Make This! Introduction to Electronics Prototyping Using Arduino

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ABSTRACT

This course is a hands-on introduction to interactive electronics prototyping for people with a variety of backgrounds, including those with no prior experience in electronics. Familiarity with programming is helpful, but not required. Participants learn basic electronics, microcontroller programming and physical prototyping using the Arduino platform, then use digital and analog sensors, LED lights and motors to build, program and customize a small *paper robot*.

CCS CONCEPTS

• **Human-centered computing** → *Human computer interaction (HCI)*; *Interactive systems and tools*; *Interface design prototyping*; • **Computer systems organization** → *Embedded systems.*

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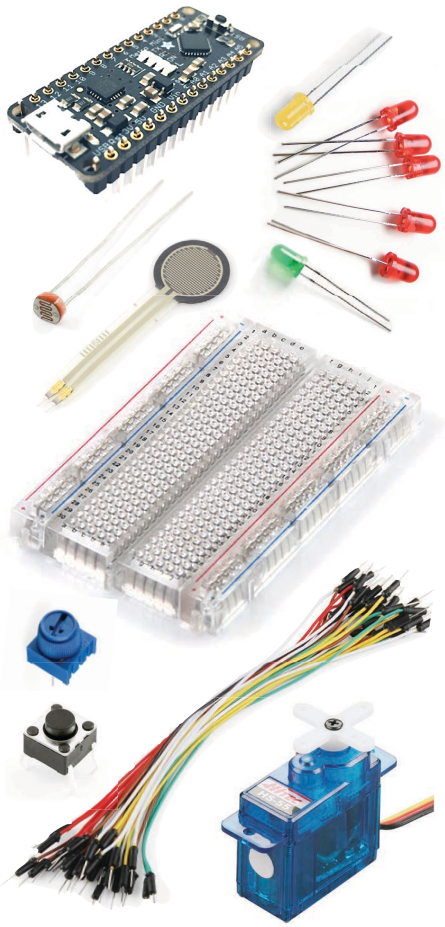

Figure 1: The course's components kit includes, from the top, an Arduino microcontroller board, various colored LEDs, light sensor, force sensor, breadboard, potentiometer, pushbutton, jumper wires, and servo motor.

KEYWORDS

Interaction design; prototyping; embedded systems; Arduino; robot.

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BENEFITS & LEARNING OBJECTIVES

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It is intended for artists, designers, engineers, researchers and hobbyists interested in creating interactive objects or environments. Using this platform, the course will present do-it-yourself software and hardware development to the CHI community, and provide the broader community with basic skills and awareness of the tools and technologies that are core to ubiquitous, physical and wearable computing, interactive device design and related topics in HCI. With Arduino's popularity as a teaching platform, the course will also be useful to instructors considering expanding their teaching portfolios to include basic electronics as a platform for more specific HCI topics.

COURSE CONTENT

Course topics and content introduce participants to:

- Fundamental electronics concepts: voltage, current, resistance, Ohm's Law and voltage dividers.
- Basic electrical components: wires, resistors, capacitors, breadboards and power supplies.
- Embedded electronics: microcontrollers, sensors, actuators and LEDs.
- Physical prototyping techniques: choice of materials, joining parts, internal fixturing.

To expose participants to a broad range of electronics and prototyping materials, we have curated a kit that includes a variety of sensors, actuators and displays, shown in Figure 1. Over the course of the session, students will learn to:

- Select from the many variants of Arduino hardware the system that best suits their needs.
- Setup their laptops to communicate with, and upload firmware to, Arduino prototyping boards.
- Navigate the bountiful selection of libraries in the Arduino programming environment.
- Keep abreast of changes in the rapidly developing hardware and software tools environment.

To provide a clear sense of purpose, as well as a fun takeaway, we guide participants through a design activity of creating an interactive *paper robot* of their own devising, using embedded microcontrollers, analog sensors, actuators and lightweight prototyping material. We provide a basic design, shown in Figure 2, which participants can readily modify or extend. In this way, they can build something that works, and still also adapt the design to make it uniquely their own.

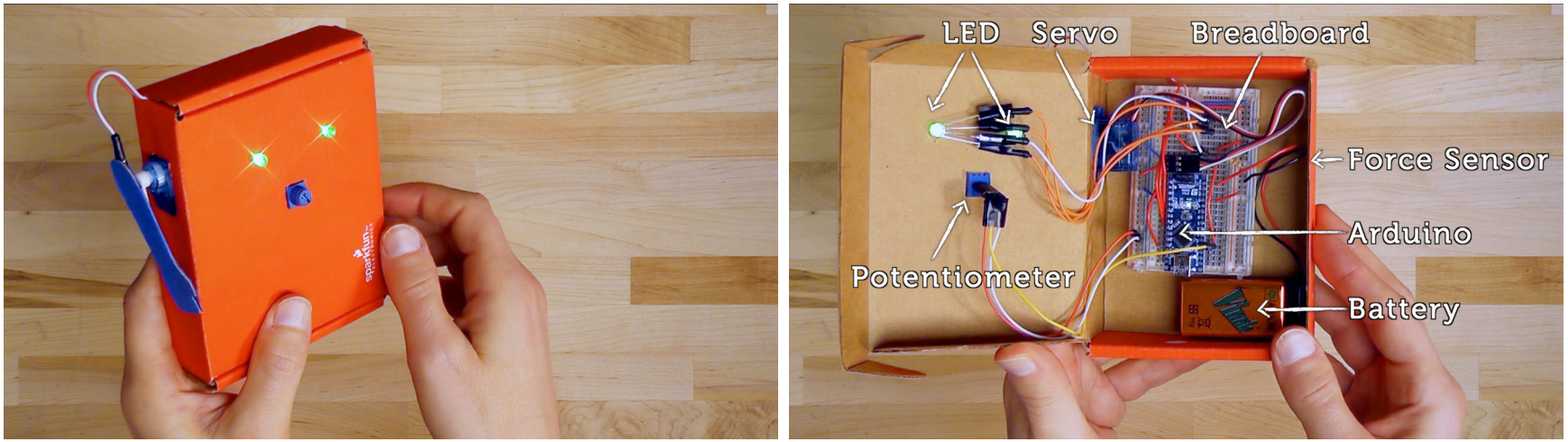

Figure 2: The basic paper robot design. On the left, turning the nose potentiometer changes the color of the eyes' LEDs; squeezing the hand triggers the servo to wave the arm. On the right, components include LEDs, sensors, actuators, microcontroller and battery.

AUDIENCE & PREREQUISITES

The course is intended for an audience that wants to know more about, or already has a passing familiarity with, the tools, techniques and resources for electronics prototyping. Participants should have sufficient technical background to download, install and run the Arduino programming environment on their laptops, and be able to physically handle (or have assistance handling) rather small electronic components, such as jumper wires, resistors and LEDs. Beyond that, no electronics or programming experience is required, although familiarity with programming methodologies, or languages such as C/C++, will be helpful.

We have experience running variants of this course, both at and outside of CHI, for audiences that include beginners and advanced students. We have found that a) providing a tutorial, with instructors on-hand to coach one-on-one, allows participants to move at their own pace, and b) interspersing open-ended design opportunities throughout the tutorial allows beginners to spend more time learning the basics, and advanced students to spend more time exploring alternatives and unique variations.

PRESENTATION FORMAT

The course is presented as an interleaving of brief interactive lectures and guided individual exercises. The first session introduces basic electronics, then moves on to electronics and physical prototyping.

The second session introduces the paper robot design activity, and provides participants with an opportunity to apply the concepts and tools presented in the earlier session.

INSTRUCTOR BACKGROUND

- David Sirkin is Executive Director for Interaction Design Research at the Center for Design Research at Stanford. He teaches design methodology, and studies human-robot and autonomous vehicle interaction. He received his PhD from Stanford, and Masters degrees in EECS and Management from MIT.
- Nikolas Martelaro is a researcher at Accenture Technology Labs. His research includes creating new tools to support interaction design with interactive and intelligent objects. Additionally, he is interested in how new tools shape how designers work. Nik holds a PhD in ME Design from Stanford.
- Wendy Ju is an Assistant Professor of Information Science with the Jacobs Technion-Cornell Institute at Cornell Tech in NYC. She received her PhD from Stanford and her Masters from the MIT Media Lab, and is the author of *The Design of Implicit Interactions*, available from Morgan and Claypool.

RESOURCES

For those interested in learning about the Arduino platform, the primary resource is the Arduino website, where you can find a store to purchase prototyping boards and kits, download the IDE, learn about the programming language and join a user support forum.

While this course is built upon Arduino, there are other platforms for electronics prototyping worth noting, such as PIC by Microchip, and BeagleBone by BeagleBoard.

For electronics and physical prototyping more broadly, several online communities—including Instructables, Make, and LifeHacker—feature articles and advice, discussions and tutorials about do-it-yourself projects that use the tools and material covered in this course. The websites of hobbyist vendors, including Sparkfun and Adafruit, provide a sense of the components and custom breakout boards available for such projects, including product selection guides and video tutorials.

The following papers describe related courses by the instructors, and may serve as a guide for educators developing a similar curriculum.

[1] Scott Klemmer, Wendy Ju, and William Verplank. 2005. Teaching embodied interaction design practice. In *Designing for User eXperience (DUX), AIGA: American Institute of Graphic Arts*. 26. http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.135.7573

[2] David Sirkin and Wendy Ju. 2014. Press play: A course in interactive device design. In *American Society for Engineering Education Annual Conference (ASEE)*. 1–10. https://peer.asee.org/22937