Interactive Textiles (e-textiles)

Clothes of the future

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Summer term 2016

http://hci.rwth-aachen.de/cthci

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Interface to your wearables


Eyes-free, on the move

Input device

Extension

Vision

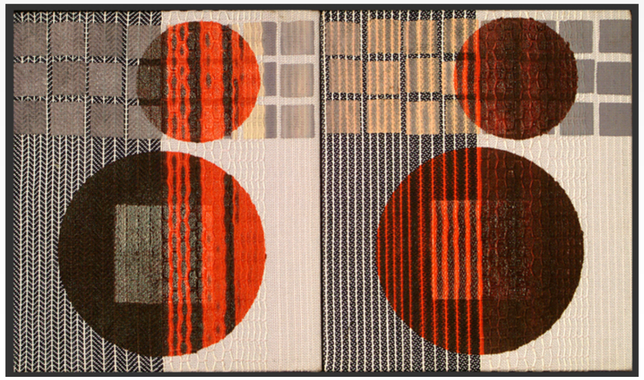
- Mark Weiser envisioned future computers that disappear into everyday environments and

  “... weave themselves into the fabric of everyday life until they are indistinguishable from it.”

- Merge the everyday physical world and digital computing
- Disappearing computing

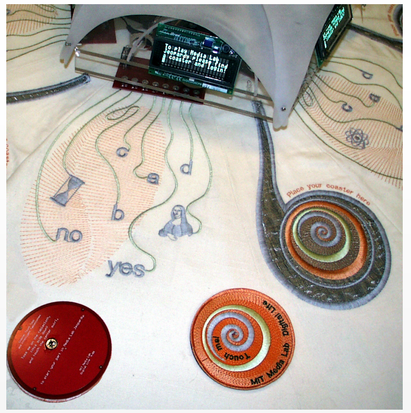
From Vision to Reality

Maggie Orth , Musical Jacket, ‘98



Maggie Orth. Big Dot, ‘03

Maggie Orth. Embroidered Musical Instruments, ‘01



Maggie Orth. Electronic Tablecloth,’99

http://www.maggieorth.com/

Motivation

- Intersection of fashion and technology
- Wearable technology and quantified self

Going beyond wearables

20 x 20
Yellow
Conductive

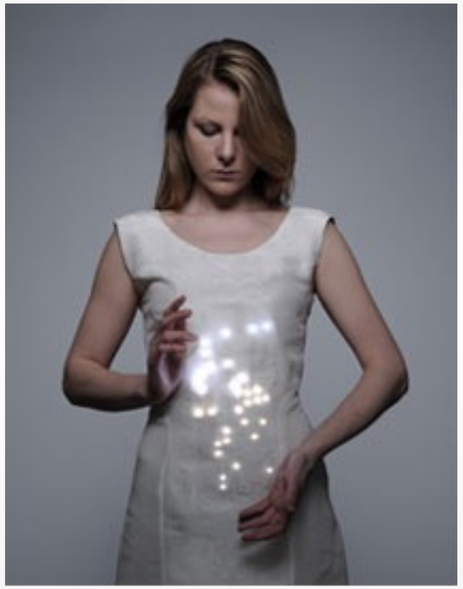
Interactive Textiles (e-textiles)

- Interactive textiles are fabrics that enable digital components and electronics to be embedded in them (sensors, actuators, MIC)
- Conductive thread is the basic construction material
- Smart textiles are textiles created using new technology, they can be responsive to stimulus via a chemical reaction. Not all smart textiles are e-textiles
- Wearable devices that are not integrated but simply attached to the garment do not count as interactive textile

Application Areas

- Fashion
- Health and fitness
  - Regulate body temperature, reduce wind resistance and control muscle vibration
  - Drug-releasing medical textiles
- Safety
  - Against extreme environmental hazards like radiation
- Interface for wearables

Max Schäth, Outsourcing, ‘11
http://www.design-research-lab.org/research-projects/



How to design for interactive textile?

- Paul Holleis explored the usability and applicability issues concerned with touch input on clothing
- Lesons learned:
  - Preserve the Original Functionality
  - Optimal Position of Controls Influenced by Posture
  - Provide Immediate Feedback
  - Need to Tackle the Fear of Accidentally Initiated Commands
  - Ensure One-handed Interaction
  - Put Fashion as a Priory

Agenda

- Input techniques
- Technical requirements
- Output techniques
- Personal style, emotional impact, social acceptance
- DIY

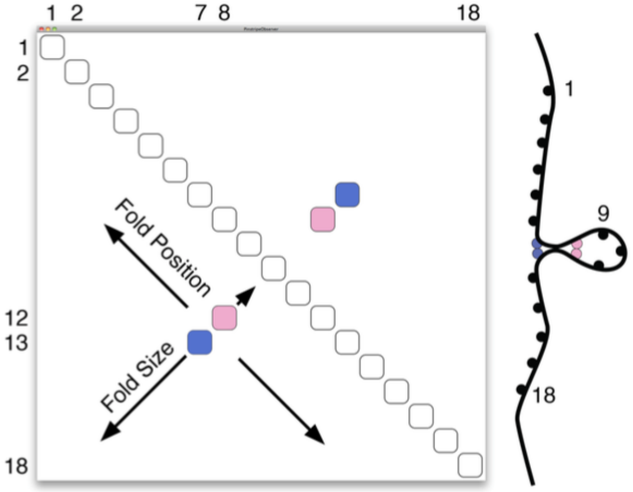
Input Techniques

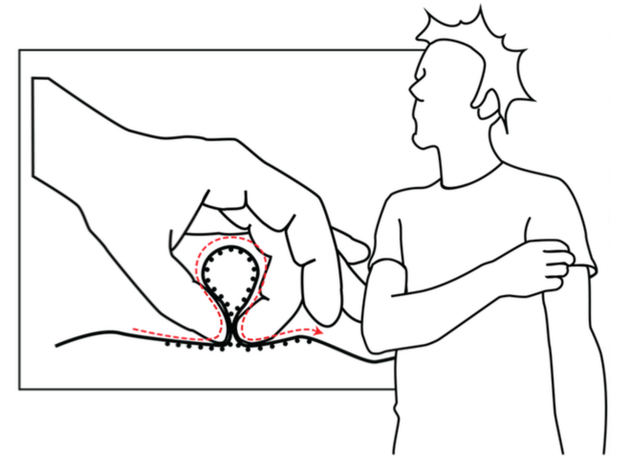
- Input tool: human hand and fingers
- Direct & indirect, absolute & relative, continuous & discrete, 1D & 2D
- Two main metaphors
  - Fabric afforded gestures,.e.g, garb and roll, crumble, stretch, pull, etc. To what interfaces can we map these gestures?
  - Touch and desktop concepts, e.g., tap (buttons), swipe (sliders or next/back)…

Pinstripe

- Affordances of textile
- Resistive technology
- (+) Avoid accidental activation
- Grab to activate the textile
- Roll to continuously control values in 1D slider
- Based on the grab size, control the coarseness of sliding

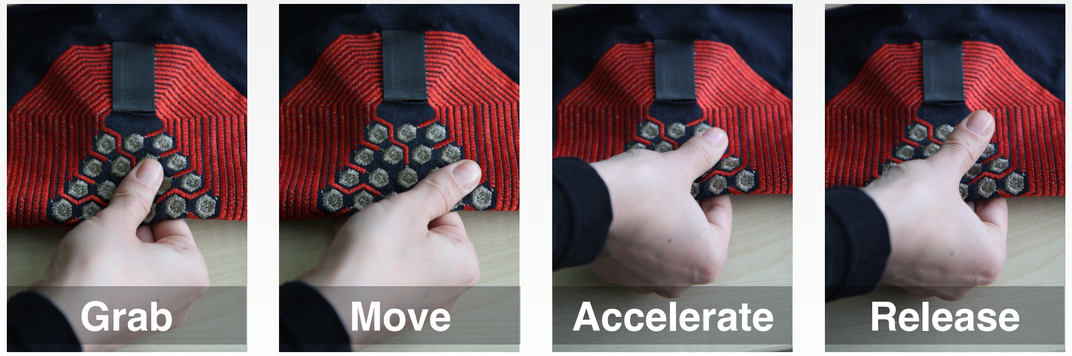
Karrer, CHI '11

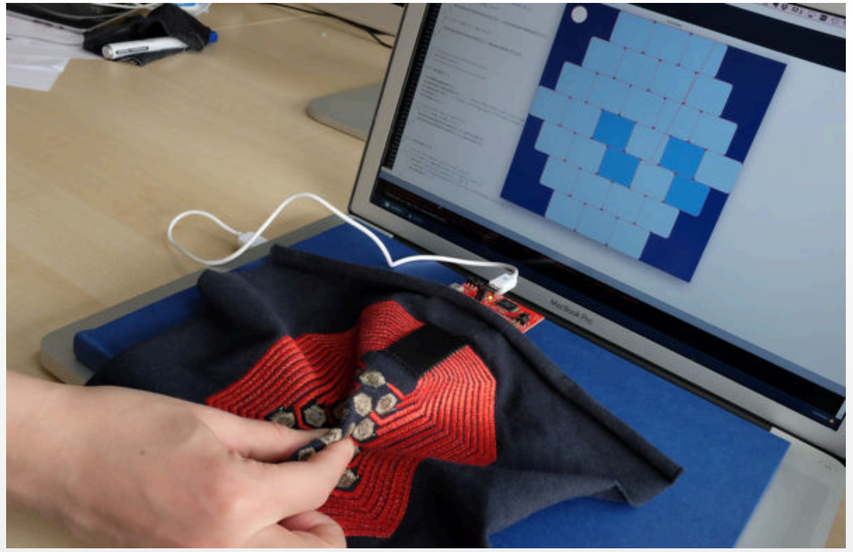




Grabrics

- Took Pinstripe one step further
- Resistive technology
- “Grab at an Angle”
  - Grab at an angle to select a menu item
  - Roll continuously to change the value of that item
- Human performance: people can grab angles between 30-45 degrees, on the forearm, eyes-free

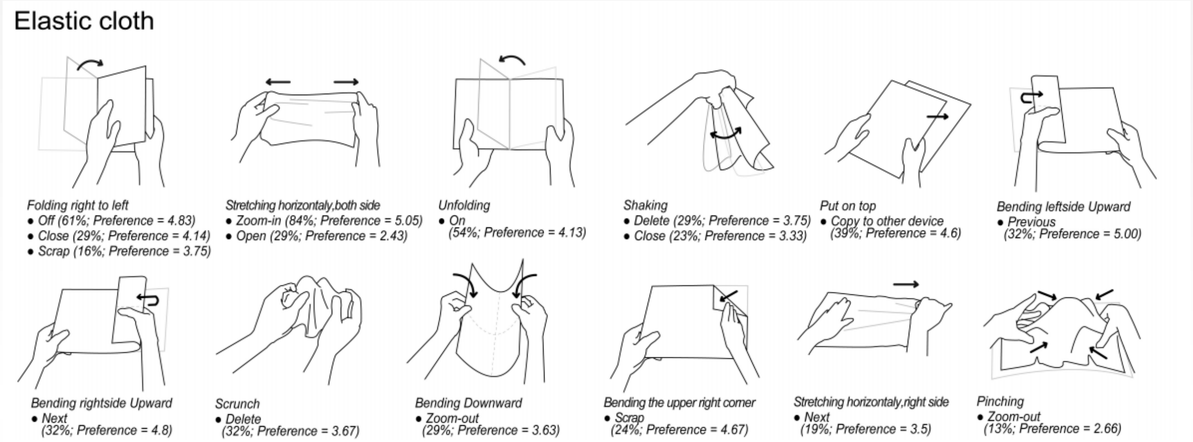




Hamdan, CHI ‘16

Deformable Gestures

- Lee defined a gesture alphabet of possible fold, bend, and distort gestures for paper, plastic, and stretchable fabric
- Several researchers have investigated intuitive gestures for deformable displays



Lee, CHI ‘10

Troiano, AVI ‘14

Interactive Furniture

- Furniture
- Capacitive technology
- 1D: swipe left & right
- Discrete input (continuos coming soon)
- Direct interface to curtain
- Visual feedback
- Considerations: spacing between parallel threads to minimise parasitic capacitance, detect when curtain folds make connections

RWTH Aachen, Intuitex Curtain, ‘16

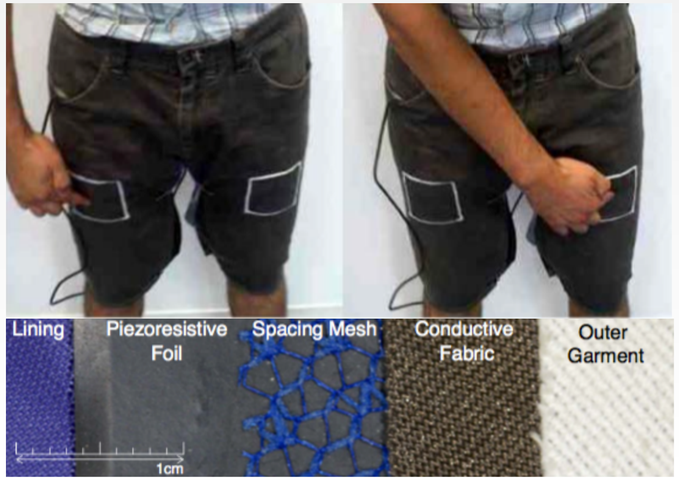
Commercial Product

- Wearable. Riders
- Capacitive technology
- 1D: touch and hold, swipe left & right
- Discrete or continuos is not clear yet
- Interface to mobile device, e.g., navigation instructions, music player…
- Audio feedback
- Tactile feedback very effective & superior interactive experience

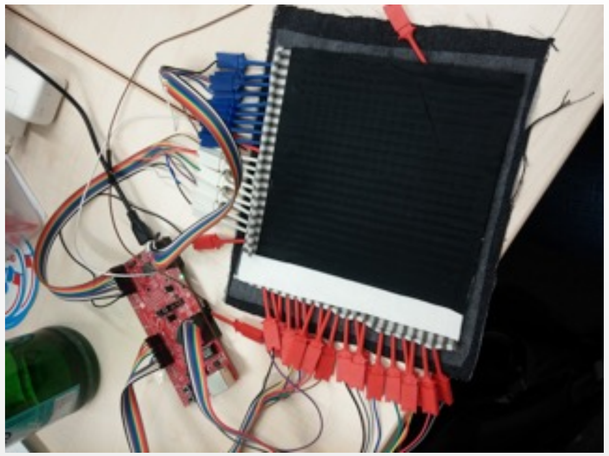
Levi's® Commuter™ x Jacquard by Google Trucker Jacket, 2016

2D and Free Form Gestures

- FabriTouch; 2D swipes; piezoresistive foil, relative voltages (resistive)
- Textile touch pad with gesture recognition; free form gestures; pinstripe material sandwiching a spacer (resistive)



Heller, ISWC '13



Hamdan and Schmidt, '16

Technical Requirements

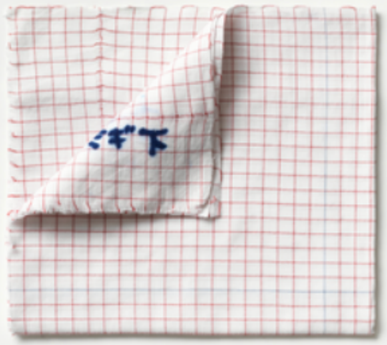
- Conductive yarn
- Sensing technology
- Wiring
- Air gaps and spacers
- Interfacing electronics
- Power

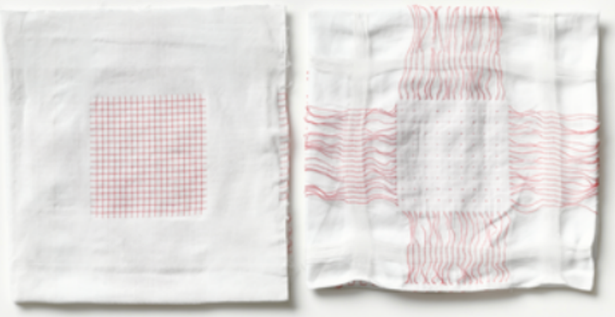
Conductive Yarn

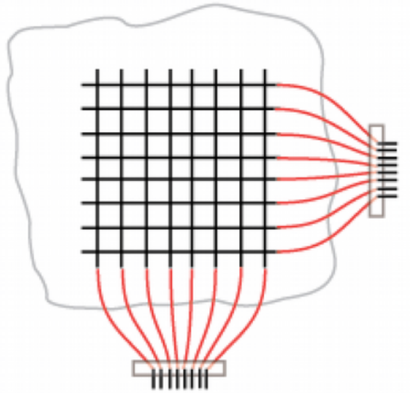
- Core of e-textile manufacturing
- Thread types
  - Silver-coated threads, high resistance, less consistent
  - Stainless steel threads, have no traditional thread core, have low resistance, can be soldered with difficulty
  - Other threads are made by twisting natural yarn over a conductive core
- Several fabric production/sewing techniques exist: embroidery, woven inlay, double weaving, crochet, knitting, etc.

Manufacturing at Scale

- Jacquard yarn requirements
  - Conventional look and feel
  - Multiple colors, thicknesses, and materials
  - Electrical conductivity
  - Strength, temperature and chemical resistance
  - Reliability
  - Electronics interconnectivity
  - Safety
  - Cost and manufacturing at scaleCost and manufacturing at scale







Capacitive vs. Resistive

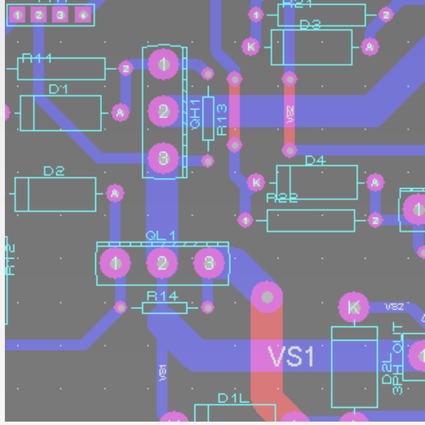
★ **Capacitive** sensing is powerful: multi-touch, near-surface interaction, less power hungry (capacitive voltage divider technique)

- Noise: parasitic capacitance, human body capacitance in case of wearables

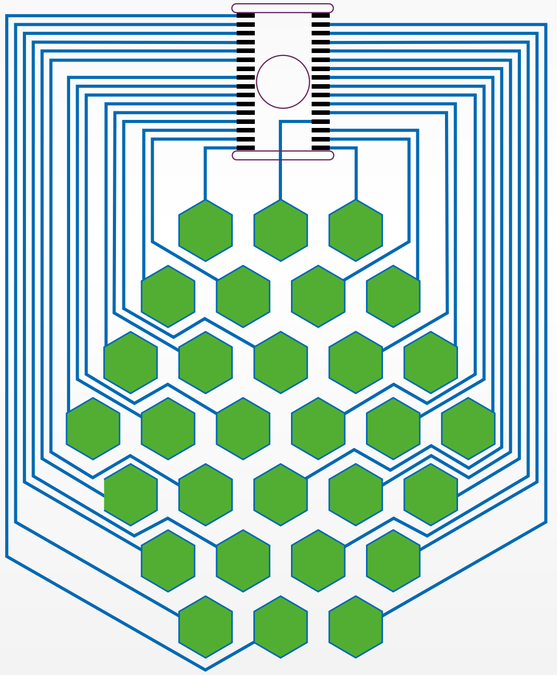
★ **Resistive** sensing is more robust against noise, can use gloved hand

- Mostly single touch, requires pressure to make contact

Wiring

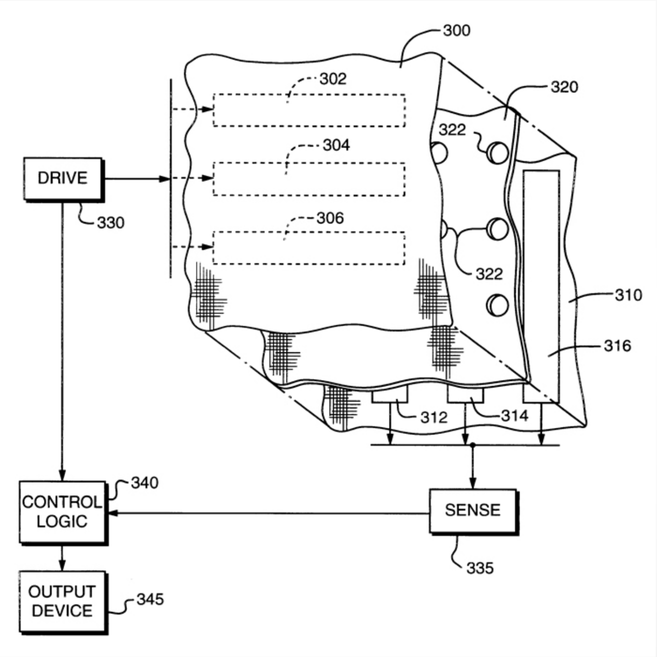


- Require minimum spacing (3-2mm) between parallel threads (flyaways, parasitic capacitance)
- Need space to connect from the interaction area to the MIC
- Need space to route the threads without crossing (~ PCB layout and bridges)



Air Gaps and Spacers

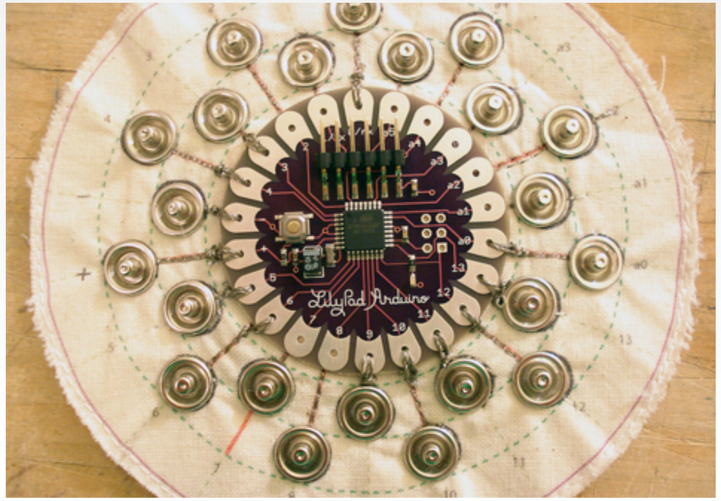
- Whether resistive to capacitive you need an air gap/ spacer between two conductive swatches of fabric
- Trade of between the flexibility and robustness against noise of the e-textile is related to the spacer's thickness, flexibility, and rigidness



Maggie Orth, Musical Jacket, '98

Interfacing Electronics

- **Lilipad**; tying nods; rapid prototyping; (-) cannot be removed, doesn't scale
- **Flexible PCB**; press conductive thread and copper foil together with a stitch or stapler; robust against aging and washing; (-) expensive, hard to make in lab

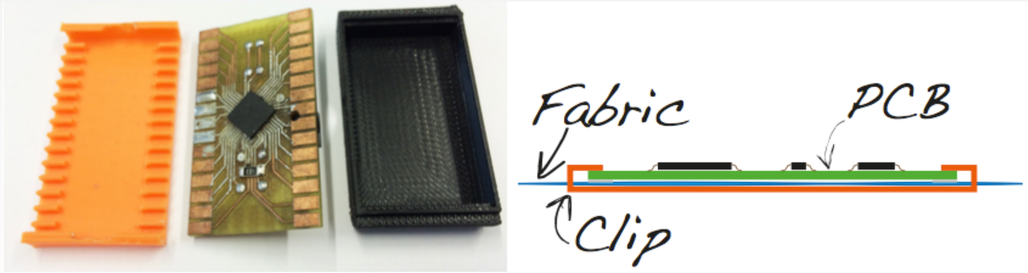


Buechley,CHI ‘08

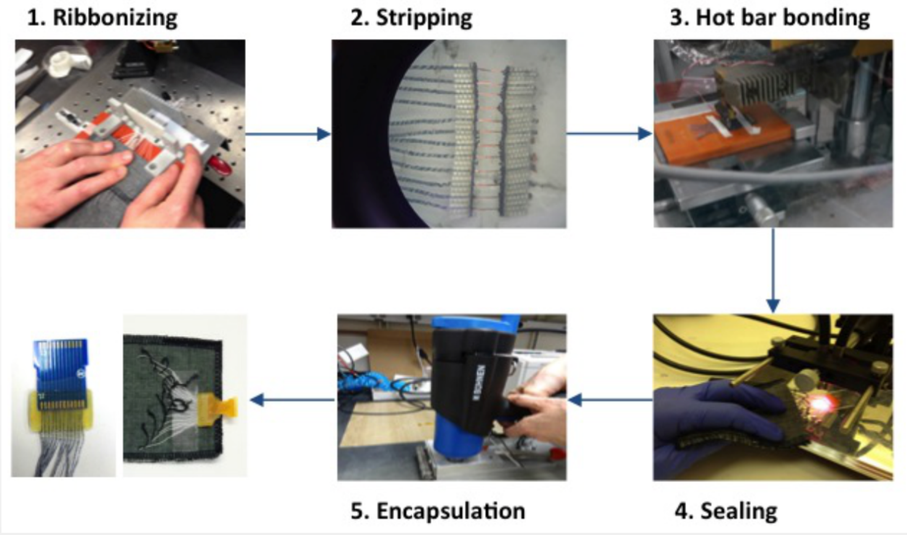
Thar, Flexible PCB, ‘13

Interfacing Electronics

- **Fabric–PCB Clip**; for rapid prototyping and separating/exchanging the controller before washing; (-) still not robust (in progress)
- **Google Jacquard**; includes stripping, hot boding to flex PCB, sealing from water; scalable; (-) hard to make in lab



Thar, 3D Fabric-PCB, ‘15



Levi's® Commuter™ x Jacquard by Google Trucker Jacket, 2016

Power

- Energy harnessing fabrics from the environment (vibrations, sound or heat)
- 3D piezoelectric fabrics generating a charge by pressure/ movement
- Flexible lithium ceramic batteries
- Google Jacquard: USB dongle (tag)

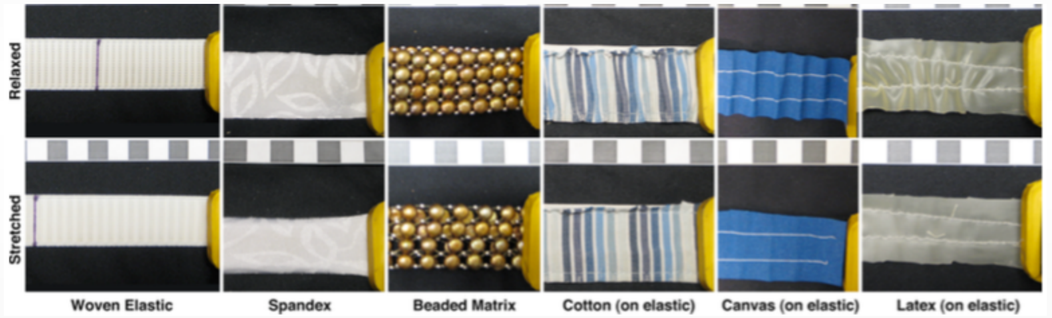
Levi's® Commuter™ x Jacquard by Google Trucker Jacket, 2016

Integration into Garments

- Where do you put all these components?
  - Textile PCBs, capacitors, resistors, and antennas are on the way

Output Techniques

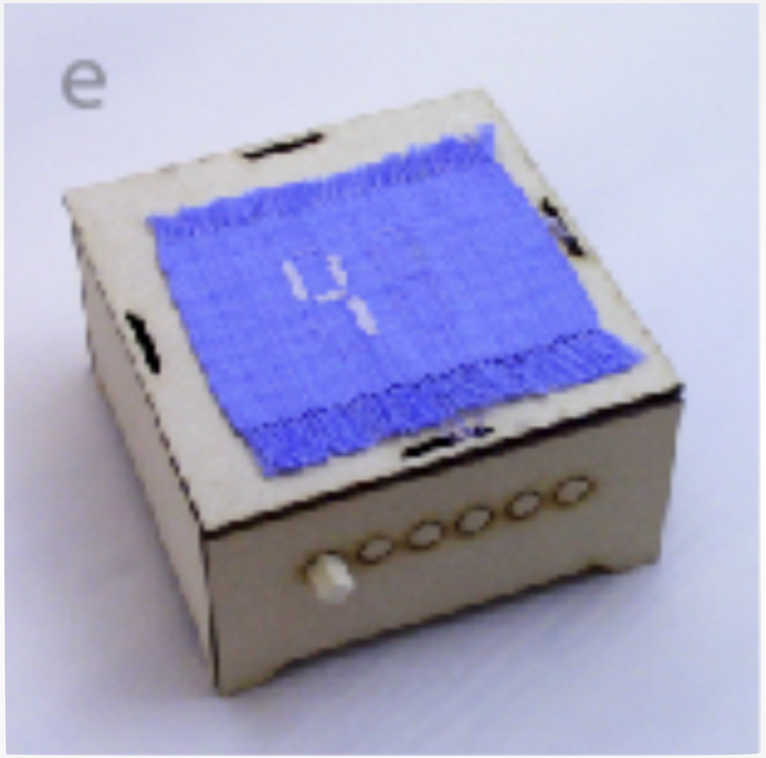
- Output devices used LED arrays, thermo chromic ink, vibration, and shape memory alloys
- Dynamic textiles that react to the environment, emotions of the wearer; or enhance social interactions, motivate fitness behaviors, give rise to increased environmental awareness



Harrison, CHI ’09

Personal Style and Dynamic Textile

- Devendorf investigated meaning of dynamic textile through a lens of personal style
- They found that
  - slowness, low-resolution, and volatility of Ebb tended to be seen as assets as opposed to technical limitations in the context of personal style
  - abstract, ambient, and ambiguous representations of information on clothing could provoke intrigue, playful and serendipitous social interactions

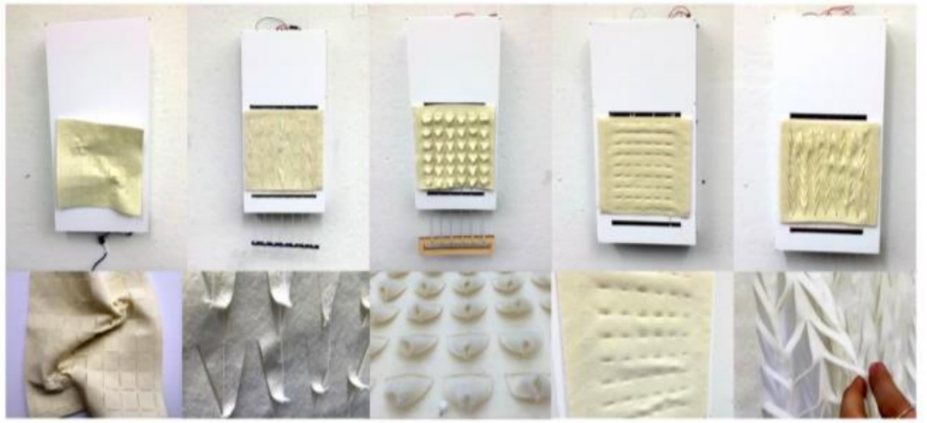


Devendorf, CHI ‘16

Ebb is a dynamic textile display made of conductive textile covered with thermochromic pigments

Emotional Chars and Dynamic Textile

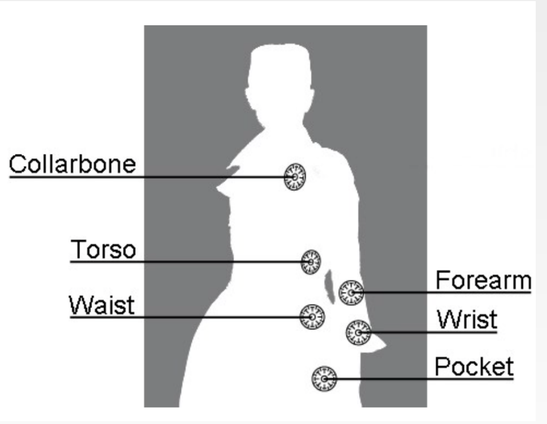
- Davis explored the emotional characteristics of physical/visual textures in fabrics
- Can designers communicate emotions via transforming textiles?
- He found that
  - touching the textile invokes more positive emotion in some cases compared to just looking at a texture
  - emotions depend on textility, a reading of body, place, and material. And that this ambiguity can be used to make one material create different emotions



Davis, C&C ‘15

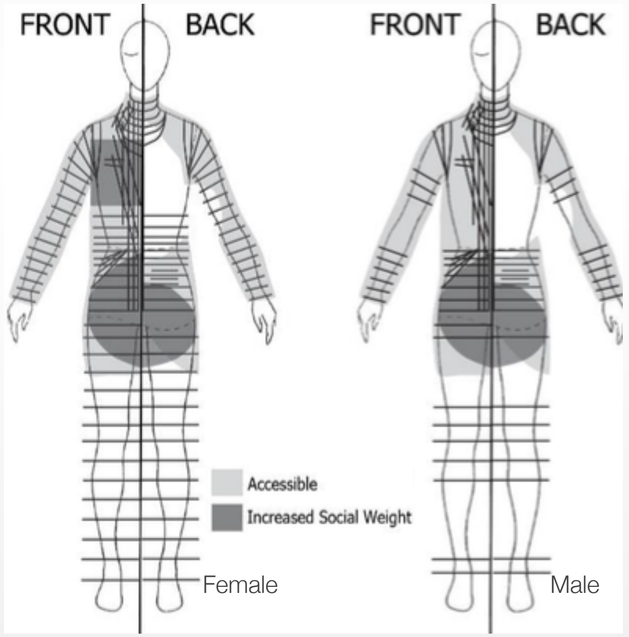
Heritage, History, and Culture

Social Acceptance

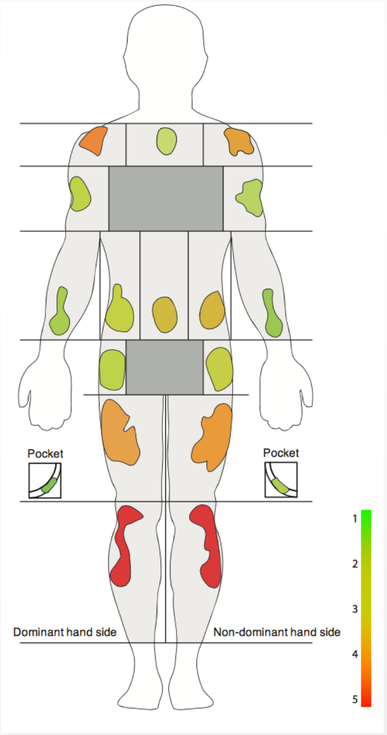


Profita, ISWC ‘13

- There are differences between women and men on acceptable location, as well as between cultures (USA and Korea)
- Arm, forearm and wrist are the more socially acceptable. Upper thigh is sometimes accessible



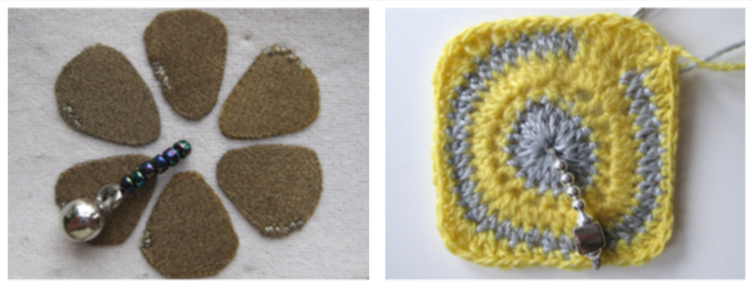
Lucy, EMBC ‘14



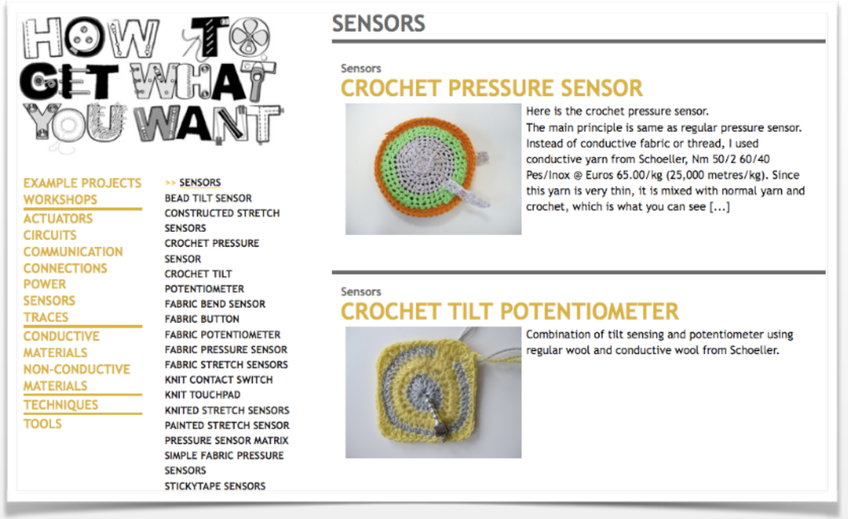
Karrer, CHI ’11

DIY

- Conductive yarns are readily available to makers
- Buechley used soft circuitry as a new language for electronics education
- Hannah Perner-Wilson introduced a kit-of-no-parts approach to building electronics from a diverse palette of craft materials
- Three benefits to using crafting martial:
  - Personalization
  - Transparency
  - Skills transfer



Hannah Perner-Wilson, TEI ‘11



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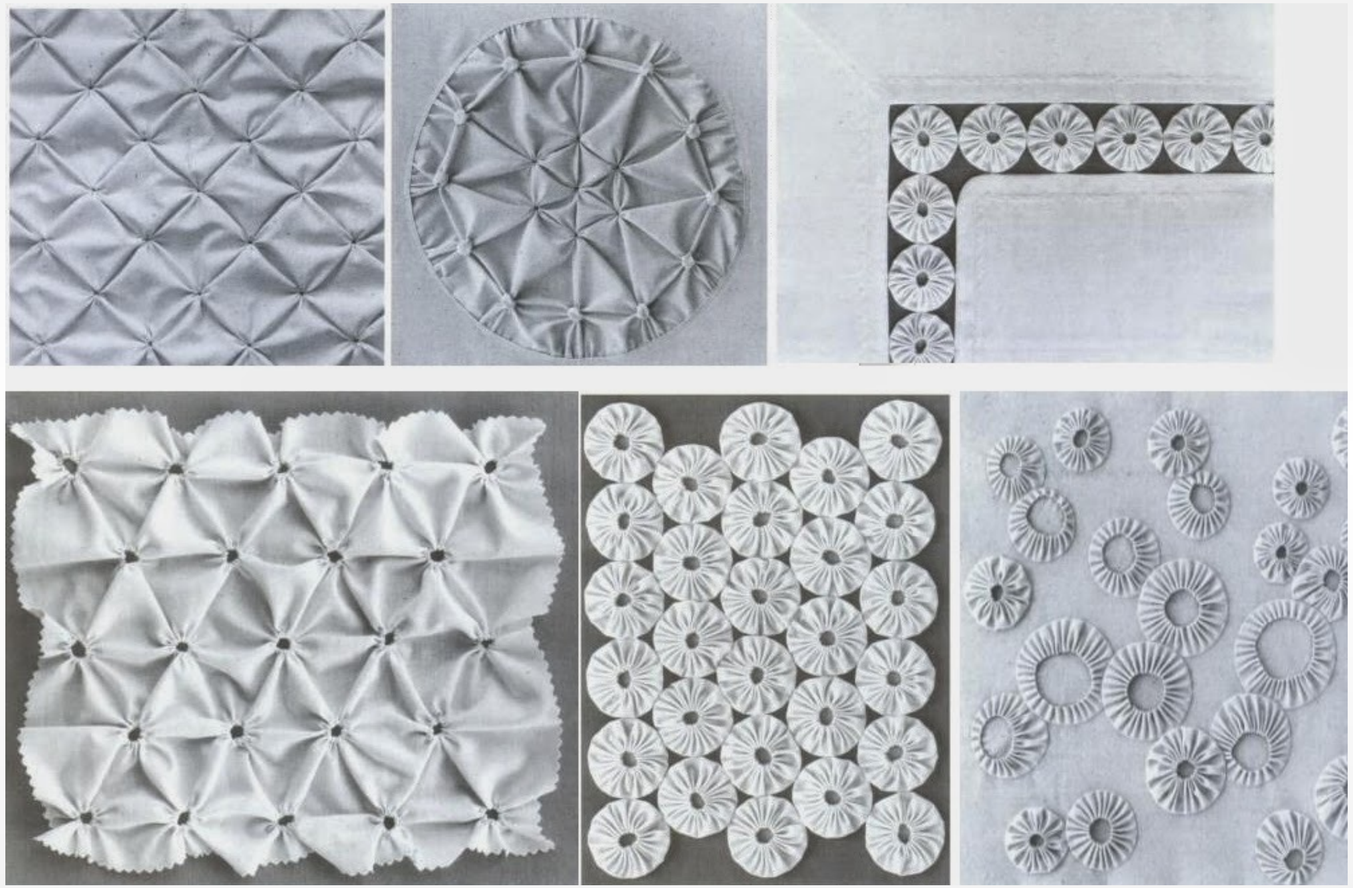
Textile Manipulation?



Yarn OS?

Fabricating Interactive Textiles?

Nervous System, ‘14

What You Need To Do Now

- Reading material will be on our website: hci.rwth-aachen.de

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