Wearable Device for Human Health Care

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Wearable Health Devices (WHDS)

- are an emerging technology that enables continuous ambulatory monitoring of human vital signs during daily life (during work, at home, during sport activities, etc.) or in a clinical environment, with the advantage of minimizing discomfort and interference with normal human activities.

- The aim was to raise people interest about their health status, improving the quality of care and making use of the new technology capabilities.
Introduction

- A device is considered wearable if:
  - Device is worn for extended period of time
  - User inputs and control possible
  - Enhancement of user’s experience

- A wearable device may include one, two or all three functions:

**Attributes of Wearable Computers**

: Key Attributes of Wearable Tech Products

; 6 key attributes that make a big difference
Introduction

A wearable can be categorized broadly into the following 6 categories:

- **Lifestyle**
  Includes Smart Watches, Smart Glasses and Devices used for Voice and Video calling, Gesture Control, etc.

- **Entertainment**
  Devices used for augmented reality, smart gloves, gesture controlled devices, etc.

- **Medical**
  Devices used for Cardiac Monitoring, HearingAid, Bionics, Remote monitoring of Patients, etc.

- **Fitness**
  Devices used for measuring heart rate, distance travelled, skin temperature, etc.

- **Gaming**
  Devices that use augmented reality for gaming.

- **Industrial**
  Devices that help in Hands-Free and Remote operation for business and industrial purposes.

- The current trend is mostly towards activity monitors. Health has been a big driver for wearable technology thus far. It will be interesting to see how far Smart Watches go and how they are implemented in the workplace.

- These devices create a synergy between multiple science domains such as biomedical technologies, micro and nanotechnologies, materials engineering, electronic engineering and information and communication technologies.

Source: Vandrico.com, Some devices can fall into more than one Category
Introduction

Use cases of Wearable Technology:

- The use of WHDs allows the ambulatory acquisition of vital signs and health status monitoring over extended periods (days/weeks) and outside clinical environments.

- This feature allows acquiring vital data during different daily activities, ensuring a better support in medical diagnosis and/or helping in a better and faster recovering from a medical intervention or body injury.
Independently of WHDs purpose, there are four main requirements on their design: low power consumption, reliability and security, comfort and ergonomics.
The Rise of the Wearable Electronic

- Recent advances in telecommunications, microelectronics, sensor manufacturing and data analysis techniques have opened up new opportunities for using wearable technology in daily life to achieve a range of health outcomes.

- With the advent of sensors integrated in smartphones initiated in 2007, wearable simply benefits from the smooth evolution of accurate technologies already integrated in smartphones.

- Today, with smaller circuits, microcontroller functions, sensor fusion and wireless data transmission, wearable sensors are now ready to flood the market.....
Wearable: Part of Internet of ThingsWave

; The human is a connected object

An industrial chain similar to IoT chain....
Vital Signs—Most Important to be Monitored

- Regarding this classification, it is possible to divide WHDs in two main areas, activity monitoring area and the medical area that is divided in three main sub-categories.

- Schematic overview of the four main data mining processes (activity, prediction, anomaly detection and diagnose/decision support) in relation to different aspects of wearable sensing in wearable health devices.

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<th>Main Topic</th>
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Valuable Vital Signs

- Electrocardiogram (ECG)
- Heart Rate (HR)
- Respiration Rate (RR)
- Blood Pressure (BP)
- Blood Oxygen Saturation (SpO2)
- Blood Glucose (BG)
- Capnography
- Body Temperature
- Skin Perspiration

Other Physiological Parameters

- Motion Evaluation
- Cardiac Implantable Devices
- Ambiance Parameters

- To obtain location and distance data, a GPS can be also added to the device.
- The best way to access reliable data of human movements is using tight clothes.

- are the environmental parameters in each subject surroundings and have a high relevance in several human body monitoring areas. The most used sensors are temperature, light, humidity and sound level.
Wearable Health Devices Generic System Architecture

- An aging population and the emergence of chronic diseases lead to a bigger interest in wearable physiological measurements devices.

- The effort in these developments is resulting in small wearable devices, with the benefits of a lower cost and higher mobility while the data is being collected.

- The generic architecture presented is divided in four modules:
  (A) Body Area Network, which can have different approaches, as we will see ahead;
  (B) Data Logger or Portable Unit with all the electronic;
  (C) Data Analysis, an offline method to see the recorded data;
  (D) and Real Time Monitoring that enables to visualize live data.
Wireless Body Area Network (WBAN) for wearable medical sensors

- Cardiovascular measurement unit
  - Measures ECG, HR, HRV

- Knee Joint monitoring unit
  - Monitors joints using IMUs, GSR, and temperature

- Activity monitoring unit
  - Measures activity related signal using on body IMUs
  - Monitors activities.

- Central BAN node
  - Collects data from BAN connected sensors
  - Limited storage and processing
  - Transmits data to home gateway

- PPG measurement unit
  - Measures SpO$_2$, pulse rate and BP

Home Gateway
MEMs & Sensors enable key functionalities.... Current battleground of the industry

MEMs (MicroElectroMechanical systems) & SENSORS ROADMAP
From More than Moore towards Beyond Law
MEMS & SENSORS : The 5 Senses

MEMs & sensors devices bring increased functionalities...


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Wearable biomedical sensors

Activity trackers
Smart watches
Smart clothing
Patches/tattoos
Ingestibles/smart implants
Wearable health devices

- Wristwatches, also known as smartwatches, are under development for a few years and are denominated as accessories for the human being.

- One of the first’s devices of this type was AMON, first presented in 2002 and capable of monitoring heart rate, blood oxygen saturation and skin temperature, already with a wireless data communication module.

Examples of some wearable health devices
Heart activity trackers of WHD on the body

- Heart activity trackers divided by **type of WHD on the body** (t-shirt, chest strap or adhesive patch) and **purpose of usage** (fitness/sport to medical/health), which goes from fitness/sport to Medical/Health, where there is also an increase of heart activity accuracy (HR $\rightarrow$ R-R Interval $\rightarrow$ ECG).

- The closer to the medical/health side the higher the accuracy and quality of heart activity is.
Mobile Heart Rhythm Monitors

(A) Leadless patch ECG monitor (Zio, iRhythm Technologies, San Francisco, California), which is placed over the patient’s left pectoral region and can provide continuous ECG monitoring for several weeks. (Image courtesy of iRhythm Technologies.)

(B) An investigational smartphone app (Cardio Rhythm, Cardio, Cambridge, Massachusetts) uses the camera for photoplethysmography (PPG) measurements from the finger. Examples of PPG recordings from a patient in sinus rhythm (top) and a patient in atrial fibrillation (bottom). Adapted with permission from Chan et al. (82).

(C) A Food and Drug Administration–approved wristband (Kardia Band, AliveCor, Mountain View, California) that attaches to a smartwatch (Apple Watch, Apple, Cupertino, California) contains electrodes to acquire a single-lead ECG for arrhythmia detection (image courtesy of AliveCor).

(D) An investigational smartwatch (Verily Study Watch, Verily Life Sciences, San Francisco, California) that combines continuous PPG with electrodes for on-demand single-lead ECG acquisition (image courtesy of Verily Life Sciences).
Medical Wearable Devices on the market already (and approved by FDA)

Portable Bio-data Logger (by Zephyr)

Portable Glucose Level Monitoring (by Medtronic)

Pain relief with Electrotherapy (by Omron)
Portable Bio-data Logger (by Zephyr)

- Monitor Posture
- Monitor Activity
- Monitor ECG
- Transmission Range: 10m
- Dimensions: 46.8×45.5×11.3mm
- Retail price ca $460
Portable Glucose Level Monitoring (by Medtronic)

Continuous glucose monitoring
- Professional use only
- 3 days (or more) of patient interstitial glucose level monitoring
- Measurements: 35.8×28.8×9.4mm
- Retail price for the entire kit: ca $460
Pain relief with Electrotherapy (by Omron)

- Transcutaneous electric nerve stimulator (TENS)
- Program circle button controls 3 set programs for the arm, lower back and the leg/foot; arrows control 5 intensity levels
- 2 pads to attach to the body and apply the therapy not directly on the skin (large surfaces)
- Operated by 21.5 V batteries (AAA) = 22.8 hours of continuous usage
- Retail price: ca. $30.
Current Health’s artificial intelligence (AI) wearable device that measures multiple vital signs has recently received FDA-clearance for patients to use at home.

The AI-enabled, upper-arm wearable passively measures a patient’s vital signs in real time. The device’s algorithms continuously analyze data to derive a patient’s health trajectory by detecting indicators of decline earlier for faster intervention.
Future Challenges

- In the sensor technology area, there are three main aspects that will have particular attention: long-term stability; resiliency; and biocompatibility.
- Smaller sensors are being associated to the electronics development, to increase functionality and portability of WHDs.
- A possible improvement of wearable sensors may include the use of nanomaterial-based signal amplification.
- Biocompatibility must be highly considerate, covering sensors with antimicrobial or protective coating, preventing any potential toxicity of nanomaterials.
Conclusions

- Wearable health devices are a recent reality in healthcare and still under development with the aim to be integrate in medical health systems.

- Data communication leads to another problem: privacy - a problem that concern healthcare, in the prevention of information, leading people to have lower confidence in these devices, resulting in ethical problems.

  → This is one of the main barriers and the suggested solution is to create clear guidelines to providing privacy, confidentiality and proper use of electronic medical information.

- With new advances in new materials, electronics and telecommunication information technology, together with the entry of big multinational companies, such as Google, but also of small startups, WHDs are expected to overcome their challenges and enter in the consumer market with a higher impact in the following years.
Thank You For Your Attention!