

Application of Human Power for Pervasive Sensing in Sports and Healthcare

Benny Lo



Outline

- **The Need for In-body Pervasive**

Sensing

- In Sport
- In Healthcare

- **Limitations of the Current System**

- **Enabling Pervasive Sensing In-body**

- Challenges
- Energy Demands
- Possible Trade-offs



Pervasive Sensing in Sport

Muscle Biopsy:

- **Measure muscle metabolism**
 - Widely used in human exercise physiology and sports medicine
- **Measure muscle glycogen content**
 - Factor in limiting performance capacity for prolonged, severe exercise
- **It's highly invasive**
 - Requires a needle for percutaneous biopsy sampling of muscle tissue



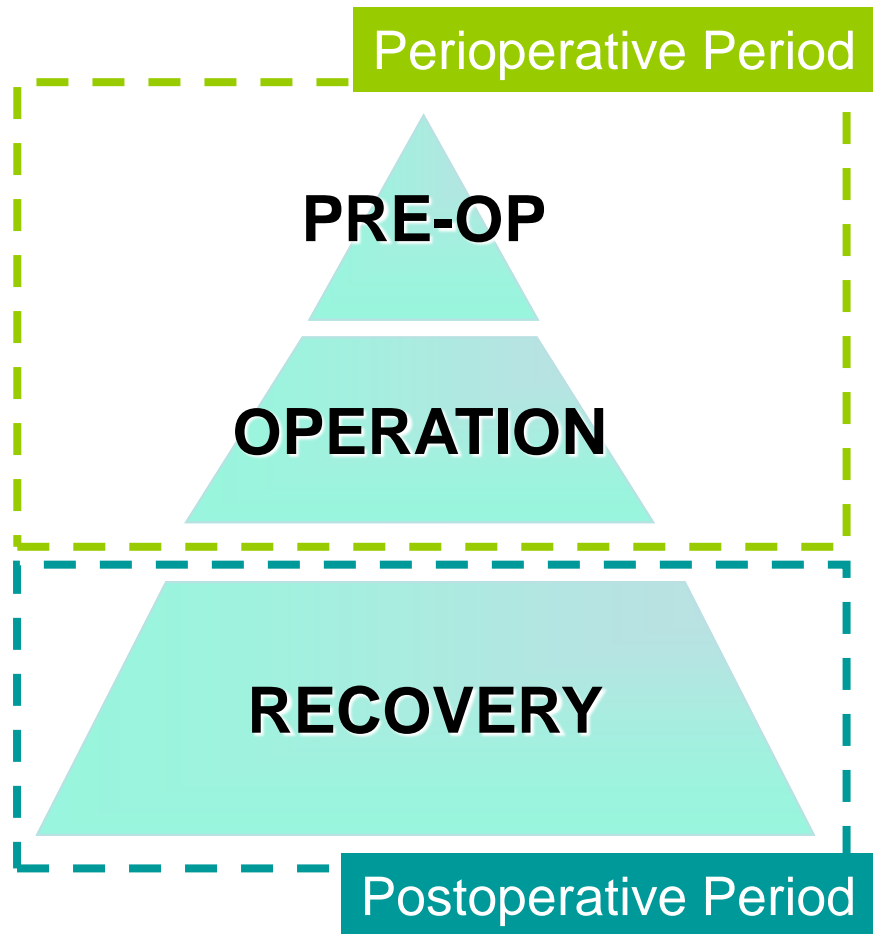
Pervasive Sensing in Healthcare

Postoperative care:

- **Role of pervasive sensing in post-op monitoring**
 - 40.3M inpatient, 31.5M outpatient operations per annum
(US National Center for Health Statistics)
 - **Immediate / Early / Late** complications
- **Tasks of a pervasive monitoring system**
 - Quantify activity, recovery, & physiology
 - Detect complications **early**



Monitoring Requirements



- Patient monitoring is currently most intensive in this period.
- More difficult to monitor here.
- Longer monitoring period.
- Remote/mobile patient.



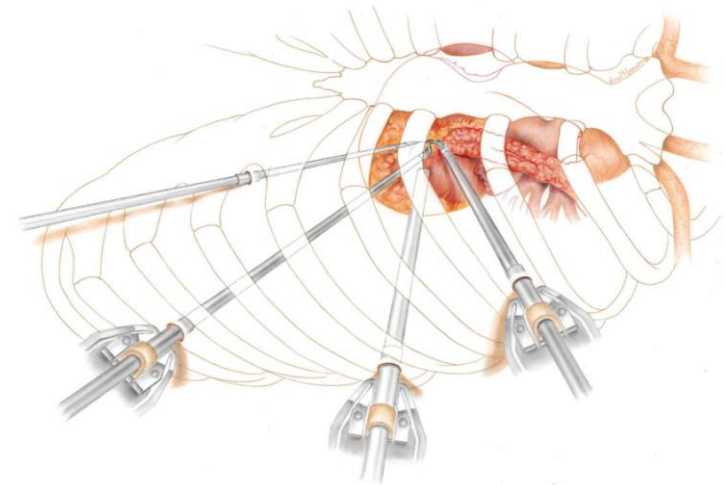
Example 1: Total Knee Replacement

- 150,000 joint replacements 2005-2006
 - 1.5 Million bed days
- 100,000 hip of knee replacements in 2010
- Postoperative monitoring resources:
 - In-hospital stay of 3-5 days
 - Physiotherapy
 - Clinical appointments
 - Postoperative x-rays



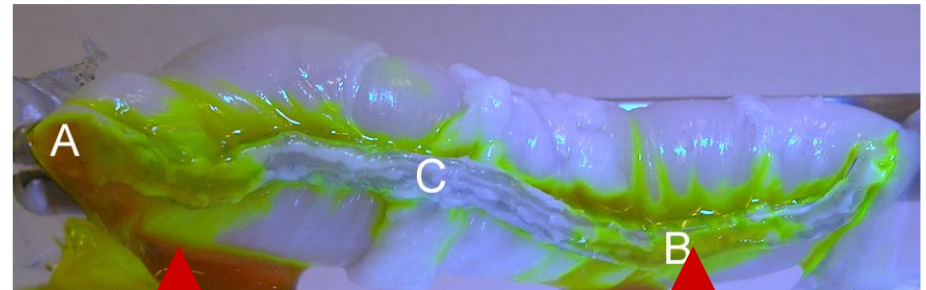
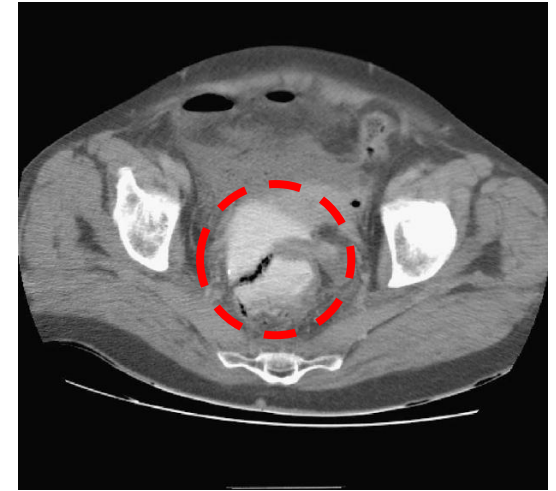
Example 2: Minimally Invasive Surgery

- Patient “X”
 - Male
 - Age 69
- Diagnosed with colorectal cancer.
- Co-morbidity:
 - Diabetes
 - Smoker
- Laparoscopic resection of cancer.
 - “Keyhole”
- Two segments of bowel joined.
- Keyhole wounds closed.
- Sent home on day 5.



The Consequence of a Complication

- Symptoms on Day 7
 - Tachycardia (HR 120BPM)
 - Body temp 38°C
 - Resp. rate 24
 - Abdominal tenderness
- Diagnosis
 - CT scan reveals leak from anastomosis
- Consequences
 - Emergency surgery
 - 21-day ITU admission
 - Colostomy bag



Leak Sites



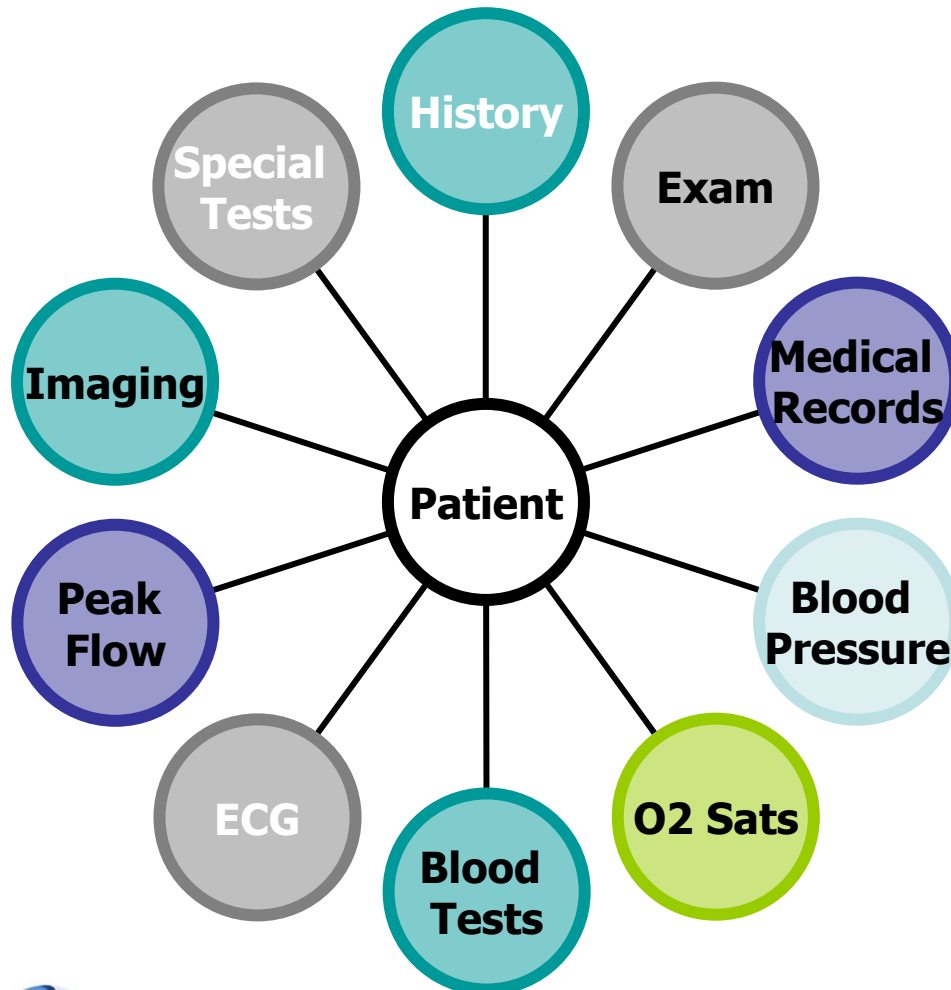
Current Monitoring

- Human resource intensive:
 - **Visit to GP practice:** patient dependent
 - **Visit from district nurse:** reserved for immobile patients
 - **Outpatient follow-up:** usually 3 weeks after discharge
 - **Clinician:** required for any biopsies

- Recovery/Performance assessment is **subjective**
 - **Return to normal activity/performance levels**
 - **Dietary habits**
 - **Self-care**
 - **Exercise/Training schedule**
 - **Wound care**



Current Monitoring



Only a **SNAPSHOT** of a patient's health



Contemporary Treatment

- Fast-track surgery
- Minimally invasive surgery
- Goal directed recovery
- Aging population
- Patient requests
- Home healthcare wards

There is a need for a more
DYNAMIC monitoring process



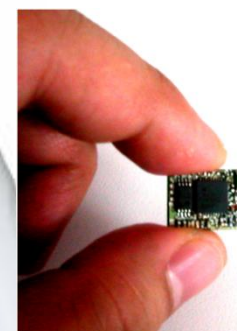
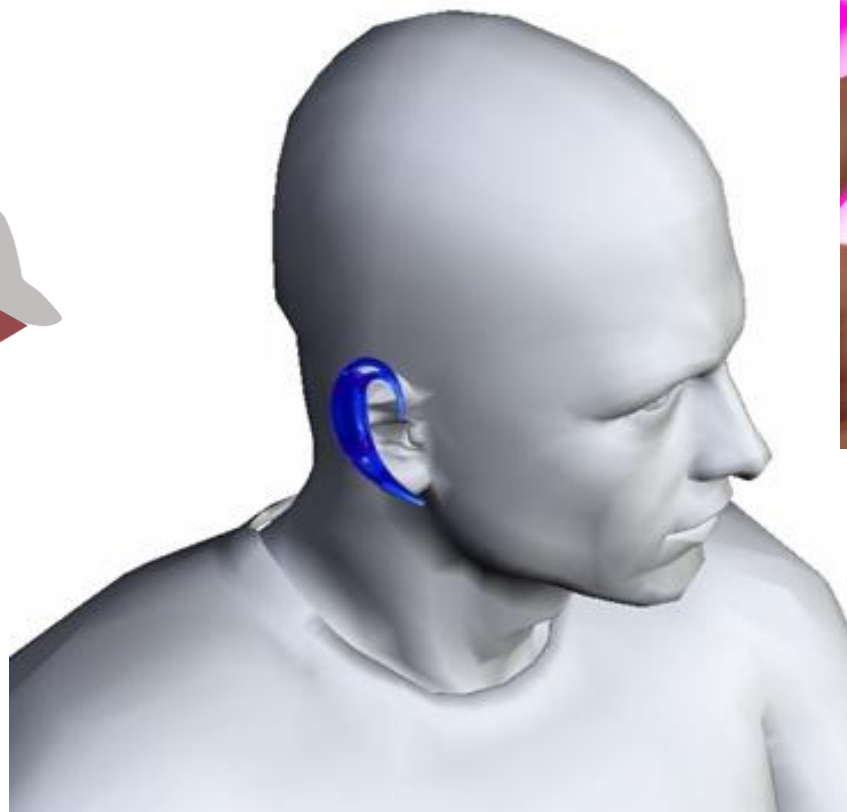
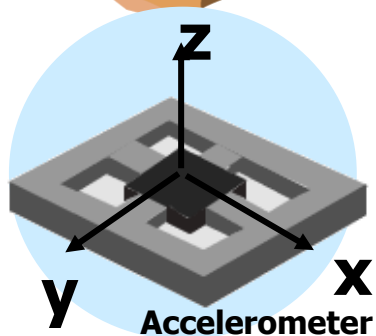
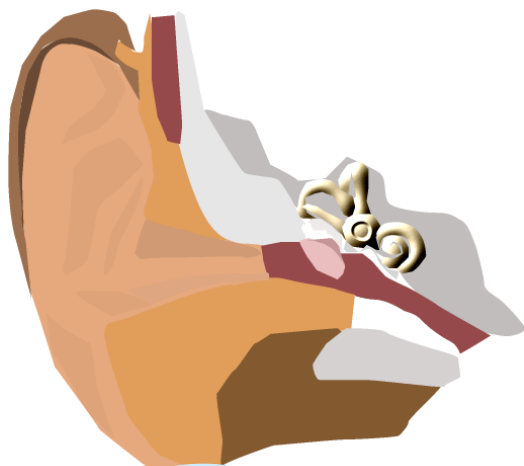
How Can a Pervasive System Help?

- Quantify recovery status
 - Mobility: *Impaired / Recovering / Normal*
- Determine normal activity patterns
 - Walking, Sleeping, Reading, Eating & Drinking, Training
- Monitor body physiology
 - Heart rate, Oxygen saturation, Temperature, Metabolism
- Enable safe patient discharge

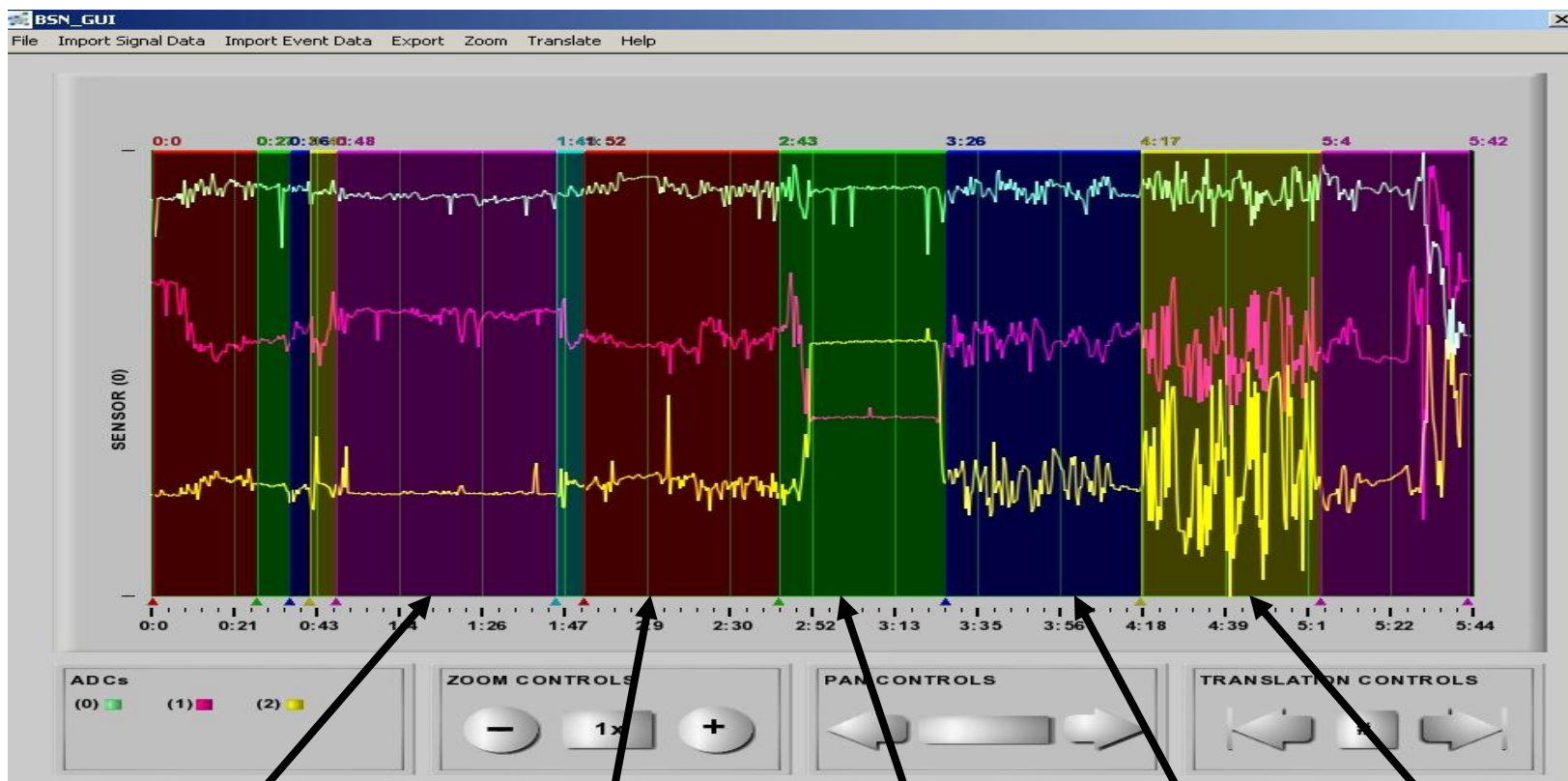


Body Sensor Networks for Patient Care

eAR Sensor (ear-worn Activity Recognition)



Activity Recognition Example



Reading

Walking slowly

Lying down

Walking fast

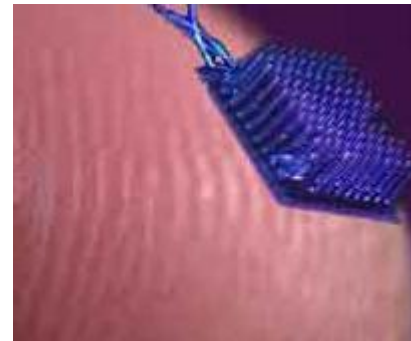
Running



Enabling In-body Pervasive Sensing

Challenges:

- What to measure?
- Size
- Biocompatibility
- Data path
- **Power supply**



Energy Demands

Data Acquisition:

- Collecting a sample of data: joules/sample
- Processing a sample: joules/sample
- Storage: joules/sample/second
- Transmission: joules/sample
- Resolution: bits/sample
- Data rate: bits/second

System Control:

- Configuration command: joules/command
- System maintenance: joules/second



Possible Trade-offs

Energy source

Sensing: Human power

Comm's: Remote power (e.g. NFC)

Data priority

Low → Synchronous, low rate, low resolution.

High → Event-driven, high resolution.

Patient mobility

Low → Daily data downloads, system updates.

High → Autonomous, context aware system-control and adaptive monitoring.



