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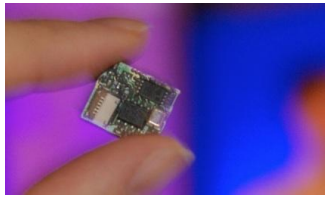
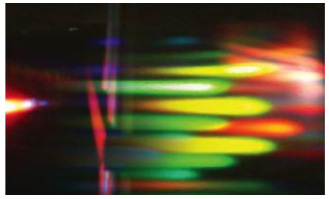

Application of Human Power for Pervasive Sensing in Sports and Healthcare

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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:

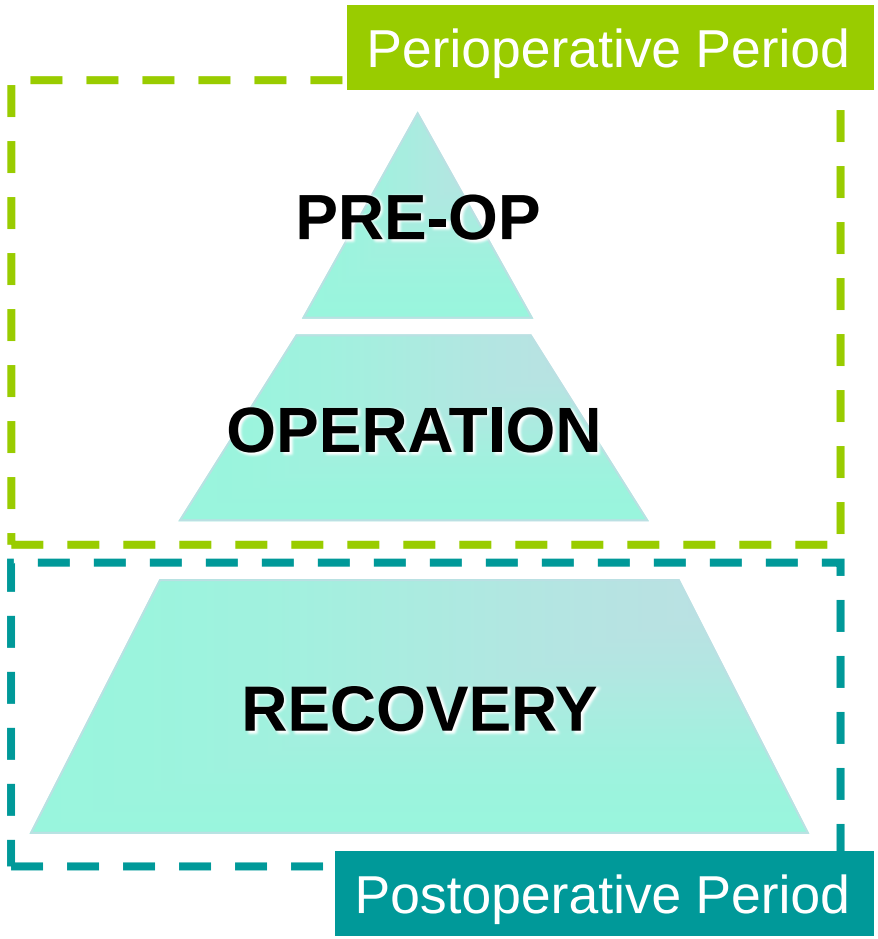
- **Measure muscle metabolism**
  - Widely used in human exercise physiology and sports medicine
- **Measure muscle glycogen content**
  - Factor in limiting performance capacity for prolonger, sever exercise
- **It's highly invasive**
  - Requires a needle for percutaneous biopsy sampling of muscle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

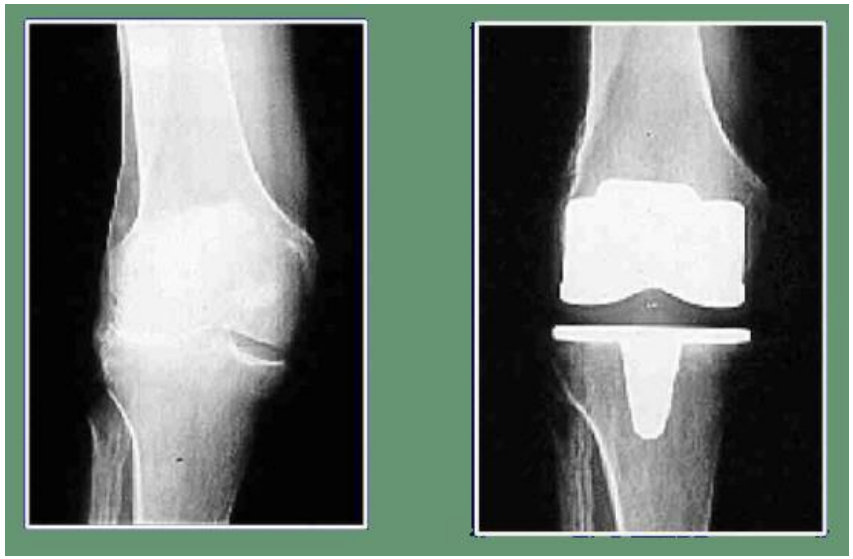


- Patient monitoring is currently most intensive in this period.

- More difficult to monitor here.
- Longer monitoring period.
- Remote/mobile patient.

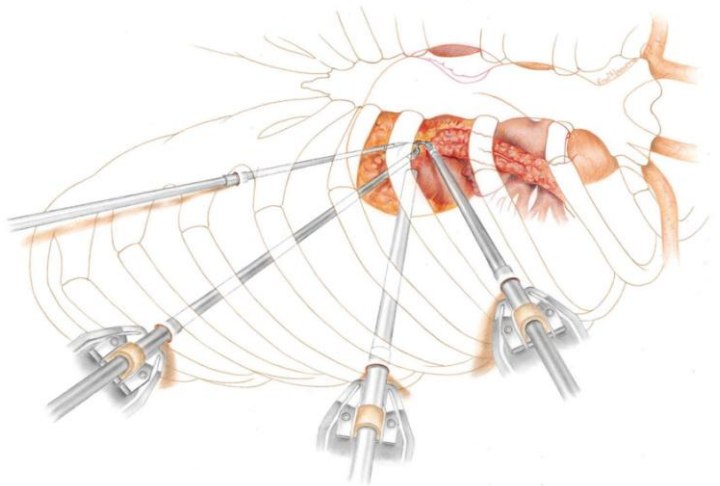
Example 1: Total Knee Replacement

- 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



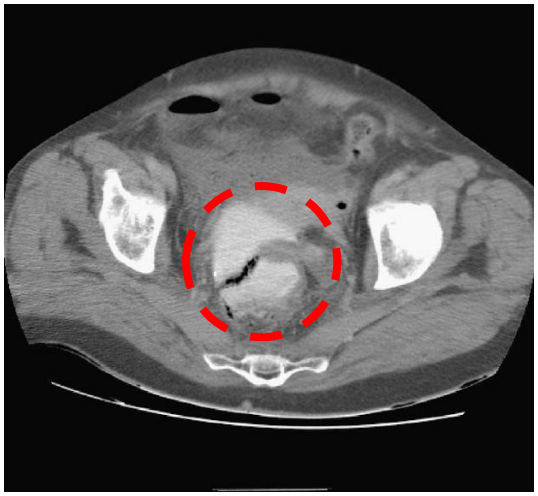
Example 2: Minimally Invasive Surgery

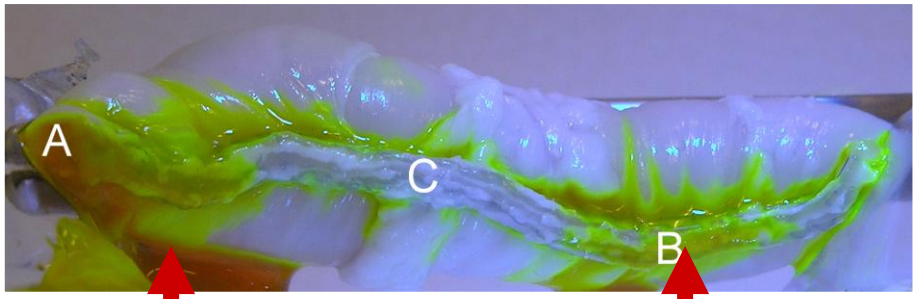
- Patient “X”
  - Male
  - Age 69
- Diagnosed with colorectal cancer.
- Co-morbidity:
  - Diabetes
  - Smoker
- Laparoscopic resection of cancer.
  - “Keyhole”
- Two segments of bowel joined.
- Keyhole wounds closed.
- Sent home on day 5.



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



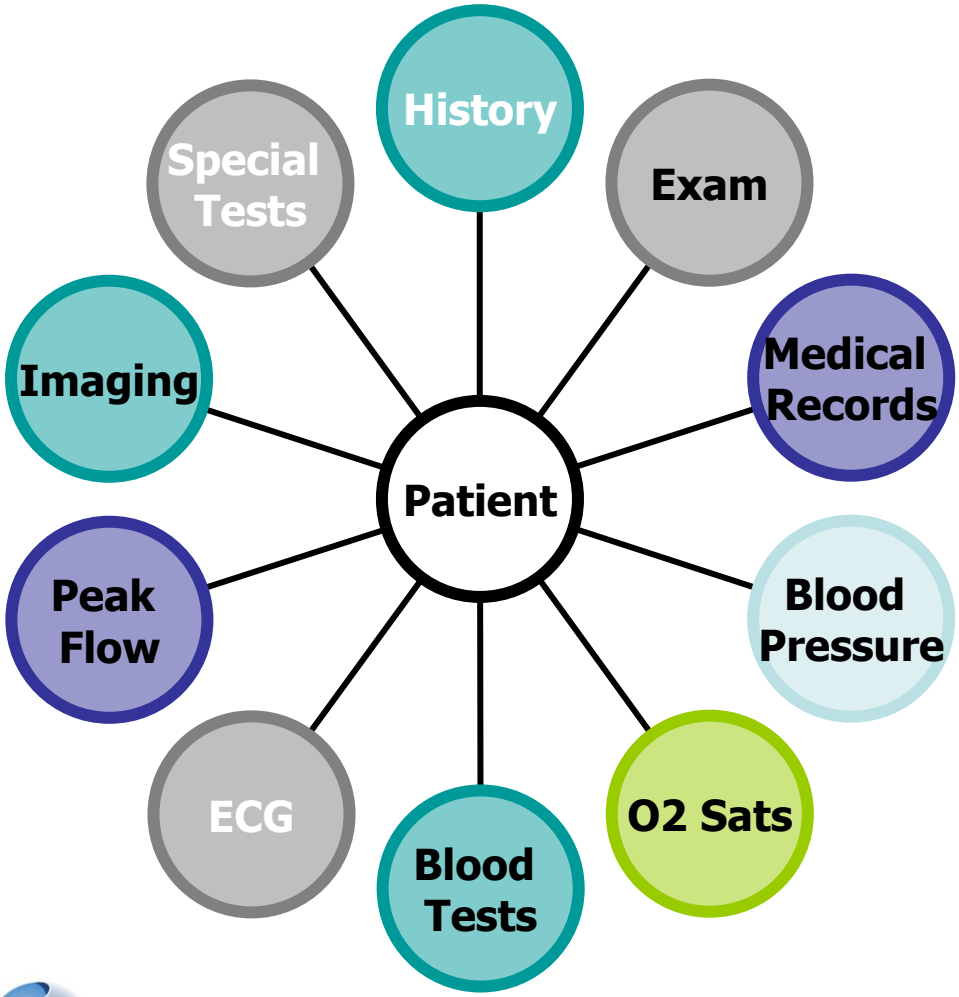


Current Monitoring

- 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

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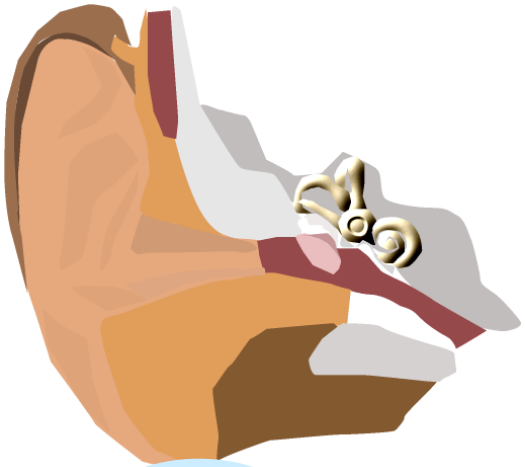
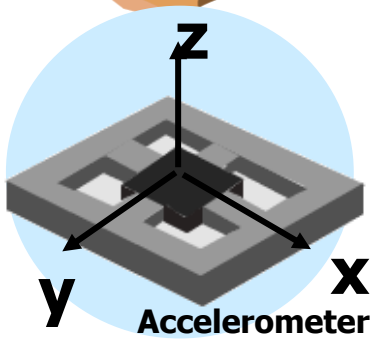
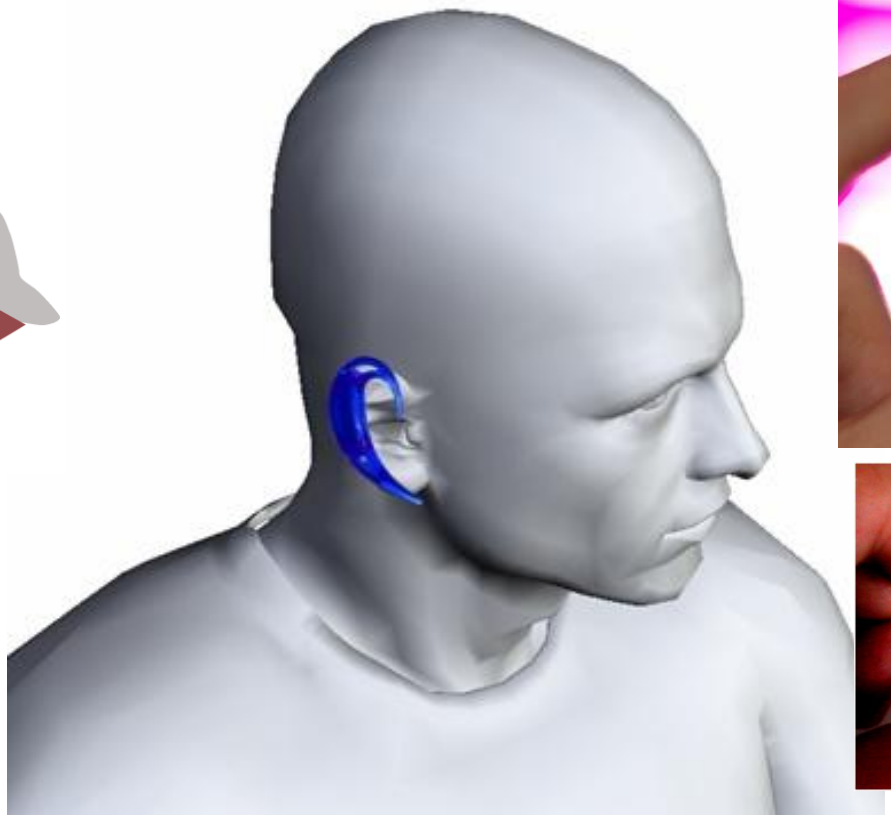
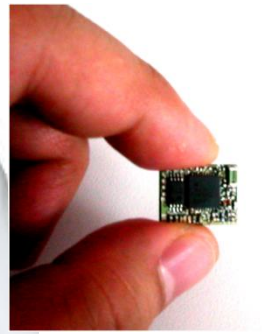
Body Sensor Networks for Patient Care

eAR Sensor (ear-worn Activity Recognition)







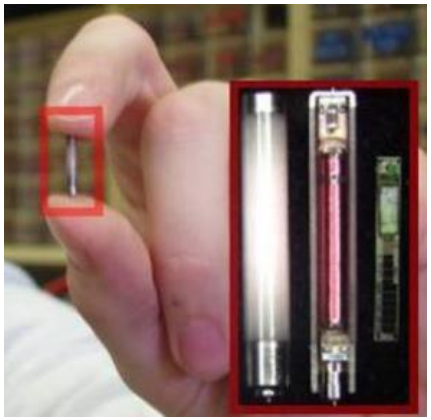


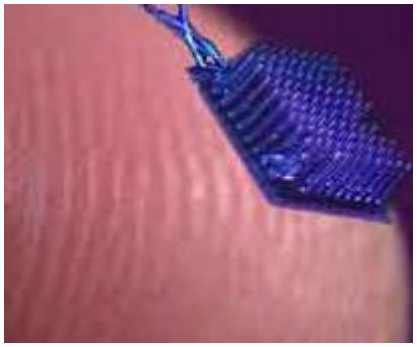
Activity Recognition Example

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.

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