Wearable Technologies for Health Care Applications - an Overview

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Overview

1. Wearable Computer Concept
2. Materials & Methods
3. Applications
4. Current status
5. Conclusions
Introduction

- Improvements in health care → longer life, worse health

- Goals of new technologies:
  - Expand the capabilities of the health care system
  - Extend its range into the community
  - Improves diagnostics and monitoring
  - Maximizes independence & participation

- Obesity in USA: 30% in most sex & age

- → Chronic conditions: diabetes, hypertension, high cholesterol, stroke, heart disease, cancers

- Clinical & commercial weight loss interventions: short-term weight loss, but majority regain ca. 40% of their lost weight in the first year
Wearable Computer Concept

Focus on interaction between user, system & environment

- Conventional mobile systems:
  - Focus on interface ↔ attention on physical activity
  - → Range of applications & situations using the system is restricted
Focus on interaction between user, system & environment

- Permanently useful & usable
  - Allows simultaneously interactions
  - Direct interaction between
    - System & environment
    - System mediating between user & environment
Implementation of wearable interaction concepts

- Interacting through different sensors distributed in different parts of the outfit
- User interface: minimal cognitive effort
- Wide range of tasks without any user interaction (e.g. automatic retrieval, delivery)
- Seamlessly integrated in the outfit
- Example: modern hearing aid computer (e.g. automatically adjust volume, optimize amplification)
Key enabling technologies

- **Wearable sensors:**
  - To monitor vital signs (e.g. heart rate and respiratory rate)
  - For movement data capturing, monitoring the effectiveness of home-based rehabilitation interventions

- **Challenges:**
  - Technological barriers such as limitations of currently available battery technology
  - Cultural barriers such as the association of a stigma with the use of medical devices for home-based clinical monitoring
Key enabling technologies

- Wearable systems consist of three main building blocks:
  - The sensing and data collection hardware to collect physiological and movement data
  - The communication hardware and software to relay data to a remote center
  - The data analysis techniques to extract clinically-relevant information from physiological and movement data.
Key enabling technologies

- Recent advances in sensor technology, microelectronics, telecommunication, and data analysis techniques have enabled the development and deployment of wearable systems for patients remote monitoring.
- Miniaturization of sensors and electronic circuits based on the use of microelectronics
- Transmit the data wirelessly to a data logger using a low-power radio
- Using batch fabrication techniques → significant reduction in the size and cost of sensors
- E-textile based systems: integrate sensing capability into garments
- Data gathered using sensor networks transmitted to a remote site such as a hospital server for clinical analysis
Functional Textiles

- Clothing as infrastructure for mobile electronic appliances
- Using functional textiles & novel electronic/textile interconnection technology to make signal & power lines, simple sensors & antennas part of the clothing itself
- Textile sensors can measure biometric or environmental data or act as an input interface
- Implement large area, flexible antennas for body area networking, BlueTooth, or WLAN
- → Textile based communication or power generation
Embedded Microsystems

- Optimal signal quality
  - Direct functional correspondence between sensors and pieces of the user’s outfit
  - Combine sensors and power generation devices in single nodes to make the electronic sensors autonomous

- Implementing robust, cheap microsystems

- In all types of clothing and accessories, permanently connected to the functional textiles layer
Attachable Peripherals

- Problem: each device uses its own keyboard, display & battery
- Solution: right placing of the IO devices + good communication infrastructure or low power wireless body area network
- Placing in the outfit allows different interaction modes, more suitable for mobile use
- Peripherals are more expensive than sensors and not robust enough to survive clothing-typical handling like washing or cleaning → associated with a particular piece of clothing or an accessory (e.g. glasses), firmly attached to it
Location of sensing technology systems

- Piece of jewelry, wristwatch, ring, necklace, brooch, pin, earring, or belt buckle
- Electronic patch or skin
- Armband with sensors that assess movement, heat flow, near-body ambient temperature, heart rate, skin temperature, and GSR
- Pyjamas and shoes (sudden infant death syndrome)
- Gloves for recording hand posture
- Miniaturised video camera, pills, gastric pressure and pH measurement
- Embedded in the users outfit as part of clothing
- Multimedia devices or systems, video camera, microphone, PDA
Monitoring

- Health monitoring systems: e.g., portable ECG systems, wrist worn blood pressure measurement systems, fitness focused commercial pulse monitors
- No burden & no interfering with everyday activities
- Examples:
  - AMON wrist worn medical monitor (for high risk cardiac/respiratory patients):
    - Continuous collection & evaluation of multiple vital signs
    - Intelligent multiparameter medical emergency detection
    - Cellular connection to a medical centre
    - → Long-term monitoring without interfering everyday activities & restricting mobility
  - GeorgiaTech SmartShirt: embeds electronic sensors, conductive elements and optical fibers in a conventional shirt
Mobile Treatment

- Often implantable & better integrated
- e.g., Smart FES (Functional Electrical Stimulation)
  - Method used to contract paralyzed muscles of patients with neuromuscular disorders
  - Aim: generate or improve lost motor functions (e.g. aided walking or hand grasp)
  - Create a highly configurable FES system on a new type of transcutaneous electrodes made out of conductive textiles
  - Idea: build an array of electrode elements (pads), subsets of which can be electrically switched between ’stimulation’ and ’off’ signals
Assisted Living Systems

- Life a independent life without nursing care:
  - Dealing with hazards and emergencies: general activity tracking, user-specific health monitoring & medical database or medications reminder
  - Simplifying everyday tasks: house environment with computer-controlled devices
  - Ensuring adequate communication: access information services through a variety of devices, without the need for any classical computing skills
Wearables for Medical Personnel

- Used in situations where the user needs to focus his attention and physical activity on the interaction with the environment
  - In a hospital: a doctor or a nurse can access and possibly enter data while interacting with a patient or performing a procedure.
  - e.g., Miniature display integrated in the glasses including patient data, output of diagnostic instruments, or direct advice from a remote expert
SWA

- Self-monitoring = key skill for weight management
- → Increases awareness of energy intake and expenditure, enhances self-efficacy, and allows for individuals to monitor progress and change over time
- The SenseWearTM Armband (SWA)
  - = Physical activity & lifestyle monitor
  - Measures objectively & accurately free-living energy balance & sleep
  - Includes software for self-monitoring of daily energy expenditure & energy intake
SWA

- **Goal of the SWA:**
  - Create a wearable device that could quantitatively assess energy balance, sleep, and physical activity in free-living environments
  - Offers valuable assistance with the goal to simply self-monitor the physical activity and caloric intake
  - Self-monitoring correlated significantly with weekly weight loss
- Self-monitoring of diet and physical activity with the SWA related to successful weight loss
Lifeguard system

- For extreme environments, space and terrestrial conditions
- Includes:
  - Physiological sensors (e.g., ECG/respiration electrode patch via impedance plethysmography, heart rate, SpO2, body temperature, blood pressure monitor and body movement)
  - Wearable box the size of a cigarette pack
  - Base station where data are sent via Bluetooth
Land Warrior System

- Enables soldiers to view computer generated graphical data and maps
- Engages targets at night without exposing soldiers to hostile fire
- Shares intelligence information and video images, and coordinates
- Synchronises actions with peer groups via mobile networks
Smart Vest

- Able to monitor vital signs (e.g. ECG, photoplethysmogram (PPG), heart rate, systolic and diastolic blood pressure; body temperature and GSR)
- Without the attention of the wearer
- Transmitted using a RF link to a remote monitoring and analysis station along with the geo-location of the user
- Measurements in real time
Sudden cardiac death

- Wearable defibrillator or automatic external defibrillator is frequently used in cases of sudden cardiac death
- Able to restore sinus rhythms in patients with ventricular tachyarrhythmia
capsule endoscopy system

- Patients be examined from data collected by the camera
- Composed of the capsule itself, a portable image receiver/recorder unit and battery pack, and a computer workstation
- Useful for diagnosing gastrointestinal bleeding, inflammatory bowel diseases, taking small bowel radiography and monitoring postsurgical small bowel transplantation
Conclusions

- System efficiency, reliability and unobtrusiveness
- User needs and privacy
- User perception and acceptance
- Reimbursement or cost
- Social inclusion and ethical issues
References

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Monitoring Systems
Thank you for your attention!
Sensing technology

- **Wearable sensors**
  - Physiological measures of interest in rehabilitation: heart rate, respiratory rate, blood pressure, blood oxygen saturation, and muscle activity
  - Biochemical sensors:
    - Used to monitor the biochemistry and levels of chemical compounds in the atmosphere (e.g. to facilitate monitoring people working in hazardous environments)
    - e.g., Glucose monitor:= minimally-invasive wearable closed-loop quasi-continuous drug infusion system

- **Ambient sensors:** ambient assisted living (AAL):
  - Refers to intelligent systems of health assistance in the individuals living environment
  - Covers concepts, products and services that interlink and improve new technologies and the social environment