f3.js: A Parametric Design Tool for Physical Computing Devices for Both Interaction Designers and End-users

Jun Kato, Masataka Goto

The presented system is publicly available at http://f3js.org
Physical computing devices, everywhere
Physical computing devices, everywhere

- Physical user interfaces (as opposed to GUI)
- Home appliances
- Smart devices
- Internet of Things
Personal fabrication made easy

3D print in “Maker” venues

Soldering with parents

Working prototypes

How about device programming & assembly?
Research questions regarding physical computing devices

For interaction designers

- How can we support prototyping of the devices?

For end users

- How can we support personal customization of the devices?
Preliminary observations:
photos of 200 devices and informal interviews
Design patterns in Physical User Interfaces

- 187 devices have physical user interfaces on planar surfaces
- 139 devices have modules placed along straight lines
- 51 devices have modules placed on circular paths
Mental gap between software & hardware

- Designers need to imagine hardware while writing code
- “new Button()” does not infer any hardware layout
Difficulties in exploring design alternatives

- **Expensive switching** cost between two activities in two tools
- Prior efforts in either one of these (software *or* hardware)
Preliminary observations (summary)

- Typical **design patterns** should have tool support
- **Mental gap** between software & hardware exists
- **Comparing alternatives** is crucial for good design
f3.js: integrated support for programmers

- **Live Programming with intuitive APIs** of features & layout
- Interactive development of IoT devices in **one environment**
Module repository for hardware metrics
APIs for 3D extrusion and 2D layout

3D extrusion

Partial extrusion (black lines ignored)

Extrusion (w/o opposite plane)

Line layout
(align, padding: 25mm, wrap: true)

Circle layout
(distribute, valign: top, clockwise: false)

Line layout
(distribute, rotate: false)

Circle layout
(distribute, size: false, rotate: false)

2D layout
f3.js for parametric design of physical computing devices

- Typical **design patterns** should have tool support  
- **Mental gap** between software & hardware exists  
- Comparing **alternatives** is crucial for good design

☑ supported
☑ addressed
☑ supported
f3.js: customizing support for end-users

- **Interactive UIs** for customization
- Automatic generation of device building instructions
User studies

• 14 teams to create physical computing devices with f3.js
  • 5 interaction designers and 16 university students
  • Intel Edison and Grove modules, acrylic panels and screws provided

• 3 interaction designers and 3 end-users with revised f3.js
  • 3 interaction designers asked to create parametric designs
  • 3 end-users asked to customize and assemble devices
User studies: results & discussions

• Creativity support environments, not tools
• 3D vs 2D layout managers
• Interface builders are important
• Code-centric tool complements to 3D modeling tools
• Domain-specific language support (like HTML)
f3.js: A Parametric Design Tool for Physical Computing Devices for Both Interaction Designers and End-users

Jun Kato, Masataka Goto

The presented system is publicly available at http://f3js.org