TortillaBoard: Wearable Sleeve for Electronics Prototyping

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Abstract
Exploration into wearable technology can bring about emergent interactions between body, device, and culture. However, to explore these interactions prototyping tools need to allow interactive devices to be relocated and tested on the body. TortillaBoard is a prototyping tool enables designers to add interactive widgets to a flexible wearable sleeve. The sleeve allows physical widgets to be attached, remote controlled, and be relocated throughout the sleeve. In this note, I present the design of TortillaBoard and potential avenues for future work.

Author Keywords
Prototyping, Wearable Technology, Breadboard, IOT

ACM Classification Keywords
H.5.2: User Interfaces

Introduction
Wearable technology can enhance our abilities, watch our lives, and are a means of self-expression. Creating such devices requires consideration for both the aesthetics and functionality. A common approach is to sketch the design as a low fidelity prototype and implement those interactions into a higher fidelity prototype, refining the design in the process. Low fidelity prototyping allows designers to explore more

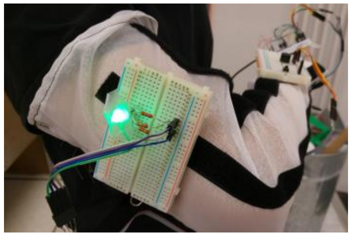

Figure 1: A wearer testing their internet connected LED widget with the TortillaBoard.

opportunities for different I/O devices as they require less commitment (time, effort, and attachment).

However, wearable technology design requires designers to think about the interplay between the body and interactive device. The location of where the device is placed is important as it determines how interactions work and the cultural appropriation of the device on that area of the body. For example, a button may be more approachable if it were on the shoulder than on the chest.

This consideration might not be discovered until the actual implementation of the device which can be costly. Current electronic components are ill-fitting and require excessive wiring. Currently tools like Arduino LilyPad [1] are low cost, low profile, sewable microcontrollers but they are difficult to work with since they require commitment to a desired body location.

TortillaBoard is a wearable technology prototyping sleeve that allows on-body electronics prototyping. It is a fabric sleeve retrofitted with various mechanisms for attaching breadboards and wiring to the sleeve. It features a modular design that allows all components to be relocated using Velcro. The devices are then laid on the flattened sleeve (figure 3) and connected to the conduit to a WiFi-enabled microcontroller. Once the components have been programmed, the designer can zip up the sleeve and test their design on their body.

In this note, I will explore the design of the TortillaBoard, how it enables low fidelity on-body prototyping, and future work in wearable technology.

Related Work

Current work in wearable technology explores the role of clothing in relation to style and personal expression. Shape changing scarves [6] and robotic apparel [5] are dynamic clothing that can be data driven from personal data. Fashion designers are capable of interaction design as it pertains to textiles and personal style when it comes to novel textile technology such as Ebb [2]. These novel technologies are examples of devices that need to be tested on the body to understand their relationship to the wearer's personal space and how they become culturally appropriated.

In prior work, Phidgets [3] enabled users by lowering the entry barrier to physical interaction design through easily programmable, modular, plug and play components. In this model, users were focused on designing interaction without needing to implement hardware. A step further was taken by d.tools [4], an interactive programming interface that featured programming through interactive storyboards. This further reduces the entry barrier as designers need not to know to program to make interactive physical interfaces. Both approaches focus users on interaction design thinking rather than hardware implementation.

Other approaches take an all-in-one digital fabrication tools (e.g. Autodesk Circuits) to creating domain specific objects. PaperPulse [7] takes the approach of digitally designing complete electronic circuits that are ready to print. Maker's Marks [8] is an approach that allows users to use tags to define interactive features in a 3D model. In both approaches, including tools that support automated fabrication of electronic devices, they require object planning which is a process that is disconnected from the body being designed for.

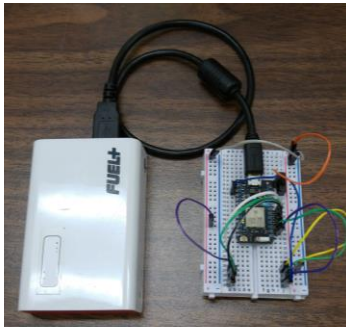

Figure 2: A Photon microcontroller connected to a portable USB battery.

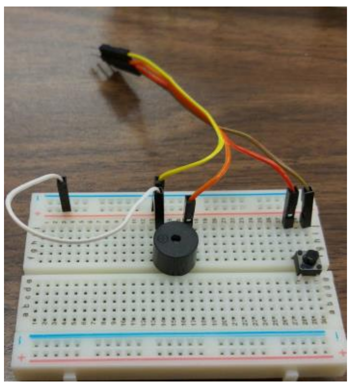

Figure 4: A piezo speaker music player widget. Plays music when the button is pressed.

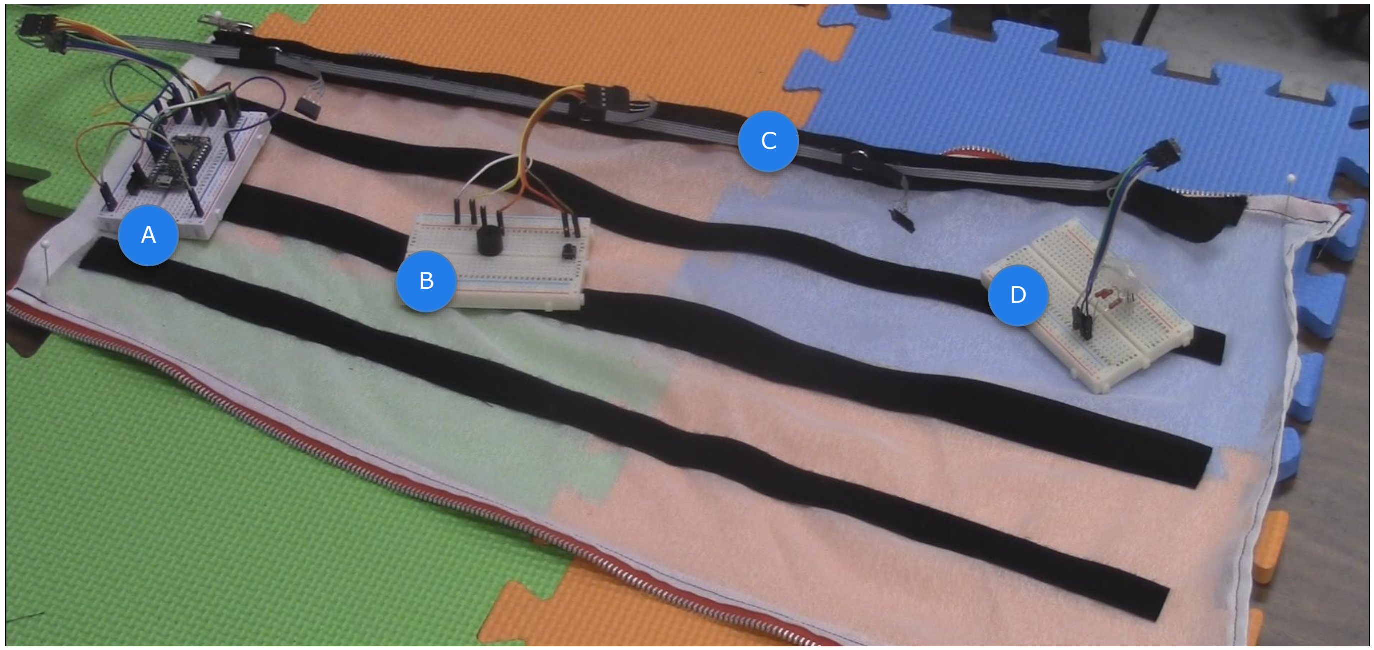

Figure 1: TortillaBoard being used to layout various widgets. (a) Photon microcontroller controls the various widgets. (b) A piezo speaker configured to play a sound on a physical button input. (c) A removable data bus attached via snaps connects widgets to the microcontroller. (d) An internet controlled RGB LED widget.

Design

TortillaBoard seeks to address the issue several issues in wearable technology design. Enabling on-body exploration through physical sketching with modular widgets. The design was inspired by breadboarding, a quick-and-dirty solderless electronics prototyping system.

TortillaBoard was built using a see-through curtain fabric with minor stretching abilities. Velcro is placed throughout the sleeve to allow widget mounting. This allows widgets to be attached to the sleeve on any position and relocated as needed. Designers can then test different locations for their widgets along the arm without the need to sew on electronics.

The sleeve features a zipper that allows designers to switch between a flat-layout and a wearable sleeve layout. With the flattened layout, designers can lay out their components and create their widgets. Once the widgets are properly connected through the bus system, the sleeve can then be zipped up and be ready to wear. The zipper allows work to be done on a table (2D) which can be easier to work with than in 3D

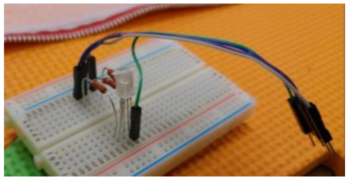

Figure 5: An internet controlled RGB LED widget

(arm). Once worn, the designer can easily adjust the widget locations as needed.

A removeable data bus (figure 3c) design allows designers to quickly connect their widgets to a microcontroller. This bus can connect two independent devices on either the upper and lower sections of the arm. A problem in wearable prototyping is routing the wires needed to communicate to each widget. By providing infrastructure to route all connections, the bus makes it easy to avoid tangling wires and relocate widgets along the whole arm.

Figure 6: Wearing the Tortillaboard prototype. At this point, the user can relocate their widgets as they see fit.

To support testing with bodily movement, a WiFi-enabled microcontroller (Photon) was used (figure 2). It can be programmed and controlled remotely through the web IDE. Using this method, the sleeve allows designers to remote control widgets through a web interface. Or even be data driven by live events on the internet.

Users will need to explicitly place the photon and a USB power supply use the sleeve as it is a key challenge in designing a wearable device. This makes the designer responsible for factoring in power and microcontroller constraints for their devices.

Limitations

The TortillaBoard can only support two independent devices running simultaneously on the sleeve. Additionally, the bus only allows one widget per upper and lower section of the arm.

Additionally, the zipper section has no Velcro which lacks a section of the arm that cannot have widgets be placed on.

Future Work

In future work, I plan to make improvements to the design of TortillaBoard.

While each widget is a mini-breadboard, I envision these as modular badges that are completely functional, standalone, and plug-and-play devices. Like Phidgets [3], each widget would be attached to the sleeve be universally compatible with the system. Furthermore, these widgets need to be low profile and physically flexible to enable exploration into as many body locations as possible.

Ideally in future iterations, the bus will be able to support many more devices at the same time and can be swapped out for different bus designs for different applications. For example, a bus that features a high current power rail can be useful for supporting large arrays of LEDs.

A potential avenue for this project is to explore the transitioning between this system and higher fidelity sew on devices. The sleeve could act as a low-level layer for electronics, but can then interface with higher fidelity prototyping for clothing design. Devices like Arduino LilyPad [1] can be used to aid designers to shifting into a high-fidelity prototype. This can allow designers to explore how technology interacts with different textiles and create novel effects.

Since on-body interactions can bring about new emergent interactions through their relationship to the body, we can support Wizard of Oz prototyping. Through a web API, the system can be controlled remotely over the internet which can then serve as an interface for a wizard. It is a matter of abstracting device logic and mapping those to high level behaviors which a wizard can output. We can support this by making an easy to program state-diagramming interface much like d.tools [4].

Finally, we can consider extending this prototype to other parts of the body such as the torso. As a first step, TortillaBoard was designed for the arm to understand potential design challenges that we may face when prototyping for other parts of the body. Having low profile badges and flexible parts may become paramount to prototyping on other parts of the body.

Conclusion

TortillaBoard is a flexible sleeve that enables low fidelity prototyping on the arm. The sleeve allows designers to explore on-body interactions through relocatable widgets and modular design. In future work, we hope to improve the design to feature modular low-profile widgets; interface with higher fidelity materials; and enable design on other parts of the body.

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