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
The Hamlyn Centre
The Institute of Global Health Innovation

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
Body Sensor Networks for Patient Care

eAR Sensor (ear-worn Activity Recognition)

Accelerometer
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
<table>
<thead>
<tr>
<th>Possible Trade-offs</th>
<th>Sensing:</th>
<th>Comm’s:</th>
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<tbody>
<tr>
<td>Energy source</td>
<td>Human power</td>
<td>Remote power (e.g. NFC)</td>
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<tr>
<td>Data priority</td>
<td>Low→ Synchronous, low rate, low resolution.</td>
<td>High → Event-driven, high resolution.</td>
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<tr>
<td>Patient mobility</td>
<td>Low → Daily data downloads, system updates.</td>
<td>High → Autonomous, context aware system-control and adaptive monitoring.</td>
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