We present the first fully functional and self-contained projection smartwatch.
ubiquitous computing

“The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.”

computing is made to appear anytime and anywhere

if everything is a computer, everything will also sense user input and everything will be a display for output
ubiquitous computing

“The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.”

computing is made to appear anytime and anywhere

if everything is a computer, everything will also sense user input and everything will be a display for output
how can we **prototype** this to make everything in our surrounding appear to be a display?
projection

as a place holder for freeform screens
**Foldable display?**

- Tracking with infrared (IR) LEDs
- Display with a projector

Goal is to simulate the flexible display interaction when technology is not ready yet.
Foldable display?

Tracking with infrared (IR) LEDs
Display with a projector

Goal is to simulate the flexible display interaction when technology is not ready yet
**Sphere display?**

No Master User Position or Orientation

Visible Content Changes with Position and Height

Smooth Transition Between Vertical and Horizontal Surfaces

Borderless, but Finite Display

---

**how does this work?**

---

**Sphere: Multi-Touch Interactions on a Spherical Display**

**Stefan Andrä**, Andrew D. Wilson, and Eran Agmon

*School of Computer Science*

*University of Toronto, Toronto, ON, Canada*

**Abstract**

This paper presents an implementation of a novel, multi-touch-enabled, spherical display platform, which allows for the manipulation of virtual objects and the display of immersive content on a single, four-sided sphere. This device can be used in a variety of settings, from entertainment to education, and is designed to provide an immersive, interactive experience for users of all ages. The sphere is constructed from high-quality materials and is touch sensitive, allowing for intuitive interaction with virtual objects and content. The device is also equipped with a high-resolution camera system, enabling real-time tracking of user interactions and providing a seamless, immersive experience. This paper describes the development of a multi-touch interface for the sphere, as well as the implementation of various applications and games that leverage the unique characteristics of this device. The results demonstrate the potential of the sphere as a new platform for interactive, immersive experiences.
Cold mirror: reflects the entire visible light spectrum while very efficiently transmitting infrared wavelengths.
Foldable display
Skin as display?
Skin as display?
Kinect + projector
Skin as display?
do not limit your imagination
to what is available in terms of technology right now.

we move very quickly (and also learn from the history)…

in HCI we often prototype interface concepts
before the hardware / software becomes available…
so **how far** are we with display tech?
let’s look at where we came from…

(1957) cathode ray tube (CRT)
(1957) split-flap display
(1961) flip-disc display
(1968) light-emitting diode (LED)
(1968) stroboscopic display
(1969) braille display / pin screen

(1971) liquid crystal display
(1974) electro-luminescent (EL)
(2004) e-ink
so **how far** are we with display tech?

let’s look at where we came from…

(1957) cathode ray tube (CRT)

(1957) split-flap display

(1961) flip-disc display

(1968) light-emitting diode (LED)

(1969) stroboscopic display

(1971) liquid crystal display

(1974) electro-luminescent (EL)

(2004) e-ink

(1971) braille display / pin screen
(1957)
cathode ray tube (CRT)
monochrome cathode ray tubes
cathode ray tube (CRT):

- Image is created line by line
- Beam consists of negatively charged electrons
- Electromagnets steer the beam to the correct location
- Screen is coated with phosphor that lights up when hit
Light Pen

when CRT beam hits the light pen, the pen senses the light changes and notifies the computer about the exact timing

since CRT scans display line by line, one pixel at a time, the computer can infer the pen's position from the latest timestamp

1963: Ivan Sutherland’s Light Pen on CRT
In HCI we develop interaction concepts that work across technology. The light pen does no longer work on today’s screen, but the interaction concept remains.
(1957)
split-flap display

(1961)
flip-disc display
1957 split flap display (electro-mechanical)
The characters are split between two flaps

the flaps are hinged on a rotating spool

there's a catch at the top to keep the upper flap from falling down
http://www.instructables.com/id/Split-Flap-Display/
1961 flip-disc display (electro-magnetic)
100 μs to 1 ms pulse depending on coil type

Thin, permanently magnetized disc free to rotate on its axis disc with permanent magnet.

Pole pieces
Electromagnetic core with high remanence.

Residual magnetism provides memory.
how would you build a equivalent “light pen” input for this?
(1968)

stroboscopic display
1960s stroboscopic displays: rotating cylinder, but it appears to be standing still!
stroboscopic effect

series of intense light flashes at specific intervals emitted onto an object that rotates at high speed makes the object appear to stand still
if you have one flash per turn, you see the actual number of fan blades
Floating sphere display
What if we apply to objects with different textures?
yes this is real wool and real felt.
any idea how this works?

Dynamic Stop Motion
Animation using wool and felt
Rendering shape with **real** material

Remix **real** physical objects

**Dynamic Stop Motion**

Animation using wool and felt
braille display / pin screen
1969 braille display for the blind and visually impaired
Hyperbraille: a hypertext system for the blind

Authors: T. Kieninger
N. Kuhn

Published in:
- Proceeding
  Assets '94 Proceedings of the first annual ACM conference on Assistive technologies
  Pages 92-99

much later 1994: HyperBraille
(allow blind users to browse the internet)
What if we scale it up?
was the inspiration for some newer tech…
this is very expensive… $10,000+
how would you build a **cheaper** tactile interactive display?
swell paper
create black line drawing

- >

put in heater
only black lines
attract heat & swell
swell paper + laser cutter (almost 0% power + defocus)

Can we make the “display” refreshable?
use a 3D printer!

Printed lines offer haptic feedback

Large space so no need for fast refresh rate

Printed line can be removed off
(1971)

liquid crystal display
liquid crystal display
**polarizer**

optical filter
lets light waves of a specific polarization pass
blocks light waves of other polarizations

**liquid crystals** acts as a polarizer switch!
Light panel

Polarizer 1

Liquid crystals
  twisted the light 90 degree naturally

Polarizer 2

RGB pixels
Liquid crystals twisted the light 90 degrees naturally when electricity applied, molecules realigned that light will not be twisted. Control the electricity changes the amount of the light.

Light panel

Polarizer 1

Liquid crystals

twisted the light 90 degree naturally
when electricity applied, molecules realigned that light will not be twisted
control the electricity changes the amount of the light

Polarizer 2

RGB pixels
(1974)

**electro-luminescent (EL)**
electroluminescent display: also uses **phosphor**!

—> no more electron beam, instead apply electricity directly
Why EL display?
Blue Electroluminescent (EL) Tape Strip - 100cm w/ two connectors

EL tape is the big sister to EL wire - it has the same glow effect but with a flat, wide shape instead of a round shape. The glowing part of the tape is 1 cm wide (the plastic coating is about 1.5 cm wide). The other side has an adhesive on it so you can stick the tape onto something. Its covered in what seems to be PVC, the tape is thus weather-proof - but note that the connectors are NOT waterproof, just a bit of heatshrink. This isn't...

ADD TO CART $8.95
54 IN STOCK

High Brightness Blue Electroluminescent (EL) Wire - 2.5 meters - High brightness, long life

EL Wire, also known as Electroluminescent wire is a stiff wire core coated with phosphor and then covered with a protective PVC sheath. When an AC signal is applied to it, it glows an aqua (blue green) color. You can make it look different colors by changing the coating, for example this is a vivid blue. It looks a little like thin neon. Very bendable, it keeps its shape and you can curl it around your finger. Its an easy way to add some glow to...

NOTIFY ME $12.00
OUT OF STOCK

Electroluminescent (EL) Panel - 10cm x 10cm White

EL panel is the big sister to EL wire - it has the same glow effect but with a flat shape instead of a round shape. This is a big sheet of flexible plastic coated with EL material so its like one big glowing square. It emits an even glow over the entire shape. The glowing part of the panel is 10 cm x 10 cm (approx. 4” x 4”). There’s a plastic coating is about 10.4 cm x 10.4 cm. Its covered in what seems to be PVC, the tape is thus weather-proof...

ADD TO CART $13.95
IN STOCK

https://www.adafruit.com
4-layer sandwich structure
Top and bottom electrodes act as a capacitor
Apply high voltage and low current AC, **phosphor** emits photons
use **screen printing** to make them
(2D inkjet printing and 3D printing them is still hard)
Prototyping ubiquitous display

PrintScreen: Fabricating Highly Customizable Thin-Film Touch-Displays

Sean Olberding, Michael Wosny, Jorgus Holdo
Max Planck Institute for Informatics and Saarland University
Campus E1.1, 66123 Saarbrucken, Germany
(jorgus, mwwosny, seanolberding@mpi-sb.mpg.de)

Abstract
PrintScreen is an enabling technology for digital ubiquitous thin-film touch displays. Thin-film touch displays have advantages in terms of reliability and rigidity among materials, including PET substrates, biaxial glass, and others. Touch displays can also be fabricated on flexible substrates, allowing users to peel and paste screens onto surfaces, including table tops, walls, and more. In this paper, we introduce a new technology that enables digital touch screens for ubiquitous displays and then how to assemble them with touch, paper, and flexible electronics. Furthermore, an oligomer casting technique enables digital touch displays.

Introduction
Print Screen is a promising and affordable technology for ubiquitous displays. The technical advantages of thin-film technology and print Screen are that print can be used flexibly and for touch displays. The material handling and production phase reduce the time and cost of touch displays. Thin-film displays, such as E Ink and Ocular Display, used a high-quality touch screen to create a high-resolution touch display for many applications. However, using a single touch screen can reduce the touch-screen resolution and performance of touch displays. For example, the single touch-screen configuration can be used for high-resolution touch displays.
Prototyping **ubiquitous display**
Stretchable display
EL embedded in silicone
SkinMarks

Enabling Interactions on Body Landmarks Using Conformal Skin Electronics

Martin Weigel¹, Aditya Nittala¹, Alex Olwal², Jürgen Neubeck
¹ Saarland University, Saarland Informatics Campus
² Google Inc., USA

ACM CHI 2017
How to scale up? (like for room-scale interactions?)
Sprayable User Interfaces: Prototyping Large-Scale Interactive Surfaces with Sensors

Michael Wessely, Ticha Sethapakdi, Carlo C. Jackson, Ollie Hanton, Isabel Fraser, Mike Fraser, Anne Roudaut, Stefanie Mueller
electroluminescence is also used in **OLEDs**
EL displays concept, but organic instead of inorganic phosphors
zooming out...
ubiquitous computing:
computing is made to appear anytime and anywhere

if everything is a computer,
everything will also sense user input
and everything will be a display for output

Special thanks to Prof. Stefanie Mueller. These slides are largely based on hers.
Sprayable User Interfaces: Prototyping Large-Scale Interactive Surfaces with Sensors and Displays

Michael Wessely1, Yvonne Schlegel2, Carla Costabile1, Jackson C. Snodgrass1, Olle Hansson1, Isabel P.S. Stemmer1, Mike Fraser1, Anne Rosenthal1, Stefanie Mueller1

1 MIT CSAIL, Cambridge, MA, USA
2 University of Bristol, Bristol, UK

ABSTRACT

Sprayable User Interfaces: Prototyping large-scale interactive surfaces with sensors and displays enabled by spray-deployed functional inks. Since designing is inherently tactile, designers can use spray-coating to explore and design prototypes that are oriented towards a mobile, interactive architecture.

INTRODUCTION

Sprayable user interfaces are a new method for creating interactive surfaces. The technology has the potential to enable new forms of interaction, particularly in public spaces. The technology is based on spray-coating functional inks, which can be used to create sensors and displays.

Author Keywords:

spraying, fabrication, printed electronics, ubiquitous computing, mobile, interactive.

Optional readings

CHI 20

Wessely et al.

SkinMarks: Enabling Interactions on Body Landmarks Using Conformal Skin Electronics

Martin Weigel1, Aditya Shekar2, Nitin2, Alex Olivas3, Jérôme Steinmetz2,2,3

1 Simon Fraser University, Vancouver, BC, Canada
2 University of California, Santa Cruz
3 Google Inc., Mountain View, California, USA

ABSTRACT

SkinMarks are conformal in-skin sensors and displays. They enable interaction via five types of body landmarks: (a) digital landmarks, (b) skin microstructures, (c) static landmarks, (d) visual skin landmarks, and (e) accessories.

INTRODUCTION

The body is recognized as a promising input-surface for mobile computing, as it offers a large and naturally accessible area for input. To make use of this area, skin electronics that can be placed on body landmarks can help in developing body interfaces, guide input on the body, and allow for easy input of markers. Our main contribution is SkinMarks, novel size 2D skin device for precisely localized input and output on body landmarks. SkinMarks comprise skin electronics on temporary submillimeter electronics for marking. Taken together, SkinMarks expands the interactive interface space to more detailed, highly curved and challenging areas on the body.

Author Keywords:

On-body interaction, skin sensors, skin display, e-textiles, wearable computing, flexible electronics, interactive body landmarks, wearable computing.

ACM Classification Keywords:

B.5.3: User Interfaces. Input devices and techniques, Interaction techniques, Graphical user interfaces, Human-Computer Interaction.

This research is funded under a Creative Commonwealth Attribution International 4.0 License.

Weigel et al.

CHI 17