

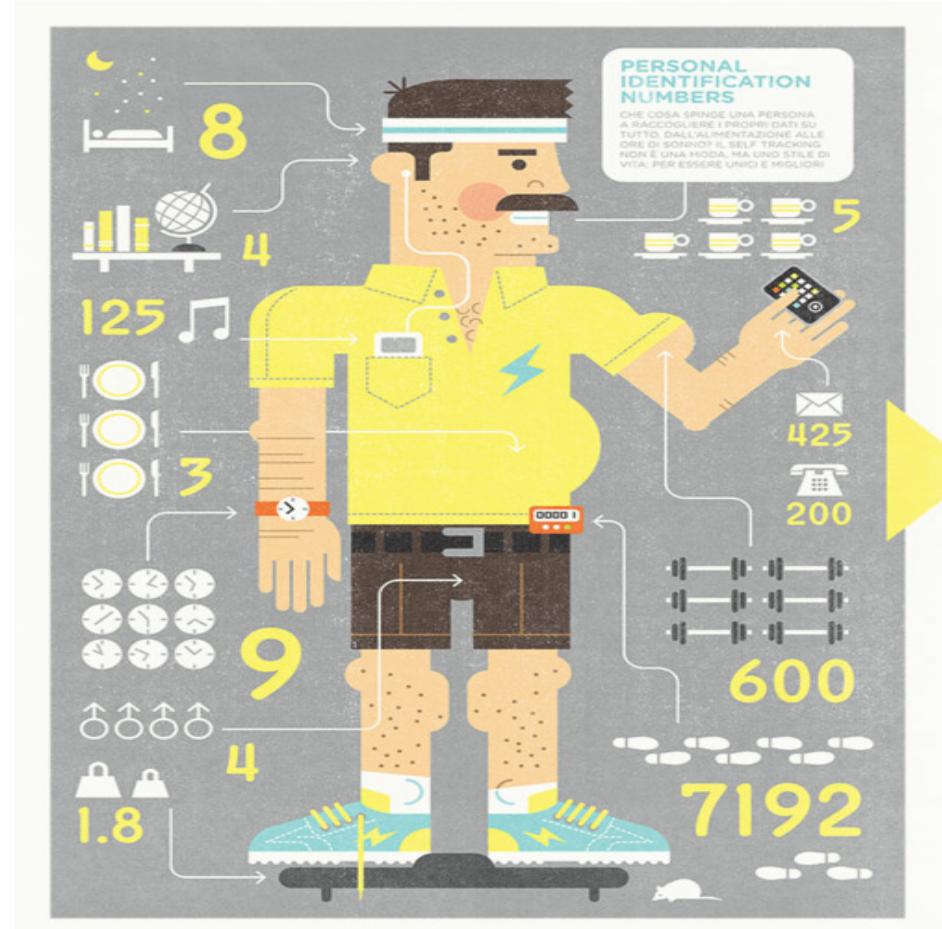
Sensor-based Wearable Systems

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- Physiological variable detection through wearables. The Quantified Self
- Application examples:
 - E-health
 - Sports
 - Interaction between clothes and oneself/others/environment
- Structure of the sensor-based wearable systems
- Rapid prototyping of sensor-based wearable systems
 - Plux Bitalino kit
 - Adafruit Flora kit

- Physiological variable detection through wearables. The Quantified Self

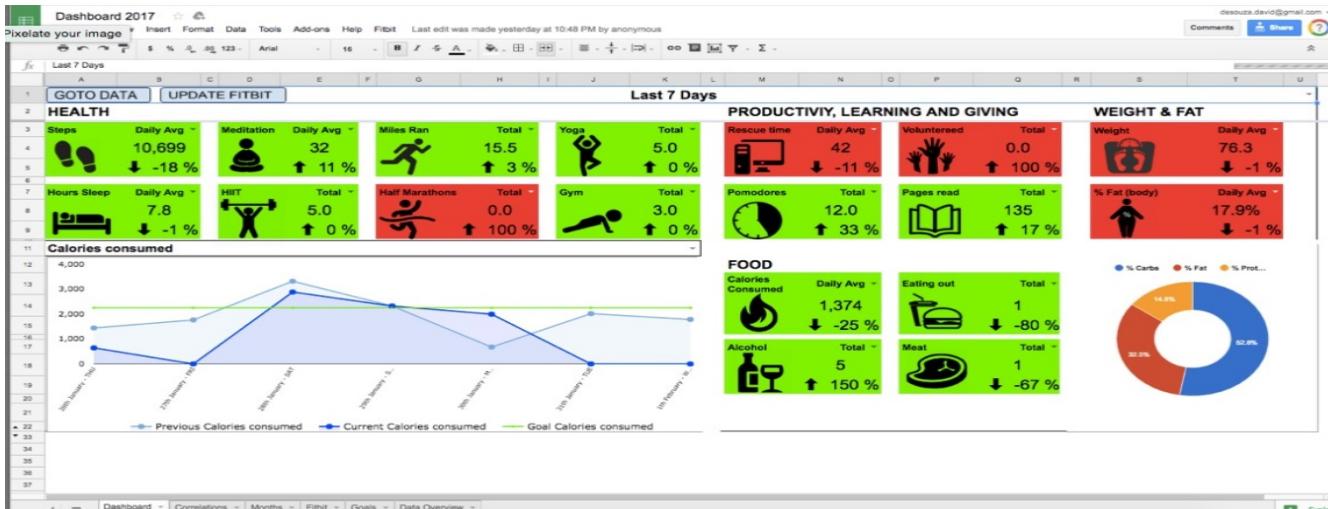
- Individual engagement in the selftracking of any kind of biological, physical, behavioral, or environmental information
- Data acquisition through technology: wearable sensors mobile apps, software interfaces and online communities
- Proactive stance: obtain and act on information



- Physiological variable detection through wearables. The Quantified Self.
 - Physical Activities (walked distance, steps, ...)
 - Physiological variables (heart and respiratory rate, blood oxygen saturation, body composition, ...)
 - Diet and Nutrition (calories, carbs, fat, protein, ...)
 - Psychological, Mental, and Cognitive States and Traits (mood, happiness, irritation, emotion, anxiety, ..., alertness, focus, verbal fluency, patience, creativity, ...)
 - Environmental Variables (location, weather, noise, pollution, light, ...)
 - Situational Variables, Social Variables, ...

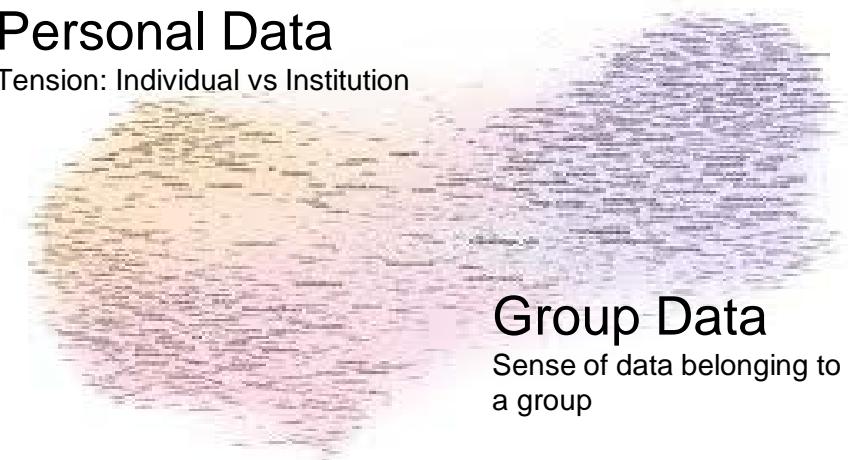
Sensor-based Wearable Systems

- Physiological variable detection through wearables. The Quantified Self.
 - Visualization of individual data (dashboards). Use of Big Data



De Souza, 2017

Personal Data
Tension: Individual vs Institution



Group Data
Sense of data belonging to a group

Swan, 2013

- Physiological variable detection through wearables. The Quantified Self.
- Desired outcome for the individual:
optimization and improvement *vs* pathology resolution
 - Personalized intervention for depression, low energy, sleep quality, productivity, cognitive alertness, ...
 - Rapid and pragmatic resolution
- Desired outcome for the collective:
 - Continuous health information climate, preventive care plans, resilient cities



- Application examples:
 - E-health
 - Sports
 - Interaction between clothes and oneself/others/environment

Sensor-based Wearable Systems

- Application examples: E-health



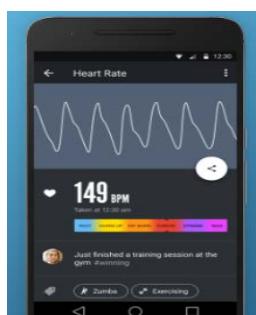
Smartring (ElectricFoxy)



Electronic tattoos (mc10)



Pulse oximetry



Smartphone HR



ECG



Self-Positioning harness



HB-KTH



Continuous Monitoring (Medtronic)
accenture

Sensor-based Wearable Systems

- Application examples: Sports



Fitbit



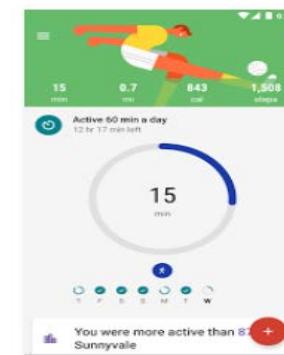
Polar band



Hexoskin Smart Shirt



Warm-X



Activity monitoring Apps

Sensor-based Wearable Systems

- Application examples: Interaction between clothes and oneself/others/environment
 - Fashion:



Moon Berlin



U-Tope



Electric Foxy



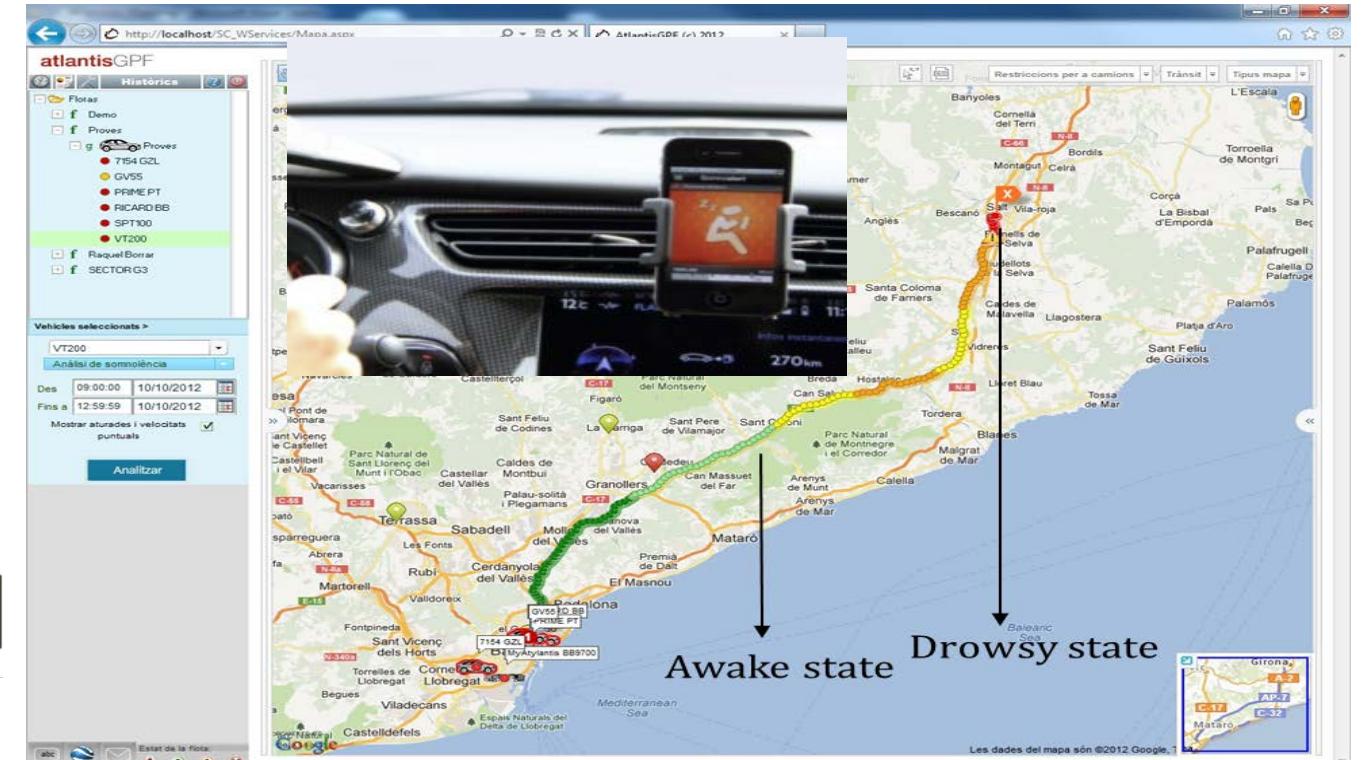
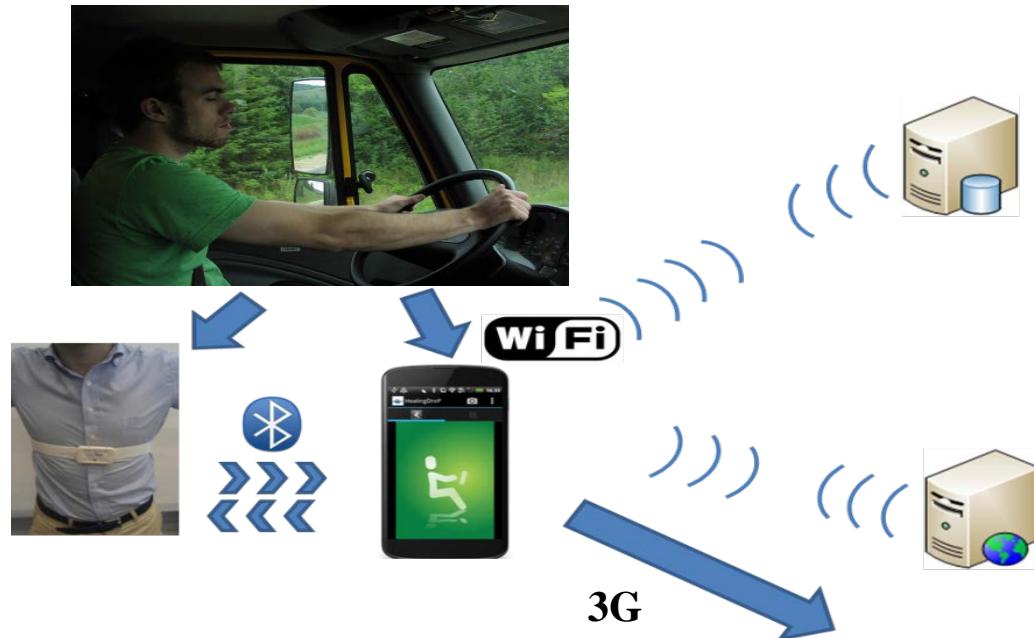
Hug-Shirt



Cute-Circuit

Sensor-based Wearable Systems

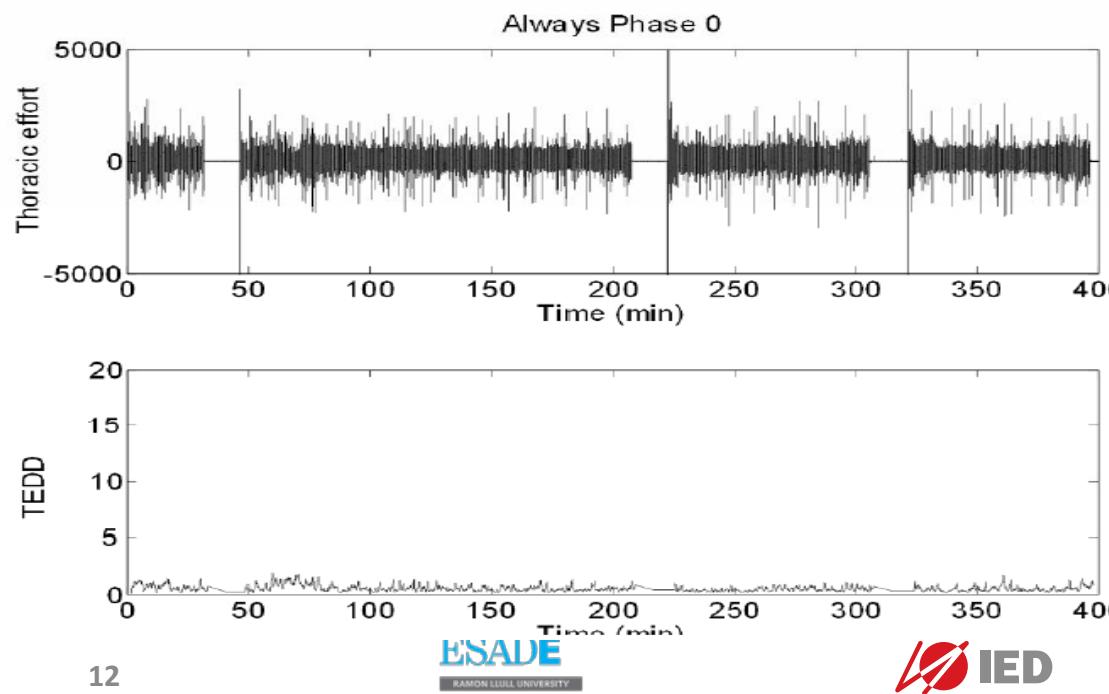
- Application examples: Interaction between clothes and oneself/others/environment
 - Drowsiness detection in drivers



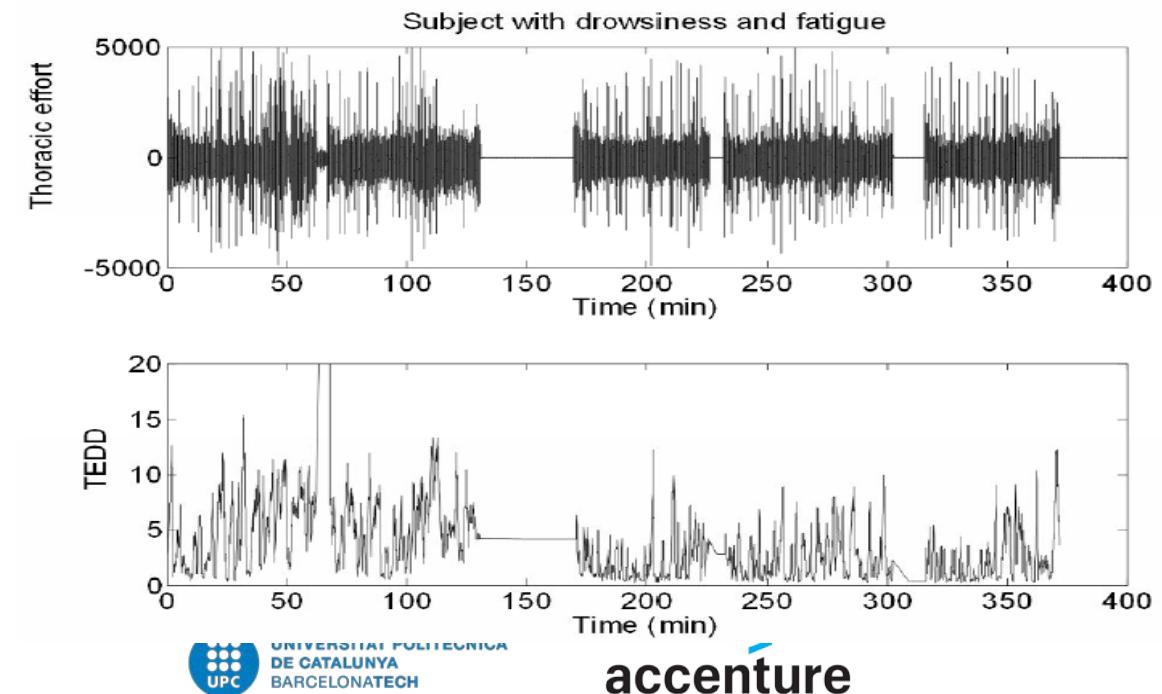
Application example: Drowsiness Detection by ventilation rate analysis

- ✓ Effect of drowsiness on the autonomic system signals

Alert



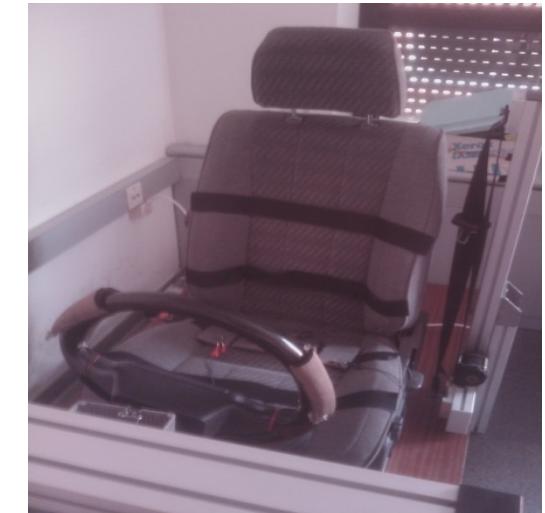
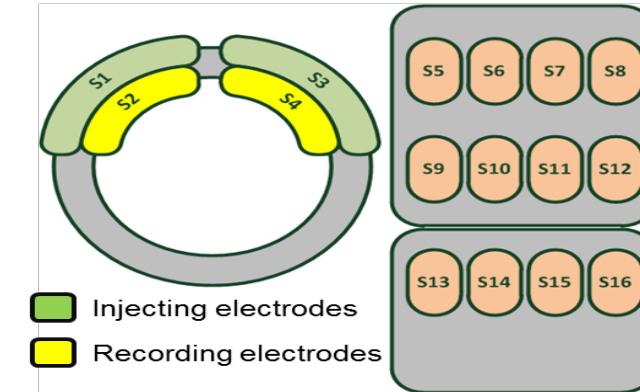
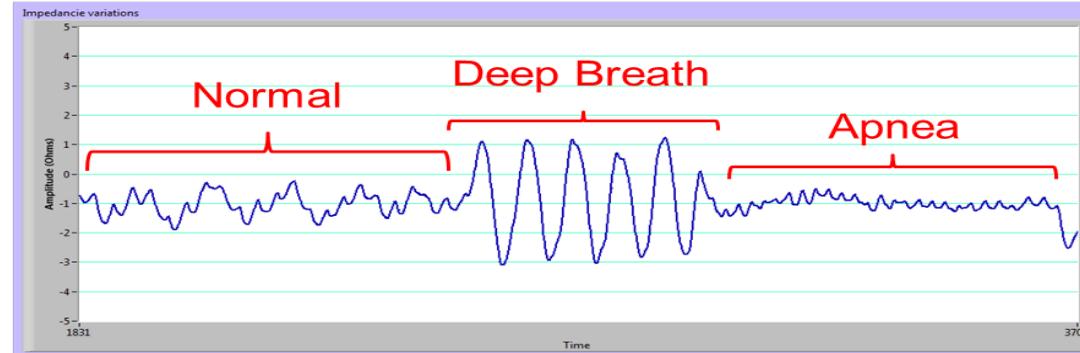
Drowsy



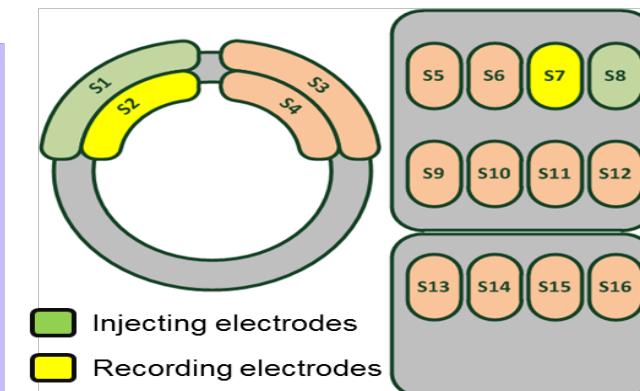
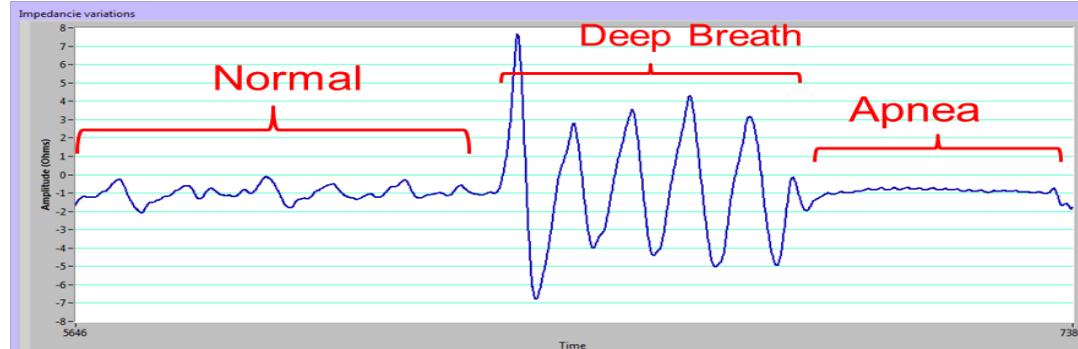
Sensor-based Wearable Systems

Application example: Drowsiness Detection by ventilation rate analysis

SW - SW Configuration

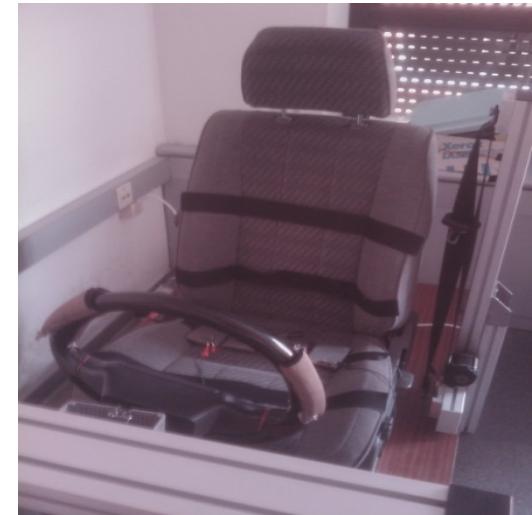
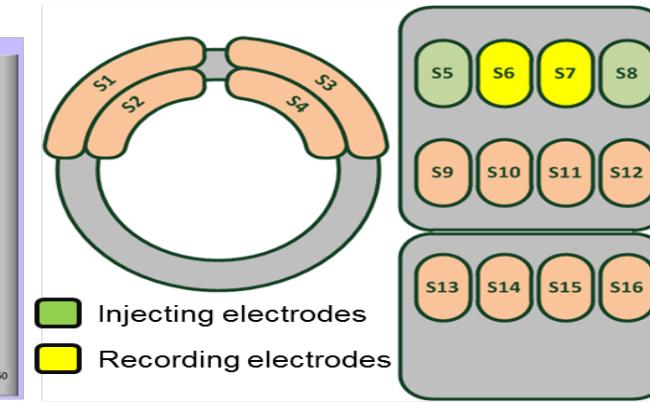
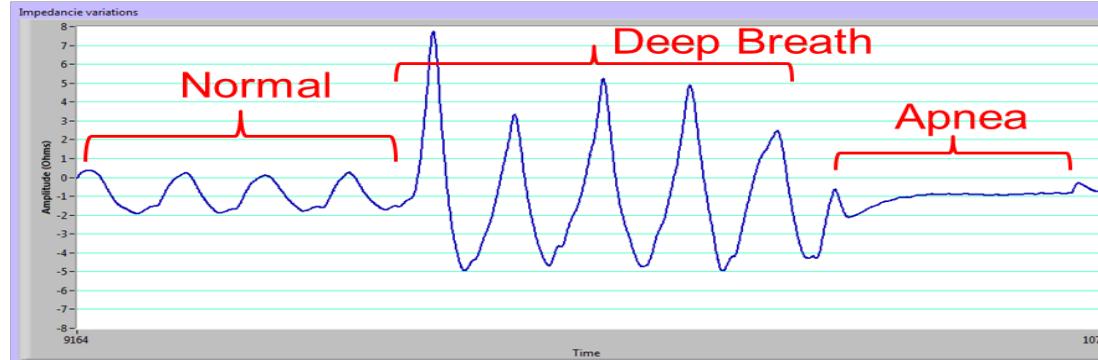


SW – Upper Back Seat Configuration

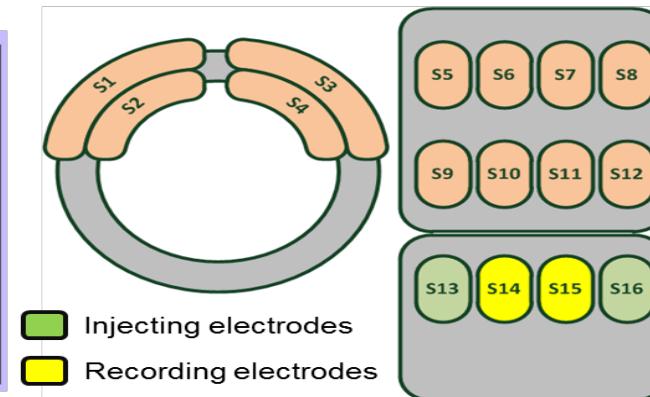
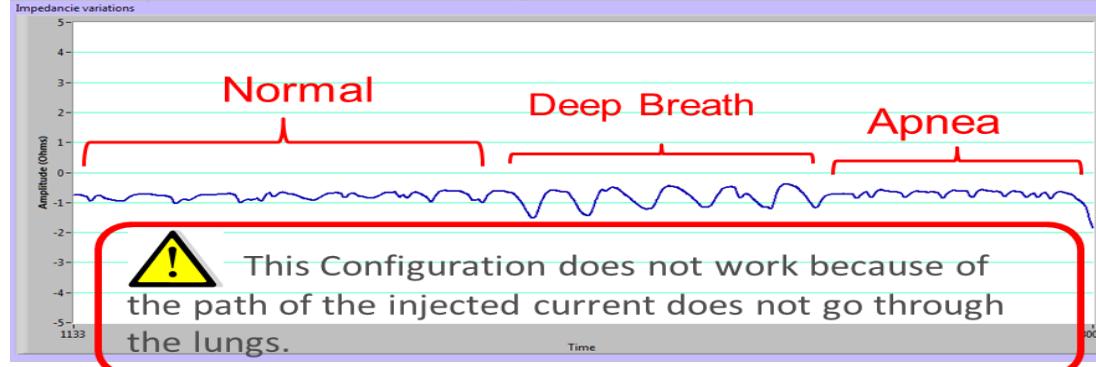


Application example: Drowsiness Detection by ventilation rate analysis

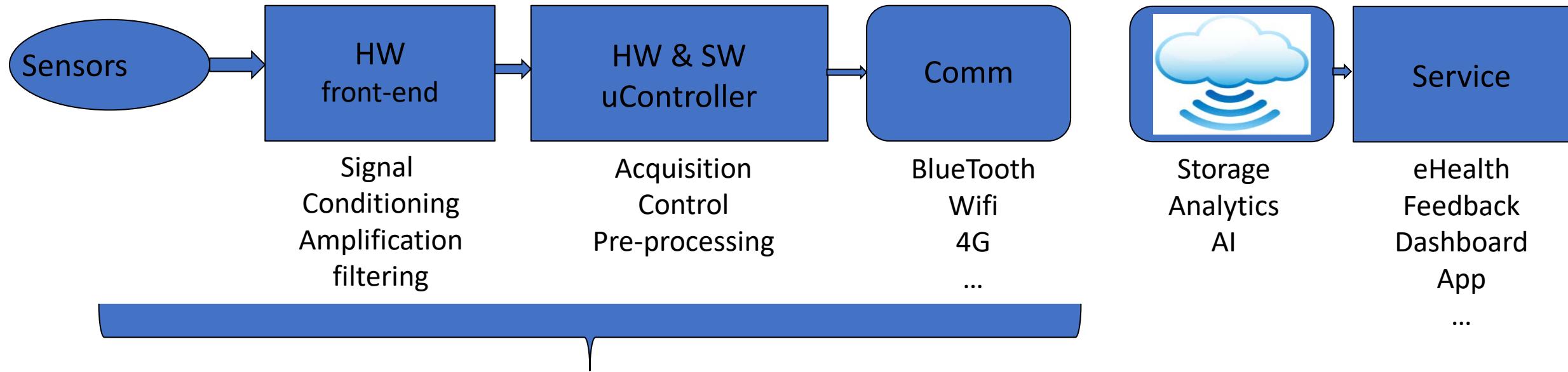
Upper Back – Upper Back Configuration



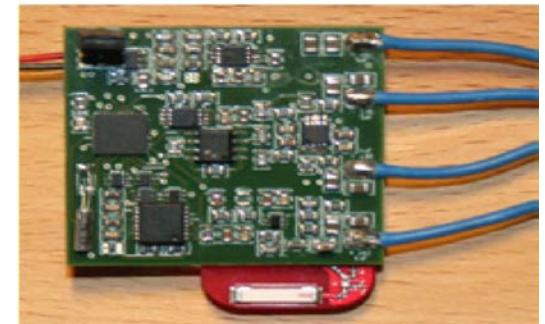
Car Seat – Car Seat Configuration



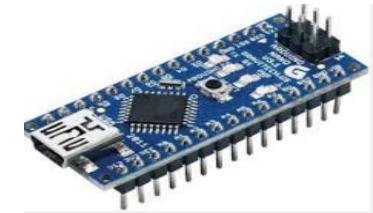
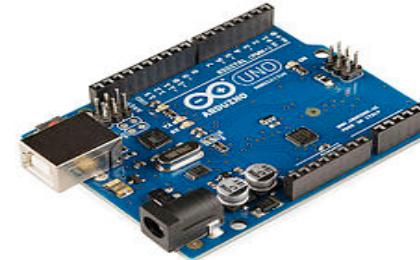
- Structure of the sensor-based wearable systems



- Custom development (to reduce cost, fit size).
- Long development time
- Use of ready-made platforms for prototyping

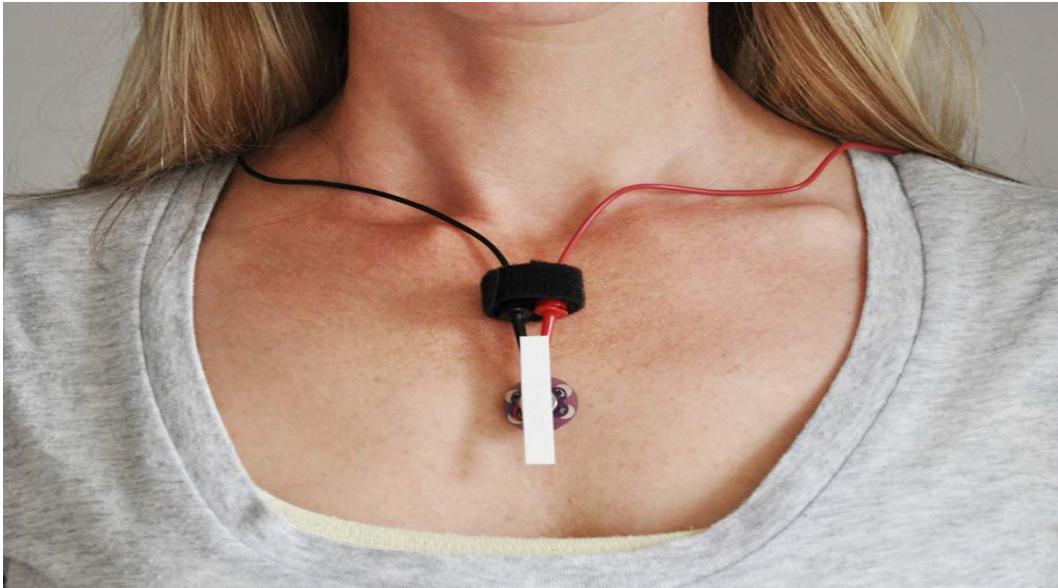


- Hardware (HW) prototyping. Electronic parts
 - Proof-of-concept prototypes:
 - Boards specifically designed for prototyping (HW-SW prototyping)
 - Arduino
 - Raspberry Pi
 - Beaglebone
 - Edison
 - Red Pitaya
 - NI-RIO
 - ...



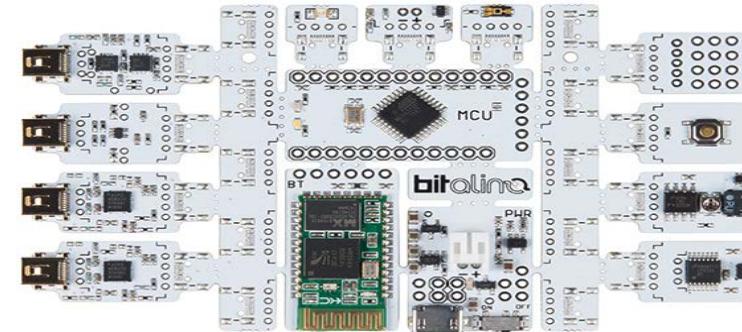
Sensor-based Wearable Systems

- Hardware (HW) prototyping. Electronic parts
 - Proof-of-concept prototypes:
Example: Electric Foxy Bar concept

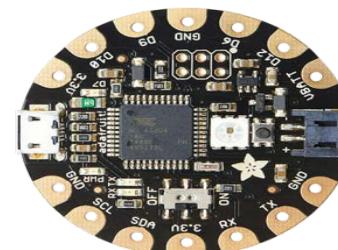


Sensor-based Wearable Systems

- Rapid prototyping of sensor-based wearable systems
 - Plux Bitalino kit

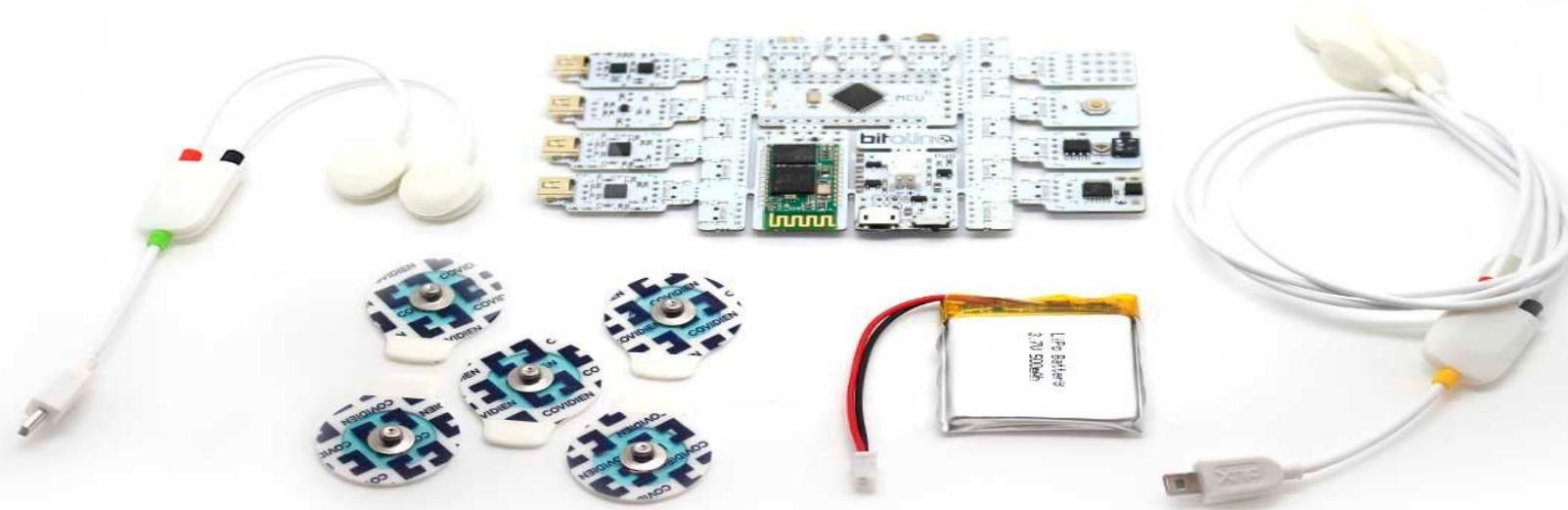


- Adafruit Flora kit



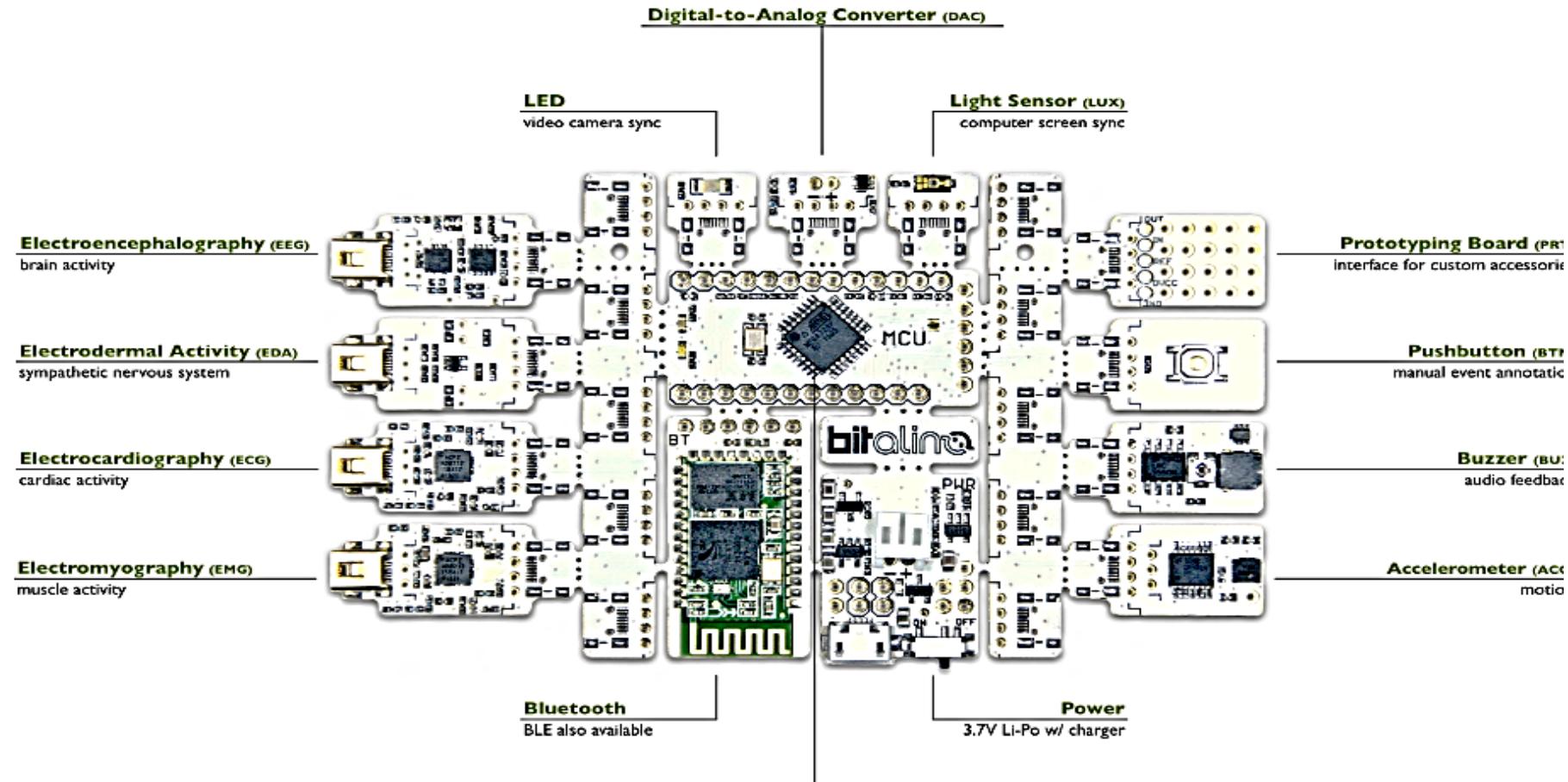
Sensor-based Wearable Systems

- Plux Bitalino kit (Bitalino (r)evolution BT

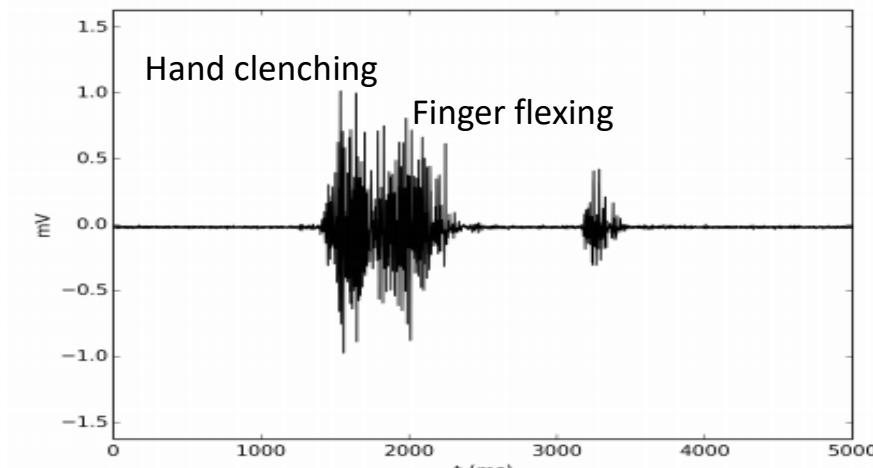
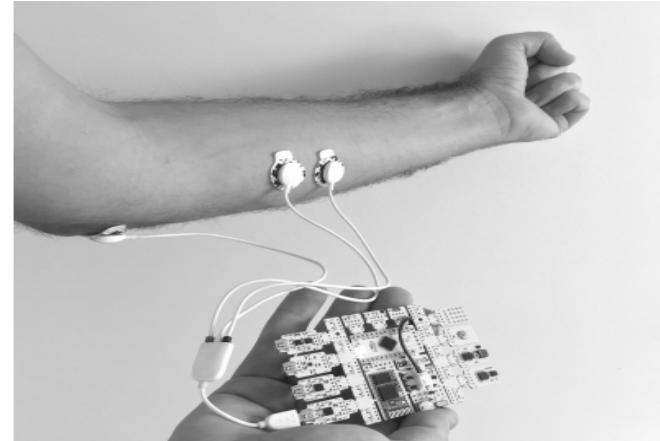


Sensor-based Wearable Systems

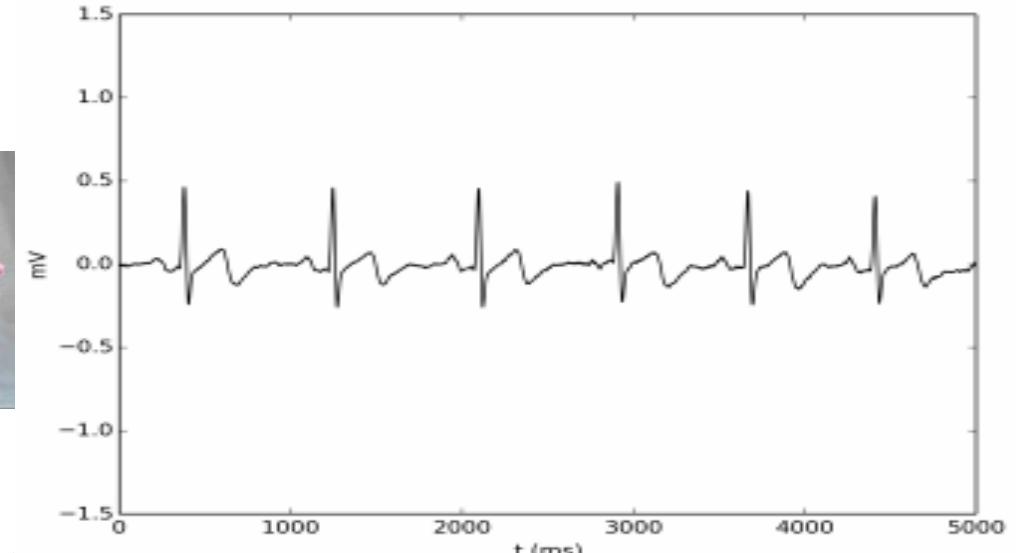
- Plux Bitalino kit



- Plux Bitalino kit
- Electromyography (EMG).
 - Muscle activity
 - Human-Computer Interaction (HCI)
 - Prosthesis control
 - Biofeedback

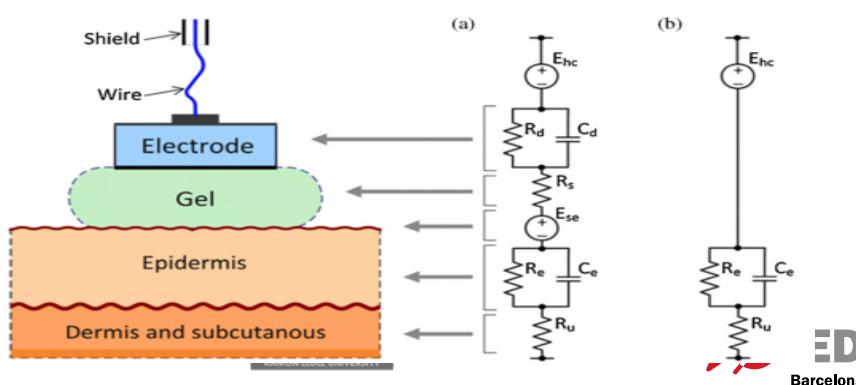


- Plux Bitalino kit
- Electrocardiography (ECG).
 - Cardiac Activity, cardiac pathologies diagnosis
 - Heart beat Rhythm (HR) (effort, stress)
 - HR variability (stress, awareness, drowsiness)



- Possible need of electrodes. Electrochemical sensors
- Biopotential recording electrodes

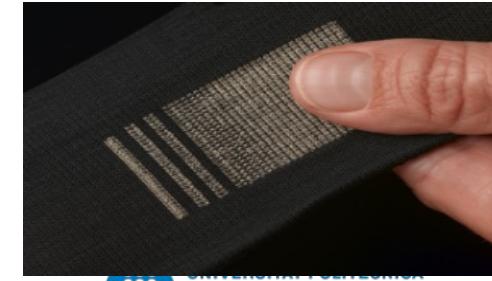
Non-Polarizable
Electrochemical reaction



Polarizable
capacitive coupling
Metallic plates, conductive rubber

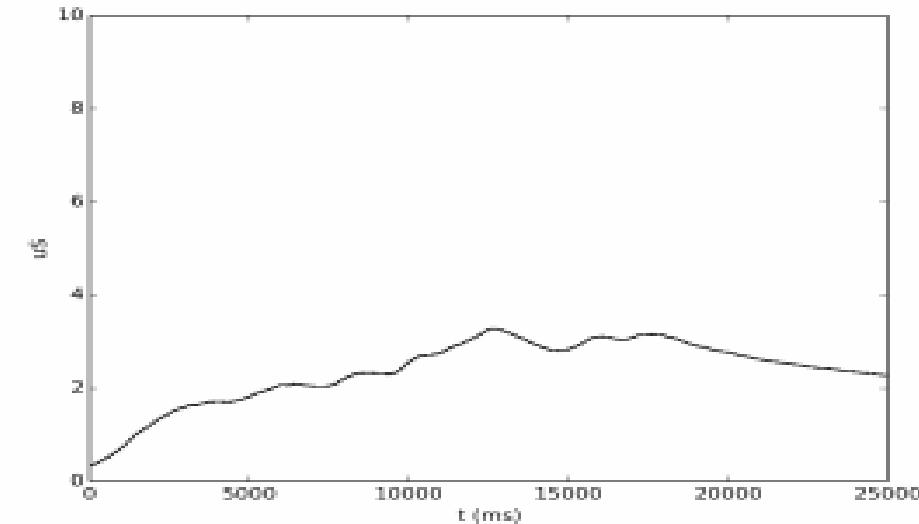
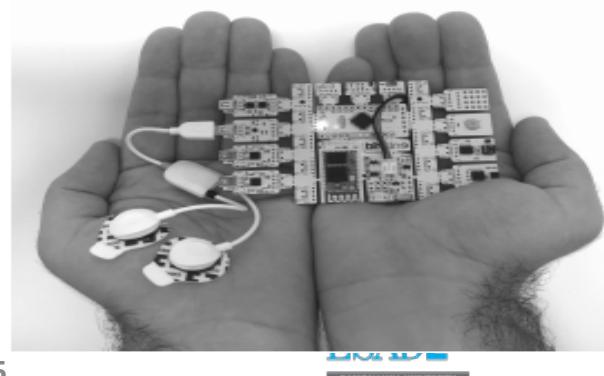


Textile electrodes, wearable devices



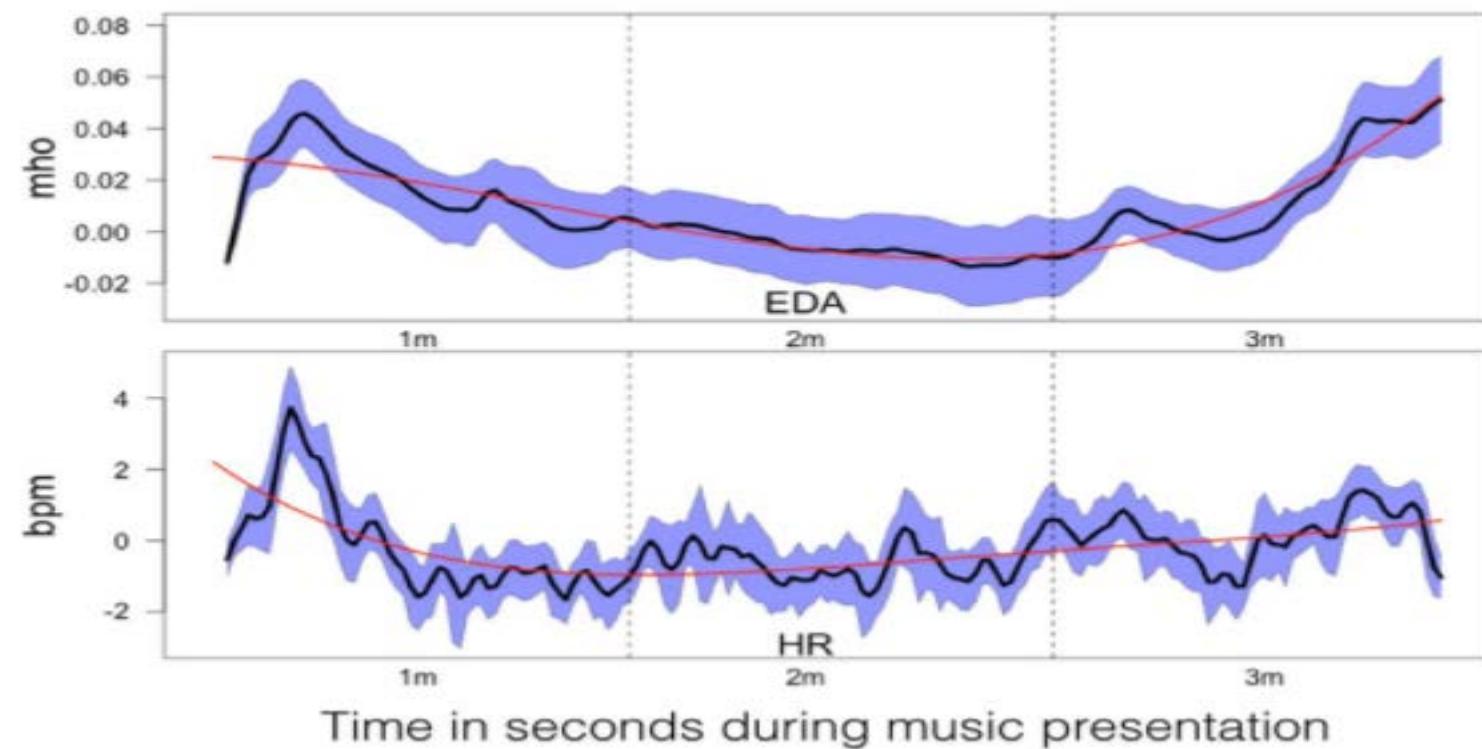
accenture

- Plux Bitalino kit
- Electrodermal Activity (EDA). AKA Galvanic Skin Response
 - Sympathetic nervous system (body's fight-or-flight response)
 - Microsweating (Liar detector)
 - Human-Computer Interface
 - Affective computing
 - Relaxation biofeedback



Sensor-based Wearable Systems

- Plux Bitalino kit
- Electrodermal Activity (EDA). AKA Galvanic Skin Response

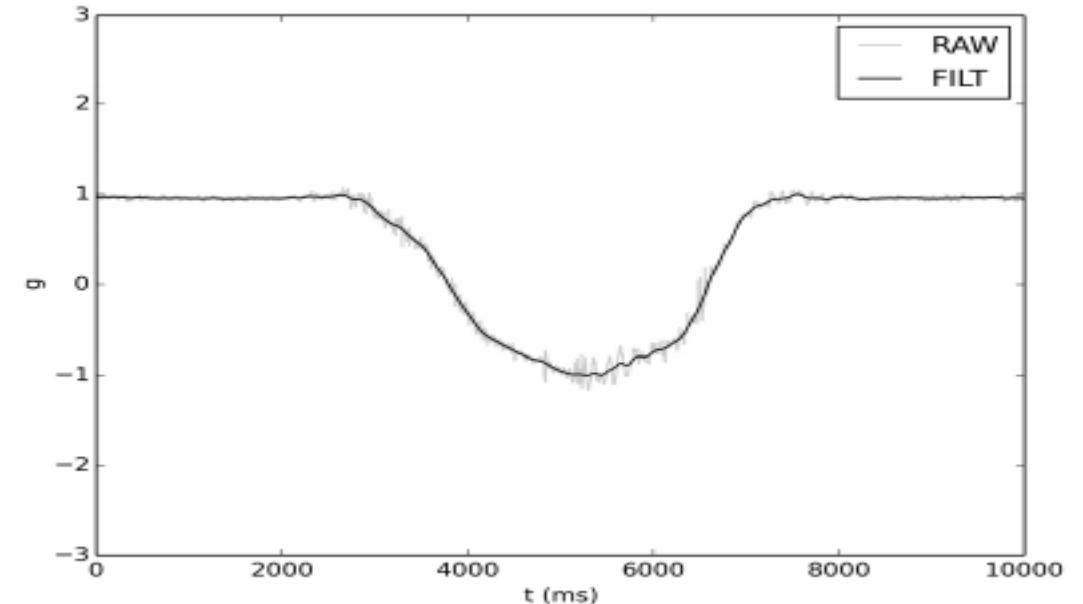


Sensor-based Wearable Systems

- Plux Bitalino kit
- Electroencephalography (EEG). Brain activity

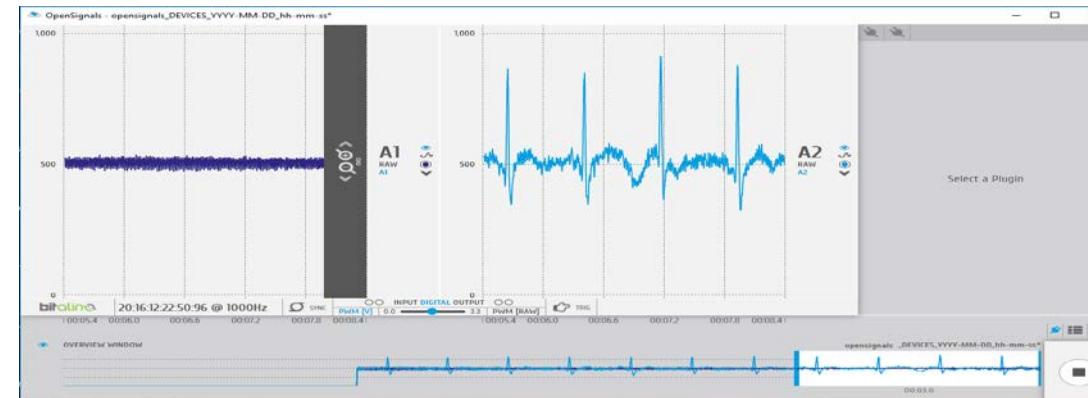
^***** skip*****

- Plux Bitalino kit
- Accelerometer. Movement (of the Bitalino board)
 - Activity monitoring
 - Tilt detection
 - Vibration measurement
 - Human-Computer Interaction
 - posture detection
 - step counting
 - fall and shock detection

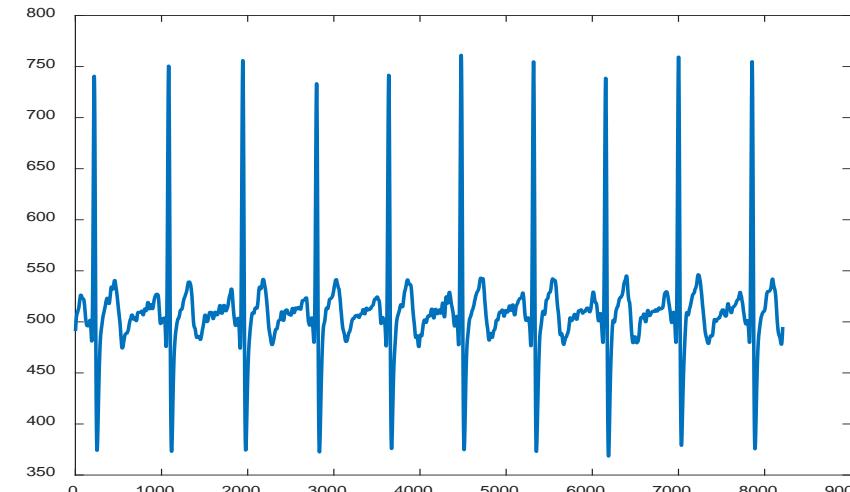


- Plux Bitalino kit
- Other features:
 - Light (LUX). Ambient light monitoring, synchronization with other devices
 - Pushbutton (BTN). Manual trigger, biofeedback.
 - Temperature (a component has to be added to the board)
- Three actuators:
 - Light-Emitting Diode (LED)
 - Buzzer (BUZ)
 - 8 bit Digital-to-Analog Converter (DAC)

- Plux Bitalino kit. Software
 - Already programmed (open source)
 - Parameters selected through the Bluetooth link
 - Channels to be acquired
 - Sampling rate (1, 10, 100 or 1000 samples/s)
 - OpenSignal application for Windows/Linux/Mac/Android



- Plux Bitalino kit. Software
 - APIs for the mainstream programming languages and development frameworks (Python, C++, Matlab, Java, C#, Raspberry Pi, Arduino, LabView, Unity, ...)
 - Instructions for configuration of Python and example of code to configure the Bitalino, acquire signals and store them to a file are provided.



- Plux Bitalino kit. Software
 - *****insertar video demo?*****
 - *****insertar demo directament?*****

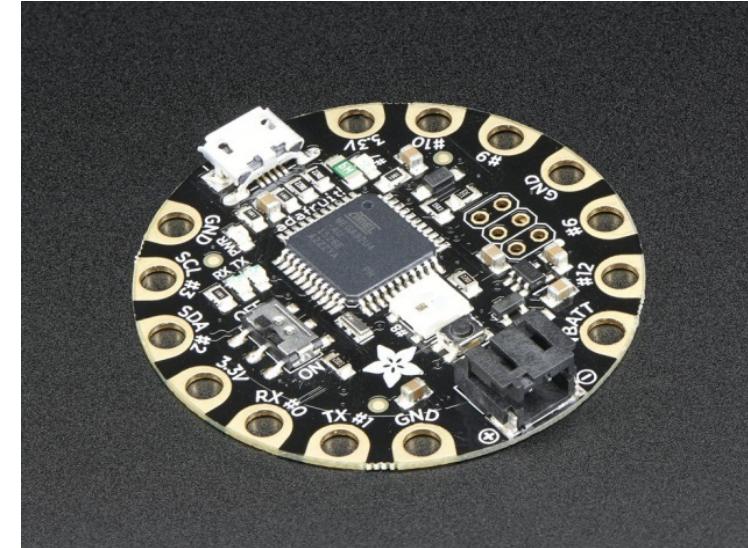
Sensor-based Wearable Systems

- Adafruit Flora Sensor Pack

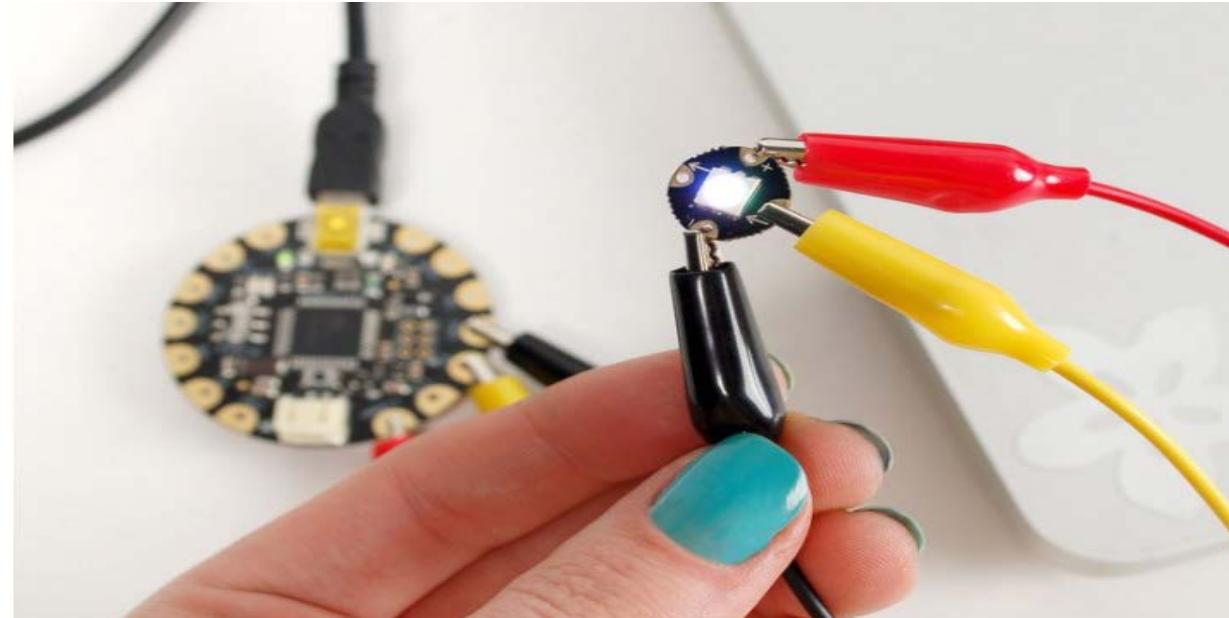


- Adafruit Flora Sensor Pack

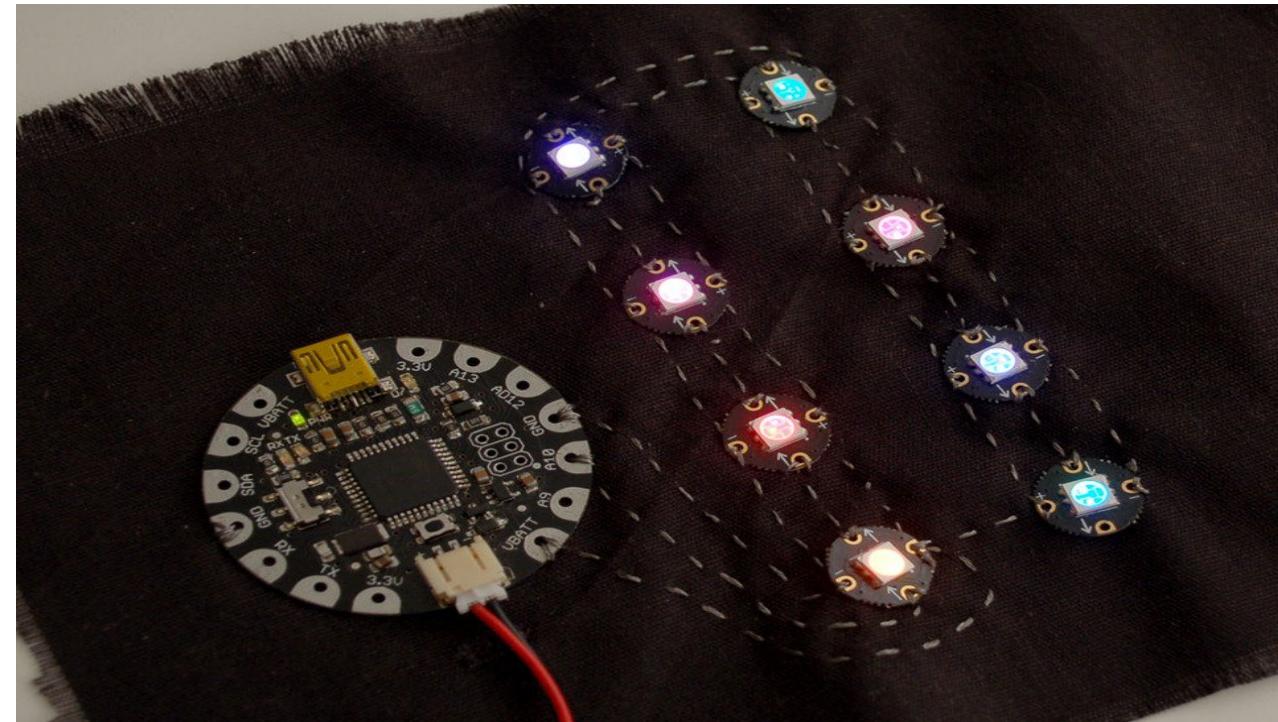
- Flora board (Arduino compatible)
- 4 RGB programmable NeoPixel LED
- Color sensor
- Accelerometer/compass sensor
- Light (Lux) sensor
- Woven Conductive Fabric (for capacitive touch sensing)
- Sewable snaps and stainless steel conductive thread



- Adafruit Flora Sensor Pack
 - All components are designed to be sewable
 - A preliminary prototype can be built using crocodile clips

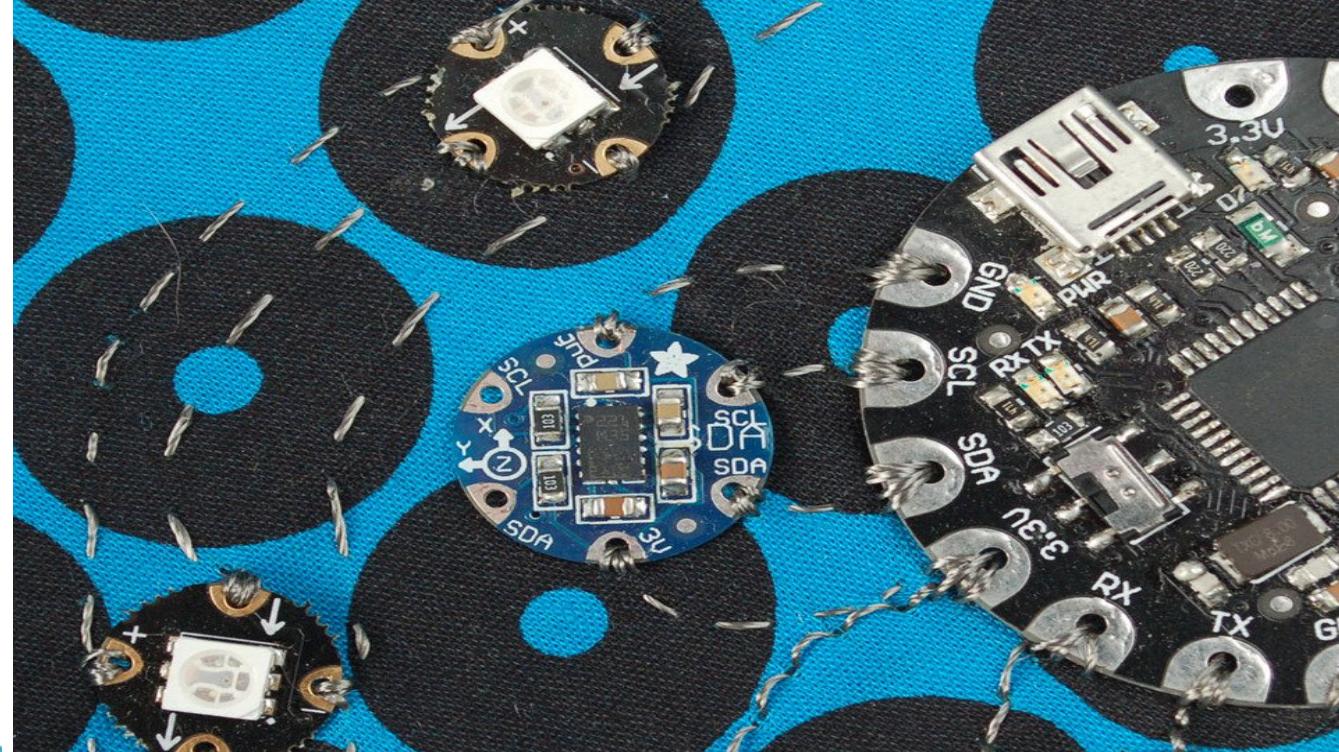


- Adafruit Flora Sensor Pack
 - All components are designed to be sewable
 - The connections are made using the stainless-steel thread:



Sensor-based Wearable Systems

- Adafruit Flora Sensor Pack
 - All components are designed to be sewable
 - The connections are made using the stainless-steel thread:



Sensor-based Wearable Systems

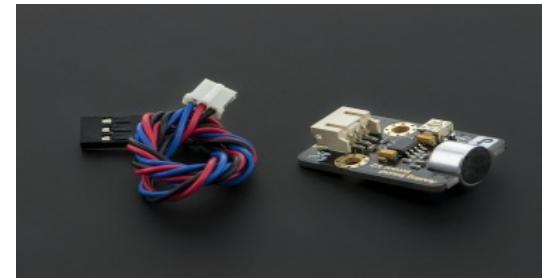
- Adafruit Flora kit
- **** vídeos o fotos d'exemple de Flora, o demo****

Sensor-based Wearable Systems

- Additional materials and sensors
 - Pressure-Sensitive Conductive Sheet (velostat)

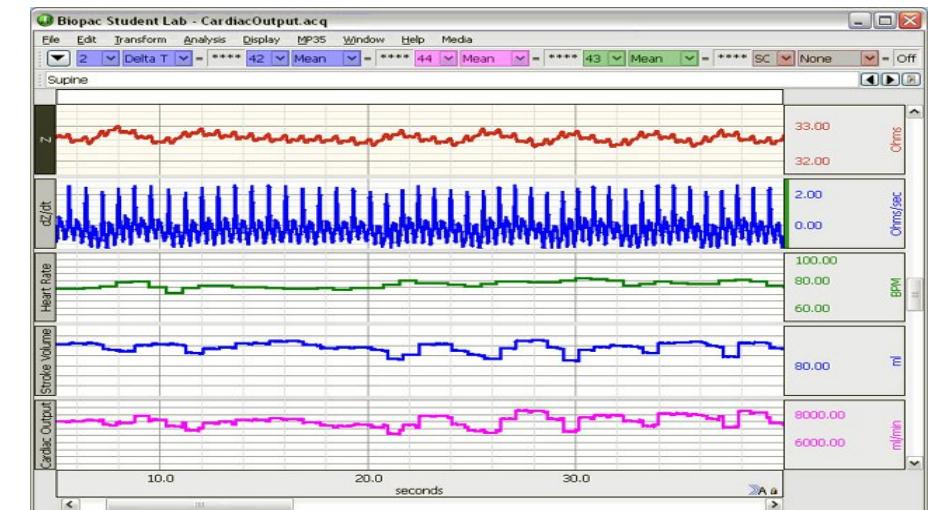


- Sound detector



Sensor-based Wearable Systems

- Reference system: Biopac MP36



Sensor-based Wearable Systems

- Reference system: Patient simulator



Concluding Remarks

- Top-Down design: having started by identifying a user need, generate specifications from the user requirements:
 - Variables to be measured
 - Needed ranges, accuracies. Constraints
 - Sensors selection according to the product specifications
- For the proof-of-concept prototype, over-dimensioned sensors and acquisition systems are allowed, but the suitable sensors for the envisioned product should be specified

Thanks for your attention!

Questions?

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