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IoT for Healthcare

Outline

- Handheld Devices and Wearables
  - Monitor and Assist
- Challenges and some Research Directions
  - Types of sensors and actuators, Quality of data, Form Factor, Localization, Power Consumption
- My Research Group Vision
- Future Directions

Healthcare and IoT

- Healthcare Landscape is Changing
  - Obesity is growing
  - Poor diet
  - Population is aging (number of people older than 65 in the US is 70 million)
- 75-80% of health care spending is on chronic disease management
- Huge market for new systems which improve productivity cut costs and support the shift of healthcare from hospital to the home

Applications

- Monitoring elderlies
- Monitoring patient behavior
- Stress monitoring
- Monitoring social activities
- The Preventive Healthcare & Continuous Multiparameter Monitoring
- Using IoT to monitor different therapies
- Using Healthcare Monitoring to Improve Drug Discovery and Development

Applications

- Improving processes
  - Finding people and equipment
  - Tracking hospital equipment
  - Patient ID and tracking
  - Preventing medication errors
  - Tracking samples (e.g. Blood samples)
  - Anti-counterfeit measures
  - Product recalls
  - Tagging implants and remote charging of batteries

Sensors and Wearables

Now

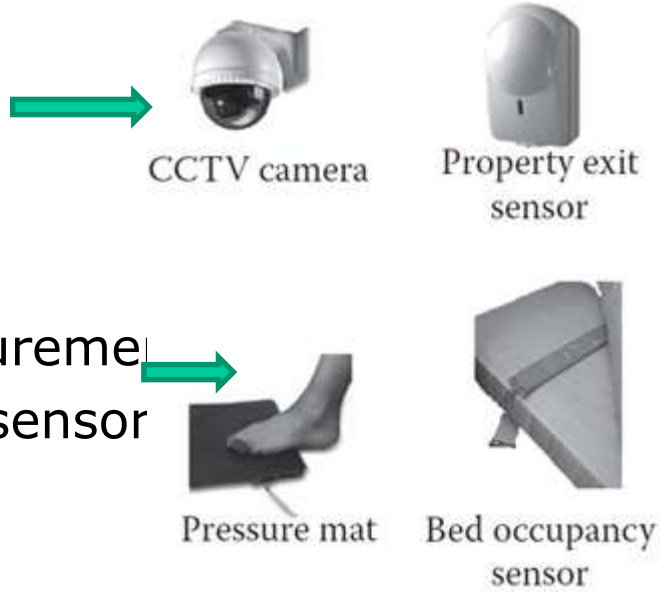
- Monitor = vital signs, falls, wandering, …
- Assist = alarm, notification, graph …

Future

- Monitor More = context-aware measurement, daily activities, social interactions, …
- Assist More = actuate, stimulate, transdermal medication as needed, …

Infrastructure sensors

- Infrastructure sensors
  - Remote
    - Radars, cameras
  - Combined wearable and remote
    - Real-time location systems
  - Close proximity detection or measureme
    - Pressure mats, bed occupancy sensor
- Application of infrastructure sensors
  - monitoring of health signs
  - human–environment interactions
  - monitoring falls
  - human physical activity



Actuators

An actuator is a mechanical or electrical device for moving or controlling a mechanism, thus enabling a system to perform a physical function

- Usually sensor input is used to trigger output
- Several types:
  - Initiate movement
    - Leg actuator
  - Initiate reaction
    - Fall prevention due to balance loss
  - Treatment
    - Neurostimulation for pain management

Sensing and Form Factor

- Smart-phone
- Shirts
- Smart watches
- Smart jewelry
- Arm band

- Headphones
- Hearing aids
- Shoes
- Dental appliances
- Eyeglasses, …

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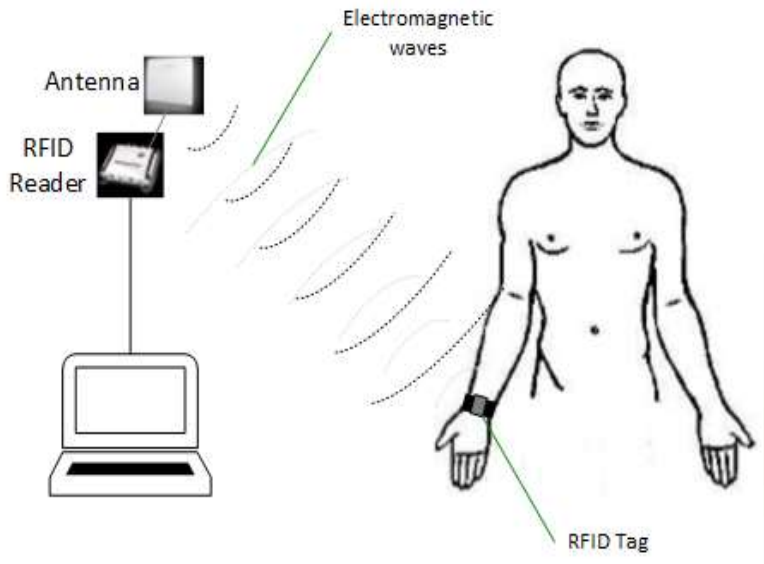
Activities and Interactions RFID and Wireless

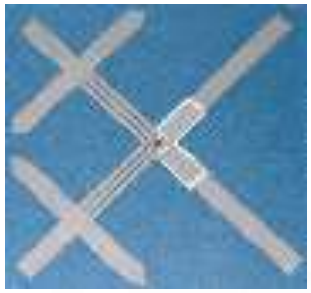
Radio Frequency Identification (RFID)



- Near Field Communication
  - Short range: couple cm
- Far Field RFID
  - Long range: 10 m
- Current applications
  - Detecting presence and wandering
  - Retirement homes
- Future sensing application
  - Detect interactions and activities
  - Localize people

RFID – Sample Tags / Readers

Sample Tags



Pallet tag, UHF (Matrics)

Plastic crate tag, UHF (Rafsec)

Cardboard-case tag, MW (Matrics)

Sample Readers

Stationary reader and antenna (Alien)

Signpost activator (Savi)

Handheld reader (Checkpoint)

Stationary reader (Matrics)

Doorway antenna (Checkpoint)

Stationary reader and antenna (SAMSys)

Stationary readers are typically deployed at warehouse portals or loading docks, on conveyor belts or forklift arms, on store shelves, check-out lanes, etc.

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Basic types of tags

- Active
  - Tag transmits radio signal
  - Battery powered memory, radio & circuitry
  - High Read Range (100 m)
- Passive
  - Tag reflects radio signal from reader
  - Reader powered
  - Shorter Read Range (1 cm- 10 m)
- Semi-passive
  - Communicates with the reader in the same way as passive
  - Have batteries for the electronics
  - Range (up to 30m)

RFID Tag Spectrum

Tag Type Selection

active tags

passive tags

Transport

- Road tolling
- Container tracking
- Pallets

Transport **Under development**

- road pricing
- train location
- fleet management

•Access Control
•Automotive Immob

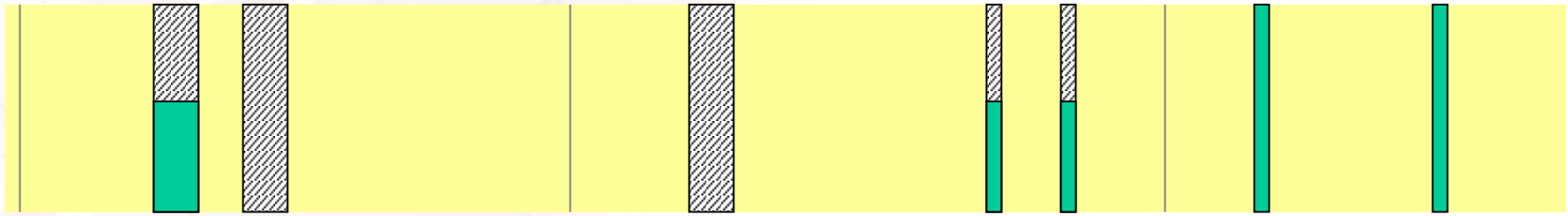
•Animal-ID
•Asset Tagging

•Access Control
•Logistics

•Post
•Parcel
•baggage
•libraries

•Item
•Carton
•Case
•Retail

LF 125 ~134Khz **HF 13.56Mhz** **UHF 868 ~ 928Mhz** **2.45Ghz** **5.6Ghz**



100kHz **1MHz** **1GHz** **Frequency**

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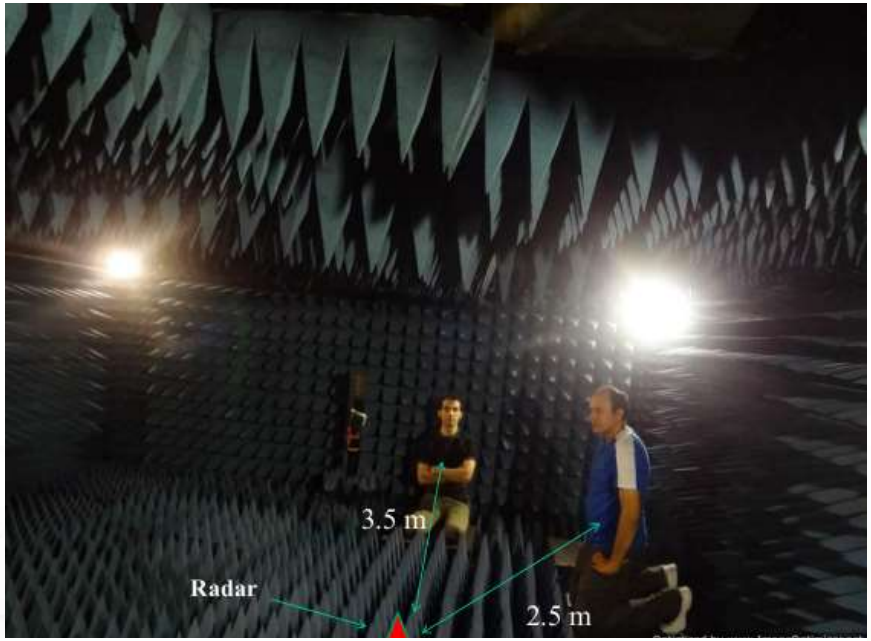
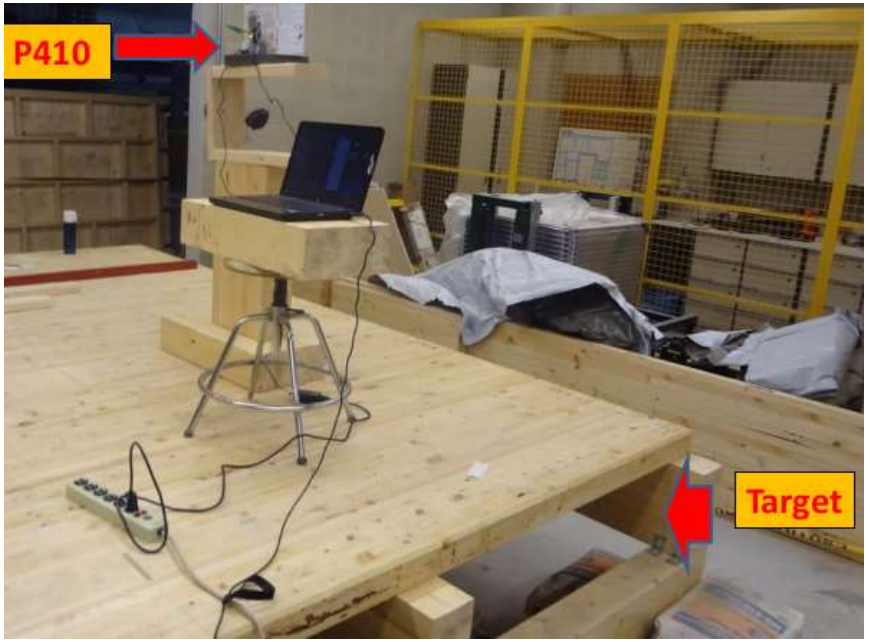
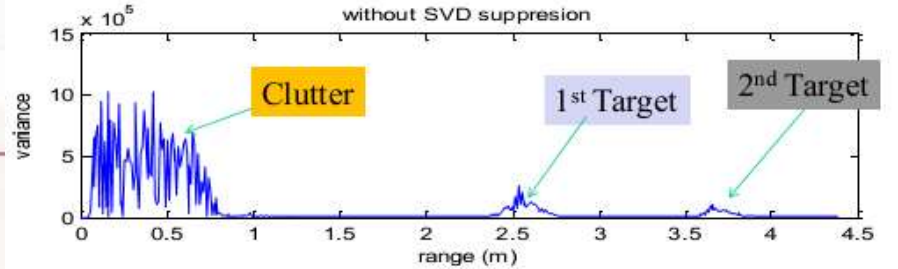
Remote Monitoring of Activities and Interactions - Biomedical Radar

- Through-the-wall radar
  - Police, firefighters
- Finding people under the rubble
- Detection of posture and activities of people
- Detection of stop-breathing events
  - Suicide events
  - Independent living
- Radar sensor networks

Biomedical Radar - Experiments
Ranging and Detection of breathing



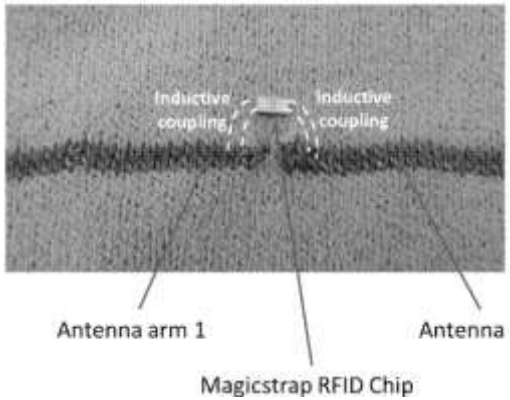




Power Consumption

- Battery-less sensors
  - Temperature sensing patch
  - Knitting the antenna into a sweater
- Rechargeable batteries, energy harvesting
  - Radio-frequency
  - Temperature
  - Movement
- Low power design
  - Communication
  - Processing

Flexible battery



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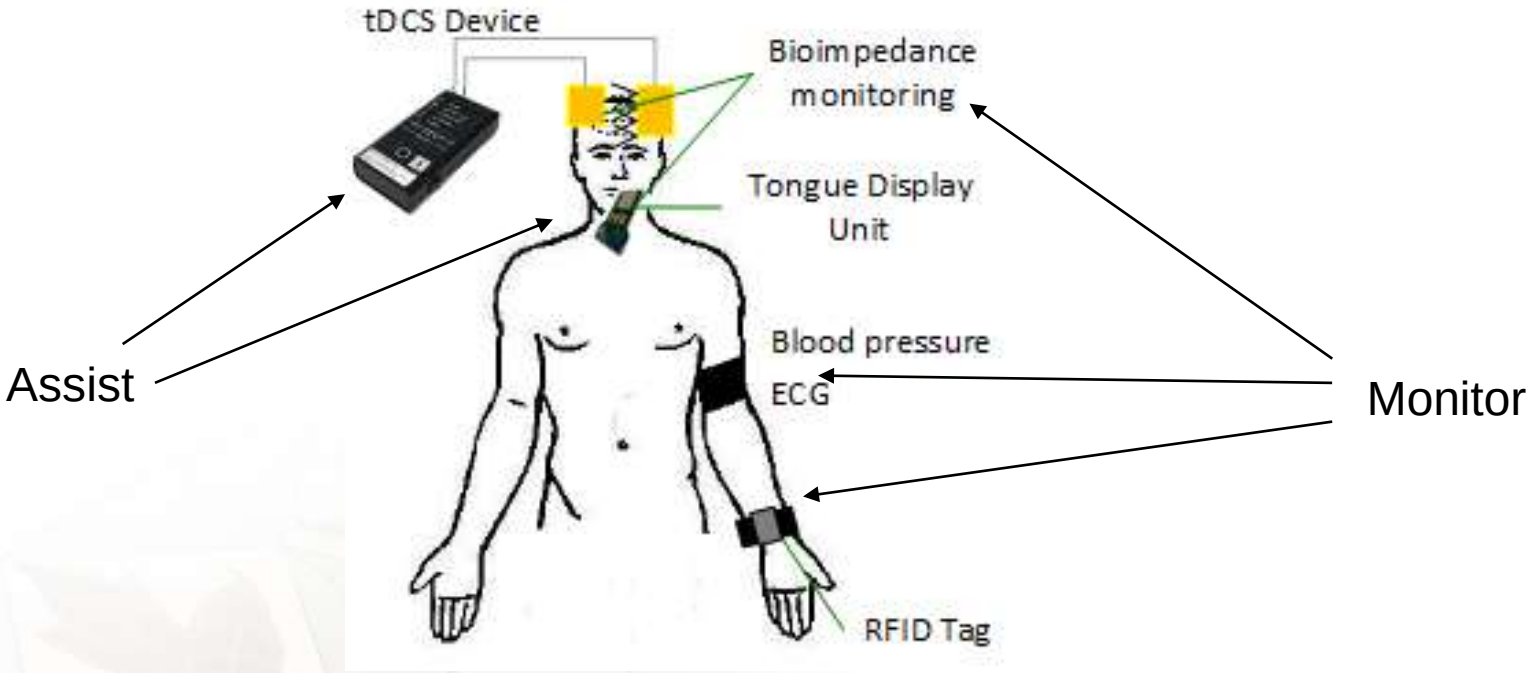
Data Quality and Content

- Unsupervised data collection – automatically or by the patient.

- Quality: How do we know that data is accurate/correct?
  - ❖ Quality of raw data, data aggregation data, learning algorithms
  - ❖ Identity and quantify noise, artifacts, activities …
  - ❖ Automatic signal quality analysis and mitigation

- Content: When data implies emergency, No false alarms,…

My Research



Assist with neural interfaces for sensing + neuromodulation

Monitor to capture daily activities and vital signs

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Future Directions in the Field

- Miniature sensors
- Power harvesting
- Having a unique communication system that will allow for communication between different platforms
- Automated storage and security support
- Automated analysis of data

Research Directions

- Measure
  - *Everything that we wear* becomes wearable device
  - *Everything that we hold* becomes hand-held device (steering wheel, book, …)
  - Identifying the person holding the device
  - Achieving sufficient measurement quality
  - Achieving security and confidentiality
- Assist
  - Intelligent actuation/stimulation in the loop
  - How to control its use