TangiWoZ: A Tangible Interface for Wizard of Oz Studies

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Abstract
Wizard-of-Oz (WoZ) is a very common methodology used by computer science researchers to test interfaces and interactions without implementing an entire system. In this late-breaking-work we present work exploring how tangible controls can help address the known issue of high cognitive load experienced by wizards. Our Tangible WoZ system is composed by a set of atomic modules that can be composed to meet a study's requirements. In addition to presenting the system design, we discuss our plans for a comparative study, and the extension of our work as a software and hardware framework, and collaborative repository of tangible modules.

Author Keywords
Wizard-of-Oz; HCI; Tangible Interfaces; Research Tools

ACM Classification Keywords
H.5.2 [User Interfaces]: Input devices and strategies (e.g., mouse, touchscreen); H.5.2 [User Interfaces]: Prototyping

Introduction
The vast majority of computer interfaces rely on sight. We may use haptic and proprioceptive cues to interact with the mouse and keyboard, but those actions are normally tied to feedback on the computer screen. Mobile phones have even lost their physical keys to gain display space. Display-

centricism diminishes our capability to keep track of our surroundings.

Researchers have long considered how tangible devices can assist computer users by providing information using our sense of touch [2], [12]. With such devices, it is possible to reduce the amount of visual attention paid to a computer screen.

Because HCI researchers are often most interested in interaction and not the underlying system implementation (including in cases where the proposed system would be hard to achieve with current technologies), a technique called Wizard of Oz (WoZ) is often employed in studies. The concept behind WoZ is to test the interface without a complete system implementation. To achieve this, a human (the "wizard") keeps track of the participant using the interface, and whenever an interaction is spotted the wizard uses software or other means to generate the appropriate response in the participant's interface.

One of the issues with the WoZ technique is the high cognitive demand on the wizard, as they need to keep track of the participant and at the same time be ready to select a quick and accurate response to any participant interaction. This issue is aggravated when researchers are using WoZ for mobile, whole-body, and/or gestural interactions as the wizard needs to track every move that the participant makes, in a physical environment that is often less constrained than a desktop computing setup.

In this work, we propose TangiWoZ, an approach intended to reduce the cognitive load on the wizard by providing a WoZ interface that requires little or no visual attention. We seek to answer the question: **will a tangible interface increase the wizard's awareness of user interactions and the study environment over a standard GUI approach, thus enabling more accurate simulation of system responses?** After considering related work, we present our TangiWoz implementation. We then outline our current study design and plans for a TangiWoz toolkit.

Related Work

The Wizard-of-Oz concept was first introduced by Kelley in 1984. In his work [6] he proposes an automated system for inputting appointments in a computerized calendar application. His work involved several iterations with participants during the implementation. Participants would interact verbally with the computer, unaware that another person was listening to them and manually adding their events in the calendar.

WoZ has since become a standard technique for testing novel interface concepts, and the interfaces of systems prior to or during development. In a recent example, Chen *et al* [1] used this methodology with paper prototypes of mobile applications (a wayfinding app, in one case). In their implementation, a camera recorded the paper prototype and broadcasted it to the participant's phone. The wizard converted the participant's touch interactions into manipulations of the paper prototype, giving the sense of a working (but still evidently unimplemented) application. In [8], Molin used WoZ to test and enhance an interface for a surgery robot. With the aid of WoZ it was possible to test the interface with prospective users early in development, and make quick on-demand changes to the interface.

This technique, however, is not perfect. The high demand on the wizard to provide fast and accurate responses to the participant actions creates a high load on the wizard as discussed in the literature [9]. HCI researchers have explored ways to mitigate this problem. Approaches include creating generic WoZ interfaces embodying best practices for target

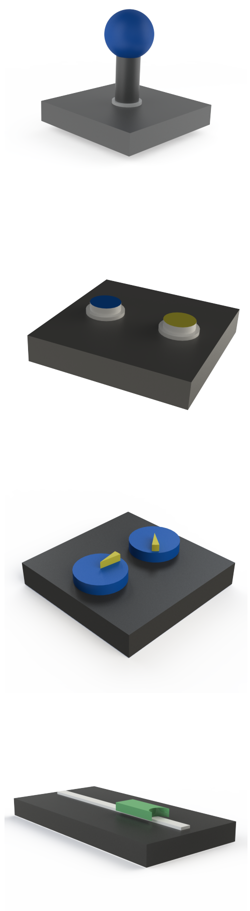

Figure 1: Four tangible modules: 2DOF joystick, push buttons, knobs and a slider.

domains (e.g., [10] for speech and language technologies), and using multiple wizards [9].

Tangible computing (and its advantages over more common modalities like mouse and touch) is an active research area. Fitzmaurice's early work [5] explored the advantages of specialized graspable interfaces over GUI, providing evidence that a specialized tangible interface can outperform a mouse-based GUI. A similar concept is explored in Lucchi *et al's* work [7] where tangible interfaces were found to be more effective for spatial tasks compared to touch in several factors such as faster to use, more spontaneous, persistence and extra feedback such as tactile and audio. There is however a caveat for tangible interfaces: they have to be designed for a specific task and creating a good design is challenging because it requires a diverse skill set.

It is important for the wizard to be aware of the entire WoZ setup, to be able to provide accurate responses. Endsley introduced [3] and further evaluated [4] the Situation Awareness Global Assessment Technique (SAGAT). SAGAT is an intrusive awareness technique based on a set of previous established queries regarding key aspects of the system that participant is using. At determined time points the system freezes and the screens are blacked-out; the participant then is introduced to the questionnaire. A summary of this work is provided by Wickens in [11]. We propose to use SAGAT to assess the situational and interface awareness of wizards using our TangiWoZ prototype, presented in the next section.

Tangible WoZ

TangiWoZ is composed of two elements: a set of tangible widget "boxes", that can be combined into a single interface according to researcher needs, and a software API for communicating with the tangible interface. Each box is an

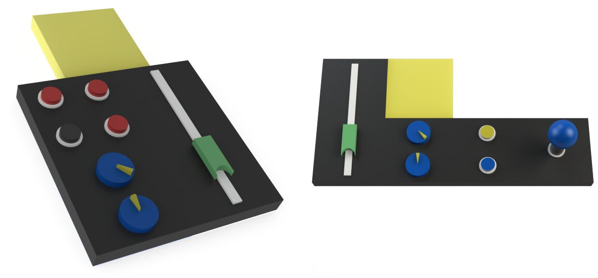

Figure 2: Two possible arrangements for a TangiWoZ interface. Left: three box assembly: 4-button box, 2-dial box, and slider box. Right: four box assembly: slider box, 2-dial box, 2-button box, and joystick box.

atomic unit containing one or more tangible widgets such as sliders, push buttons, knobs, etc.

This approach creates a space-multiplexed input[5] for the wizard, which we believe can reduce their reaction time. In our approach each button has its function hence the wizard does not need to look at the interface to use it, as opposed to a mouse and GUI, therefore potentially increasing his awareness of the participant. Design challenges can be mitigated by researchers sharing their own successful boxes prototypes in a shared repository.

The final tangible interface is assembled by the researcher according to the needs of his specific project. We believe that this is feasible since many HCI research laboratories have a 3D printer and students capable of doing simple electronics. Figure 1 depicts a rendered set of atomic elements, and Figure 1 shows two possible combinations of tangible modules.

Our prototype uses a central microcontroller (we use an

Arduino) with multiple inputs for the tangible modules. It is responsible for collecting module interactions and transmitting them via USB or WiFi. We use Open Sound Control (OSC) as the communication protocol. It is a text-based protocol with broad support across different programming environments, devices, and target applications [13]. This allows mocked up applications to respond to events coming from TangiWoz directly (a mobile application for example), or indirectly through intermediary WoZ control software (for example, controlling components in a smart home).

The tangible modules can be digital or analog. Analog components such as sliders and knobs are individually connected to the the microcontroller's analog-to-digital converter (ADC). Buttons are connected directly to digital inputs to save ADC channels. Digital modules *e.g. accelerometers, gyroscopes, and encoders* communicate with the micro-controller trough the I^2C bus; this allows for custom tangible modules with more exotic sensors to be added as they only need to talk I^2C. A discovery routine in the microcontroller takes care of finding new devices connected to it as long as there is no address collision.

Figure 3 shows an overview of the prototype schematic. The elements inside the red box are implemented as a framework and should work out-of-box for the researcher who wants to create a tangible WoZ interface. The researcher has only to define which tangible modules they want to use for their study and connect them to the control box.

We use a 3D printer to create the boxes that house the individual widget assemblies. These assemblies can be as basic as a single button or slider, or can themselves be a composition of widgets intended to support a certain abstract control. For example, a toggle button and slider can be mapped to control of a graphical filter, where the slider controls the intensity of the filter and the toggle button turns

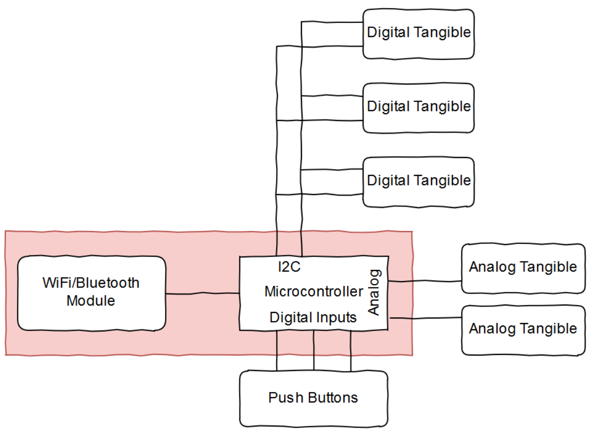

Figure 3: Schematic of the TangiWoZ prototype system. Implementation for the elements inside the red squares are provided by the framework.

the filter on or off. The boxes are attached to each other using Velcro. The result is a 1D or 2D control panel for the wizard to use, with one space dedicated to the microcontroller. Because the boxes interlock with each other, this facilitates both composition of widget sets and reconfiguration of widget locations. The box boundaries provide another haptic cue for the wizard when they need to access a particular control in a panel. It is also possible to print texture on individual boxes to assist in disambiguation.

The number of modules that can be used at the same time depends on the type of the selected microcontroller. For example, an Arduino UNO can take up to 5 Analog tangibles and 13 push-buttons where an Arduino Mega is capable of 54 push-buttons and 16 analog tangibles. Digital tangibles share the same bus and the amount is limited by the I^2C specification to 128 digital tangibles. Each box has a raceway underneath that permits wiring for individual analog widgets to connect directly to the microcontroller, and a passthrough connector to chain digital widgets (since they share a single bus).

TangiWoZ Integration
With the tangible boxes arranged and connected to the computer, the researcher still needs to program the software he wants to control. TangiWoZ broadcasts information from the moment it is turned on, but it is up to the software to receive the messages and interpret them accordingly.

Messages are sent in three different groups: *buttons, digital and analog*. Each message consists of the current readings for the input channels. The readings are ordered from sensor 1 to *n*, as indicated in the input connections in the TangiWoZ microcontroller. Input channels are identified using default device IDs and device type, but the OSC message includes an optional programmer-defined name with each device, to facilitate programming. These names are defined by sending an OSC message to the microcontroller with a (deviceID, name) pair.

TangiWoZ does not provide any data interpretation from the boxes' readings. We believe this provides needed flexibility for WoZ control. This also keeps TangiWoZ open to new tangible widgets that might behave differently than what we have anticipated.

Discussion
We envision that using tangible controls for WoZ is well suited for studies that make use of the physical environment and/or the user's body. This includes gesture recognition, distributed or mobile interactions, and whole body interaction. In such scenarios it is difficult for the wizard to keep track of the participant's hands, their position, and the state of the environment, all while looking at a computer/tablet screen at the same time. With a specialized tangible interface we believe that the researcher will not need to look away from the participant and their surroundings—operating the WoZ interface solely using haptic and proprioceptive cues—, and that this will lead to more accurate and responsive simulation of user interaction.

Another advantage is reusability; it is not common for multiple WoZ experiments to share the same control interface, however, because TangiWoZ is physical and modular, researchers can use it in different studies by re-arranging components into the desired scheme.

Both GUI WoZ and tangible WoZ require significant training with the interface before running the study with real participants. One reason is to reduce learning effects on the part of the wizard, which can invalidate collected data, especially for the first set of participants. As argued in the literature, tangible interfaces may be easier to learn [7] than GUI interfaces; this may reduce the training time of wizards prior to a study.

Future Work
We are planning to release an open framework for TangiWoZ, which will include fabrication and assembly instructions, software libraries, and sample applications. Our aim is to create a repository where other researchers contribute their own atomic modules, and use others' designs in their own research, further decreasing development time. Possible future technical innovations include configurations for mobile use, and modifications for non-WoZ applications.

We believe that TangiWoZ can outperform a GUI-based wizard interface in the scenarios described, but this requires evaluation. We have designed a study to evaluate this interface against a GUI approach. In it we conduct a fake experiment where the actual participant will be our wizard (called "ultimate participant" here) while a fake participant (a confederate) performs experimental tasks. As discussed above, we believe that our interface is well-suited for over-the-air, mobile, and whole-body interaction studies; our fake experiment involves both gestural interaction and tracking the subject's orientation around a physical model, with system responses (in this case, projection-mapped elements on the model) controlled by the ultimate participant.

Our study will explore the following research questions:

- **Will a tangible interface enable a wizard to provide faster response times?**
- **Can the wizard be more aware of the participant actions if he is using our tangible interface over a GUI one?**

Participants will be informed prior to the trials that they will be evaluated according to response time but also by their awareness of participant actions, thus biasing all the participants towards increased awareness, which is expected for wizards in WoZ studies. Response times will be captured by the time span between the fake participant's action and the ultimate participant's response by using video cameras synchronized with the tangible and GUI interfaces. The awareness evaluation protocol follows the SAGAT guidelines proposed by [4].

REFERENCES

1. Kevin Chen and Haoqi Zhang. 2015. Remote Paper Prototype Testing. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15)*. ACM, New York, NY, USA, 77–80. DOI:http://dx.doi.org/10.1145/2702123.2702423
2. Victor Adriel de J. Oliveira and Anderson Maciel. 2014. *Assessment of Tactile Languages as Navigation Aid in 3D Environments*. Springer Berlin Heidelberg, Berlin, Heidelberg, 104–111. DOI: http://dx.doi.org/10.1007/978-3-662-44196-1_14
3. M.R. Endsley. 1988. Situational awareness global assessment technique (SAGAT). *Proceedings of the National Aerospace and Electronics Conference* (1988), 789–795.
4. M.R. Endsley. 2000. Direct measurement of situation awareness: Validity and use of SAGAT. *Situation Awareness Analysis and Measurement* (2000).
5. G.W. Fitzmaurice and W. Buxton. 1997. An empirical evaluation of graspable user interfaces: towards specialized, space-multiplexed input. *Proceedings of the SIGCHI conference on Human factors in computing systems* 1 (1997), 43–50. DOI: http://dx.doi.org/10.1145/258549.258578
6. J. F. Kelley. 1984. An Iterative Design Methodology for User-friendly Natural Language Office Information Applications. *ACM Trans. Inf. Syst.* 2, 1 (Jan. 1984), 26–41. DOI: http://dx.doi.org/10.1145/357417.357420
7. Aurélien Lucchi, Patrick Jermann, Guillaume Zufferey, and Pierre Dillenbourg. 2010. An Empirical Evaluation of Touch and Tangible Interfaces for Tabletop Displays. In *Proceedings of the Fourth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '10)*. ACM, New York, NY, USA, 177–184. DOI: http://dx.doi.org/10.1145/1709886.1709917

8. Lennart Molin. 2004. Wizard-of-Oz Prototyping for Co-operative Interaction Design of Graphical User Interfaces. In *Proceedings of the Third Nordic Conference on Human-computer Interaction (NordiCHI '04)*. ACM, New York, NY, USA, 425–428. DOI: http://dx.doi.org/10.1145/1028014.1028086
9. Daniel Salber and Joëlle Coutaz. 1993. A Wizard of Oz Platform for the Study of Multimodal Systems. In *INTERACT '93 and CHI '93 Conference Companion on Human Factors in Computing Systems (CHI '93)*. ACM, New York, NY, USA, 95–96. DOI: http://dx.doi.org/10.1145/259964.260126
10. Stephan Schlögl, Anne Schneider, Saturnino Luz, and Gavin Doherty. 2011. Supporting the Wizard: Interface Improvements in Wizard of Oz Studies. In *Proceedings of the 25th BCS Conference on Human-Computer Interaction (BCS-HCI '11)*. British Computer Society, Swinton, UK, UK, 509–514. http://dl.acm.org/citation.cfm?id=2305316.2305408
11. Christopher D. Wickens. 2008. Situation Awareness: Review of Mica Endsley's 1995 Articles on Situation Awareness Theory and Measurement. *Human Factors: The Journal of the Human Factors and Ergonomics Society* 50, 3 (2008), 397–403. DOI: http://dx.doi.org/10.1518/001872008X288420
12. L. Winfield, J. Glassmire, J. E. Colgate, and M. Peshkin. 2007. T-PaD: Tactile Pattern Display through Variable Friction Reduction. In *Second Joint EuroHaptics Conference and Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems (WHC'07)*. 421–426. DOI: http://dx.doi.org/10.1109/WHC.2007.105
13. Matthew Wright, Adrian Freed, and Ali Momeni. 2003. OpenSound Control: State of the art 2003. In *Proceedings of the 2003 Conference on New Interfaces for Musical Expression (NIME-03)*. 153–159.