POLITECNICO DI MILANO

Noi Domani

Le Sfide della Longevità

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La Bioingegneria al Servizio dell'Invecchiamento

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- L’Unione Europea ha attivato un Progetto “**European Innovation Partnership on Active and Healthy Ageing**” (EIP-AHA) per realizzare entro il 2020 tre obiettivi primari:
- i) migliorare la salute e la qualità di vita degli anziani,
- ii) migliorare la sostenibilità e l’efficienza dei sistemi di assistenza,
- iii) creare opportunità di crescita e commerciali per le Imprese. Il solo mercato della e-Health, rivolto allo sviluppo di tecnologie e servizi in questa fascia di popolazione, si prevede che supererà i 300 miliardi di dollari nel 2020.

Contributi della Bioingegneria per AHA

La Bioingegneria per il Benessere e l'Invecchiamento Attivo, M.C. Carrozza, E. Guglielmelli, R. Pietrabissa eds., Pàtron editore, Bologna 2016.

- i) Ricerca Scientifica (Materiali, Metodi e Tecnologie innovative)
- ii) Applicazioni per il monitoraggio del soggetto per la determinazione di variazioni significative di parametri di Salute ed Abitudini di Vita (indoor & outdoor)
- iii) Applicazioni per il trattamento di riduzione di deficit nell'anziano (riabilitazione, mantenimento e stabilizzazione di funzionalità residue, sviluppo di sistemi assistivi per promuovere la vita indipendente, etc.)

Vital Parameters ***everywhere*****,** ***everytime*** **for** ***long-term recordings*** **→** ***huge amount*** **of data**

Challenges for BME:

i) Innovative sensors

ii) More sophisticated algorithms for correct detection of biomarkers in an «uncontrolled» environment

iii) Compromises to be reached: invasivity/intrusivity vs reliability, on-board vs on-server processing, etc.

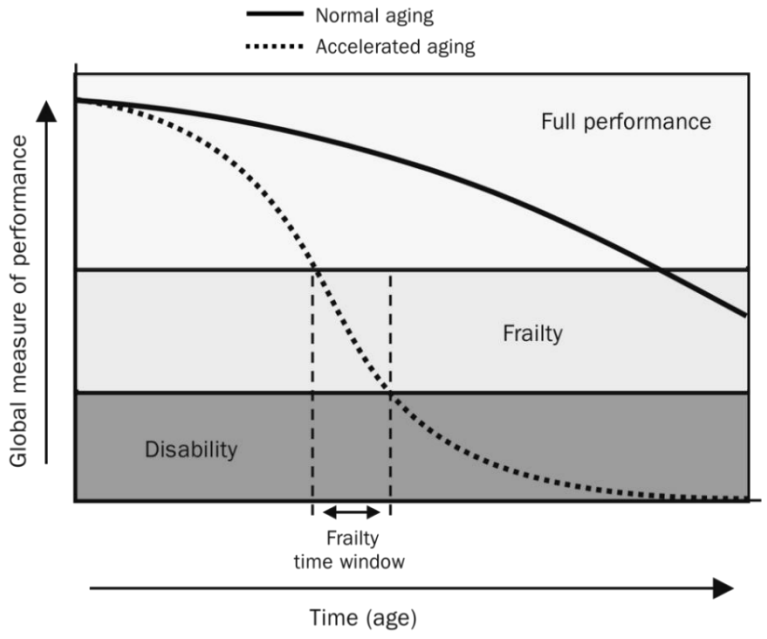
Wellbeing & Active Ageing: Challenges of a modern concept of Health Care

- Sustainability
- Technological development

To Care ↔ To Take Care

Modern concept of Health Care

Decline towards possible frialty & disability in normal ageing

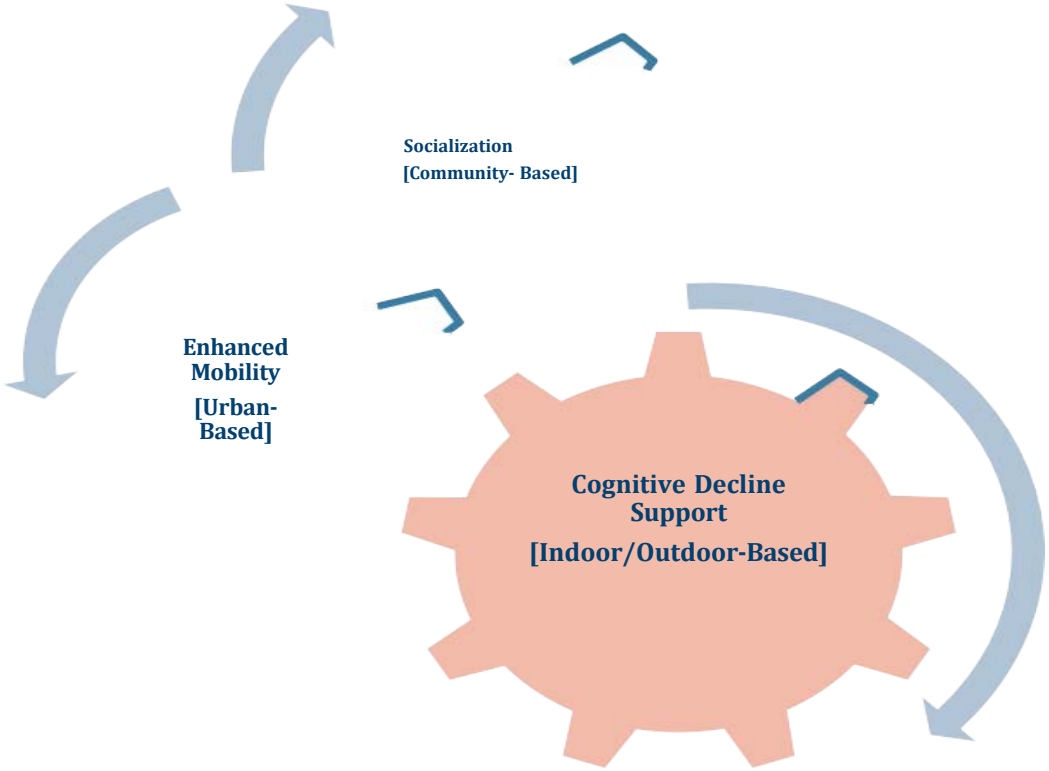


Comprehensive influences of cognitive decline

Smart wearables & sensors

Smart homes

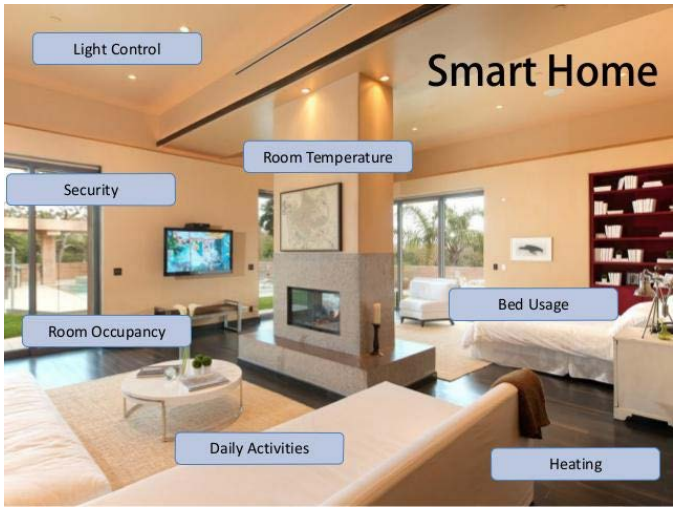
Smart urban environment



Biorobotica e Ambient Assisted Living

- Protesi ed ortesi

- Ambient Assisted Living (AAL)

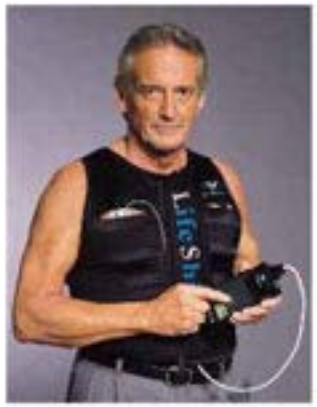


Smart Sensors

Examples of wearable devices for the monitoring of physiological parameters and activity status of the subject

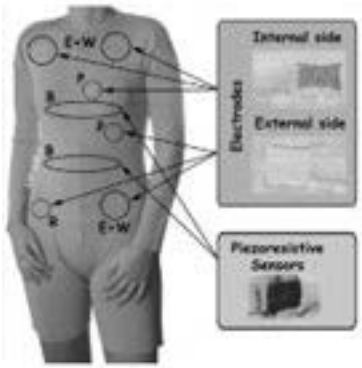
(a)

(b)



(c)

(d)



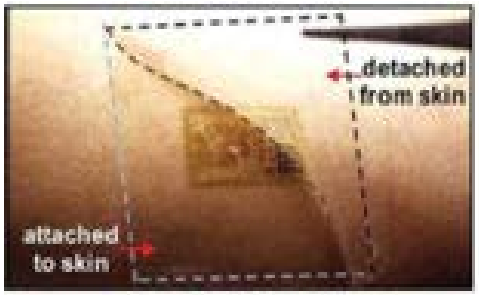
(e)

(f)

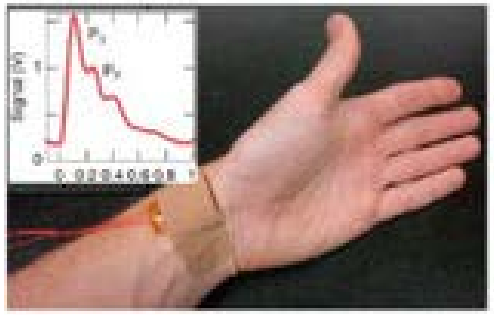
(g)

Zheng, et al., 2014

Smart Sensors

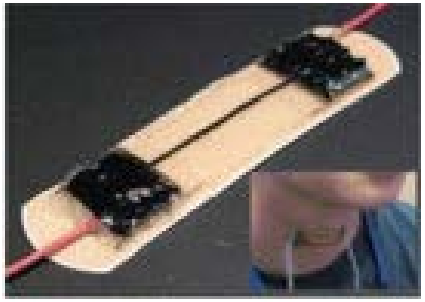


(a)



(b)

(c)



(d)

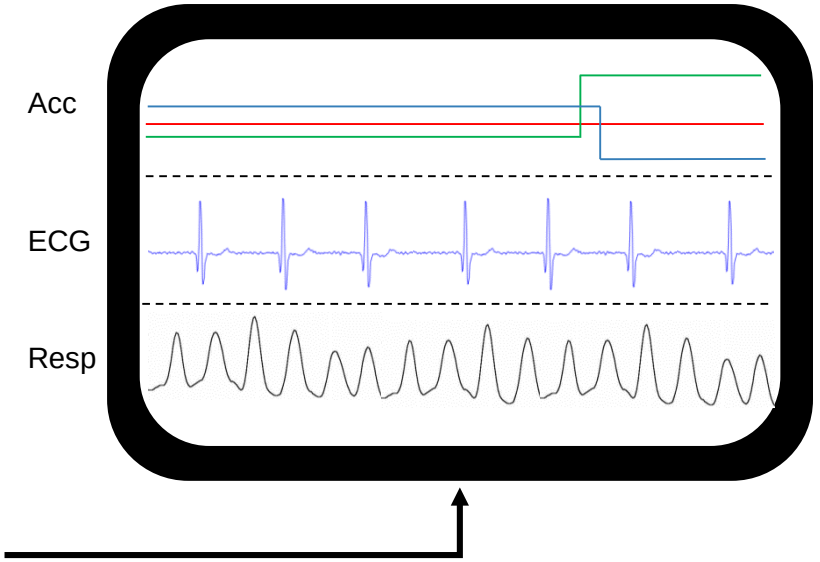
(e)

Devices which can be directly put in contact with the human body for the monitoring of vital parameters: a) multifunction device for temp & stress; b) capacity pressure sensor for radial pulse; c) e-skin (press & temp); d) respiration; e) tattoo electrochemical biosensor for lactate measurements (sweat)

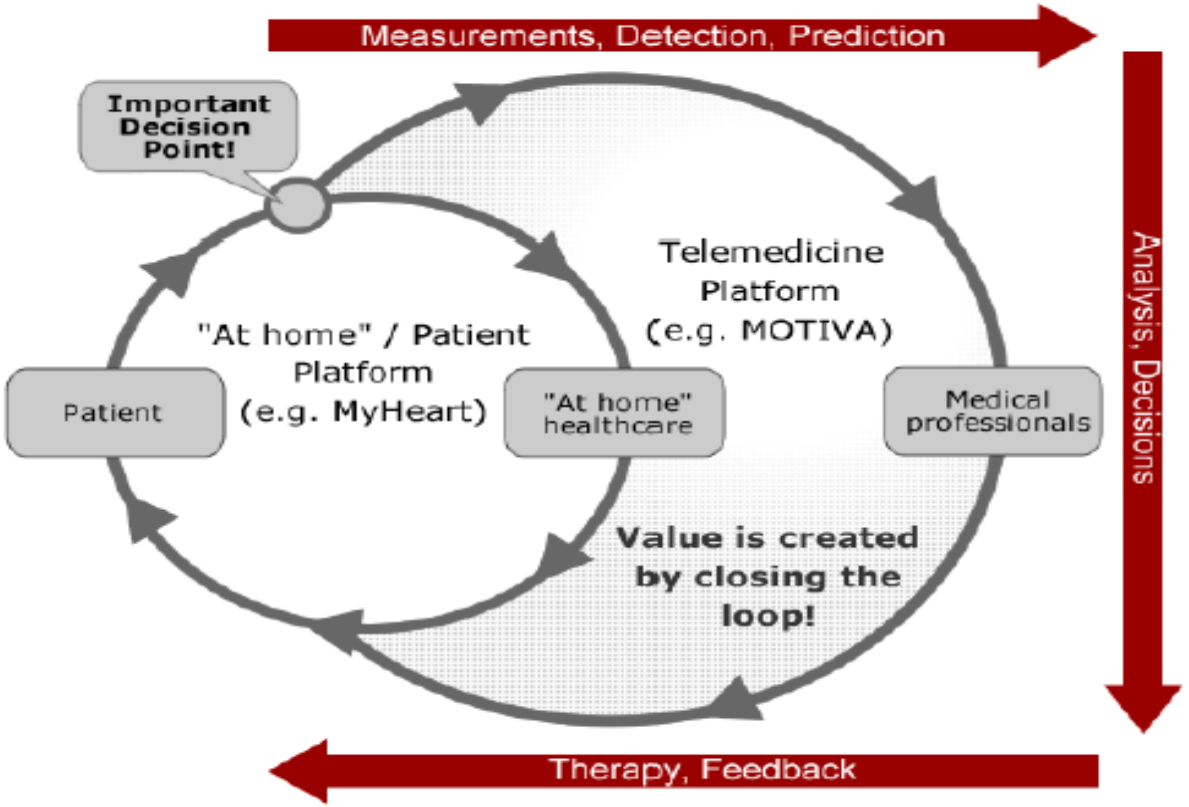
Zheng, et al., 2014

Sensorized T-shirt

- Wearable device
- ECG, Respiratory signals and Movement (accelerometers)
- Real-time signals visualization on ***tablet*** or *smartphone*

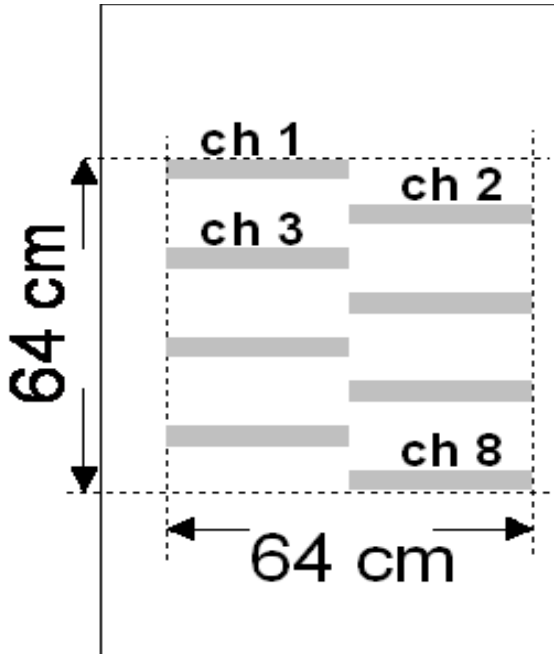


Concept of double loop



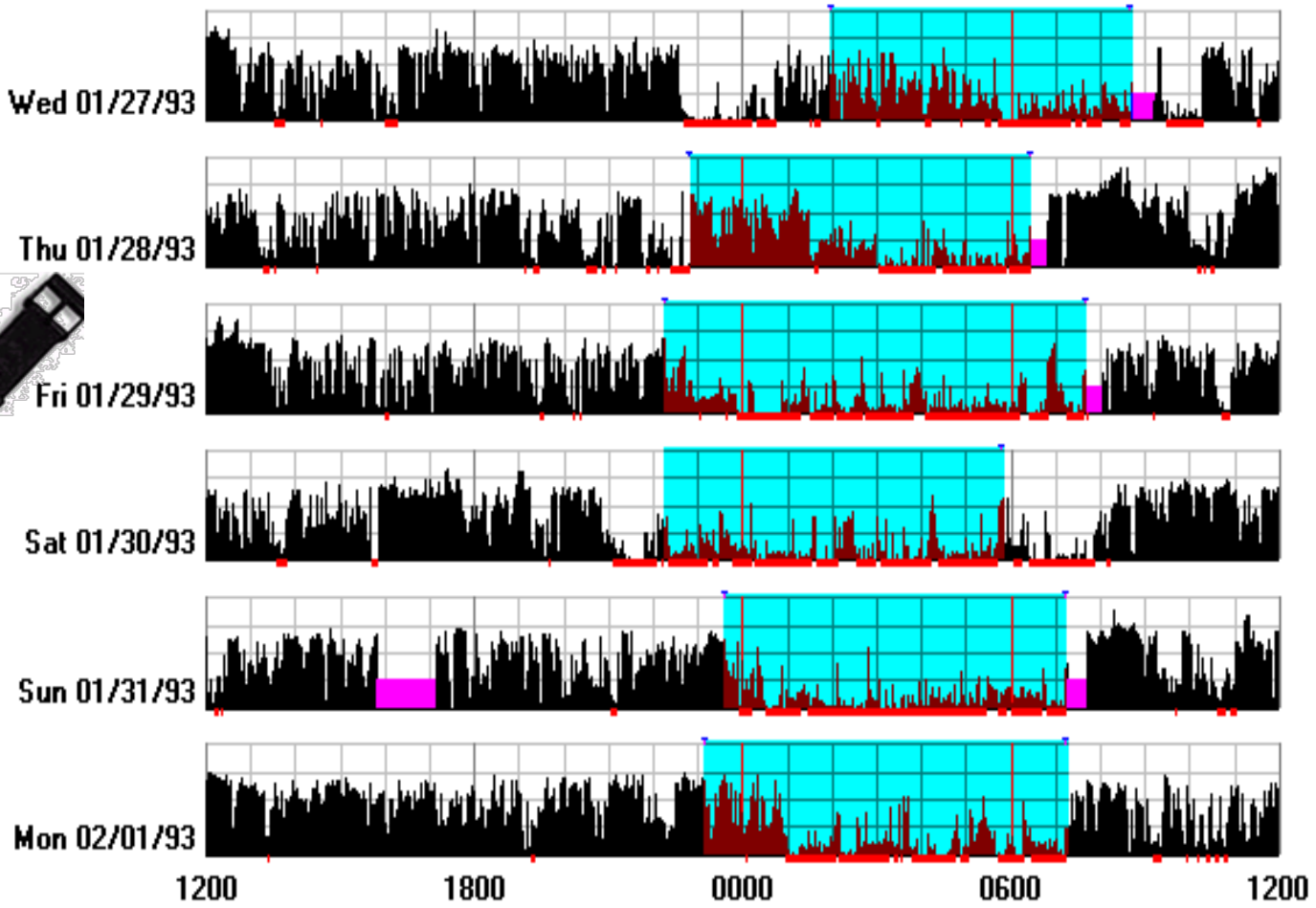
Concept of various EU Projects: double-loop patient management system, My-Heart, HeartCycle, Psyche, Welcome, Chronius

Bed Foil (VTT)

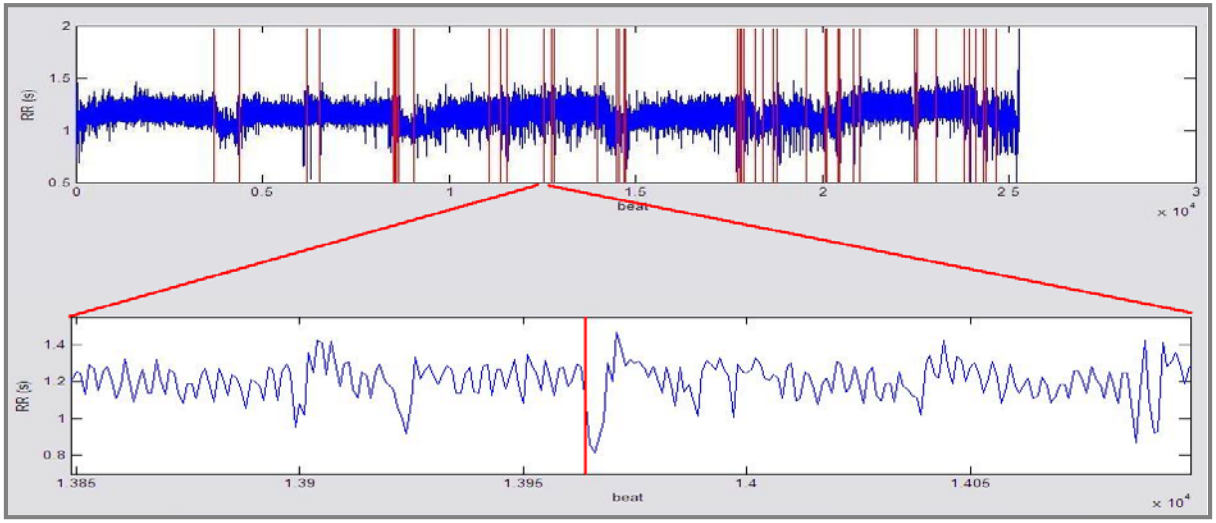


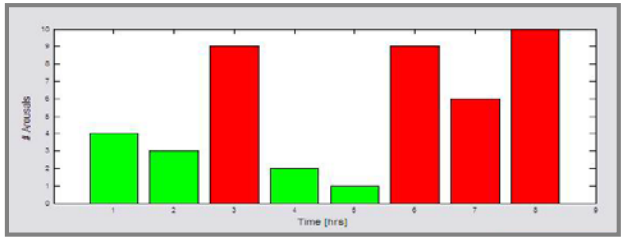
Bed Sensor with 8 channel piezo foils

Bodily accellerometer



Sleep fragmentation index





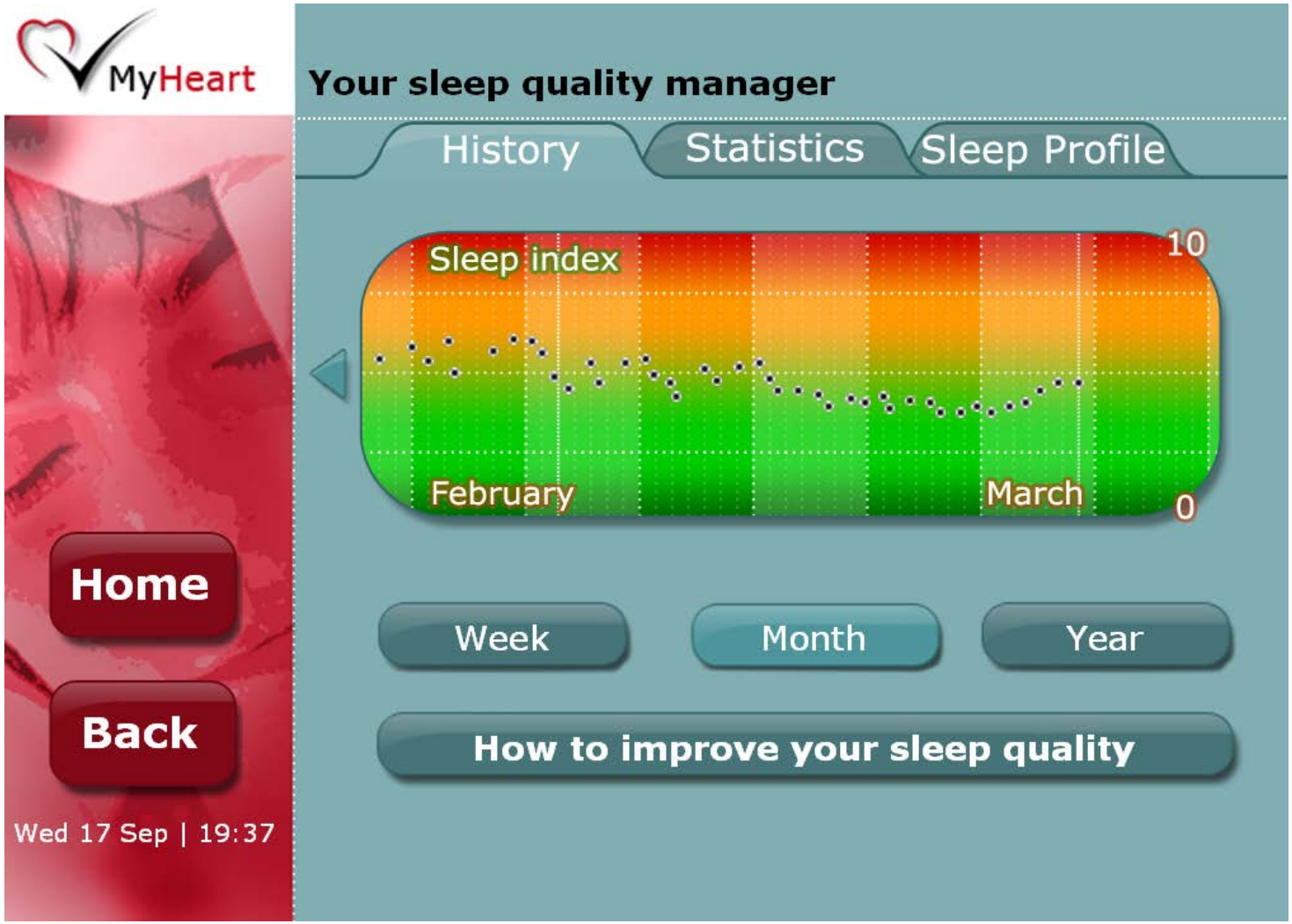
Sensitivity = 81%
Specificity = 99%
Accuracy = 98.5%

Sleep Fragmentation Index (SFI)

SFI = 3* (No. Arousals in TST 1/3) + (No. Arousals in TST 2/3) + 0.33* (No. Arousals in TST 3/3).

SFI < 70	70 < SFI < 100	SFI > 100
GOOD	MODERATE	BAD

Sleep fragmentation index



Applications in Motor Rehabilitation

- Elderly people often experience a loss of motor capabilities (e.g., stroke, chronic diseases, etc)
- Key role of functional motor rehabilitation of upper and lower limbs

Intensive and repetitive training

- ✓ Possible rehabilitation in a home environment (physiotherapists or robotic devices)
- ✓ Repeatable therapeutic exercises

Patient active participation

- ✓ Residual muscular activity (EMG signals)
- ✓ Monitoring of brain activity (EEG signals)

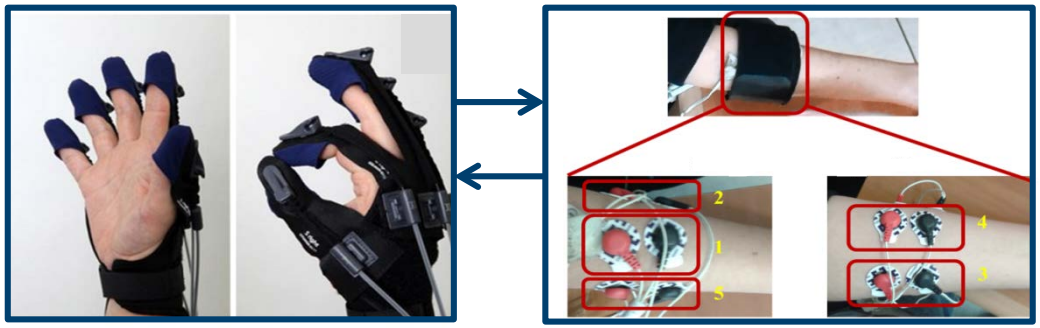
THINK&GO

Transfer Health INnovation through Knowledge & Generate Organised technological approaches in rehabilitation

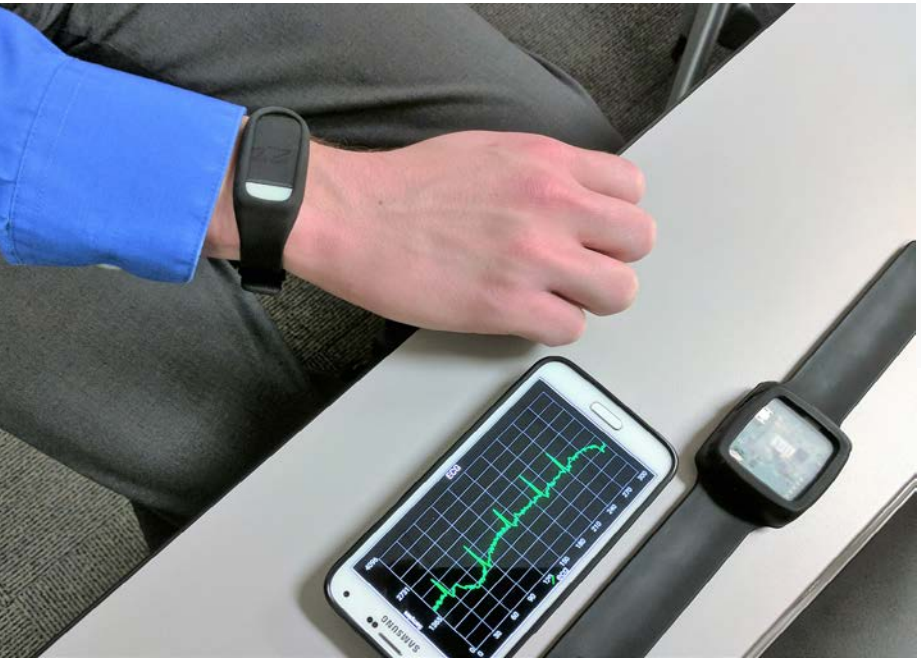
- EMG/Glove module → Hand rehabilitation through a robotic glove
- EEG module → Biofeedback based on brain activity

EMG/Glove Module

The robotic glove is triggered by the EMG activity of the patient (*M. Gandolla et al., 2016*)



Utilizzo di Smartphone

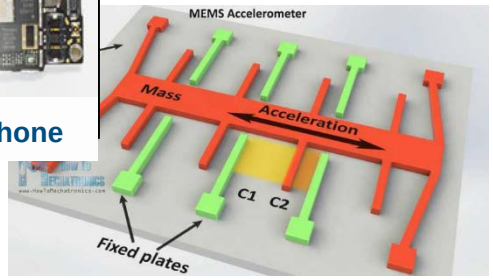


Apple Watch 4

Mobile devices offer the possibility to track the resting heart rate for fitness purpose, thanks to externally-connected devices or to embedded sensors technology.

Camera-based Photoplethysmography

Accelerometer (Iphone 6)



MEMS (Micro-Electro Mechanical System) accelerometers

MEMS 3-axis accelerometer consists of a mass suspended by 4 piezo-resistive beams at the center of the sensor chip. While accelerated, the mass causes the beams to deform thus changing resistance in the piezo material.

Clinical trial involving an App Medical Device [Digital-AF Study, Antwerp, BE]

Digital-AF study

Local newspaper article
92 638 subscribers

Download the app
Create account
Scan QR-code

Information
60s recording
Symptoms

Steady position
2 measurements/day
1 week

Instant feedback
Centralized reviewing
Summary report

12 328
registered users
in 48 hours

120 446
60-second PPG traces
in 1 week

ESC Congress
Munich 2018

Contactless measurement of physiological parameters

Luca Iozzia, Ph.D. student at Deil Politecnico of Milan

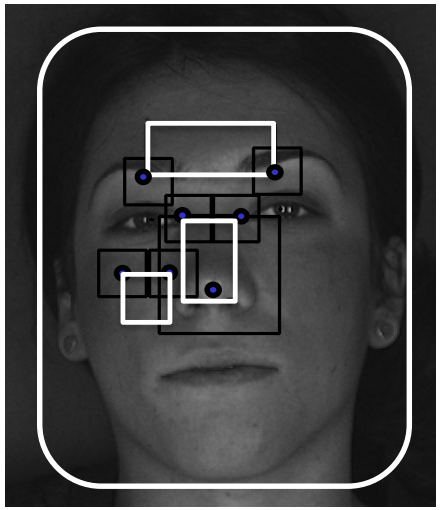
RECOGNITION OF FACIAL EXPRESSIONS

- **Webcam**
- **Dedicated Software**

Contactless medical devices

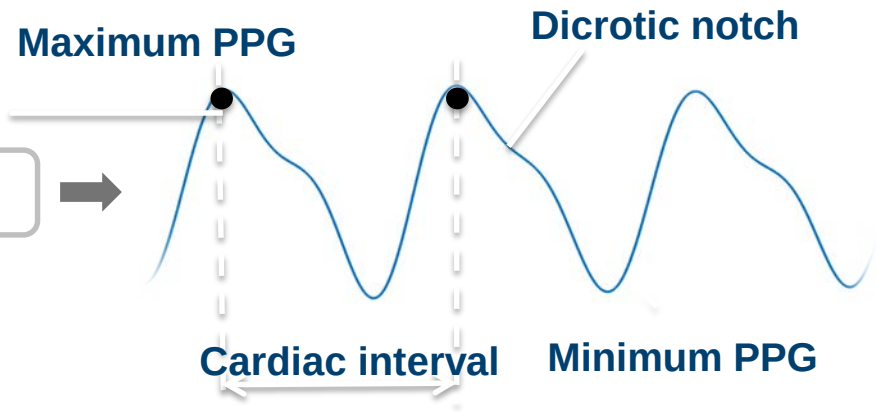
Face recognition

Fiducial points and PPG analysis

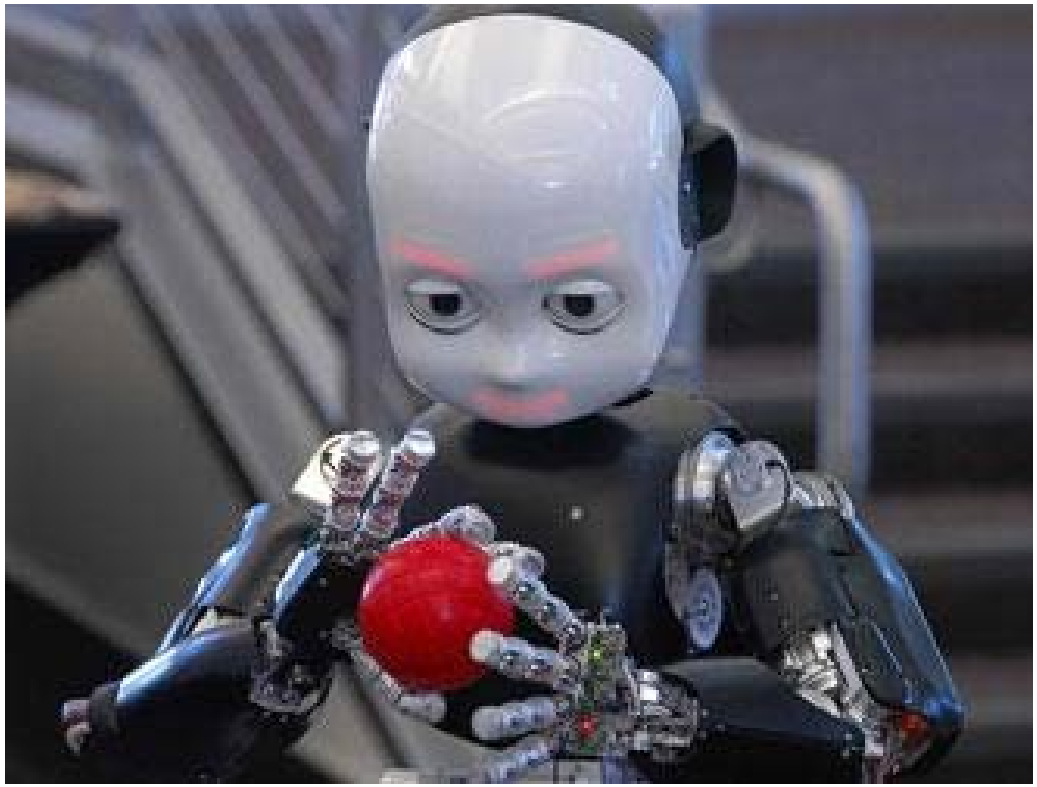


Processing

Video BVP



Robot Companion



Conclusions

- Advancements in mobile health (**mHealth**) technology greatly empowers and enables the possibility for unprecedented **patient participation and active engagement** in their own medical education and healthcare.
- Technological innovation: not only for **Health demands**, but also for **Life Style progresses** and **new paradigms** of **Health & Wellness**
- **“Anytime ECG monitoring” by approved smartphone medical use** has the potential to allow users to learn about and characterize their heart rates & rhythms, as well as to provide global identification and **early diagnosis** of arrhythmias at any time. Importance of the **double-loop follow-up monitor**.
- Several applications, once properly validated, could be considered (sleep monitoring, rehabilitation procedures, respiratory, neurological & cardiovascular early diagnosis and follow-up).
- Ethical problems: cost-benefit analysis, wearable, contactless, minimally invasive versus implantable devices (?)