October 6th 2015

Physical Computing

In the Real World

Who Is This Person

Meanderer

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🎓 Design Computing Graduate, Exchanged in San Diego

Meanderer

I’m currently a freelancer predominantly at the Google Creative Lab who likes creating interactive installations.

Love doing 24-48 hr hackathons because you create something quickly, even if you’re not ready.
I graduated Design Computing a couple years ago. Did exchange in San Diego through the exchange program here which I highly recommend looking into. Most of my electives were in computer science, arts, or cognitive science.

Never know where I’ll be a year away, but always pursuing what I like at the moment.

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Contents

1

History

A little bit of evolutionary history

History

Lights : Evolution

Sun – Fire – Candle – Oil Lamp – Gas Lamp – Electric – LEDs – Automated – IOT Lights

Let’s look at the evolution of lights.

Earth’s existence is inextricably tied to the Sun, a star that provides light during the day and sleeps at night.
Millenia’s ago, early humans discovered that by **rubbing the right resources** together we could create fire. Giving us the ability to turn light, and heat, off and on at will.
As we gradually **refined our resources**, the fuel used to control light also became more refined as we progressed towards candles, oil lamps, and gas lamps - making it easier to switch light on and off - an interactive physical system. We simply **restocked** the fuel when it ran out.

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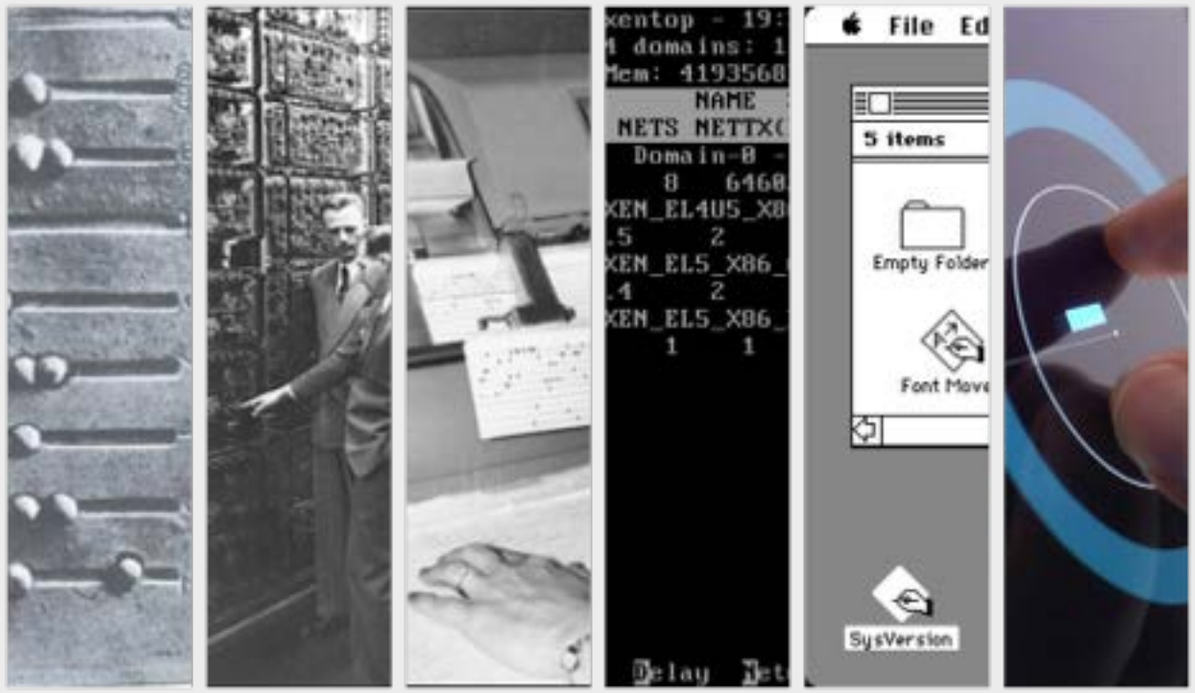
Then we discovered **electricity**, and the system to turn off and on a light, was able to shift its resources externally to the electric grid.
We continued to refine our lights.
Now we have “intelligent” lights that can think for themselves, detecting if a human is present at night, and automatically turning themselves on to provide light.
With the advent of the internet, like electricity, **intelligence** and **information** can also be separated from the control-system as an **external resource**, with lights that connect to the internet (known as the **IOT**) for external information such as the weather, your personal calendar, etc.

As lights evolved, **many other interactive physical systems** also became more convenient and refined over time including water-delivery systems, doors, writing, and musical instruments.

History

Computers : Evolution



Abacus - Mechanical Computing Machine - Punch Cards - CLI - GUI - Touch

Meanwhile the calculator was evolving from the abacus to massive electronic machines in the late 1800s, up to the point that you could feed in punch cards and receive a calculated result. Then came the awesome Command Line Interface - which was awesome because you could actually see what you were typing, you could learn the computer's language, type a question into the computer and it would tell you something in return.

History

Computers : Mother of all Demos

December 9, 1968, Douglas Engelbart's mind blowing "Mother of All Demos"

Then computers got even more powerful, and on December 9, 1968, Douglas Engelbart presented the "Mother of all Demos", blowing peoples minds with the mouse and a Graphical User Interface that demonstrated many of todays modern elements including windows, files, word processing. These metaphors for the real world were even more natural to humans than the Command Line.
Decades passed, GUIs became more refined, computers got better and reached more consumers, a whole field 'Physical Ergonomics' became popularised to help people fix the unnatural postures they had using computers.

History

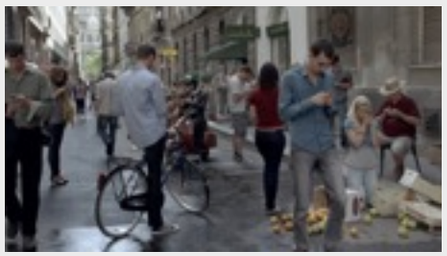
Computers : Touch User Interface

Jeff Han's Ted Talk - 2:31-3:32

* Meanwhile further progress was made in academic circles with alternative interfaces such as Pen based and Touch based interfaces.
Multitouch interfaces were rapidly growing in popularity and there was sincere excitement for it as a more intuitive interface as seen in the reaction to Jeff Han's TED Talk in 2006. [video 2:31-3:32]
A year later, such multitouch interfaces began hitting consumers in even greater force with the first iPhone.
These wounderful touch based interfaces again reduced the interface, closing the distance between what we told the computer to do and what we wanted to do.

History

Computers : Smartphone Parodies



Human Evolution Comic – Windows Phone Really? (Commercial Series) – Phone Sidewalk

After we had some time to get use to the new power of such devices. We now have parodies of people using their phones too often (phone-necking parodies - comics, animations, walking lanes, Microsoft ad etc.).

2

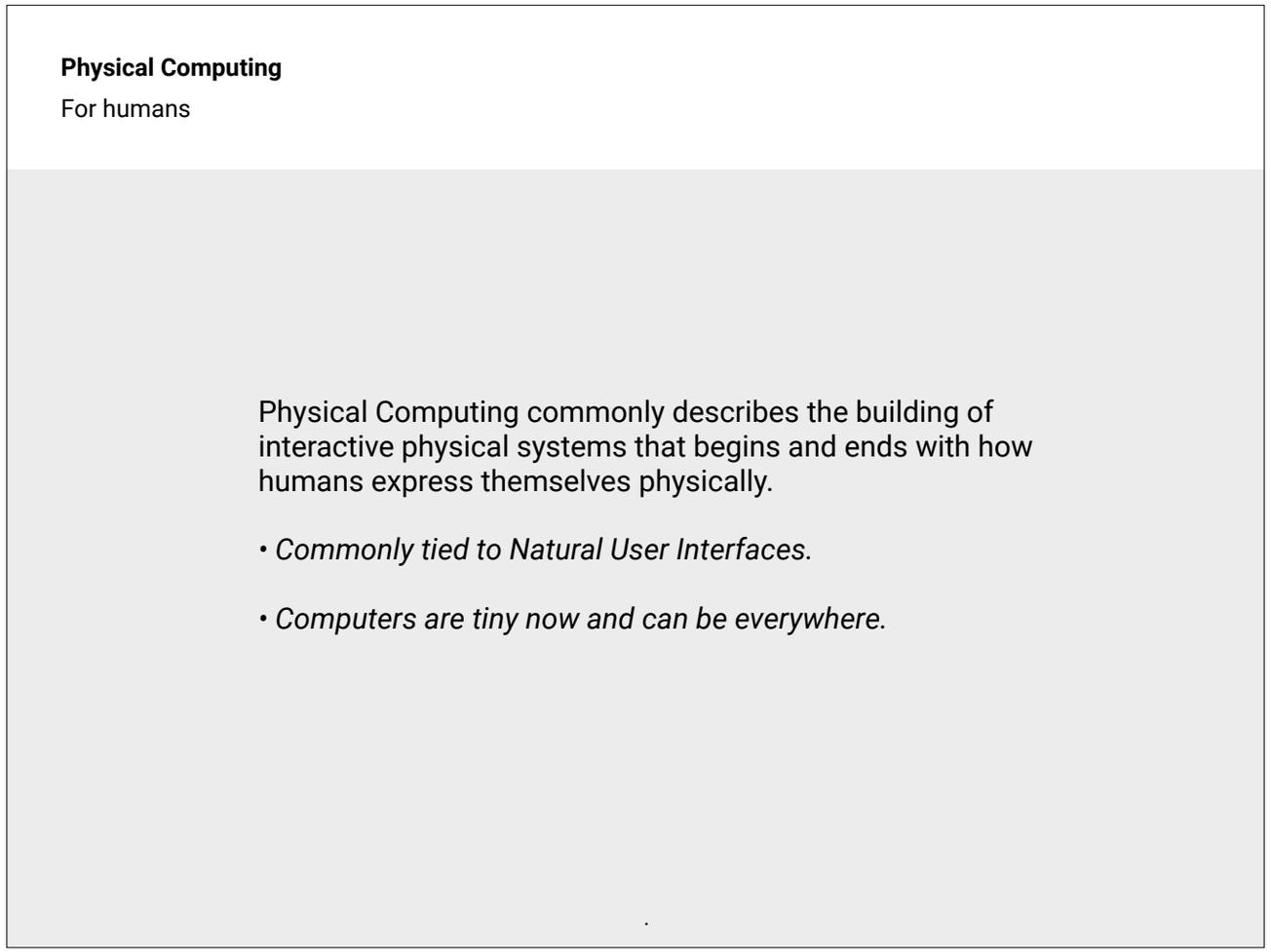
Physical Computing

A broad generalisation

Bill Buxton has a great quote

When I started in this industry, the challenge was whether we could make these things work, but now we can do anything, the question becomes should we do it?

Bill Buxton



And this is where we're at now: Physical Computing.

Physical Computing commonly describes the building of interactive physical systems that begins and ends with how humans express themselves physically.

It is commonly tied to NUIs or Natural User Interfaces.

NUIs, like CLIs, GUIs, multitouch, are attempts at making **computing more natural**. Making it easier for users to learn increasingly powerful interactions. With interfaces in our modern age though, we must also consider that computing itself has changed, it is no longer so big that it has to reside in a single machine, it **can existing in the physical world around us, our environment, and the common objects and architectures therein.**

// ~ This quote is by Tom Igoe, whom authored the book 'Physical Computing: Sensing and Controlling the Physical world with computers' with Dan O'Sullivan which has a great introduction into this topic.

3

Interactive Physical System Structure

From user, to system, to user

Interactive Physical System Structure

The skeleton

An Interactive Physical System consists of input (through **sensors**), internal processes, and Output (through **actuators**). With Physical Computing, it is also important to consider how the user affects the input, and is effected by the output.

// (Using the office lights example: A person walks into an unlit room at night, the systems' sensory input detects a person, the system processes this event - determining to turn on the light because it's night time, then the system outputs light. The person now has light.)

Note: Even though the **terms 'input' and 'output**' here are used in relation to the system, in Physical Computing, we are always mindful of how they connect with the user.

In the following slides we will explore each of these sections further with current and emerging technological examples.

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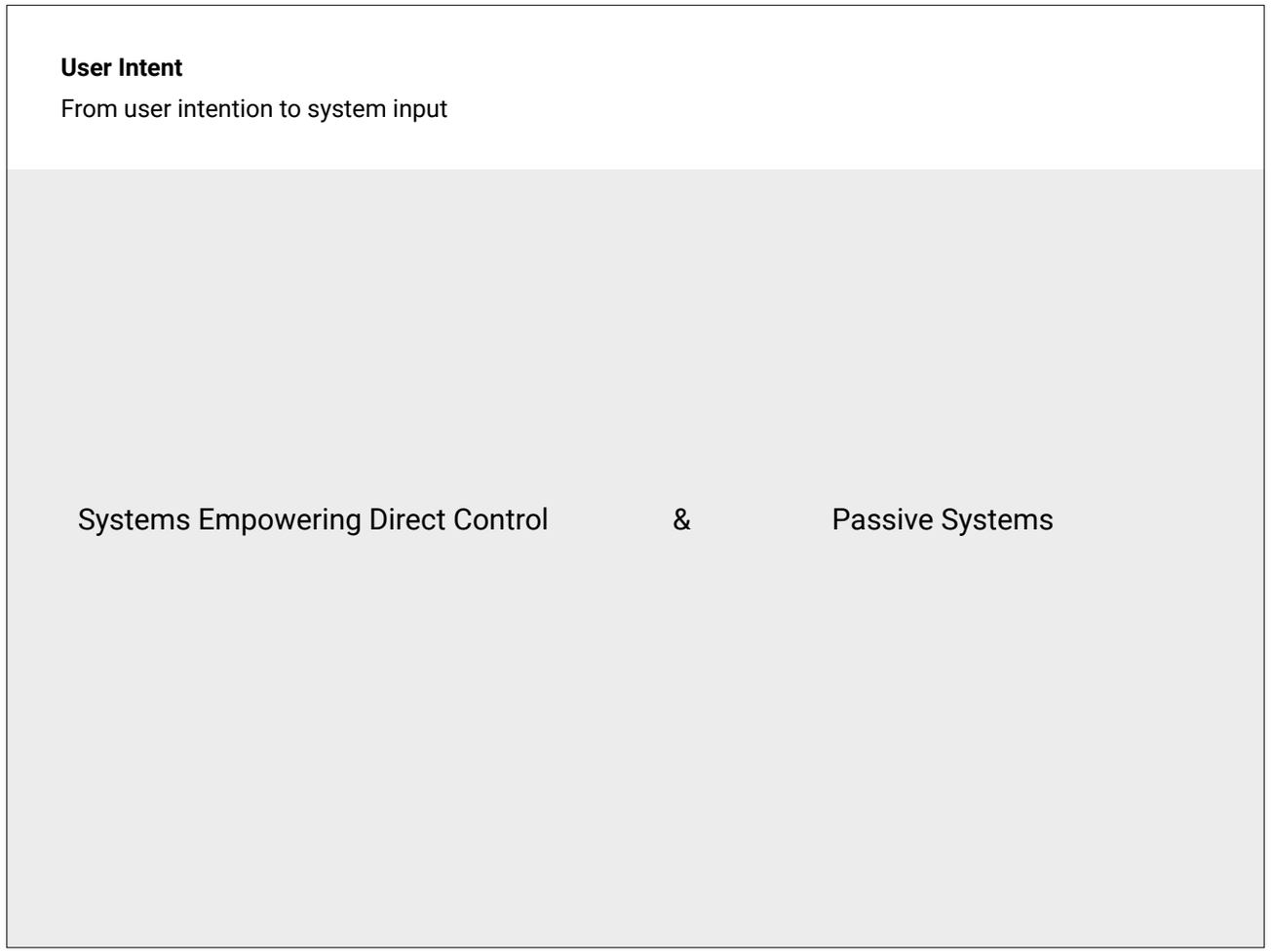
User Intent

Direct or passive

User Intent

From user intention to system input



People can have multiple intentions when interacting with systems. These can be broadly classified into systems that empower the user by facilitating immediate control, or passive systems.

User Intent

Direct Control - 1/3

Harry Potter: Magic Wand – Dr Who: Sonic Screwdriver – Futurama: Holohponor

In the fictional world, notably in science fiction, we commonly find artifacts that empower us in manipulating our environment or creating content. From pointing devices such as magic wands (Harry Potter) and Doctor Who’s sonic screwdriver, to musical instruments such as the Holophonor in Futurama.

User Intent

Direct Control - 2/3 (& Prosthetics)

Avatar Mech Suit – Military Exoskeleton – Honda's Walk Assistant – 17yo Easton Lachappelle EEG prosthetic – Neil Harrison's Eyeborg – Phantom Terrains

Our bodies can become augmented with prosthetics and mech-suits (Avatar, Real World Military, Real World Senior Aid) that **naturally act as an extension of ourselves**.
You can do amazing things with the simplest of tools, as demonstrated by 17yo Easton Lachappelle's EEG (electro-ence-phalogram) prosthetic - which started off with just some basic flex sensors.

Sometimes giving us abilities beyond our natural one.

User Intent

Direct Control - 3/3

Volkswagen Commercial “The Force” – Minority Report

At times, there are no physical artifacts at all - replaced by an intelligent environment or invisible force (Star Wars ‘The Force’, Minority Report - free hand gestures). Even if these cultural examples of direct manipulation may have obvious issues, they can allude to abstractions of human and cultural desires.

User Intent

Passive Systems

Her: Samantha – Legend of Zelda: Navi – The Hobbit: Sting

Though, **fictional worlds** make a **great show** of depicting the **empowerment** of humans with the ability to control things directly. One of the more **subtle facets** of Physical Computing is **passive**; **looking at how common actions or inaction be invisibly improved**. In imagined worlds, this is often found in more **efficient systems**, smoother travel flows and **omniprescent intelligences** (in utopic or dystopic futures). These intelligences just know what you want, when you want it, sometimes before you know you want it.

—

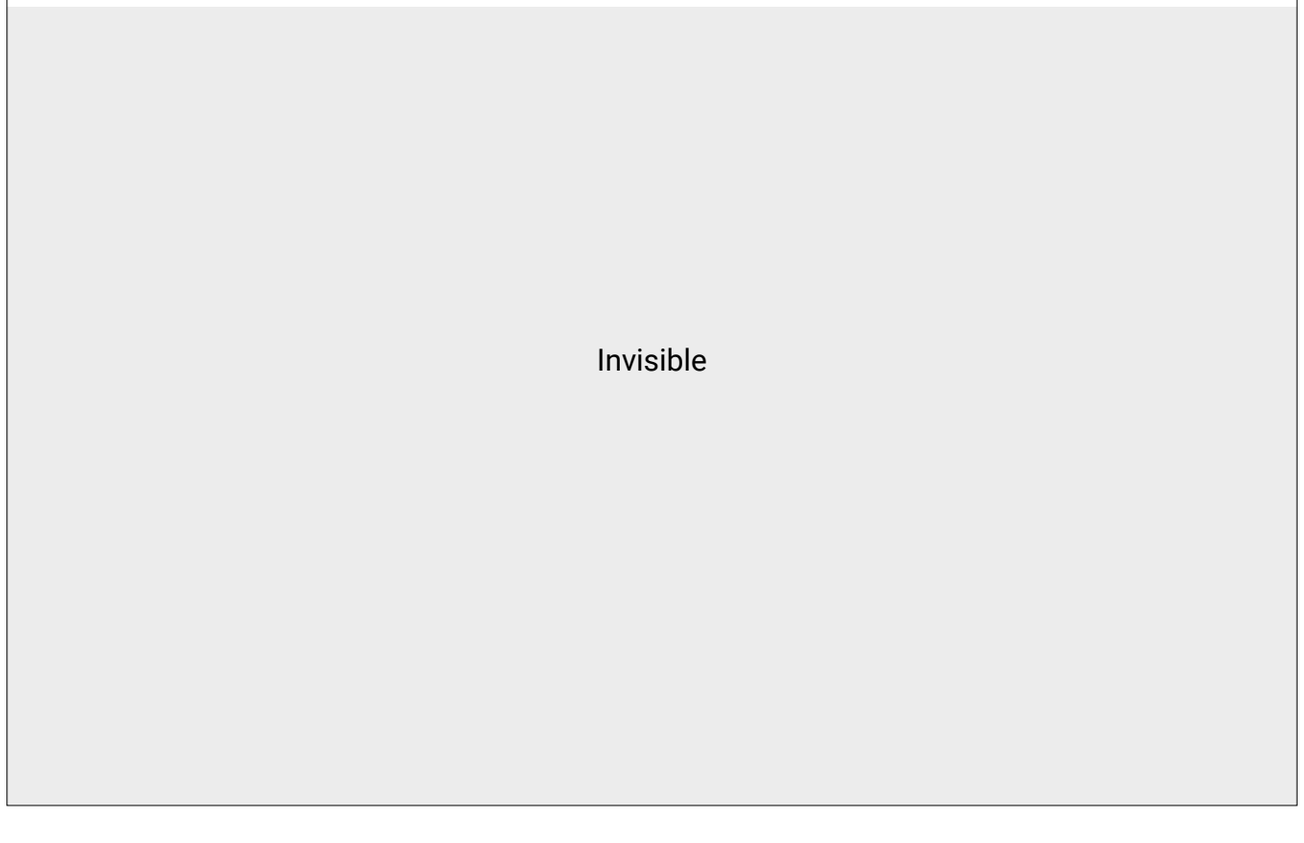
Even though their suggestions are subtle, in the fictional world always happen just at the right time (unless you’re in a horror movie and you get a notification).

Good design is actually a lot harder to notice than poor design, in part because good designs fit our needs so well that the design is invisible

Donald A. Norman – The Design of Everyday Things

User Intent

Passive Systems



These invisible intelligences already exist in the real world (lifts, auto car lights).

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They can subtly suggest actions (‘oral-b’ brush teeth - apps that notify, google now cards / google now: catch last train now, siri proactive).

—

Suggestions can be informed by invisible sensors (passive heartbeat reading, observing/recording/analysing human behaviour (above exampels), cars that alert you if it looks like you’re driving angry/sleepy).

User Intent

Passive Systems

- Automated Lifts & Car lights.
- Proactive Suggestions (e.g. Oral-B Toothbrush, Google Now Cards, Siri Proactive)
- Heartbeat and Emotion monitoring.

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System Input

What goes into the system

The output of users, intentional or not, is received by the interactive physical system as input.

System Input

Traditional Sensors

Little Bits – Arduino Starter Kit

The **oldest** type of sensor is the **simple button**. Other basic sensors include switches, sliders, potentiometres, flex sensors.

System Input

The Smartphone is chock full of sensors

Everything Machine

Traditional sensors include sensors that can be found on your phone such as: Camera, Microphone, compass, GPS and motion sensors.

System Input

Other Sensors - Kinect

Sculpture Lens: Strike a Pose

Besides the smartphone, there are also other standard consumer devices that can be hacked together and used for input in the realm of Physical Computing. These include fitness orientated wearables, the Kinect, Wii Controller, and electronic kits.

You can do a lot working with these sensors.

System Input

Other Sensors - Wii

Controlling a crane with a wiimote

System Input

Other Sensors - Brain Waves

Lightwell's Brain Battle at Beams

On the technological fringe we have: Brain Wave readers, Eye Trackers, and the adoption of every day objects as signal carriers (Disney Touche).

System Input

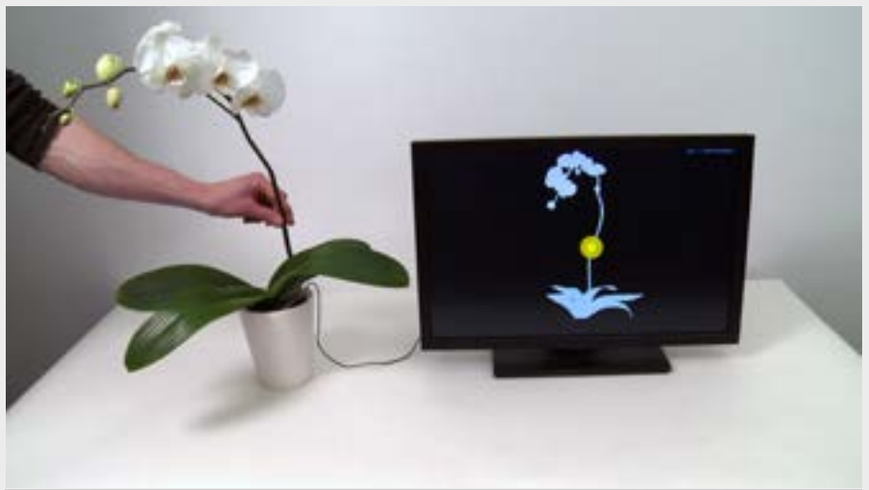
Other Sensors - Eye Tracking

Eyewriter

(All of these reflective images or underlined text are hyperlinks btw)

System Input

Other Sensors - Electricity



Disney Research: Botanicus Interacticus: Interactive Plant Technology

6

System Processes

What the system thinks about

[[halfway through - should be 10:20]]

System Processes

External Resources

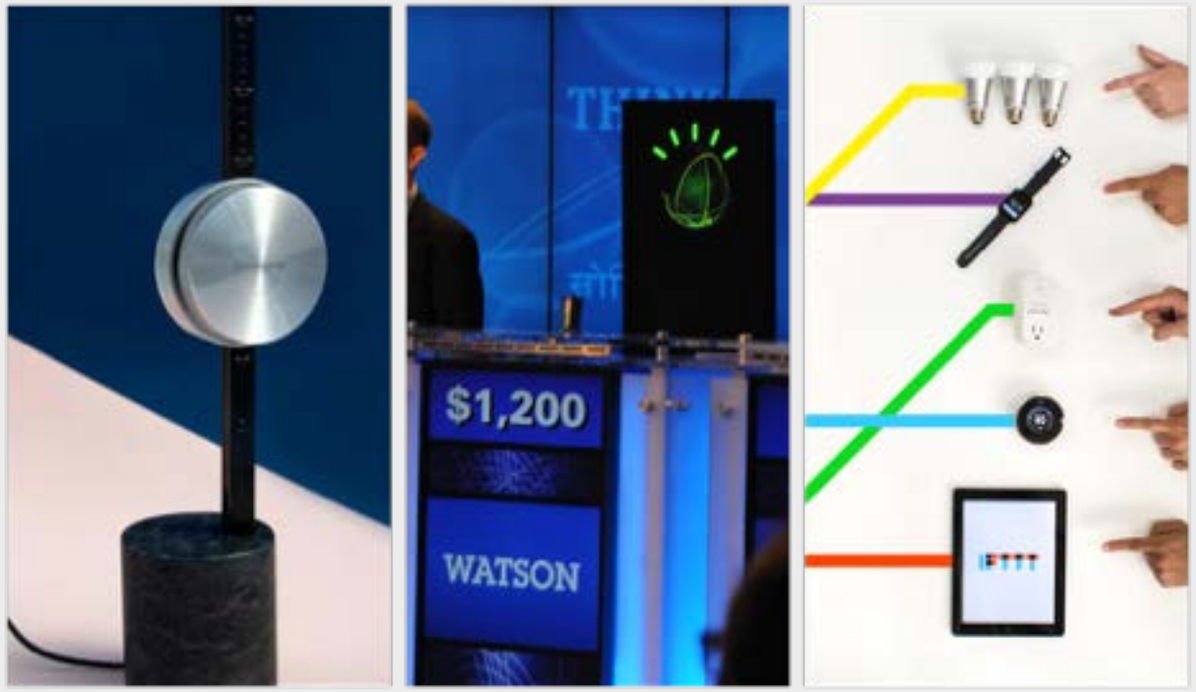
Helpful External System Resources

☀️ electricity (e.g. Solar, Electric Grid, Human Generated)
ℹ️ information (e.g. via the internet)
🎓 computational power (e.g. via the internet)

As technology evolved throughout human history, our interactive physical systems adopted a larger variety and quantity of resources such as water and electricity.

System Processes

External Resources - examples



Metronome-Inspired Spotify Interface – IBM Watson on Jeopardy – IFTT

Today we have access to information as an external resource, allowing systems to access cultural content such as ones spotify playlist, and perform computations through services such as IFTTT (e.g. tell Siri to make sure all the lights are switched off) and IBM Watson.

The increasing affordability and power of electronics has allowed both local and external computing power to perform increasingly complex calculations. The most notable of these computations is the field of Machine Learning.

System Processes

A.I. - Fiction and Non-Fiction

The cultural definition of artificial intelligence — or A.I., as it is known — goes something like this: ~~**“A.I. is the science of how to get machines to do the things they do in the movies.”**~~ No wonder the subject makes some people nervous.

...

Building intelligent machines can teach us about our minds — about who we are — and those lessons will make our world a better place. To win that knowledge, though, our species will have to trade in another piece of its vanity.

System Processes

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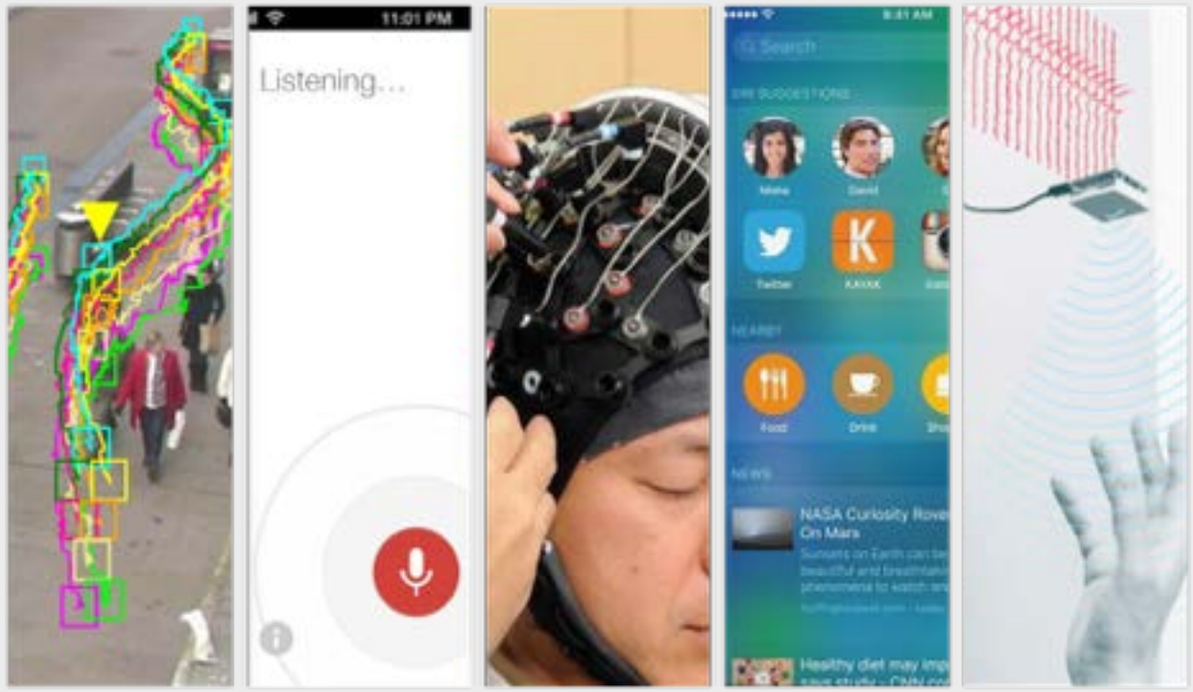
Astro Teller - on "Smart Machines and Why We Fear Them"

AI, and ML is not what you may think. Understanding that is important. Distinguishing fiction from non-fiction allows you to better understand and opens up the floodgates to what you can conceptualise and accomplish in your projects.

System Processes

Machine Learning Possibilities

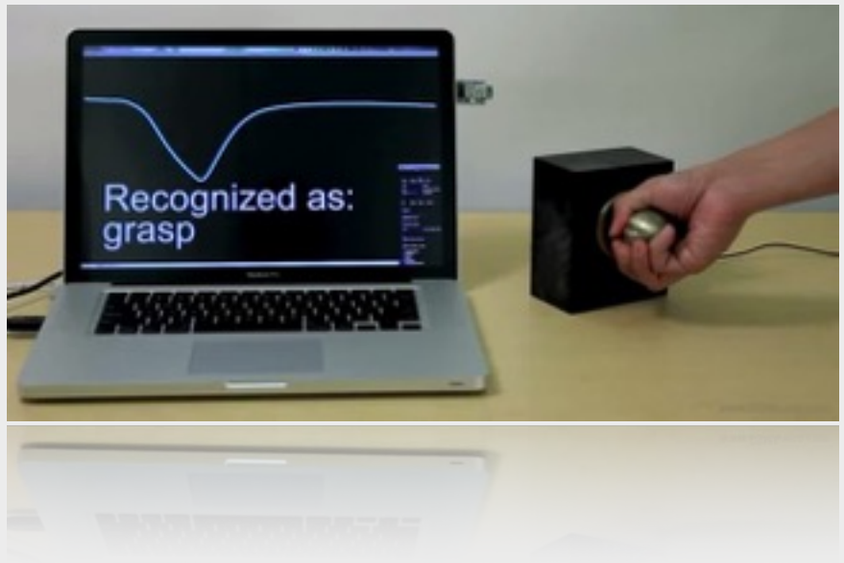


Computer Vision – Voice Transcription (Google Now) – Thought controlled bots (Honda) – Contextual Assistance (Siri) – Project Soli [0-1:40]
Others: Japanese Demographic-sensitive vending machines, Vehicle-determined McDonalds Orders, G.Now Nudge to catch your last train.

Machine learning is becoming **increasingly accessible** both on the consumer level and the tools that help a creator utilise them. Such algorithms can be used to interpret camera feeds, understand spoken words, read brain waves, contextually predict what we want from our time and location (google now, siri proactive) or our **bodily attributes** (japanese vending machines), or by **our personal tastes** (our vehicle and maccas orders). It can also be used to analyse various direct or indirect gestures such as the micro gestures in Project Soli, or the method by which we grab a door handle or stroke a plant, interpreted as an electric signal.

System Processes

Machine Learning Possibilities - example - Disney Touche



Disney Touche - Video

7

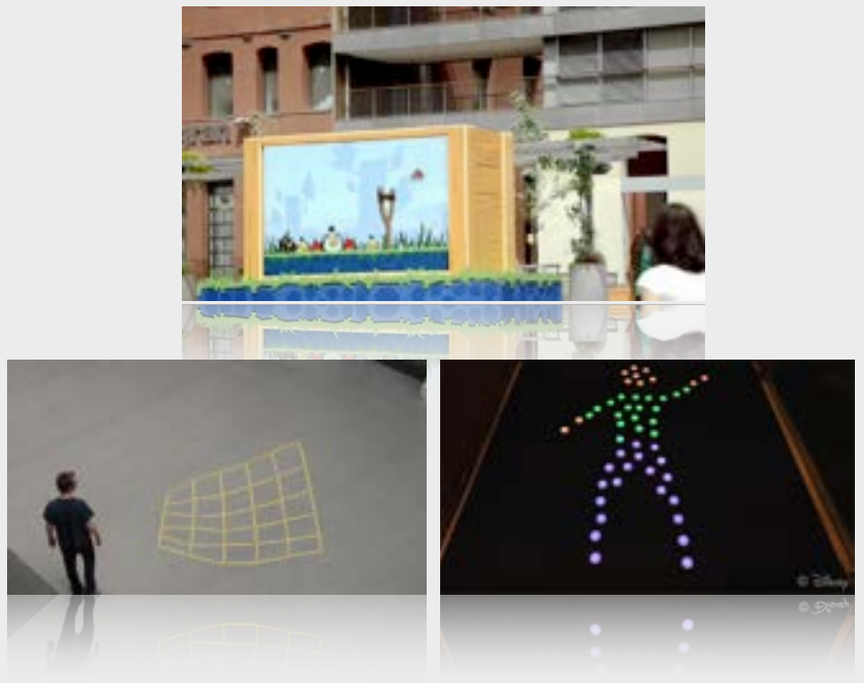
System Output

What the system does as a result of its input and thinking

The output of Interactive Physical Systems can be intended to manipulate: either: - the environment around a user, effect a user directly via one or more of their human senses, or both.

System Output

Moving Objects and Environments

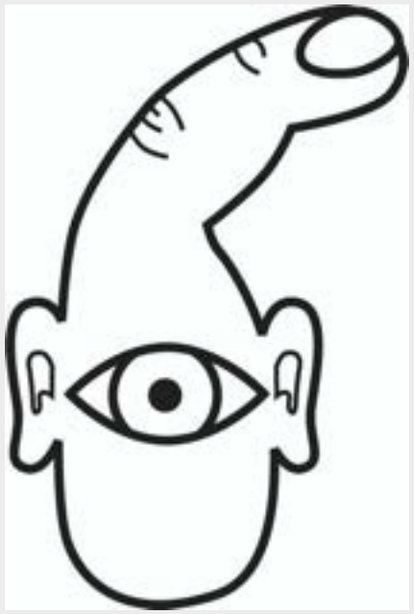


Greg Brunkalla (Legs) > Rokkit > Saatchi & Saatchi > TMobile's: Angry Birds Live – Tele-Present Water – Disney Research: Pixelbots

One of the most common outputs of interactive physical systems is the movement of objects, from little robots, drones, doors, to walls (or just big doors), to massive angry bird slingshots.

System Output

Human Sensors (Not System Sensors!)



How Computers see us now – from 'Physical Computing' by Dan O'Sullivan and Tom Igoe (2004)

Basic Human Senses

(Commonly Utilised in Computing)

Visual
Auditory

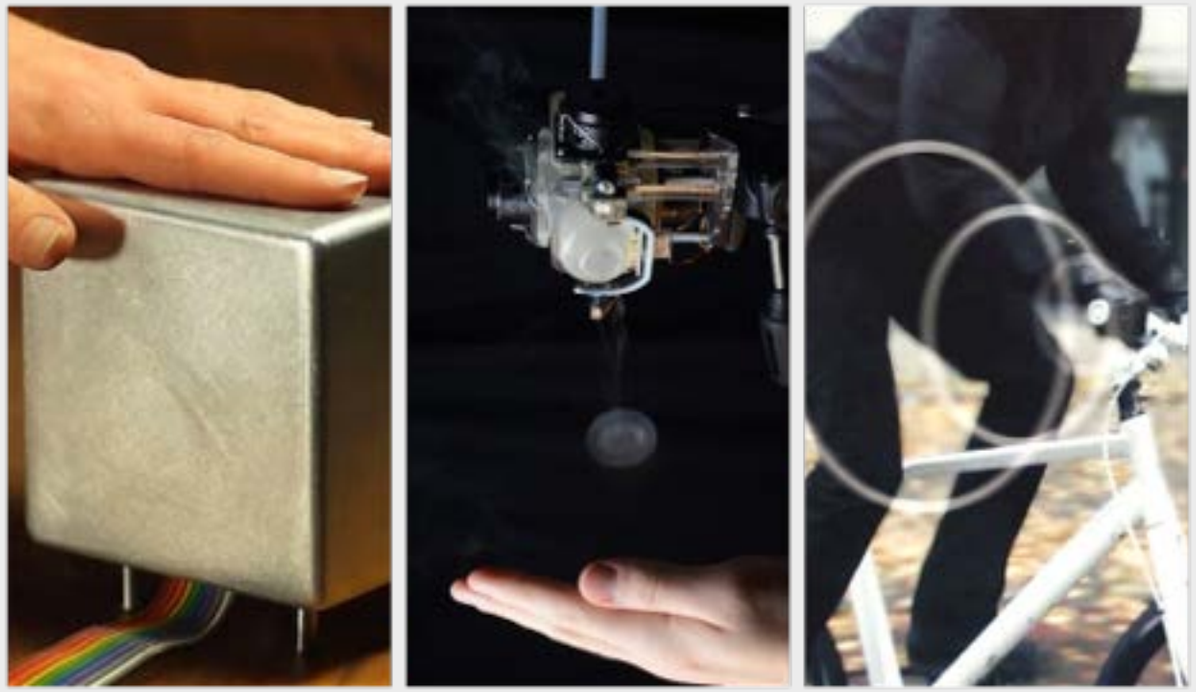
(Uncommon)

Gustatory
Olfactory
Haptic (Changing)

Two of our senses are commonly reached by computing systems. These are visual, and auditory - what we see and hear. Olfactory, gustatary, and tactile feedback are traditionally much less common, and immature, within the world of screens and glass. With olfactory and gustatory senses, this is partially due to their low-resolution as information carriers. Even though tactition can carry a lot of information, it has traditionally been difficult to digitise as a computed output, however, that is looking to change.

System Output

Haptics



Cyroscope: Feel the Weather – Disney: Aireal – smrtGrips (bike handlebar wayfinder)

Some examples of systems with tactile feedback include this weatherbox where you can touch it to feel the temperature (example), this system where you can feel objects through the air (Aerial - in air - example), and as a subtle way-finder in watches, clothes or shoes to guide you to your destination.

System Output

Haptics

electrical/physical oscillating surfaces for texture (eg Revel) – and movement (eg Surround Haptics)

Surfaces can also be vibrated in such a manner as to provide high resolution senses of texture and movement.

8

New Mediums

A few examples of fun & inspirational new tech

So that’s interactive physical systems, from input, to processes, to output.
This section looks at some new mediums, it is no way extensive, but they’re interesting to keep an eye out on.
We’re seeing interesting things with the use of common everyday objects as new mediums.

New Mediums

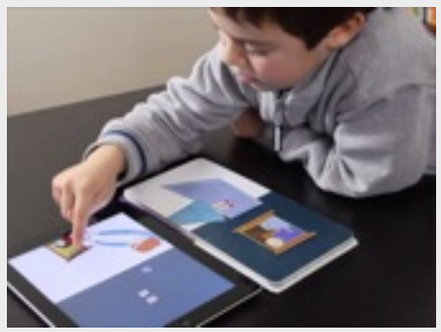
Projection

Pranav Mistry, MIT's Sixth Sense – *Disney MotionBeam*

Projection (Augmented Reality) onto surfaces.

New Mediums

Book Pages and Food



Drawdio – Electric Vegemite – Paper Generators – Bridging Book

And new tools that can be used to send signals through a variety of mediums (Drawdio - through a variety of mediums, Bannana and Vegemite, rubbing Paper Books, Magneting Physical Book + iPad - examples).

New Mediums

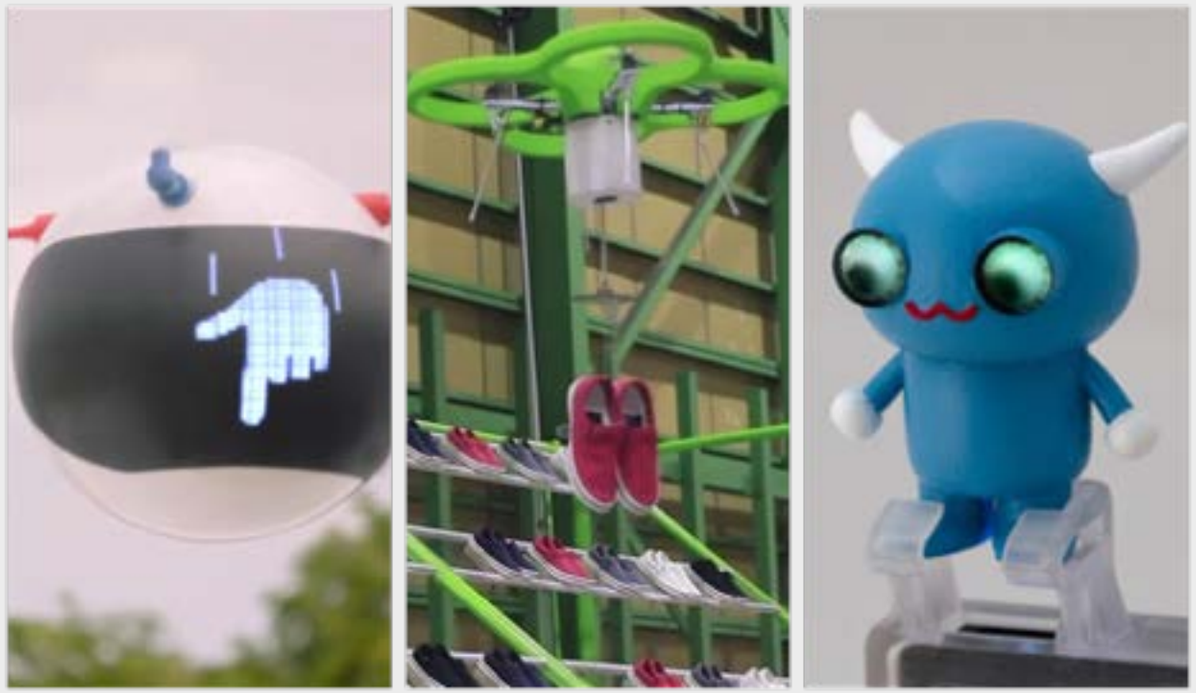
Ecosystems

Visible Light Communication – *Constellaction*

As seen with the magnetic book. Systems can communicate with other systems, and that form of **communication needn’t be via electricity or the internet**. We can carry **invisible auditory signals, and visual signals**. Allowing for device to device interaction and creating the opportunity for interesting ecosystems.

New Mediums

The Third Dimension



Pepsi Drone Friend Finder – Crocs Drone – Printed 3D Optics

Leaving the realm of keyboards and glass screens, we inevitably open ourselves to the **third dimension**. Drones and the opportunities they bring are intriguing.

3D printing offers new opportunities.

New Mediums

The Third Dimension

MIT inForm – Jinha Lee: Grab a Pixel – Common Sand/Foam Table

MIT has shown off some 3D interfaces (inForm, Grab a Pixel examples). And then there's the highly popular Sand Table (sand, foam, example) which has been used in artistic, eductional, and military contexts.

New Mediums

The Third Dimension

V Motion Project – *Connected Worlds: Interactive Ecosystems*

It is important to note now that our computers no longer occupy entire rooms, they’re not even the size of laptops anymore. And with that they can become invisible.
The spatial capacity for our computing-imbued environments have grown immensely. From dj and vj events where your entire body is a controller, to funky playgrounds where you can move physical objects around to manipulate virtual artifacts that have been given life in the real world.

9

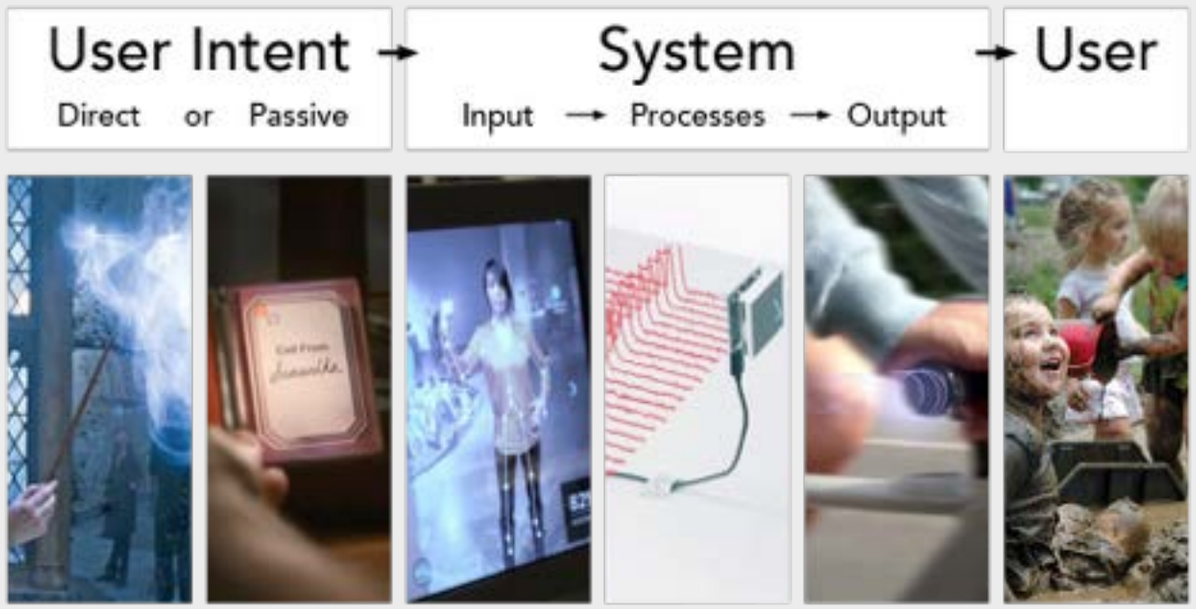
Summary

From user, to system, to user

To Summarise,

Summary

Physical Computing - User from Beginning to End



To summarise, Physical Computing is about the user, from the beginning to the end of the system. With improvements in Machine Learning, Materials, and simpler yet more powerful tools, we've covered just a few of the technological advances that are opening up the possibilities of Physical Computing.

As designers and technologists you seek out, and notice, existing and emerging issues and technologies. Some you would've never heard about, and some you may have taken for granted. Your challenge is to think about them in the context of Physical Computing and the human experience.

Summary

Living

> **Computing is not about computers any more. It is about living.**
>
> ***Nicholas Negroponte***

?

Questions