YAWN: Yet Another Wearable Toolkit

Jan Thar[1], Sophy Stönner[1], Florian Heller[2], Jan Borchers[1]

[1]RWTH Aachen University
52056 Aachen, Germany

{lastname}@cs.rwth-aachen.de

[2]Hasselt University - tUL - Flanders Make
Expertise Centre for Digital Media
Diepenbeek, Belgium
florian.heller@uhasselt.be

ABSTRACT

Wearable toolkits simplify the integration of micro-electronics into fabric. They require basic knowledge about electronics for part interconnections. This technical aspect might be perceived as a barrier. We propose YAWN, a bus-based, modular wearable toolkit that simplifies the interconnection by relying on a pre-fabricated three-wire fabric band. This allows quick reconfiguration, ensures washability, and reduces the number of connection problems.

ACM Classification Keywords

H.5.2. Information Interfaces and Presentation (e.g. HCI): User Interfaces: Prototyping

Author Keywords

smart textiles; wearable computing; construction kits.

INTRODUCTION

Toolkits like Arduino, mbed, etc. try to lower the level of knowledge required to program a microcontroller. The same applies to wearable toolkits, like the LilyPad [3], which also removes the overly technical look by moving away from the breadboard to interactive fabrics and fashion. These factors contribute to the success of the LilyPad platform and the ones it inspired, such as the Adafruit Flora [1] and the Arduino Gemma[2]. One aspect the existing wearable platforms did not abstract is the logic behind the wiring. To address this issue we propose YAWN, a bus-based, modular wearable microcontroller toolkit that uses the same clip-based connector for all its components. The bus consists of three fabric lines, providing both power supply and communication. We created a total of 45 modules for a variety of applications, reaching from a simple LED to a GPS receiver with a form factor of 13×20mm for small modules and 21×20mm for bigger ones.

RELATED WORK

The original LilyPad [3] got rid of the rigid PCB used in Microcontroller toolkits like Arduino and uses electronic components on a textile circuit board, which could be then sewn through onto larger textile circuits. The more common LilyPad Arduino [4], Adafruit Flora and Arduino Gemma use a rigid PCB with holes that are used as connectors. The connection to the textile is made by wrapping conductive yarn around the conductive pads around the holes and stitching it to the textile. Fabrickit [5] uses snap buttons for electrical connections, for which the button has to be either soldered or sewn onto the textile. Similarly, iCatch[10] uses snap buttons to connect PCBs with a textile bus system, using I^2C to communicate between the modules. Scheulen et al. [11] propose a connection between textiles with magnets attached to the textile using conductive glue. MakerShoes [8] proposes a system of hexagonal modules which are attached with magnets and powered from the bottom, while contact areas on the side are used for communication between neighboring modules. A simplified wiring is later used in ReWear[7]. All Shiny Lights [6] finally uses a combination of clip-on electronic and gluing for the connection between textile and rigid PCB [9]. The user still needs to understand what connections need to be made. Our system addresses this problem with a modular approach and a bus-based connection of the modules.

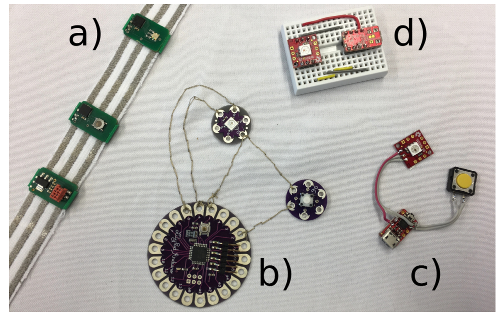

Figure 1. Basic circuit with one button and an LED made with a) YAWN, b) LilyPad, c) Soldered components d) Breadboard.

SYSTEM OVERVIEW

YAWN uses a 3D-printed clip mechanism, which presses a PCB on a three-wire bus-system. On each PCB, a dedicated MSP430G2553 micro controller is used for a unified communication over the bus system, independent of the special I/O components on the PCB.

The bus can be made of a flexible PCB, or be embroidered or woven into textile using conductive thread. The parallel connection enables the user to add or remove modules without changing the underlying bus system and prevents the system from a complete failure if one of the modules looses its connection. Based on these considerations, we decided to use the standard serial connection, but reducing it to one wire by using a combined RX/TX line. The microcontroller on each module is listening for signals on the DATA line with its hardware serial read pin, and switches to a software serial write on this

ISWC '18 October 8–12, 2018, Singapore, Singapore

ACM ISBN 978-1-4503-5967-2/18/10.

DOI: https://doi.org/10.1145/3267242.3267280

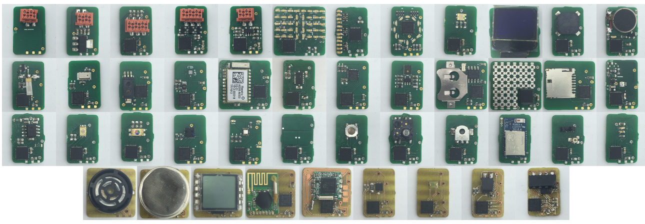

Figure 2. The modules of the toolkit so far. From left to right - Top row: Connector, Voltage regulator, I/O with Pull-up, I/O with switch, Amplifier, LED Matrix, LED Bar, LED Circle, RGB LED, OLED, Speaker, Vibration. Second row: Air Flow, Pressure, Humidity, Temperature, GPS, Acceleration+Compass, Acceleration+Compass+Gyro, Microphone, RTC, Prototyping, SD, Field sensor. Third row: Dual Daylight, Brightness, RGB Sensor, Distance, Gesture, Touch pad, Button, Joystick, Encoder, BLE, IR-Transceiver, IR-Remote. Bottom (Deprecated): Ultrasonic distance, Gas, LCD, RFM70, Radio, Acceleration, Micro vibration sensor, DC driver, Stepper driver.

pin if the controller needs to respond. The user just needs to program a master module, which could theoretically also be independent of the toolkit itself and just connected to the bus system, as long as the correct baud rate (9600 baud) and voltage level (3.3V) is used. Communication with the modules is done using commands similar to the Arduino commands, e.g., moduleRead(accelerometer, 1, x) or moduleWrite(bargraph, 7, 5, HIGH), with parameters identifying type, ID, and function as well as values to be set.

The bottom layer of the PCB connects to the textile, while microcontroller and I/O circuit are placed on top. The one-sided SMD mounting is suitable for automatic assembly, but can also be produced in a Fab Lab or at home. For stronger adhesion the 3D-printed clip has three elevated pads for pressing the corresponding wires against the contact areas on the PCB.

We developed a number of modules based upon daily use and common modules which exist for the Arduino. We reached a 13×20mm footprint for most modules, and use a 21×20mm board for those that require more/larger components or more complex circuits. Bigger ones like RFID sensors or solar cells can be connected to the bus structure using an I/O module. A complete overview of the modules can be found in Figure 2.

YAWN IN USE

To evaluate the benefits of this toolkits we compared the setup of a basic circuit with one RGB-LED and a button made with YAWN, LilyPad, a wired and soldered setup, and a breadboard version (Fig. 1). Programming effort is similar with each system. With just having to clip the modules on the 3-wired textile band, a setup with YAWN is even faster than making a setup with a normal breadboard and additionally, the bus system reduces possible wiring errors While the LilyPad system stimulates an artistic integration through embroidery, YAWN is intended to be hidden under a textile surface. Furthermore, the clip system allows easy modification and reuse as well as removing the electronics before washing. The clip prevents relative movement between the PCB and the textile band.

SUMMARY

In this paper we described the hardware system of YAWN, a wearable toolkit for effortless prototyping. We showed that we can integrate many of the common sensors and actuators known in the Arduino world on small modules. The proposed clipper mechanism works reliably for daily use, while the communication interface is kept as simple as possible. Integration of the bus system into clothing is simple (integrating one textile band), while the parallel bus structure allows modifications by adding, removing, and replacing components.

ACKNOWLEDGMENTS

This project was funded by the German Federal Ministry of Education and Research under the project "Personal Photonics" (Grant 13N14065) and by the imec ICON project SeRGIo.

REFERENCES

1. Adafruit. Flora. `https://www.adafruit.com/product/659`
2. Arduino. Gemma. `https://www.arduino.cc/en/Main/ArduinoGemma`
3. Leah Buechley, Mike Eisenberg, Jaime Catchen, and Ali Crockett. 2008. The LilyPad Arduino: Using Computational Textiles to Investigate Engagement, Aesthetics, and Diversity in Computer Science Education. In *CHI '08*. DOI: `http://dx.doi.org/10.1145/1357054.1357123`
4. Leah Buechley and Benjamin Mako Hill. 2010. LilyPad in the Wild: How Hardware's Long Tail is Supporting New Engineering and Design Communities. In *DIS '10*. DOI: `http://dx.doi.org/10.1145/1858171.1858206`
5. FabrickIt 2016. Wearable Electronic Modules. `http://www.fabrick.it`
6. Fraunhofer IZM. 2014. All Shiny Lights. `http://2014.wearit-berlin.com/party/fraunhofer-institut/`
7. Majeed Kazemitabaar, Liang He, Katie Wang, Chloe Aloimonos, Tony Cheng, and Jon E. Froehlich. 2016. ReWear: Early Explorations of a Modular Wearable Construction Kit for Young Children. In *CHI EA '16*. DOI: `http://dx.doi.org/10.1145/2851581.2892525`
8. Majeed Kazemitabaar, Leyla Norooz, Mona Leigh Guha, and Jon E. Froehlich. 2015. MakerShoe: Towards a Wearable e-Textile Construction Kit to Support Creativity, Playful Making, and Self-expression. In *IDC '15*. DOI: `http://dx.doi.org/10.1145/2771839.2771883`
9. Torsten Linz, Christine Kallmayer, Rolf Aschenbrenner, and Herbert Reichl. 2005. Embroidering electrical interconnects with conductive yarn for the integration of flexible electronic modules into fabric. In *ISWC '05*. DOI: `http://dx.doi.org/10.1109/ISWC.2005.19`
10. Grace Ngai, Stephen C.F. Chan, Vincent T.Y. Ng, Joey C.Y. Cheung, Sam S.S. Choy, Winnie W.Y. Lau, and Jason T.P. Tse. 2010. I*CATch: A Scalable Plug-n-play Wearable Computing Framework for Novices and Children. In *CHI '10*. DOI: `http://dx.doi.org/10.1145/1753326.1753393`
11. Klaus Scheulen, Anne Schwarz, and Stefan Jockenhoevel. 2013. Reversible contacting of smart textiles with adhesive bonded magnets. In *ISWC '13*. DOI: `http://dx.doi.org/10.1145/2493988.2494338`