Systems and Technologies for future Healthcare

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Challenges of a modern concept of Health Care

Keywords:

i) Sustainability

ii) Technological development

To Care ↔ To Take Care
Vital Parameters *everywhere, everytime for long-term recordings* → *huge amount of data [big data !]*

Challenges for BME:

1) Innovative sensors

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

3) Compromise to be reached: on-board vs on-server (on-cloud) processing
Esempi di dispositivi indossabili per il monitoraggio di parametri fisiologici e dello stato di attività

Zheng, et al., 2014
Dispositivi che possono essere messi direttamente a contatto col soggetto per il monitoraggio di *parametri vitali*: a) dispositivo per temp & stress; b) sensore capacitivo per la misura di pressione del polso radiale; c) e-skin (press & temp); d) respiro; e) biosensore elettrochimico tatuato per misure sul sudore

Zheng, et al., 2014
Wearable PPG sensors

Fig. 3. Several representative types of wearable PPG sensors: (a) microoptic reflective sensor with individually tailored otologic housing [24]; (b) ear-hook design of reflective sensor [25]; (c) ear clip transmissive sensor with accelerometer [26]; (d) wireless magnetic earring sensor with accelerometer [27]; (e) golf hat with integrated wireless reflective sensor [28]; (f) wireless transmissive ring sensor with accelerometer [29], [30]; (g) wireless attachable reflective sensor with receiver module [31]; and (h) Apple watch [32].

Fig. 5. Cellphone-based IPPG system with (a) showing position of the video unit comprising a white LED (WLED) and camera; (b) showing light PPG imaging of the index finger positioned to cover the cellphone video unit (modified from [77]).
Devices for the acquisition of vital parameters at home

Sensorized bracelets

Mobile EEG device

Bed sensors
FDA policies in medical field

Camera Pulsometry
- Apps for which FDA intends to exercise enforcement discretion
- Heart rate derived from video images
- For entertainment or fitness use only
- Few validation studies, accuracy and reproducibility tbd
- Available through appstores

Smartphone as ECG monitor
- Apps that transform a mobile platform into a FDA and UE regulated medical device
- ECG acquired by external devices (case, electrodes) connected to the phone
- For medical use
- More validation studies, clinical utility and feasibility proved (AF)
- Available by prescription or over-the-counter
Contemporaneous acquisition of 5 ECG leads:
- Pseudo Einthoven Leads: I, II, III
- Precordial leads: V2, V5
Measurement of respiration through piezoresistive electrodes

Thoracic and abdominal respiration signals
The sensorized T-shirt
Concept of various EU Projects: double-loop patient management system, My-Heart, HeartCycle, Psyche, Welcome, Chronius
• Focus area @ home
  
  Sleep quality improvement
  Stress management
  Daily activity management
  Weight management
Bed Foil (VTT)

Bed Sensor with 8 channel piezo foils
Bodily accelerometer
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

Sensitivity = 81%
Specificity = 99%
Accuracy = 98.5%
Your sleep quality manager

Sleep index

February 10

March 0

How to improve your sleep quality

History  Statistics  Sleep Profile

Week  Month  Year

Wed 17 Sep | 19:37

MyHeart
Classification stage

Mean RR
VLF power
HF power

Parameters

ANN

Sleep profile
Apnee
KNN

HMM

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POLITECNICO DI MILANO
Psychophysical Stress
Relaxation

TACHOGRAM

STRESS

RELAXATION

RESPIROGRAM

RELAXATION INDEX

%RSA

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POLITECNICO DI MILANO
Relaxation

Relaxation tool 2
Example 2: online feedback during relaxation exercise

Mathematical computations (Stress)  transition  Relaxing music (Relax)
Oxygen consumption

- Oxygen consumption
- Triax
  - Acceleration data
    - Features extraction
      - HMM classifier
  - Barometric pressure data
    - Features extraction
      - GMM classifier

BLACK BOX MODEL

Oxygen consumption
Energy expenditure (black-box O₂ consumption)

- Signal magnitude and Pressure Gradient are the model input.
- Oxygen Uptake (mLO₂/(Kg*min)) is the model output.
- The classification information is used to improve the model performance.

Misura di parametri fisiologici «senza contatto»

Luca Iozzia, Ph.D. student at Deib Politecnico of Milan
Come funziona?

Riconoscimento del viso

Tracking movimento

Video BVP

Picco massimo (PPG)

Fissura dicrota

Intervallo cardiaco  Picco minimo (PPG)

Post Processing

Luca Iozzia, Ph.D. student at Deib Politecnico of Milan
Fibrillazione atriale parossistica

- Identificazione della FA parossistica

Uno screening dell’intera popolazione

- Nuove tecnologie
Dispositivi innovativi: braccialetto Empatica E4

Protocollo

soggetti normali in NSR

pazienti in FA

pazienti con altre aritmie
• Handgrip alternato dx/sx (slot di 20s)
• Regressore statico (box-car) con finestre temporali di 2s
• Attivazione e recupero dell’attività di base nelle aree motorie
Applicazioni di Brain-Computer Interface (BCI)
Comparazione di sistemi fissi e mobili in esperimenti di eye-tracking
SISTEMI DI EYE-TRACKING

SISTEMI MOBILI

SMI Eye Tracking Glasses 2 Wireless
Tobii Pro Glasses 2

SISTEMI FISSI

Tobii Pro X3-120
Tobii Pro X2-60
EYE-TRACKING

Zone di fissazione
RECOGNITION OF FACIAL EXPRESSIONS

- Webcam
- Dedicated Software
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.
- Proper information is needed to **avoid misuse** of health applications not designed for medical purposes (i.e., for fitness). This includes **proper validation** and knowledge of **limits of operability**.
- “Anytime ECG monitoring” by FDA-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.
- **Sleep Studies, Atrial Fibrillation, Heart Failure** as well as various forms of **fitness & wellness** parameter measurements seem to represent the main important fields of application for this technology, with benefits in **screening** and **early detection of** various pathological states.