Textile Sensors for Personalized Feedback

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Overview

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Introduction to Smart Textiles

Healthcare applications

- Breathing feedback system

- Rehabilitation glove

Sports applications

- Smart insole

- TennisSense

Wearable sensors

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Continuous monitoring of the wearer in a natural setting

Sensors should not interfere with the wearer's daily activities and should be easy to use

Challenge to integrate sensors with textiles – must be comfortable, durable, washable

Conventional electronics are hard/brittle

-> Textile based sensors

Textile technology

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Clothing essential for warmth, comfort, culture, aesthetics,

Technical textiles have been developed to improve performance, enhance wearer's comfort

Kevlar®
bulletproof, lightweight

Moisture management
DriFit, Coolmax

Waterproof,
breatheable

Nano-coatings
- self-cleaning,
anti-bacterial

Next generation? "Smart" Textiles

Electronic Textiles

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Metallic fabrics

WarmX
Heated textiles

Luminex - Woven optical fibres

Textile electrode, ECG
Numetrex

Electex Soft switches

Philips Lumalive
Organic LEDs

Next-generation - “Smart Textiles”

Passive smart textile – senses a change in the wearer/environment

Active smart textile – inherent intelligence, responds to the change

Integration of:

- Sensors
- Actuators
- Interconnections, Control Electronics,
- Wireless Communications

Smart textiles - applications

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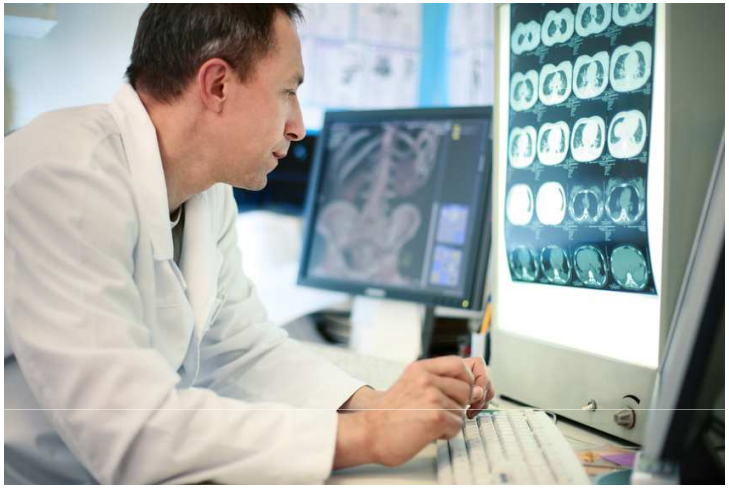

Rehabilitation,
Disease management
Preventative healthcare
Ambient Assisted Living

Sports performance,
Sports physiology
Exercise and fitness

Wearable sensors projects

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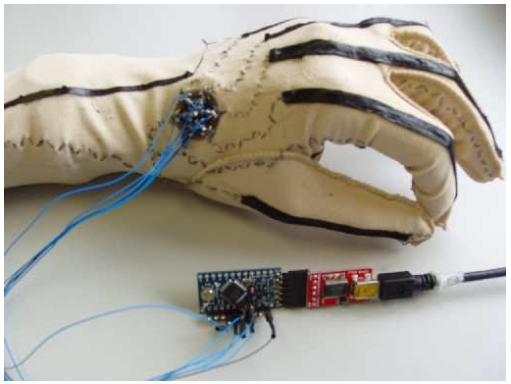
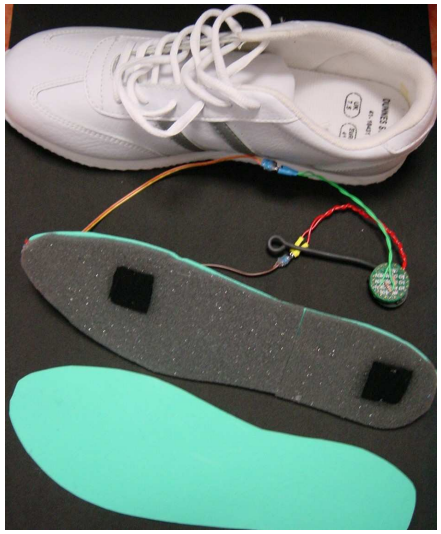


Rehab glove



Smart insole

Breathing monitoring

BIOTEX
Bio-sensing textile for health management

PROETEX

Sensors – “Smart shirt”

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Fabric stretch sensors monitor the expansion and contraction of the ribcage and abdomen during breathing.

Carbon-Elastomer(CE) sensors (piezo-resistive) are coated onto fabric

Sensors interconnected by coating over conductive stainless steel thread.

Xbee platform for wireless data capture

Applications – biofeedback system for sports/respiratory rehabilitation

Importance of breathing technique

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Sports performance

Use of full lung capacity to maximise oxygen delivery to muscles

Use of breathing techniques to calm and focus, e.g before kicking a penalty in soccer or a serve in tennis

Clinical applications

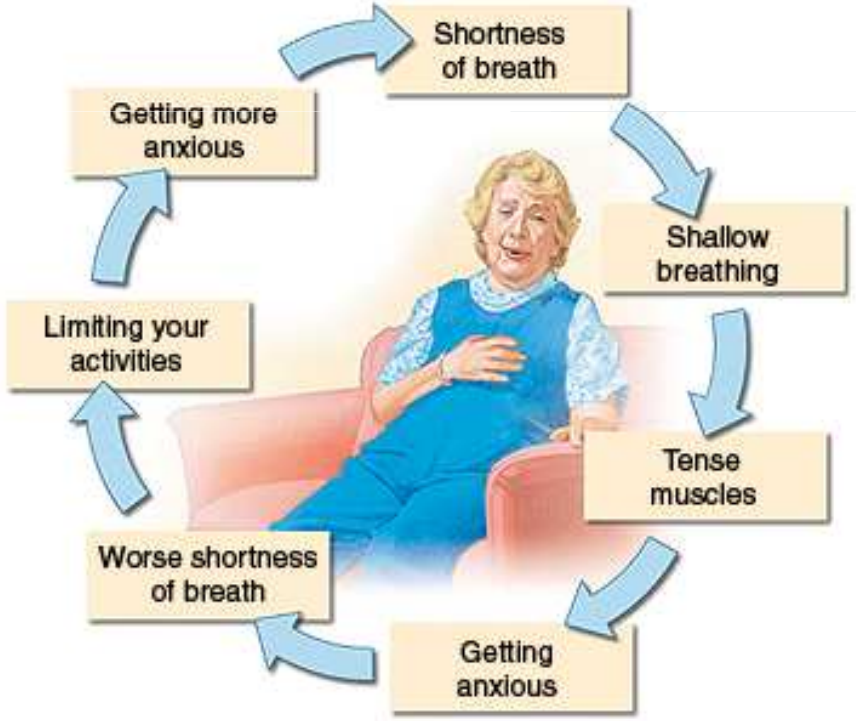
Chronic Obstructive Pulmonary Disease (COPD)

Anxiety treatment

Cystic fibrosis

Respiratory rehabilitation

Sleep Apnea



Breathing Monitoring – System Requirements

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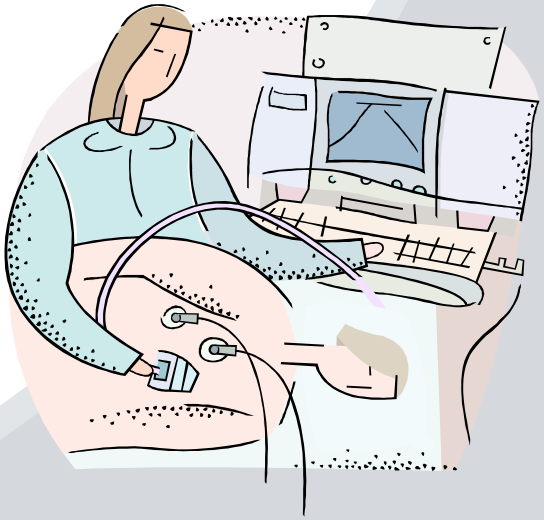
Aim – to develop a feedback system for patients to improve their breathing technique, by monitoring thoracic and abdominal movements. Give feedback to the user graphically

Sensor must be
- **Comfortable**
- **Robust**
- **Straightforward to use**

Wearable sensor/"Smart garment"



Feedback/Application must:
- **Grab users attention**
- **Have a simple interface**
- **Focus user for the full duration of the program**
- **Encourage user to correct their breathing rate**

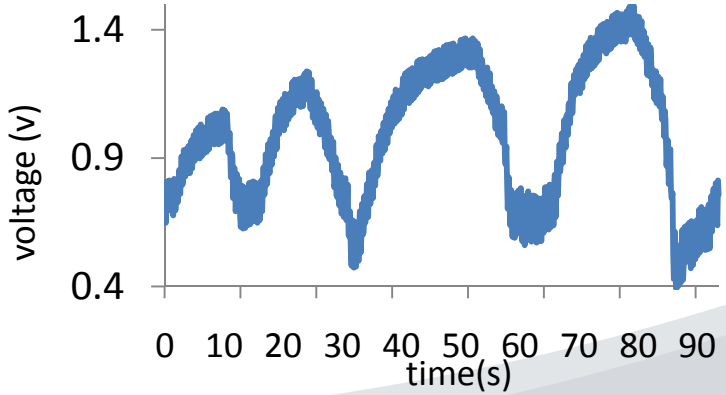
and low cost, easy to install on computer systems

Breathing feedback system

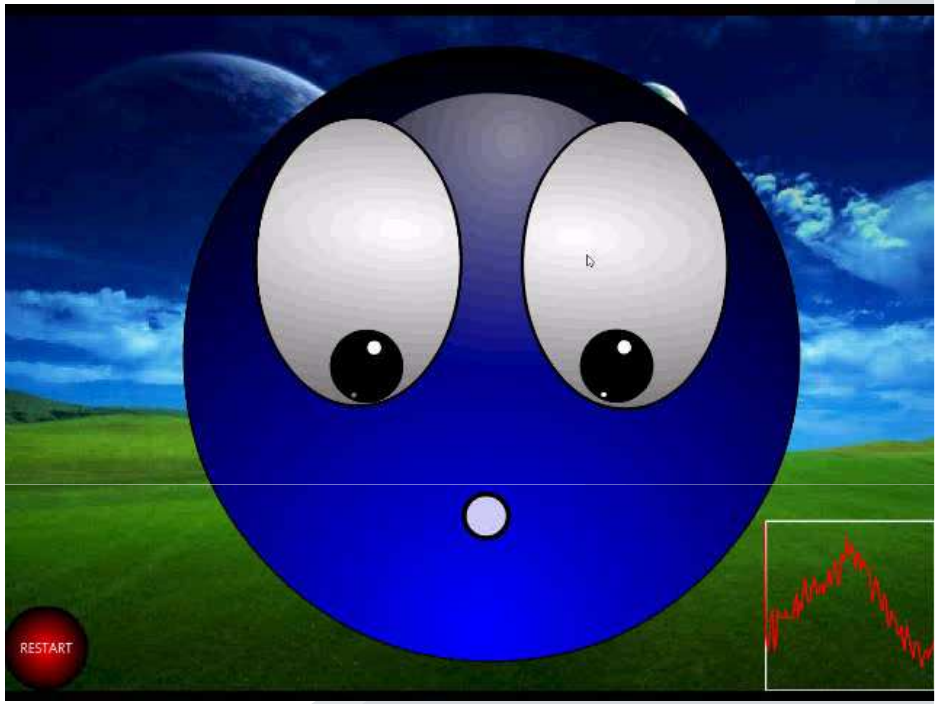
Breathing Sensor

Data capture and wireless connection (Xbee)

Data processing and User feedback



Respiratory feedback system



Graphical user interface - real-time feedback of breathing exercises

Target users – children with Cystic Fibrosis

Rehab glove

Shapehand Data glove

Suitable for Virtual reality and motion capture

Awkward to set-up

Fibre optic sensors are rigid. Glove encourages finger flexion and impedes extension.

Very expensive ~$10,000

Textile based glove

Designed for home rehabilitation

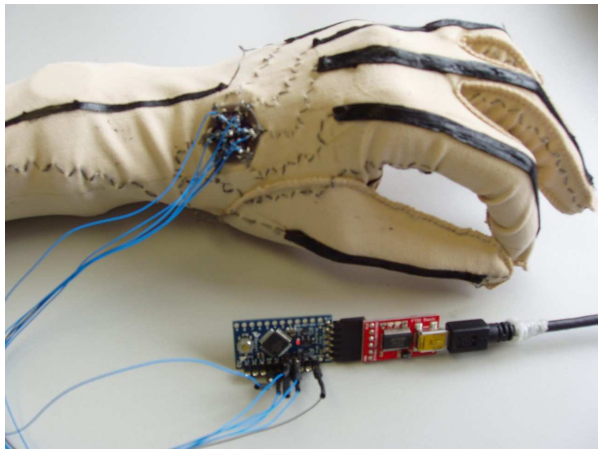
Comfortable, familiar

Oedema glove often worn by stroke patients

Light material, allows natural joint movement

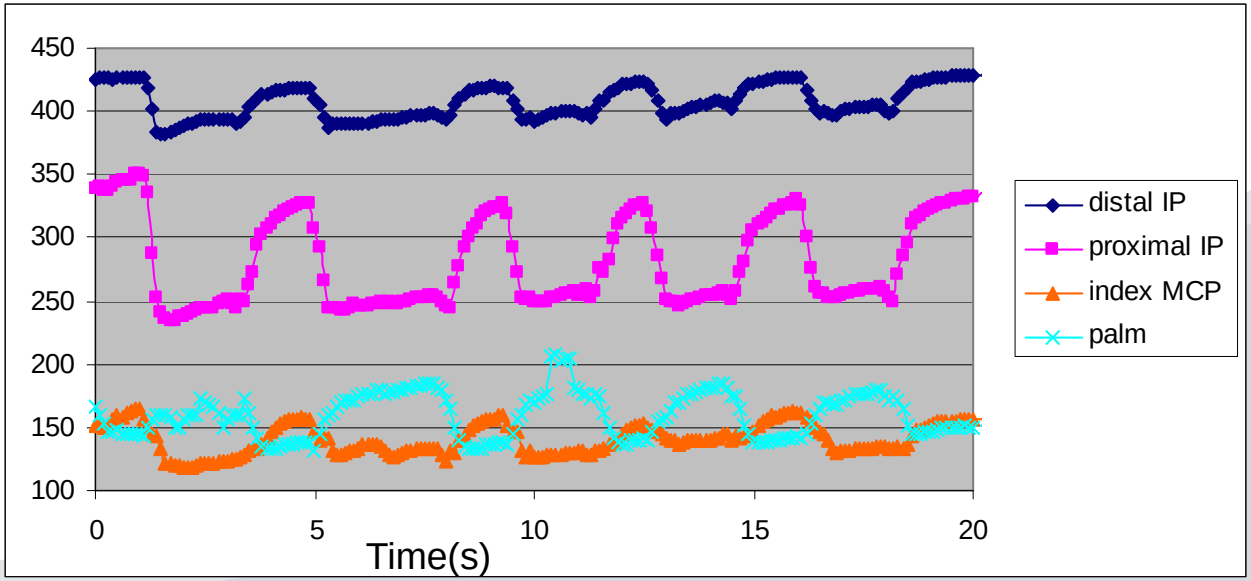
Low-cost, accessible to patients for home use.

Sensor glove



Glove for stroke rehabilitation

User feedback using BVH(Biovision Hierarchy) animation



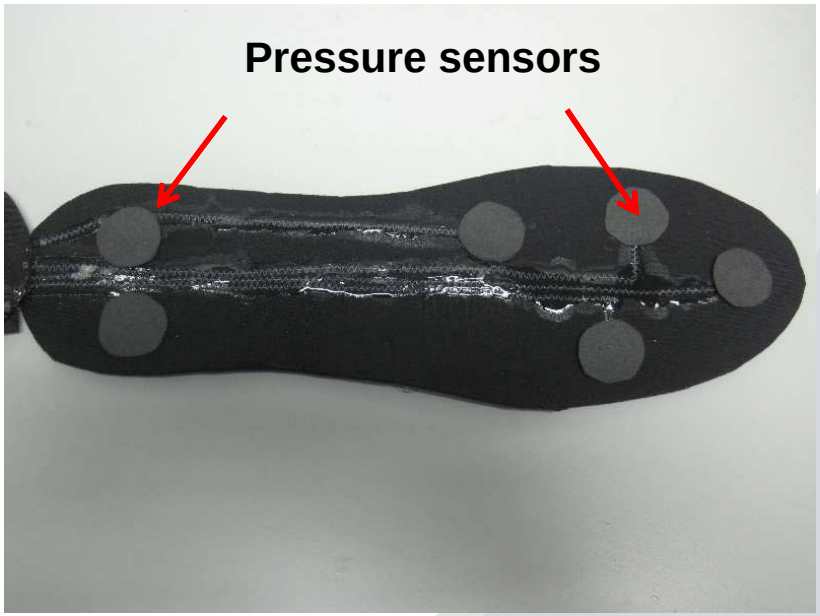
Collaboration with National University of Ireland Maynooth, Carlow IT and Adelaide and Meath Hospital, Tallaght

Sensor glove

Patient performs exercises at home

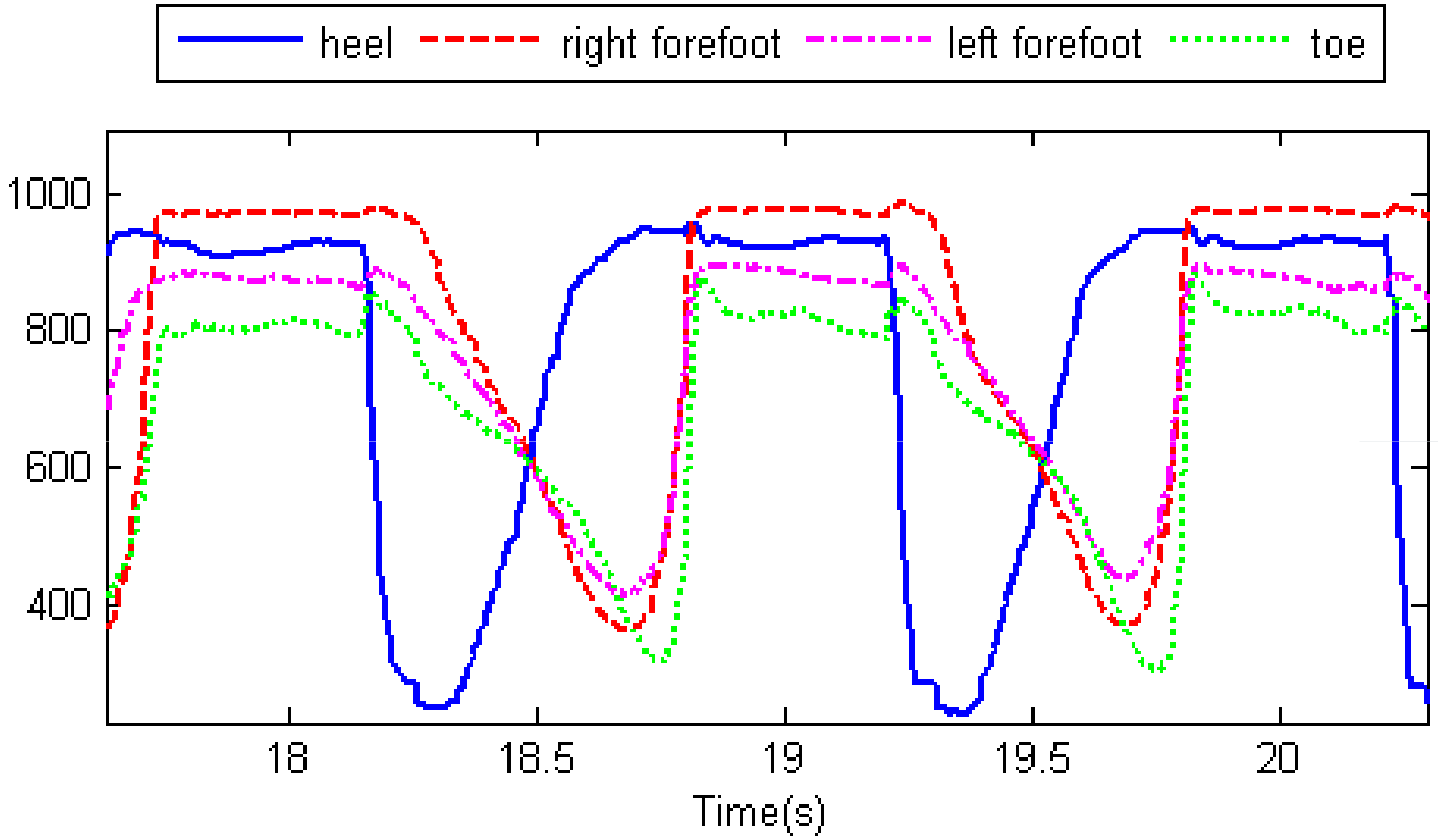
- **Real-time visual feedback**
- **Movement captured by glove and stored in BVH animation format**
- **Physiotherapist can play back and assess the patient's performance remotely**

Smart insole



Neoprene insole with textile pressure sensors in heel, forefoot and toe.
Xbee wireless connectivity – 1kHz sampling rate possible, suitable for high speed applications

Smart insole



Foot contact time with the ground, time between heel strike and toe off, investigate pronation/supination

Smart clothing and sport

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Nike+ "more than 1.2 million runners have collectively tracked more than 130 million miles and burned more than 13 billion calories" (WIRED magazine, June 2009)

Nike + iPod

Adidas miCoach - analyze your stats and get coaching feedback online, pace and heart rate

polarpersonaltrainer.com – online training diary and interactive online community

GarminConnect - worldwide community of Garmin users who track, explore and share their activities.

Adidas miCoach

TennisSense

Infrastructure to gather data – contextual, biomechanical and physiological

Real users - Feedback to athletes/coaches
- Real-time feedback during training
- Longer-term analysis: fitness levels, performance

Sports Performance **Research**
What factors lead to peak performance?

Platform for exciting research and new technology

Multi-source data-mining and data fusion

Wearable sensors

Foster Miller Vest
Physiological monitoring

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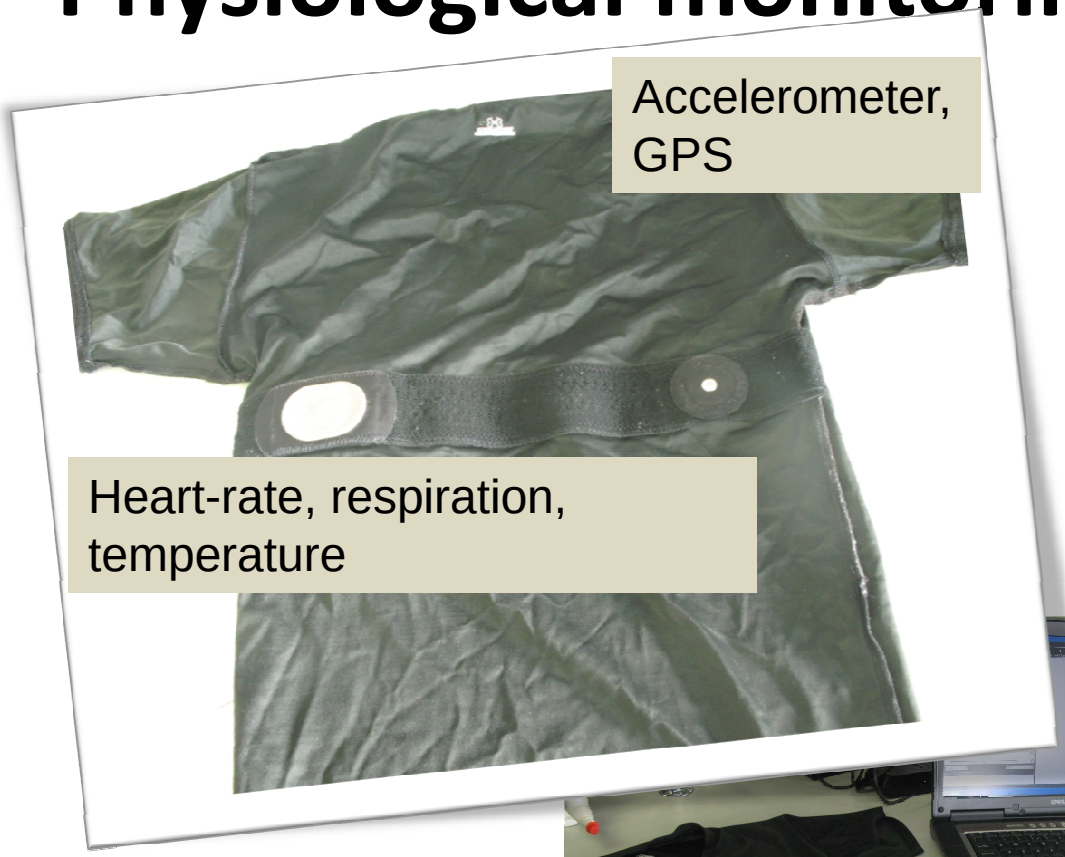
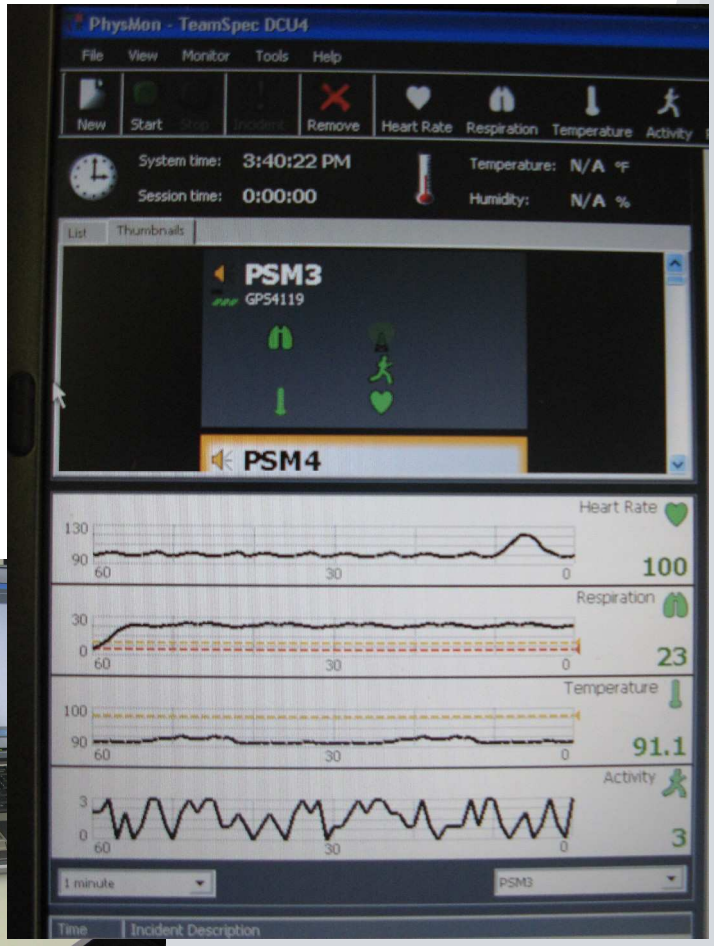
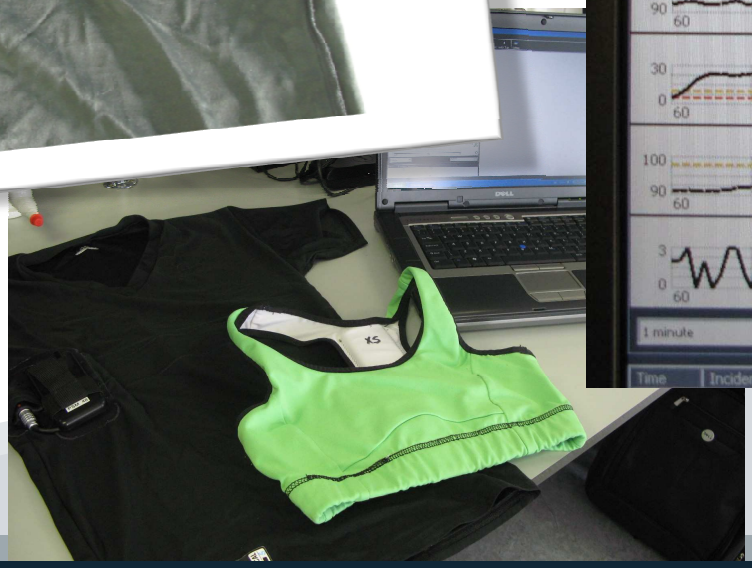






Foster Miller Vests

Physiological Data

Foster-Miller physiological monitoring vest – measures heart rate(HR), respiration rate(RR)

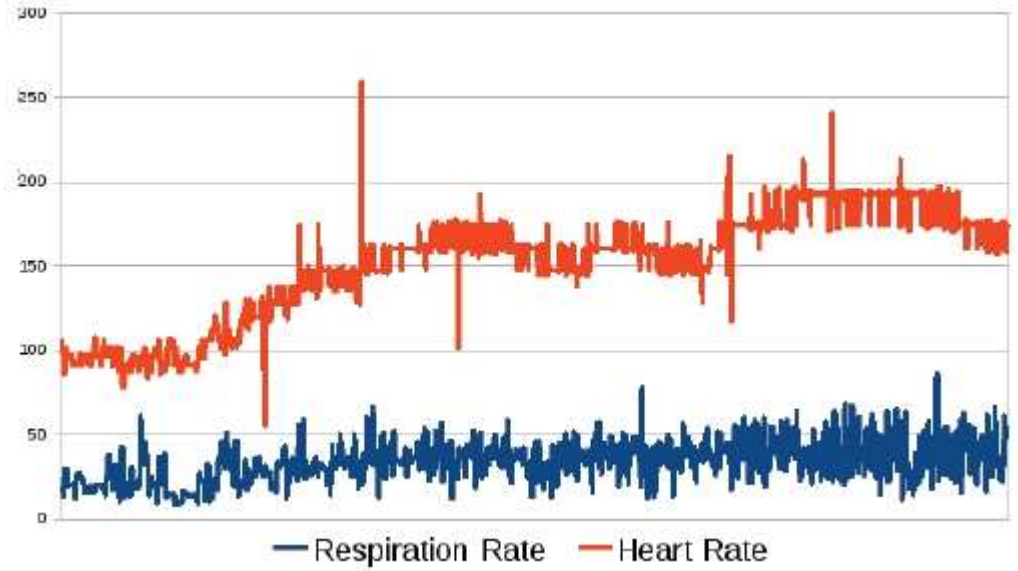
Parameters of interest
- Heart rate and Respiration rate between shots

- Average HR and RR across sets

- Peak HR and RR

-Difference between training and matches

- Comparison on different surfaces (e.g. clay can have longer rallies)



A Sensing Platform for Physiological and Contextual Feedback to Tennis Athletes, Damien Connaghan, Sarah Hughes, Gregory May, Philip Kelly, Ciaran ´O Conaire, Noel E. O'Connor, Donal O'Gorman, Alan F. Smeaton and Niall Moyna, BSN 2009

Conclusions

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Textile sensors used to find personalized information about the wearer's activities, e.g. to track progress in prescribed rehabilitation exercises or fitness training plans

Vast amount of information can be harnessed with textile sensors, e.g. breathing, heart rate, movement

Need to present data in a beneficial way – personal archive and comparison with others