects.

When placing actuated TUIs or robots on an interactive tabletop we expect them to be able to engage and attract attention beyond what is possible by visual aspects of the tabletop. However, robots can be viewed as unique entities, affording social attributes that are not demonstrated by actuated TUIs. Robots beyond their physicality and form can provide a sense of agency, a sense of being, and requiring enhanced awareness from their user, in ways that are not that remote from being aware of another human user. These characteristics allow the robots to take on different social roles [2], i.e. story teller, a companion, assistant, tool or just an attractive and engaging toy. These abilities of the robot to become a social partner [1] in an interaction scenario can dramatically enhance the interaction experience on digital tabletops.

The remaining of this note presents our work-in-progress efforts of designing and implementing our tabletop robot prototype – *Spidey*, followed by a brief discussion highlighting preliminary views of a focus group of six participants reflecting on interaction experience via physical touch, tangibles and robots. The future work and conclusion section presents more general directions for our next steps.

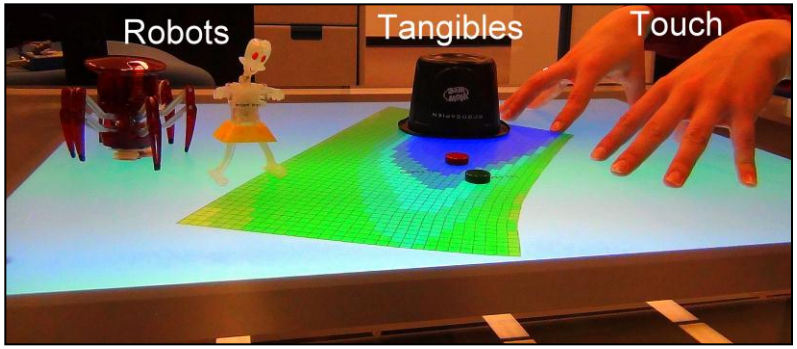

figure 1. Interaction techniques on a tabletop, from right to left: physical touch, tangibles and robots.

Tabletop robot prototype

Spidey is a tabletop robot prototype designed to work on the Microsoft Surface I (figure 2). Our design approach for *Spidey* took into consideration the following variables: size, possible action set of the robot as well as cost of the robotic platform. To meet these requirements,

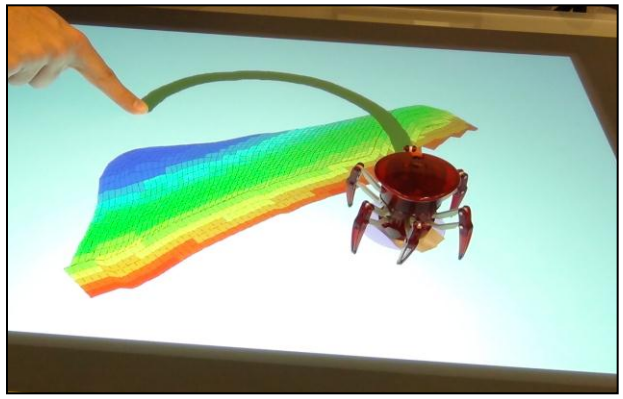

figure 2. *Spidey* on the Microsoft Surface.

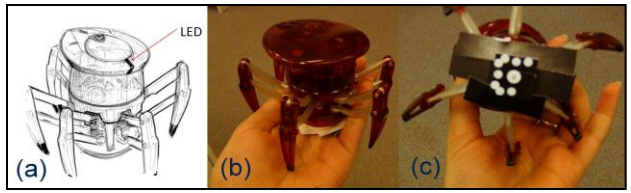

figure 3. *Spidey*: (a) schematics, (b) size and (c) byte tag attached to bottom of *Spidey's* body.

for this prototype we chose a small spider-like toy robot manufactured by Hexbug™. *Spidey* is small in size and can fit in the palm of a person's hand (figure 3b). The robot's small size helps to reduce occlusions of the digital content by the robot, and interferences to other (human) users interacting on the Surface (figure 3a). *Spidey* can move forward, backward and rotate left or right by 360°. The LED at the tip of its head gives the perception of it having an eye. The six legs touching the tabletop resemble somewhat thin fingers touching the tabletop.

Although *Spidey* appears to have a sense of agency and autonomy as it walks across the tabletop, the Surface PC is actually continuously tracking, and fully controlling the tabletop robot, and, if needed, is

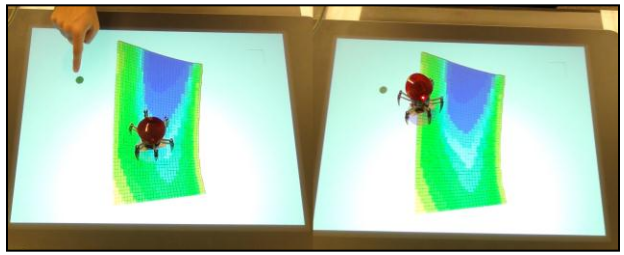

figure 4. Calling Spidey to a single destination point (Tap and Call).

responsible for augmenting the robot vicinity with visual information, creating the illusion that the robot was the one initiating an action via direct touch to the Surface. The IR remote controller of the robot is connected to a USB data acquisition, which in turn is connected to the Surface. This setup allows us to control *Spidey* programmatically. A byte tag is attached to the bottom of *Spidey's* body to enable real time tracking on the Microsoft Surface (figure 3c).

Interaction with *Spidey* currently is simple and allows users to call *Spidey* to different regions of the tabletop either by placing a destination point on the surface using a single finger (figure 4) or by sketching a path as seen in figure 2. The current prototype of *Spidey* is integrated into a 3D reservoir tabletop visualization application developed by our group [12, 13].

UX reflections

Would tabletop robots offer a different interaction experience, compared to touch and actuated TUI's? Objectively, the users tasks can be performed with all three equally effectively (and, probably also using a WIMP interface on a desktop). Could a tabletop robot play a social role? Could it be perceived as a valid interaction assistant? At this point, with only the preliminary *Spidey* prototype to demonstrate the concept, we cannot present any conclusive answers,

however the discussions with our participants were positive and hint at the possible validity of this approach. The reflections below are based on a focus group observation in which six participants, all graduate students, were asked to interact and share their thoughts about the potential roles of tabletop interaction mediators: touch, actuated TUIs and robots.

All the participants had some prior experience of having interacted at a tabletop with touch and TUIs and five out of six participants have experience in designing UX and interactions. The study included open ended questions about each of the three interaction modes – touch, tangibles and robots. We asked our participants to think-aloud and discuss their views on the potential benefits and disadvantages of each interaction mode. Tangibles and robots were presented on top of the MS Surface to facilitate discussion during the focus group study (illustrated in figure 1).

From the discussions with our participants we observed that all our participants mentioned that touch as an interaction mode felt very natural and allowed users to connect to the virtual content in a direct way, different from using a mouse. The majority of the participants mentioned that interacting with physical touch is also simpler in terms of mapping well known gestures to perform manipulation actions (i.e. rotation, translation and scaling) compared to navigating GUIs and mouse options. However, all the participants reflected on the fact that perhaps touch as a sole input is not enough. Instances of tasks such as reaching out to far regions of the tabletop or text input tasks could be better achieved with the help of tangibles.

Next, we discussed interacting with tangibles on a tabletop. While all our participants mentioned enjoying interacting with tangibles on a tabletop, an interesting observation was that tangibles in general were reflected upon as objects or things. Participants did not associate any social aspects with the tangibles we demonstrated to them, or with other tabletop TUIs they had previously experienced. In terms of usability of tangibles, static tangibles were preferred over actuated tangibles. Participants mentioned that static tangibles could be used as mediators for complex input queries, for example presenting query results by placing a TUI over digital content. Two of our participants mentioned that actuation could actually cause distraction rather than benefit or improve user interaction. One participant also mentioned that people may perhaps get scared when objects begin to move on the table. Whereas static objects on the other hand would make the interaction experience more comfortable.

Finally, we introduced our participants to two robots, a dancing girl toy and our tabletop robot prototype – *Spidey* (figure 1) to discuss their views about tabletop robots. All our participants mentioned that the robots felt socially valid and engaging, "*not sure what exactly it is, but robots are more engaging – almost like comparing pictures and cartoon, of course cartoons are more fun*", "*spiders are scary, but even that I feel is more engaging*". Participants reflected that the robots' ability to take on various forms (via anthropomorphism or zoomorphism), and behave autonomously are the primary reasons for making interactions feel more engaging. One participant particularly mentioned that perhaps robots can be just as distracting as actuated tangibles. However, in case of tabletop applications designed for children the participant said that robots

will perhaps be more effective in terms of attracting their attention, turning the disadvantage of distraction to something useful. We also asked our participants to comment on the possible differences between a generic actuated TUI such as a moving marble, and a robot which beyond moving attempts to play a social assistive role. We mentioned that conceptually the actuation and action associated to movement can be the same for both the robot and the marble and asked our participants how the user experience and engagement may vary. The most common responses for this question highlighted the difficulties in associating what a moving marble (or any arbitrary shape) mean in its movement across the tabletop. On the other hand, with a known form, such as an animal, pet or human-like robots there is a common context, and some basic understandings and expectations that may allow to interpret the robotic movement within the task setting and facilitate deeper understanding and communication, possibly resulting in an improved user experience.

Conclusion and Future Work

In this report we presented our vision for using tabletop robots for enhancing user interactions on a tabletop. We also detailed the preliminary design and implementation of a tabletop robot prototype working on the Microsoft Surface. Focus group observation findings are also included, highlighting the possible advantages and disadvantages of tabletop robots relatively to other tabletop interaction mediator. Overall we believe that the concept of social tabletop robots holds promise in terms of furthering user engagement during interactions on a tabletop.

Our *Spidey* design is only a proof-of-concept prototype highlighting some abilities and advantages of a tabletop robot, as well as some of the design challenges involved. In the short term, we are planning to improve our *Spidey* prototype and address with it some valid task scenarios which would allow us to learn more about tabletop robots, explore their potential as social interaction assistants, and their future effect on user experience in tabletop interaction

References

[1] Forlizzi, J. How robotic products become social products: an ethnographic study of cleaning in the home. In Proc. *of the ACM/IEEE international conference on Human-Robot Interaction (HRI'07)*, 2007, 129-136.

[2] Goodrich, M. A. and Schultz, A. C. *Human-robot interaction: a survey*. Foundations and Trends in Human-Computer Interaction, 2007, 203-275.

[3] Guo, C., Young, J. E. and Sharlin, E. Touch and toys: new interaction techniques for interaction with a remote group of robots. In Proc. *of CHI'09*, 2009.

[4] Ishii, H. *The tangible user interface and its evolution*, Communications, 2008, 32-36.

[5] Krzywinski, A., Mi, W., Chen, W. and Sugimoto, M. I. RoboTable: a tabletop framework for tangible interaction with robots in a mixed reality framework. In Proc. *of the international Conference on Advances in Computer Entertainment Technology (ACE'09)*, 2009, 107-114.

[6] Leitner, J., Haller, M., Yun, K., Woo, W., Sugimoto, M. and Inami, Masahiko. IncreTable: a mixed reality tabletop game experience. In Proc. *of the International Conference on Advances in Computer Entertainment Technology (ACE'08)*, 2008, 9-16.

[7] Marshall, M. T., Carter, T., Alexander, J. and Subramanian, S. Ult-Tangibles: Creating Movable

Tangible Objects on Interactive Tables. In Proc. *of CHI'12*, 2012.

[8] Pangaro, G., Maynes-Aminzade, D. and Ishii, H. The actuated workbench: computer-controlled actuation in tabletop tangible interfaces. InProc. Of the 15th annual ACM symposium on User interface software and technology (UIST '02), 2002, 181-190.

[9] Poupyrev, I., Nashida, T and Okabe, M. Actuation and Tangible User Interfaces: the Vaucanson Duck, Robots and Shape Displays. In Proc. *of TEI'07*, 2007, 205-212.

[10] Scott, S. D. and Carpendale, S. *Guest editor's introduction: Interacting with digital tabletops*, IEEE computer graphics and applications 2006, 24-27.

[11] Shaer, Orit and Hornecker, E. *Tangible User Interfaces: Past, Present and Future Directions*. Foundations and Trends in Human-Computer Interaction, 2010, 1-137.

[12] Sultanum, N., Sharlin, E., Sousa, M. C., Miranda-Filho, D. N. and Eastick, R. Touching the depths: introducing tabletop interaction to reservoir engineering. In Proc. *of the ACM International Conference on Interactive Tabletops and Surfaces (ITS'10)*, 2010, 105-108.

[13] Sultanum, N., Somanath, S., Sharlin, E. and Sousa, M. C. "Point it, Split it, Peel it, View it": techniques for interactive reservoir visualization on tabletops. In Proc. *of the ACM International Conference on Interactive Tabletops and Surfaces (ITS'11)*, 2011, 192-201.

[14] Weiss, M., Schwarz, F., Jakubowski, S. and Borchers, J. Madgets: actuating widgets on interactive tabletops. In Proc. *of the 23rd annual ACM symposium on User interface software and technology (UIST'10)*, 2010, 293-302.