Wearables (1)

CSE 162 – Mobile Computing

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In this lecture

- What is wearable computing
- Wearable sensing technologies
- Challenges in wearable computing

- The term “wearable computing” is really built around any device that is attached or worn in some way

- So, the possibilities here are vast
    - Continuous health monitoring
    - Brain-computer interface
    - Etc.

Realistic Wearable Technology

- The military is very interested in mobile computing
- Soldiers on the field could benefit from:
  - Improved hands-free communication
  - Mission / environmental information
  - Vital statistics being sent back to command

Realistic Wearable Technology

- Medical use (aka telemedicine)
  - Monitoring patient vitals
  - Administering medicine
  - Patient records
  - Virtual visits
- Smart Glasses
- Smart clothing

Everyday Realistic Wearable Technology

- What most people think about is watches and/or bracelets
- Smart Watches
  - Apple Watch - https://www.apple.com/watch/
  - Android Wear - https://www.android.com/wear/
  - Some proprietary watches
- Personal Fitness Devices
  - Fitbit - https://www.fitbit.com/home
  - Other devices

What is a wearable computer?

- A computer that is
  - Portable while operational
  - Enables hands-free/hands-limited use
  - Able to get the user’s attention
  - Is always on, acting on behalf of the user
  - Able to sense the user’s current context

Rhodes, B. J. (1997). The wearable remembrance agent: A system for augmented memory. Personal Technologies, 1(4), 218-224.

Ideal Attributes

- Persist and provide constant access to information services.
    - Everyday and continuous use.
    - Wearable can interact with the user at any given time.
    - The user can access the wearable quickly and with little effort.

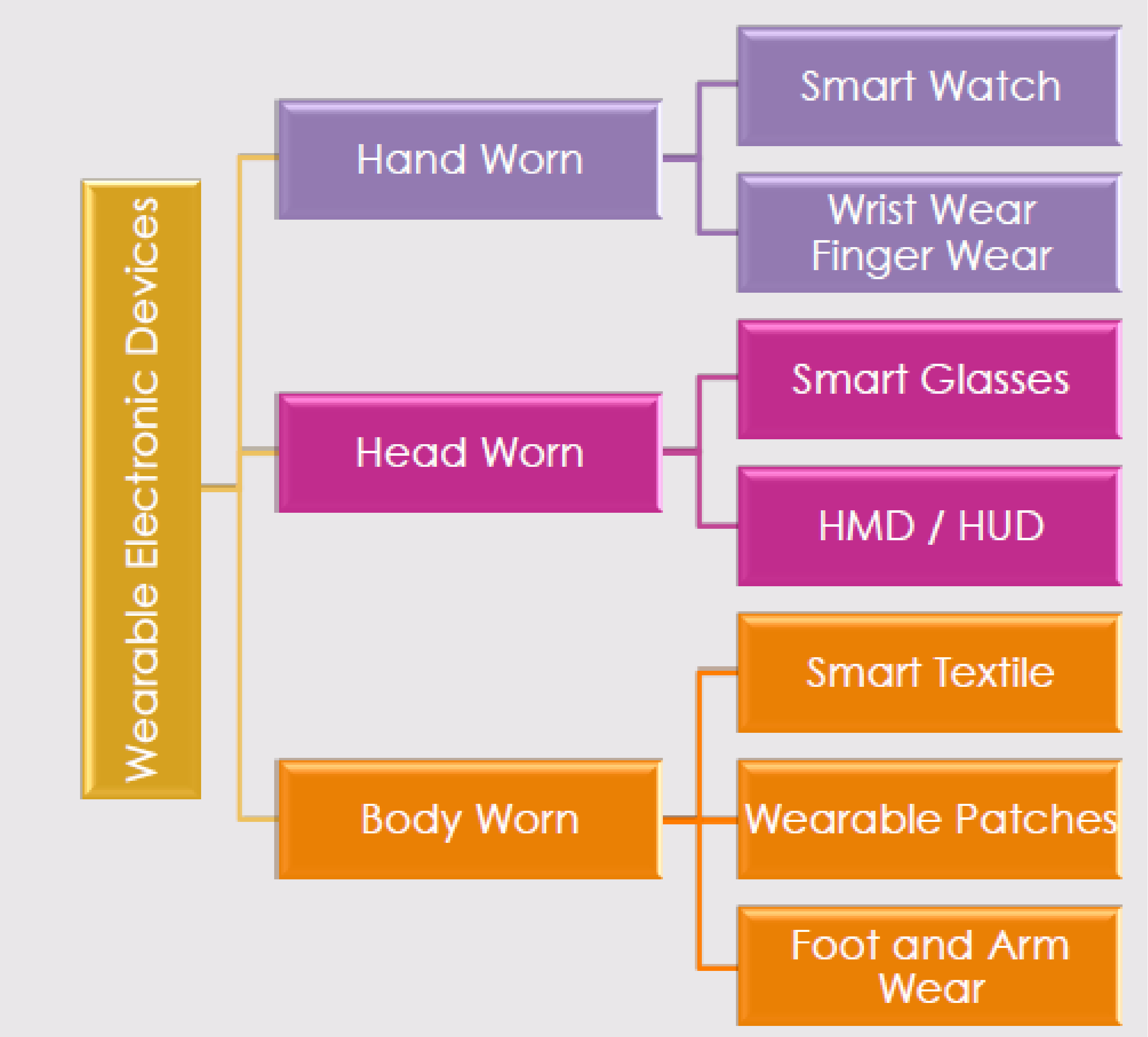
- Sense and model context.
    - The wearable must observe and model the user’s environment, physical and mental state.
    - The user could provide explicit contextual cue to the wearable.
    - The user can identify misunderstanding and explicitly tutor the wearable.

- Adapt interaction modalities based on the user’s context.
    - The wearable should adapt its input and output modalities automatically to those that are most appropriate and socially graceful at the time.

Why discuss this in mobile?

- They are, by definition, mobile devices
- They often run versions of the operating systems we are already working with (Android Wear ⇔ Android)
- The wearable devices often work best when paired with a phone or other mobile device
- Many wearable apps come as part of a pair with a phone version

Wearable devices by use

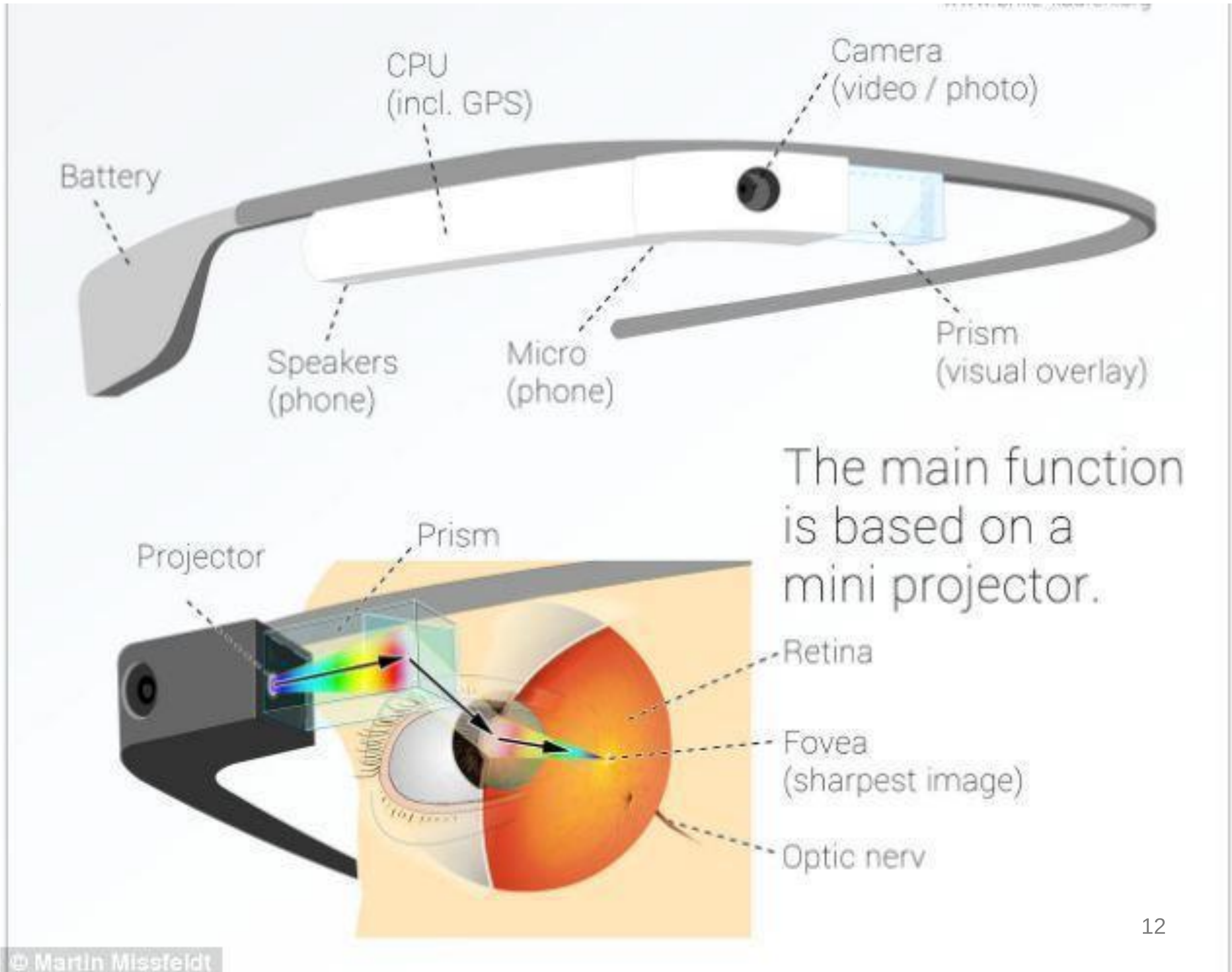


History of wearables

- 1960-90: Early Exploration
  - Custom build devices
- 1990 - 2000: Academic, Military Research
  - MIT, CMU, Georgia Tech, EPFL, etc
  - 1997: ISWC conference starts
- 1995 – 2005+: First Commercial Uses
  - Niche industry applications, Military
- 2010 - : Second Wave of Wearables
  - Consumer applications

Smart glasses

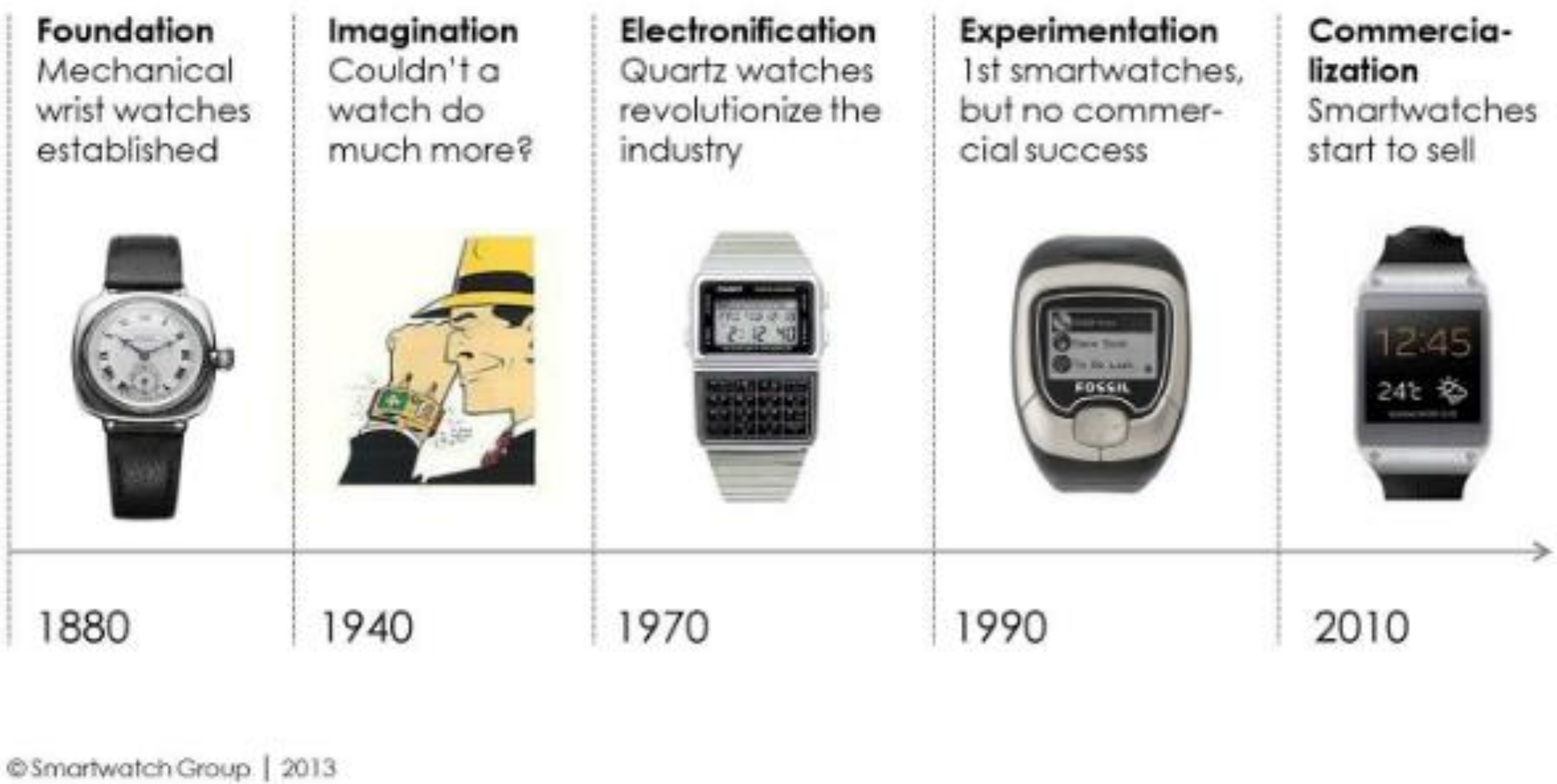
- Head Mounted Display (HMD)
- Head Up Display (HUD)



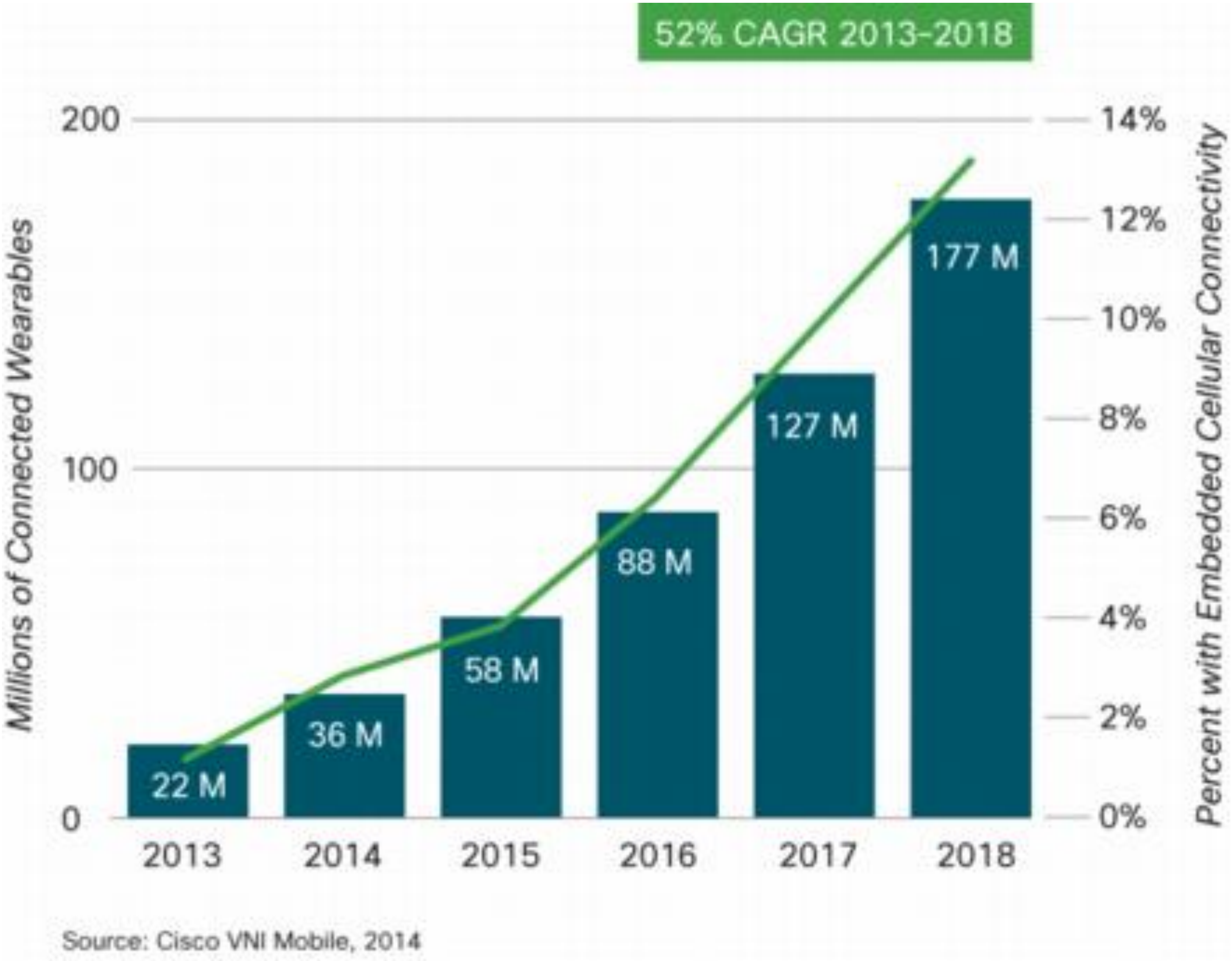
View Through Google Glass

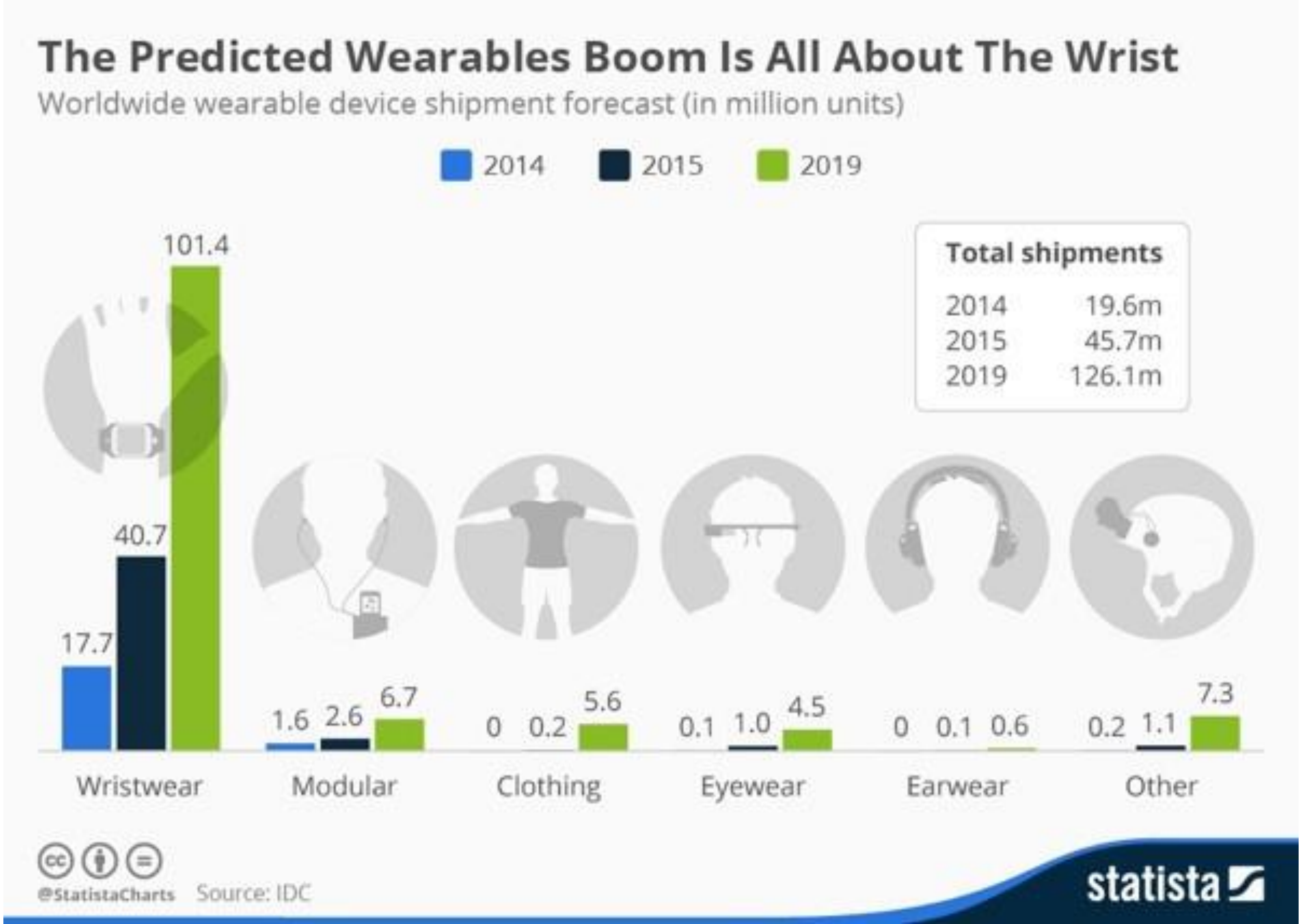
- Always available peripheral information display
  - Combining computing, communications and content capture

Smart watches



Number of Devices Shipped





The Predicted Wearables Boom Is All About The Wrist
Worldwide wearable device shipment forecast (in million units)
2014
2015
2019
101.4
40.7
17.7
1.6
2.6
6.7
0
0.2
5.6
0.1
1.0
4.5
0
0.1
0.6
0.2
1.1
7.3
Total shipments
2014 19.6m
2015 45.7m
2019 126.1m
Wristwear
Modular
Clothing
Eyewear
Earwear
Other
@StatistaCharts
Source: IDC
statista

Smart earplugs

- An emerging computing platform
- New features
  - Augmented acoustic reality
  - Real-time translation
  - Monitor biometrics
  - Fitness coaching
  - Biometric identification

Intra-oral sensing

- “Sensor-Embedded Teeth for Oral Activity”

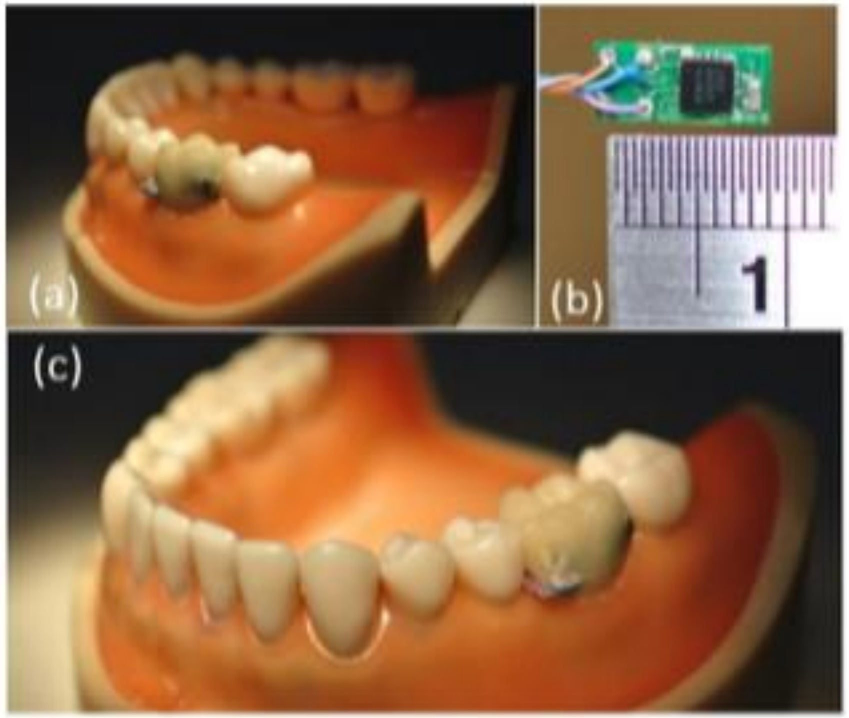


Figure 1. The breakout board with (b) tri-axial accelerometer and (a)(c) sensor embedded denture.

Android Wear

- Released in 2014
- Android Wear devices were initially designed to be second screens, but can be used independently in more situations
- Like Android itself, Wear can be adapted to many different devices
- Uses the same UI theme that the rest of Android uses

Use Cases

- Telling time
- OK Google
- Notifications and quick replies
- Phone app control (like music, for example)
- Fitness
- Basic functions (alarms, stopwatch, etc.)
- Apple Pay

When do you want a watch app?

- Good Watch Apps
  - Buy Me a Pie (grocery list)
  - Seven Minute Workout (works with sensors)
  - Due (reminders)
  - Google Maps (directions on your wrist!)
  - Pandora (control your music)
  - Shazaam (what is that song?)
  - Weather Underground (quick weather forecast)

When do you want a watch app?

- Odd Watch Apps
  - Chipotle?
  - FlightRadar?
  - Fandango?
  - AAA?
  - Amazon?

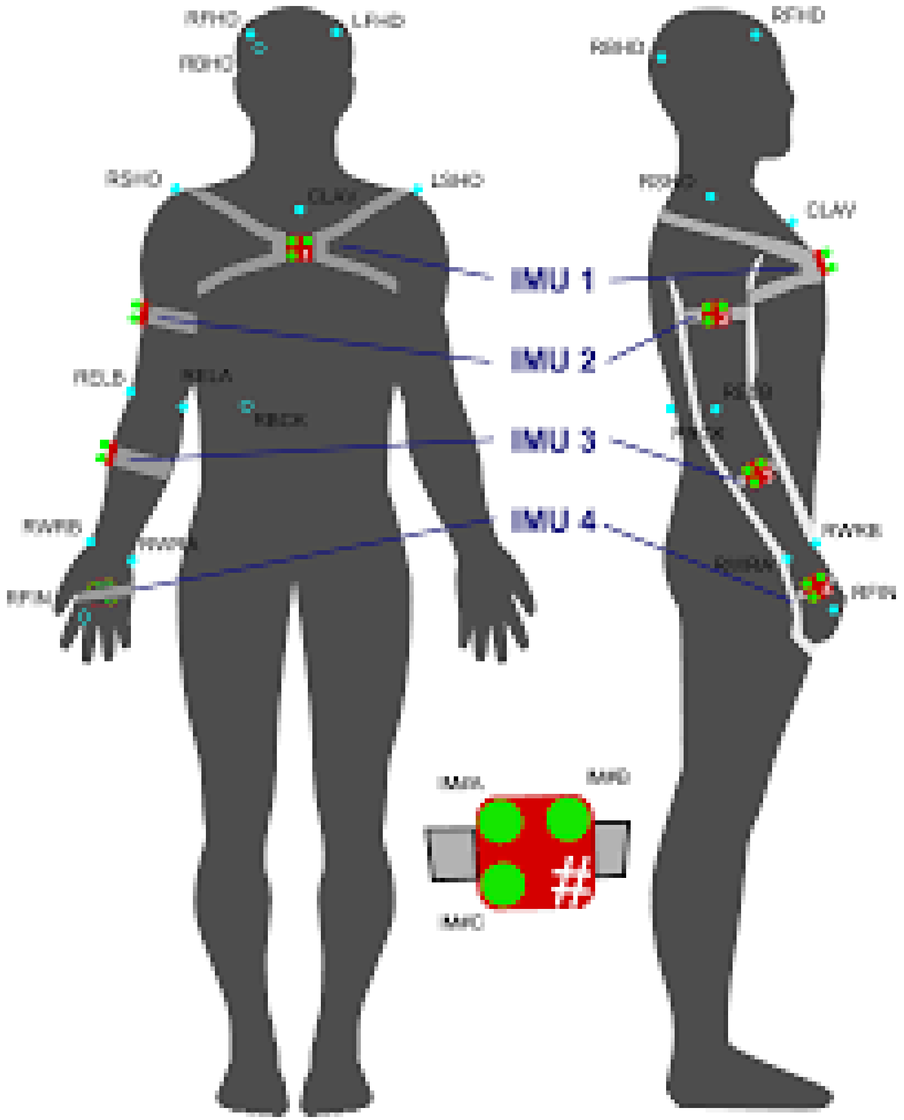
Wearable Technologies

Components of wearables

Sensors	Inertial sensors	PPG sensors	Bio sensors	Other sensors
Connectivity	Blulletooth	Wifi	Gps	Cellular
Battery	Conventional	Energy harvesting		
Interface	Speech recognition	haptics /touch recognition	Gesture recognition	
Materials	Electronic textiles	Flexible display		

Inertial sensors

- Continuous data recording
- Body posture and movements



Wearable inertial sensors for activity tracking

Nike FuelBand

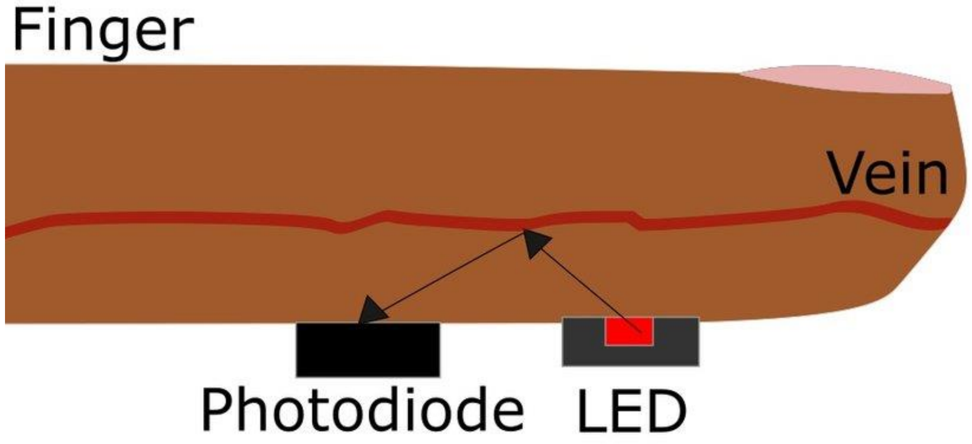
Fitbit

Basis

Jawbone

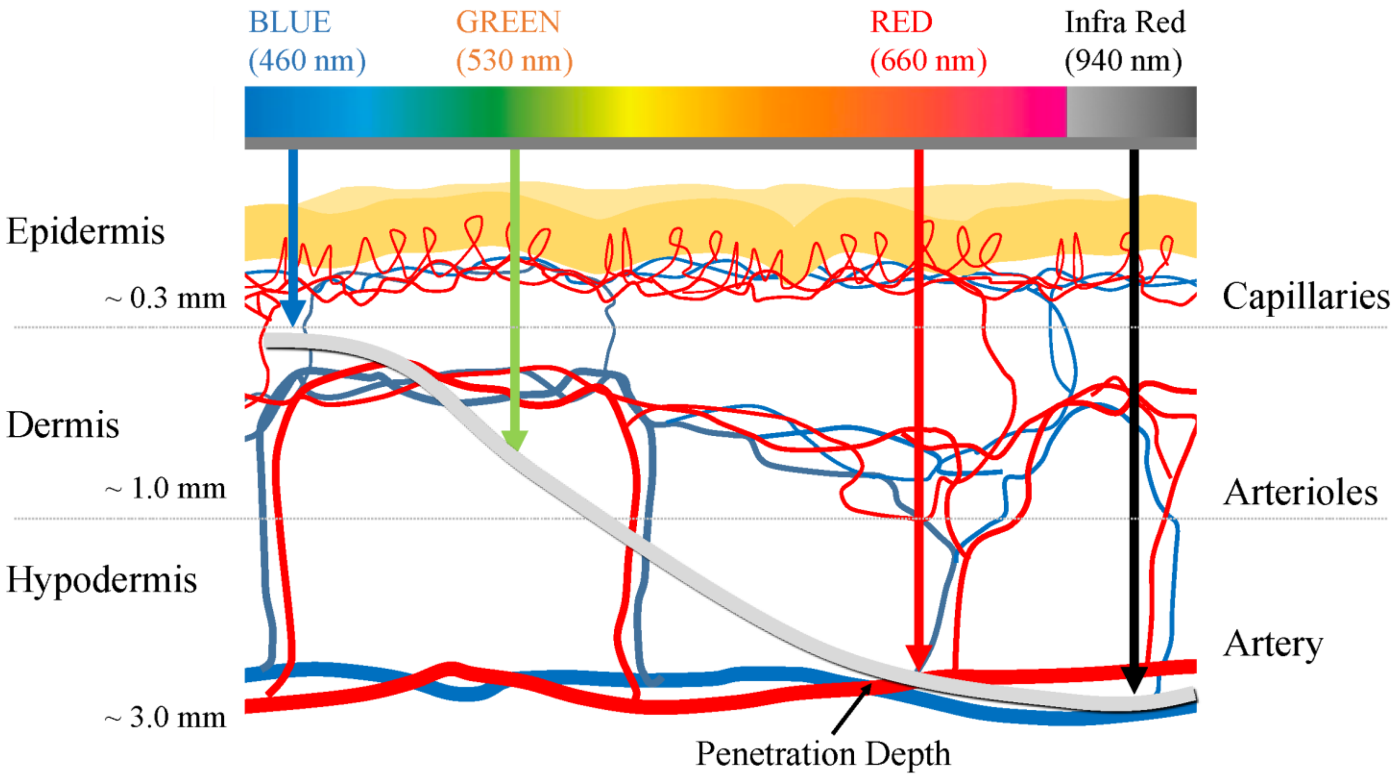
Photoplethysmography (PPG)

- How it works
  - Contains a light source and a photodetector
  - The light source emits light to a tissue and the photodetector measures the reflected light from the tissue.
  - The reflected light is proportional to blood volume variations.



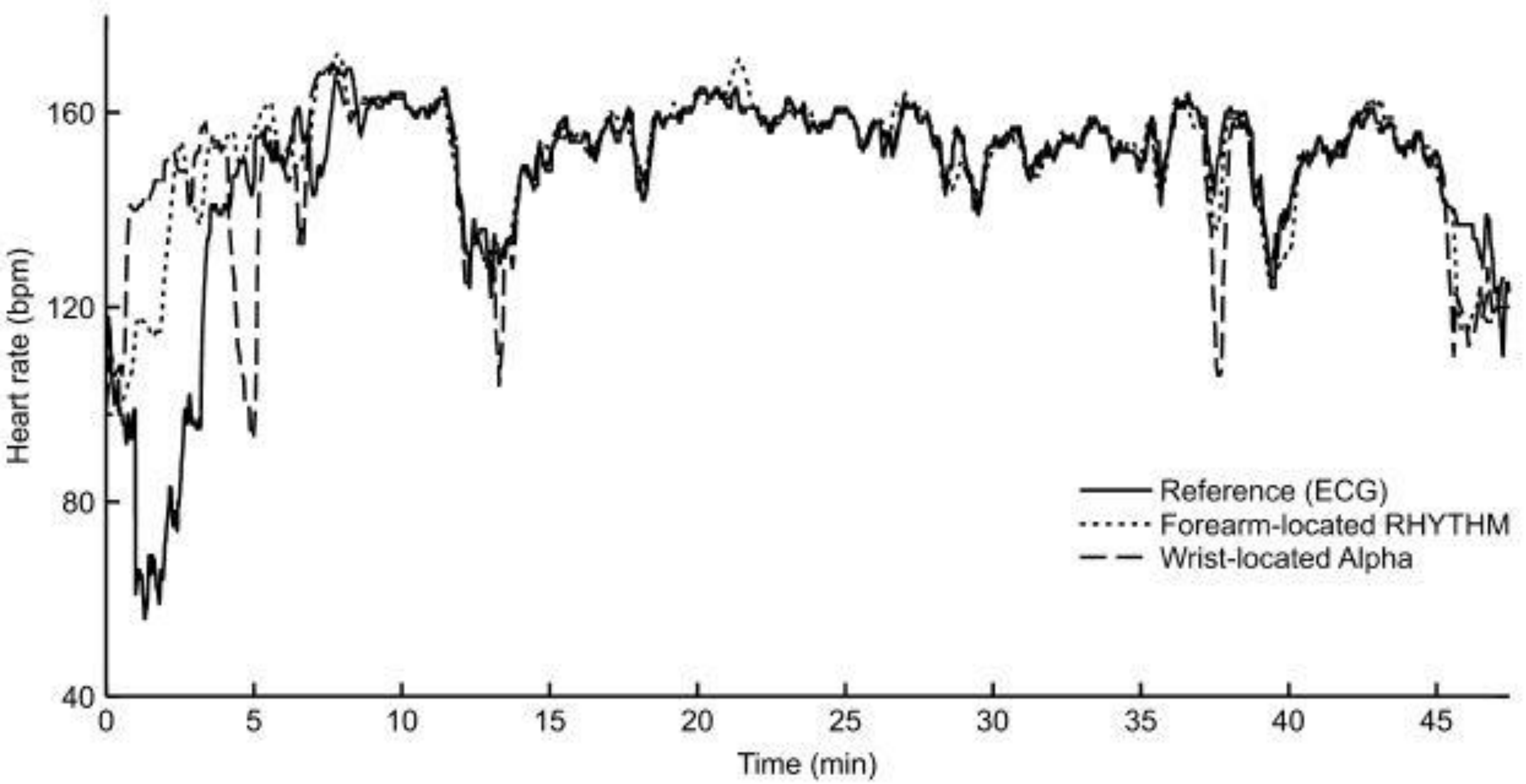
Photoplethysmography (PPG)

- Optimal wavelength:
  - Infrared, deepest penetration through skin
  - Green, robust to motion artifacts



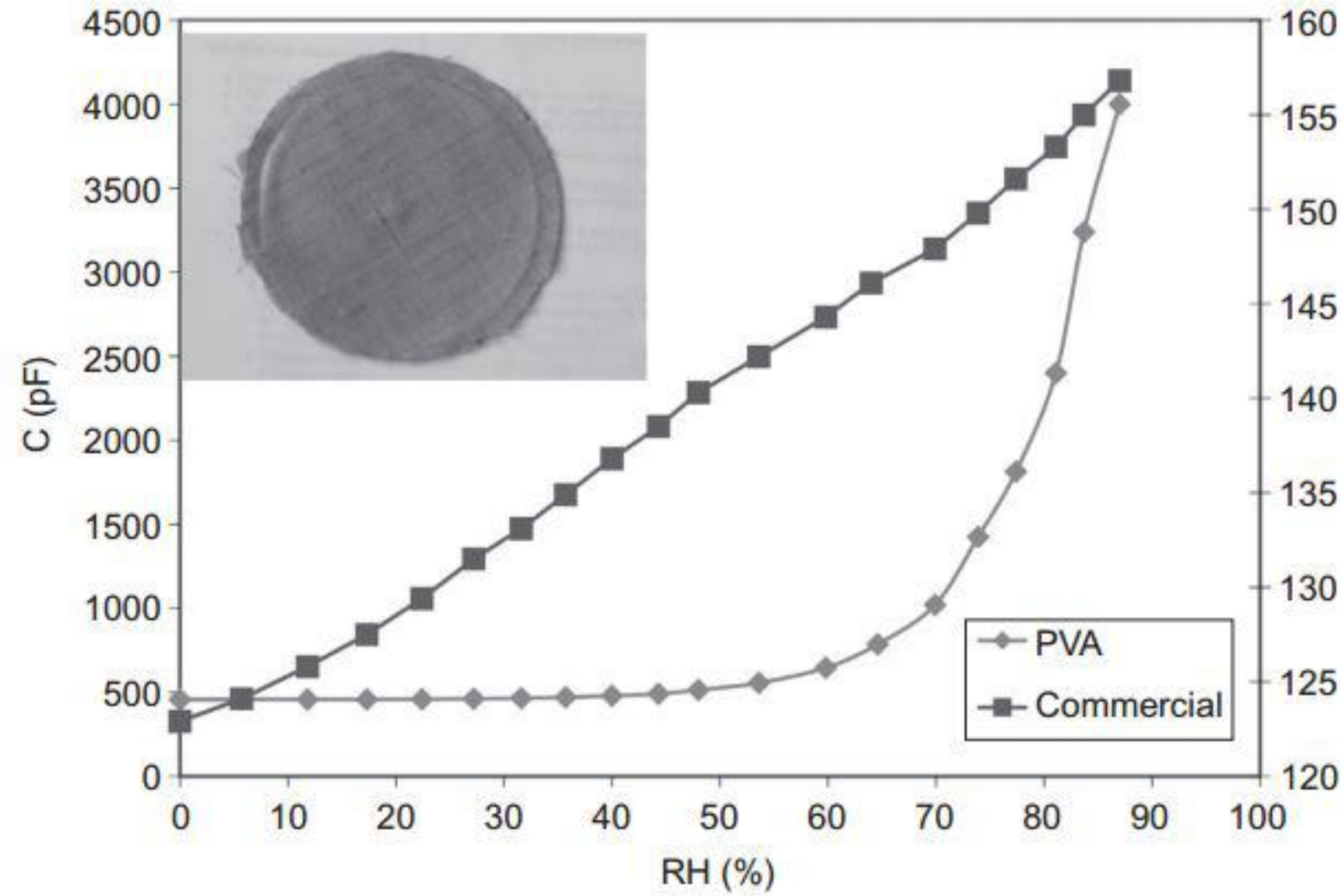
Photoplethysmography (PPG)

- Effective in monitoring heart rate



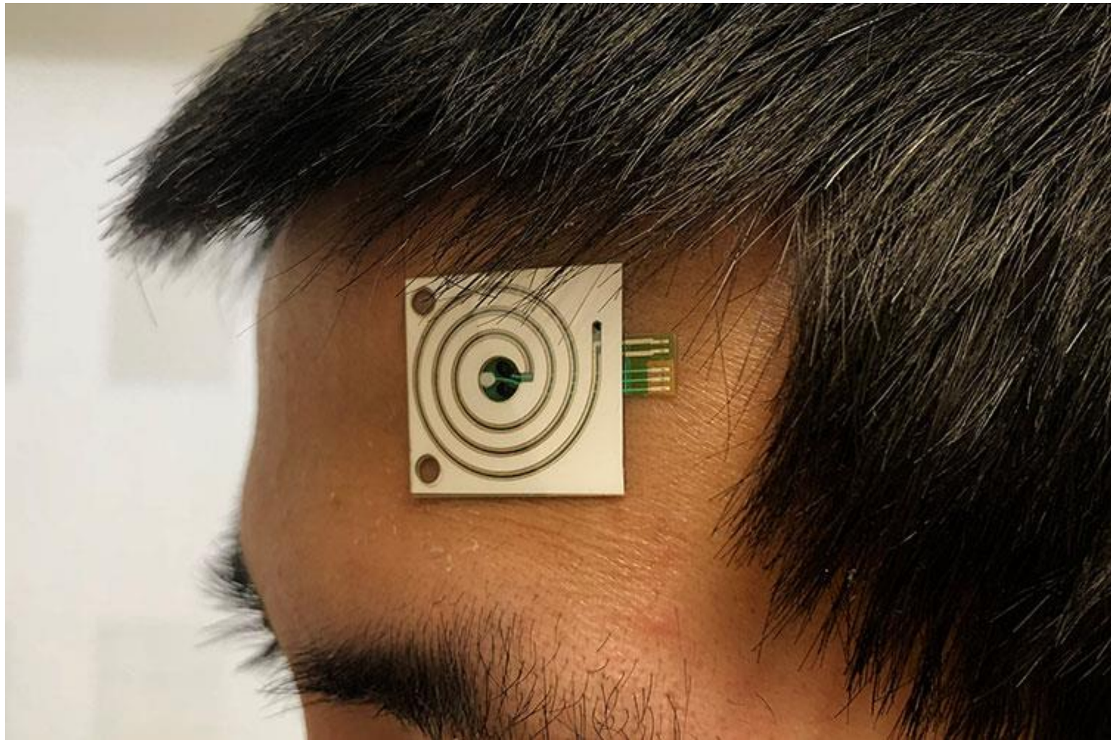
Sweat Sensor

- Used in wearable textiles
- Activity monitoring



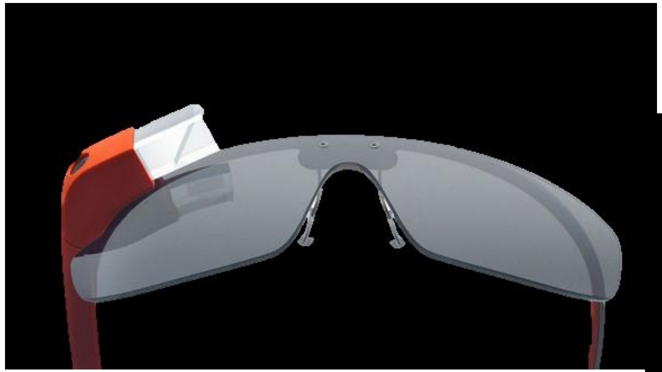
Bio-sensor

- Chemical sensors that can detect cortisol concentrations
- Monitor mental states. E.g., cholesterol biosensor
  - Based on enzymatic catalysis of a reaction



Data Display

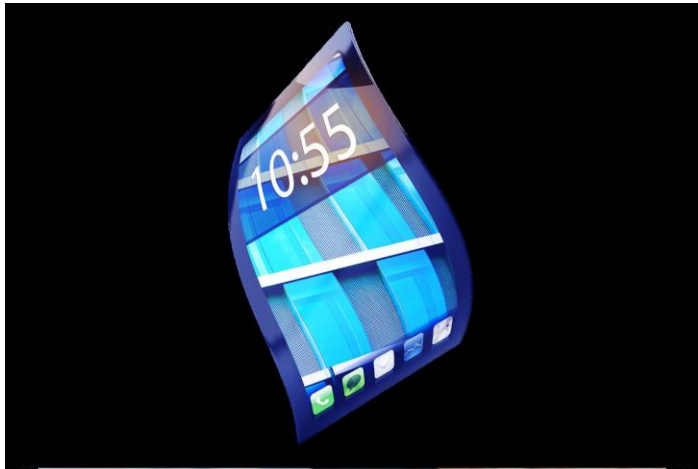
- Internal Display
  - Data displayed in the device or projected somewhere
  - Flexible display and electronics desired
  - Difficult trade off between size and HCI



- External Display
  - Data displayed in another device
  - Existing displays are sufficient
  - Less flexible, smaller wearables

Flexible Displays

- Low stiffness, low thickness, better resolution are desired
- Production costs are falling
- Better materials need to be discovered



Internal vs External Displays

- Devices with minimum information to be displayed
- Devices that can project data
- Connectivity is poor
- Larger size is desirable
- Improvements in flexible, thin display and electronics

E.g., smartwatch

- Devices that need detailed analysis of data
- Connectivity is good
- Existing display systems are sufficient
- Smaller size is desirable

E.g., implanted devices, smart ring

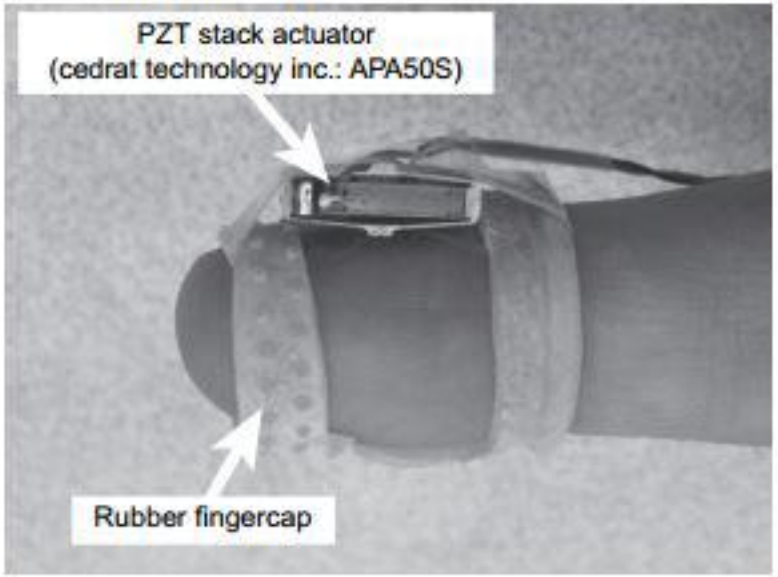
Hybrid systems are frequently used!

Speech recognition interface

- Speech recognition interfaces
  - Siri, Bixby, Google assistant
  - Wake up methods:
    - Voice
    - button
    - movements
- Use case: difficult to type text on smartwatch screens
- Applications
  - Send message
  - Make orders
  - Set timers

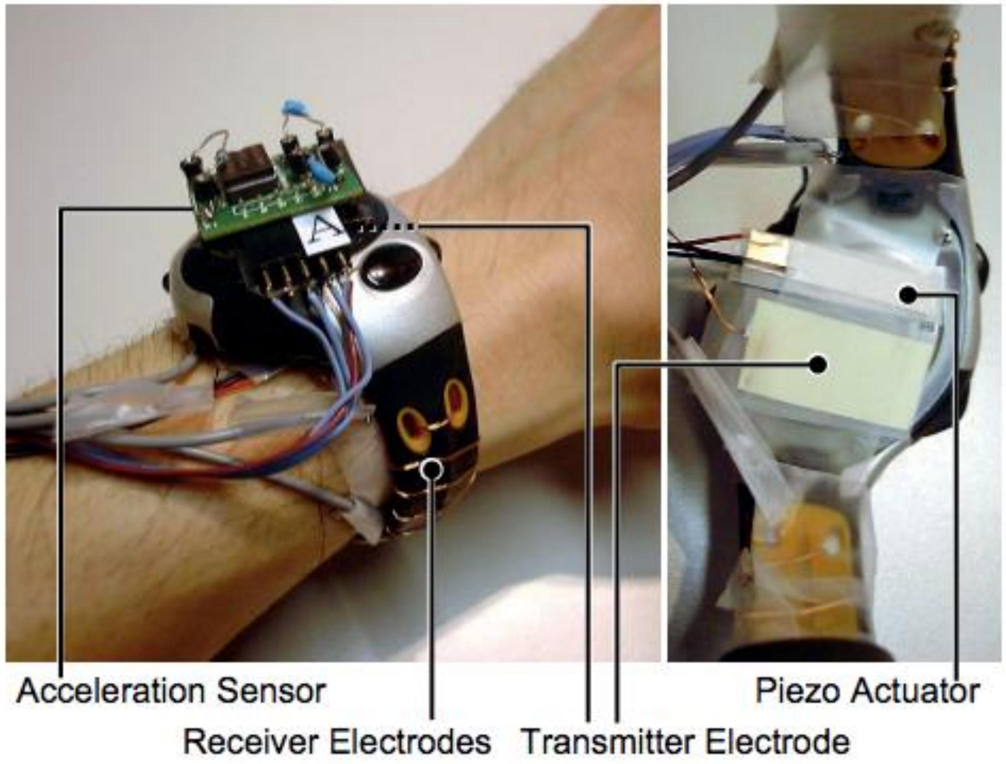
Haptics

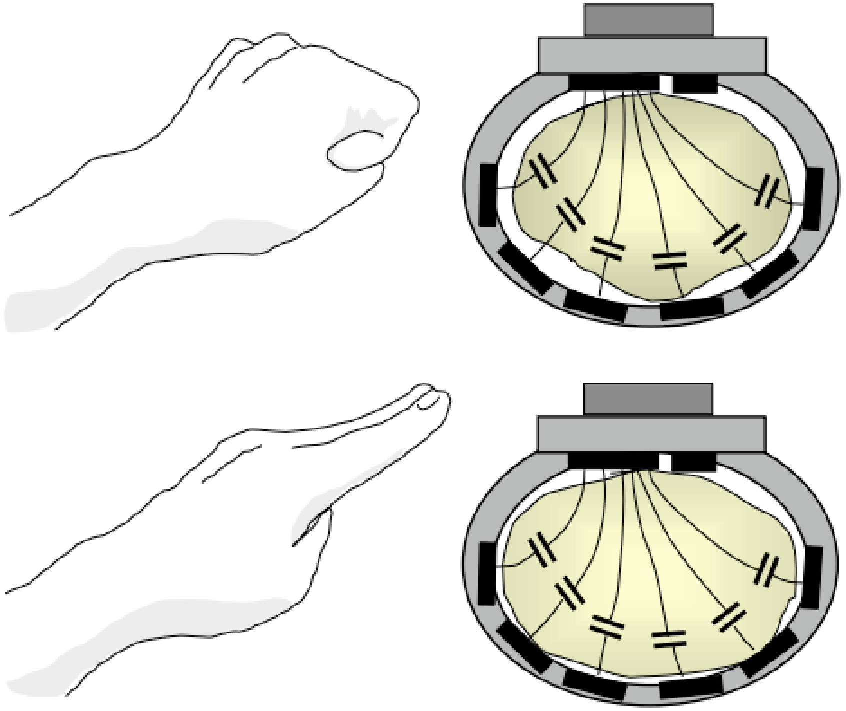
- Enables **virtual reality**
- Weight illusions based on fingertip deformation
- Sensorimotor enhancer improves **tactile sensitivity** in fingertips



Unobtrusive input devices

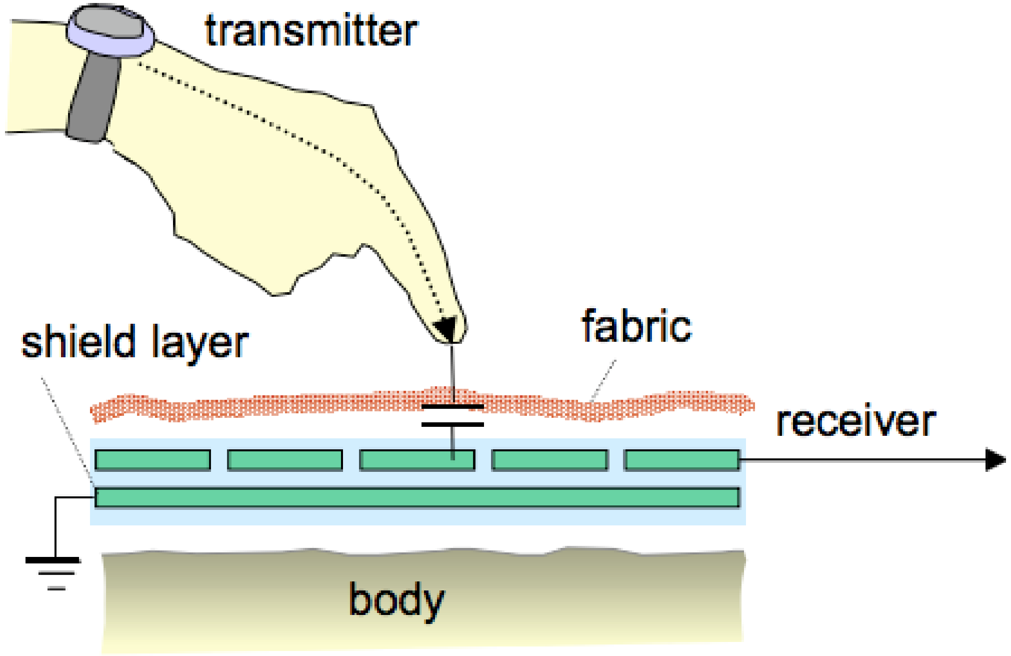
- GestureWrist
  - Capacitive sensing
  - Change signal depending on hand shape

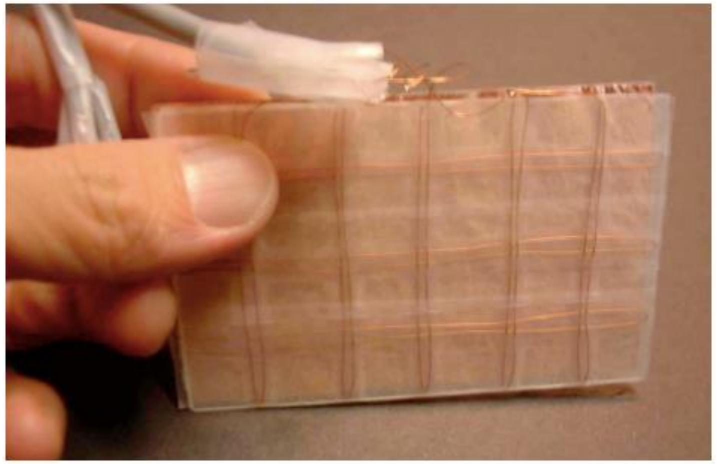




Unobtrusive input devices

- GesturePad
  - Capacitive multilayered touchpads
  - Supports interactive clothing





Challenges in wearable computing

Ideal wearables (Recap)

- Persist and provide constant access to information services.

- Sense and model context.

- Adapt interaction modalities based on the user’s context.

Ideal wearables: challenges

- Persist and provide constant access to information services.
  - Challenge: supply the energy to support all-time access
- Sense and model context.
  - Challenge: sense without too many sensors
- Adapt interaction modalities based on the user’s context.
  - Challenge: supply computing capacity for context learning

Summary: the trade-off between convenience and functions (battery life, sensing, cpu)

Battery improvements are expected to lag connectivity, display, and computing

	2010	Improvements	2020
Cellular	2-5 Mbps	**20X**	50-100 Mbps
WiFi	150-300 Mbps	**30X**	7Gbps
CPU	1 GHz	**8.8X**	4 core 2.2GHz
Battery	5.76Wh	**2.2X**	13Wh

Next generation of Wearable devices

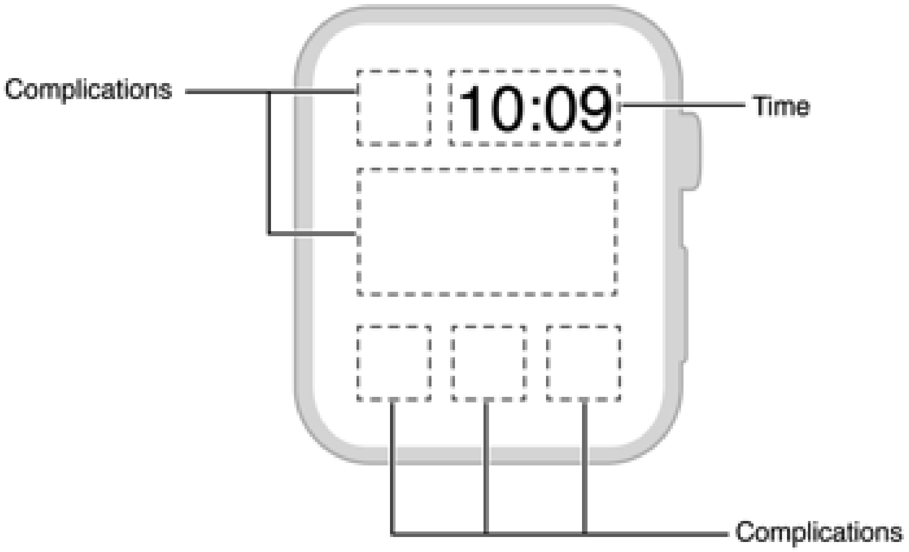
- Batteries are the major bottleneck
- Change in the architecture and power usage of ICs to make them more efficient

Battery limitation of wearable devices

- Battery power density grows slowly
- Trade-off between form-factor and battery life
- Solution:
  - Energy-efficient electronics. computing, communication, sensing
  - Energy harvesting
    - Wireless charging
    - Human-powered energy harvesting

Questions to Consider

- UI concerns regarding touch size and screen size become even more problematic...



Questions to Consider

- Would a watch app add anything to my full app?
  - What additional sensing can the watch provide?
  - Can the information be shown in a very small format?
  - Are there simple controls to the app that could be added to a watch?
- Do I have the resources/time to do this?
  - Currently limited market impact, but growing
- What type of interaction do you want the user to have?