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**Biomedical and
Wireless
Technologies for
Pervasive Healthcare**



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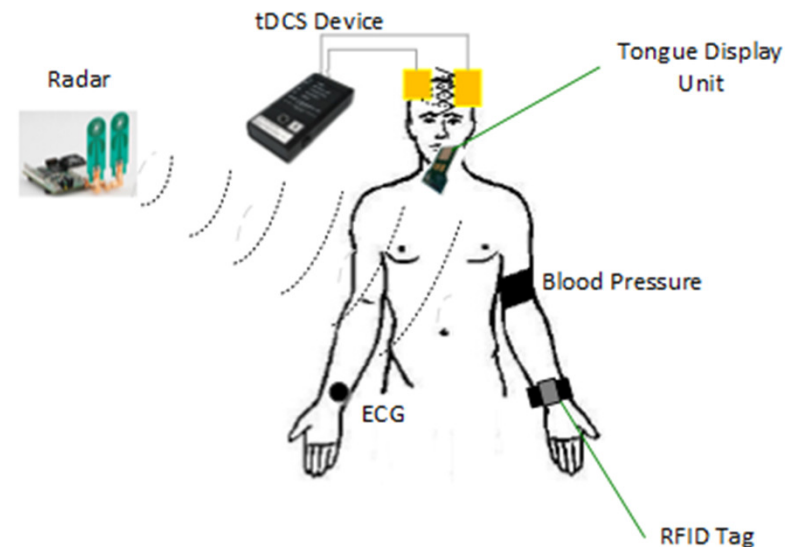
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Active Research Areas

- Biomedical instrumentation and processing
 - Processing of physiological signals
 - Non-invasive stimulation
- Wireless communication
 - RFID systems
- Computer architectures
 - Software/hardware acceleration
 - New hardware architectures

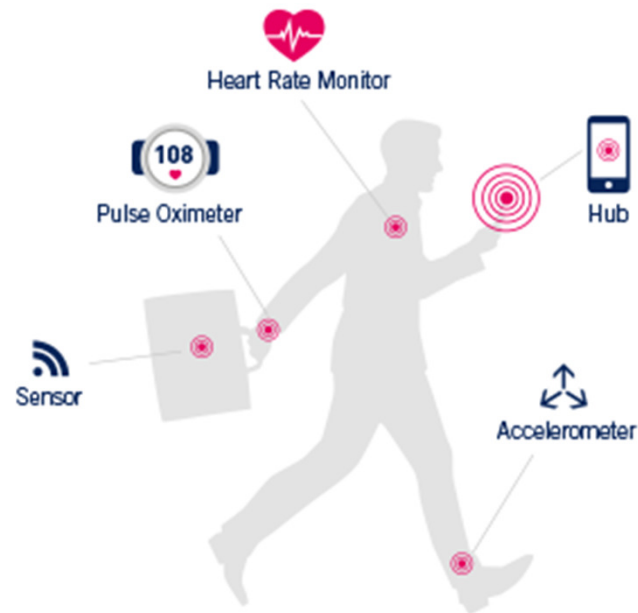
Objectives

- Introduction to Pervasive Healthcare
- My recent research projects related to biomedical engineering and pervasive healthcare:
 - Blood pressure and ECG
 - Biomedical radar
 - Radio frequency Identification
 - Tongue display unit
 - Non-invasive brain stimulation

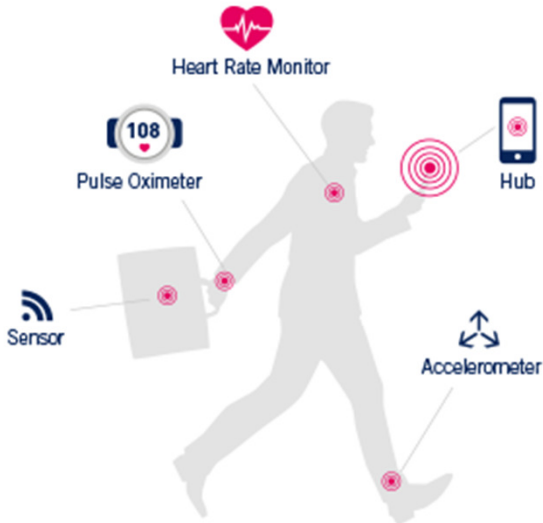








Pervasive Healthcare

Support continuous well-being, treatment and care of people rather than focusing on acute treatment and care.



Pervasive Healthcare Sensors and Actuators

Sensors		Actuators	
Wearable	Infrastructure (remote)		
 <p>Heart Rate Monitor</p> <p>Pulse Oximeter</p> <p>Sensor</p> <p>Accelerometer</p> <p>Hub</p>	 <p>CCTV camera</p>  <p>Property exit sensor</p>  <p>Pressure mat</p>  <p>Bed occupancy sensor</p>	 <p>Fall prevention</p>  <p>Leg actuator</p>	

Pervasive Healthcare Applications

- Monitoring
 - Monitoring of health signs
 - Monitoring daily life activities and social interactions
 - Monitoring for falls, wandering, location tracking
- Assistive technologies
 - Supporting elderly and disabled people
- Technologies for rescuing
- Treatment and stimulation

My Current Research

Applications

- Monitoring of health signs
- Monitoring daily activities and interactions
- Rescue
- Assistive systems
- Stimulation devices



Technologies

- Blood pressure and ECG
- Biomedical radar
- Radio-frequency Identification (RFID)
- Tongue display unit
- Non-invasive brain stimulation

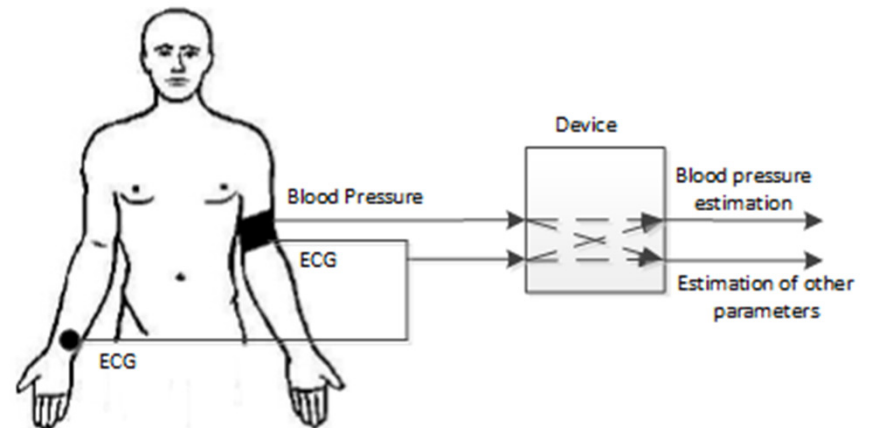
Blood Pressure

Applications

- Monitoring of health signs
- Localization, detection of activities and interactions
- Rescue operations
- Stimulation devices
- Assistive systems

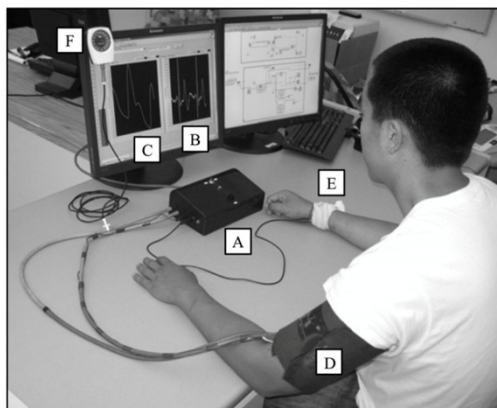
Technologies

➔ ECG-assisted blood pressure

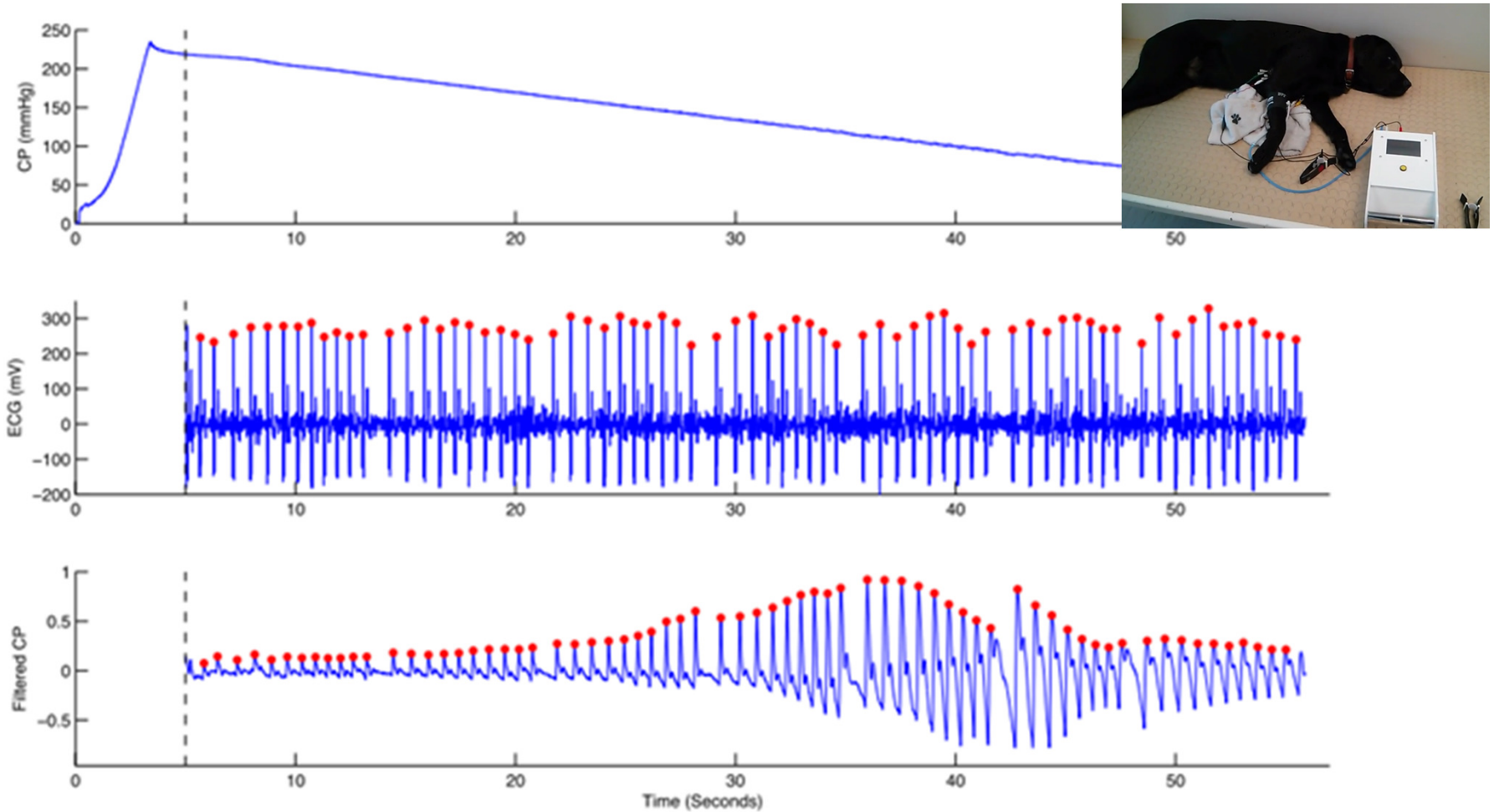


Blood Pressure – Research

Problem	Approach	Method
<p>Inaccurate blood pressure monitors for:</p> <ul style="list-style-type: none">atrial fibrillation,diabetes	<ul style="list-style-type: none">Multifunctional device: ECG+Blood pressureNovel way to determine blood pressure	<ul style="list-style-type: none">Developed dry ECG electrodesNew ECG-assisted blood pressure algorithmsMathematical Modeling



Blood Pressure - Experiment



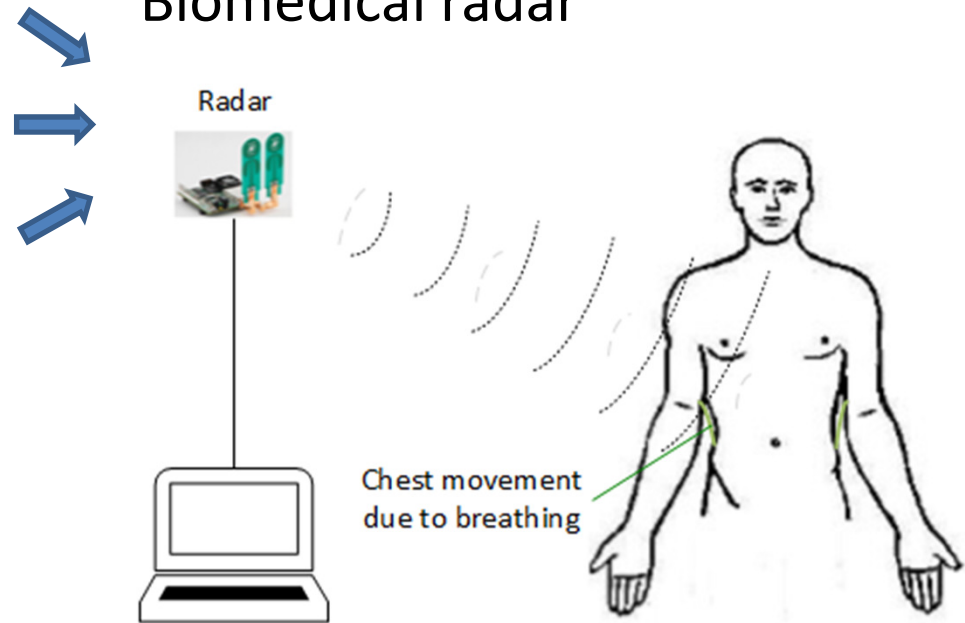
Biomedical Radar

Applications

- Monitoring of health signs
- Localization, detection of activities and interactions
- Rescue
- Stimulation devices
- Assistive systems

Technologies

Biomedical radar



Biomedical Radar - Applications

- 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

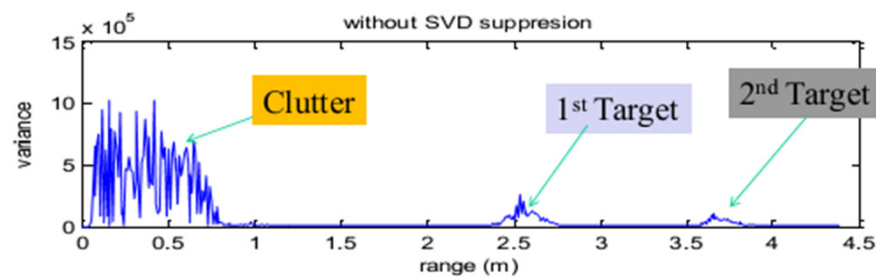
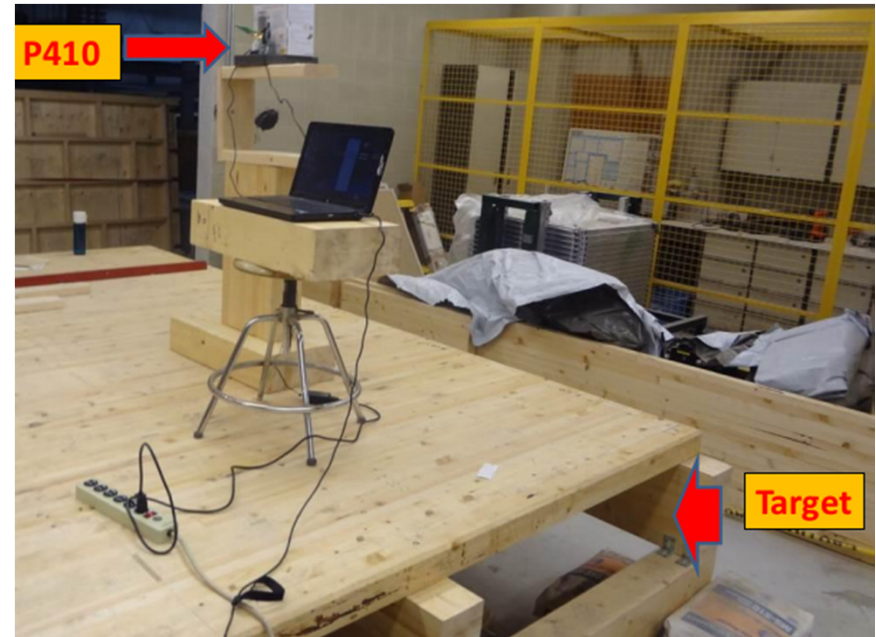
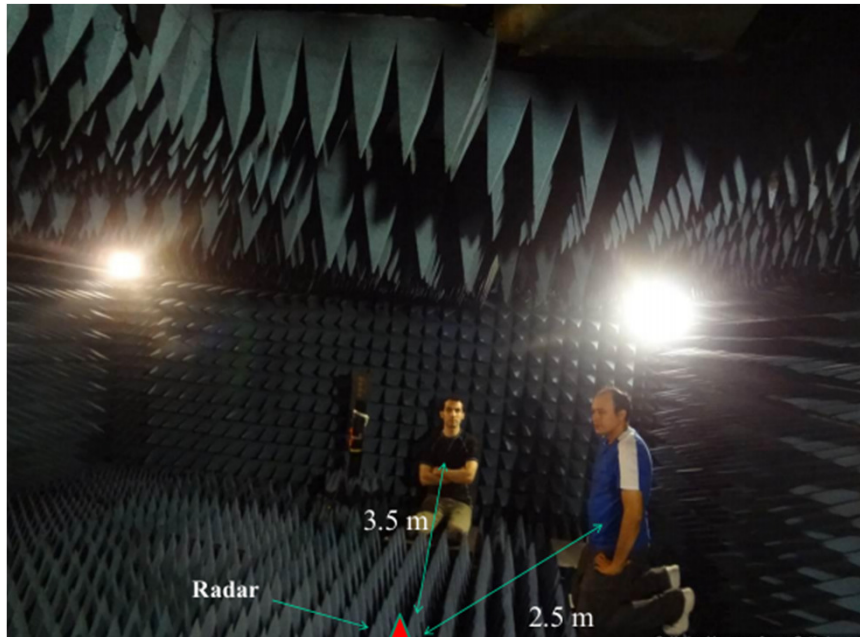
Biomedical Radar – Research

Problem	Approach	Method
<ul style="list-style-type: none">• Reliable detection of a single subject• Distinguish between multiple subjects	<ul style="list-style-type: none">• Remove noise• Localize subject(s)• Obtain clear breathing signal	<ul style="list-style-type: none">• New signal processing algorithms for breathing extraction• New method for posture detection

- Future direction
 - Distinguishing between people and animals for rescuing operations
 - Detection of stress level of people
 - Detecting suicide attempts

Biomedical Radar - Experiments

Ranging and Detection of breathing



June 12, 2014

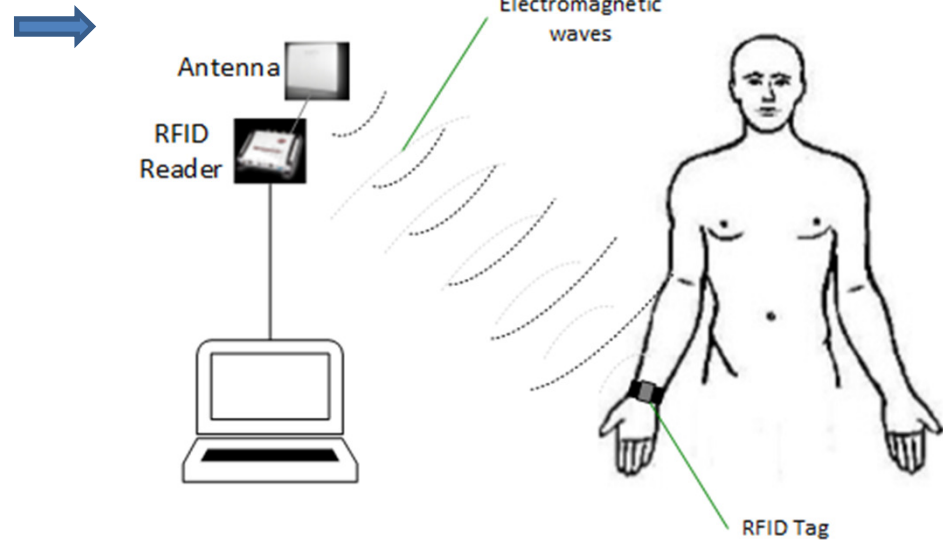
Radio Frequency Identification-RFID

Applications

- Monitoring of health signs
- Localization, detection of activities and interactions
- Rescue
- Stimulation devices
- Assistive systems

Technologies

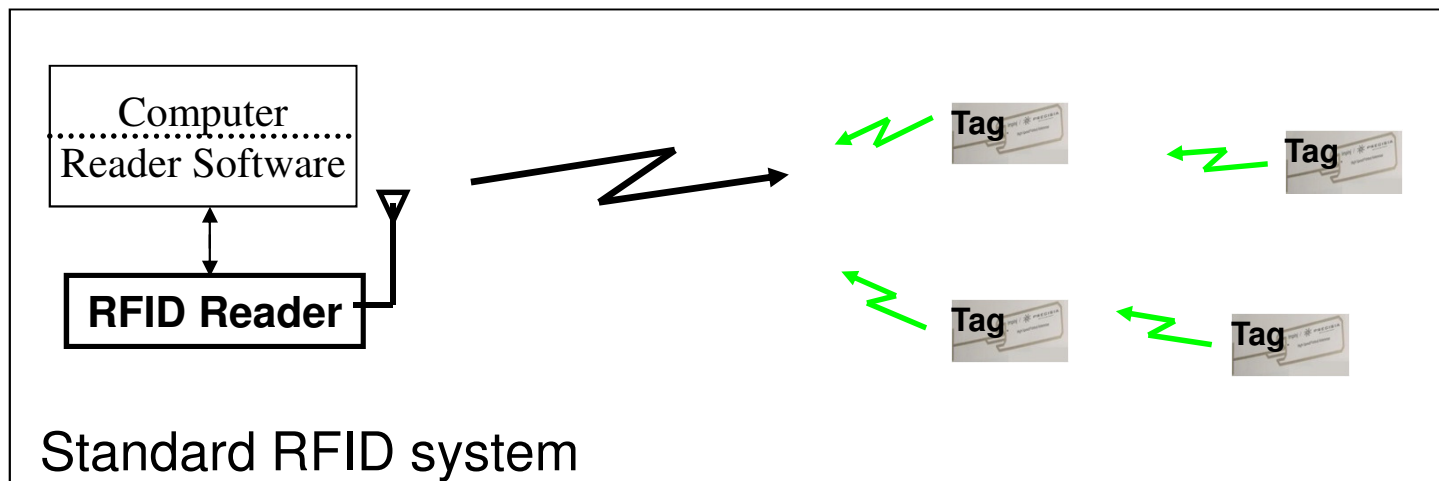
RFID



What is RFID?

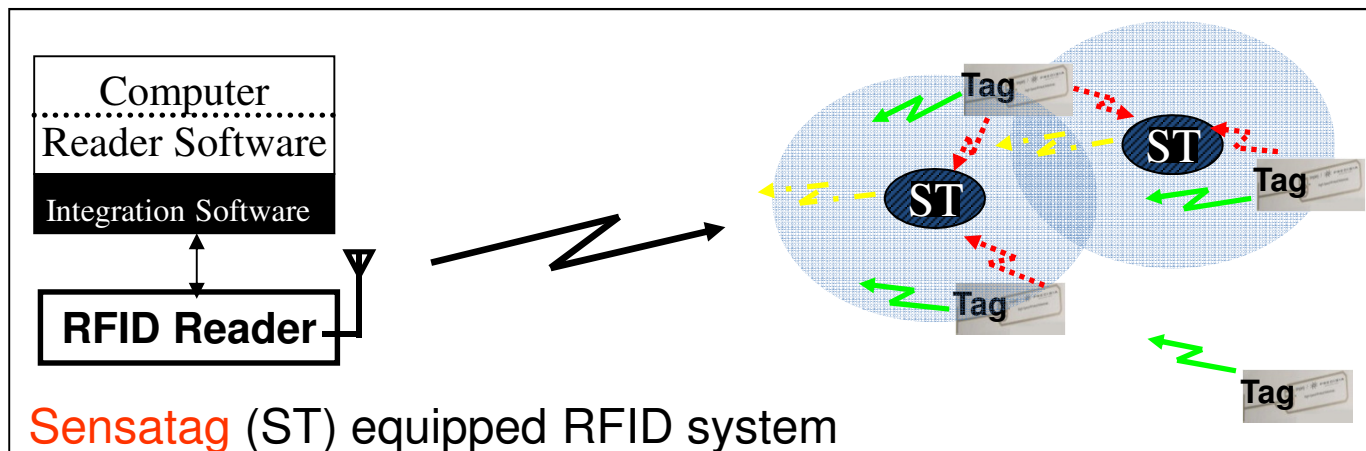
RFID is a wireless technology that uses radio-frequency waves to transfer data between a reader and a tagged item to identify, categorize and track the items.

- Identification
 - Every item will have a unique identification number
- Radio frequency
 - 900 MHz



RFID - Research

Problem	Approach	Method
<ul style="list-style-type: none"> Detection daily activities of people Detecting their interactions 	<ul style="list-style-type: none"> Detecting proximity between tagged people and tagged objects Localize moving objects with RFID tags 	<ul style="list-style-type: none"> New component - sensatag (ST) that detects proximity of RFID tags New algorithms for localization



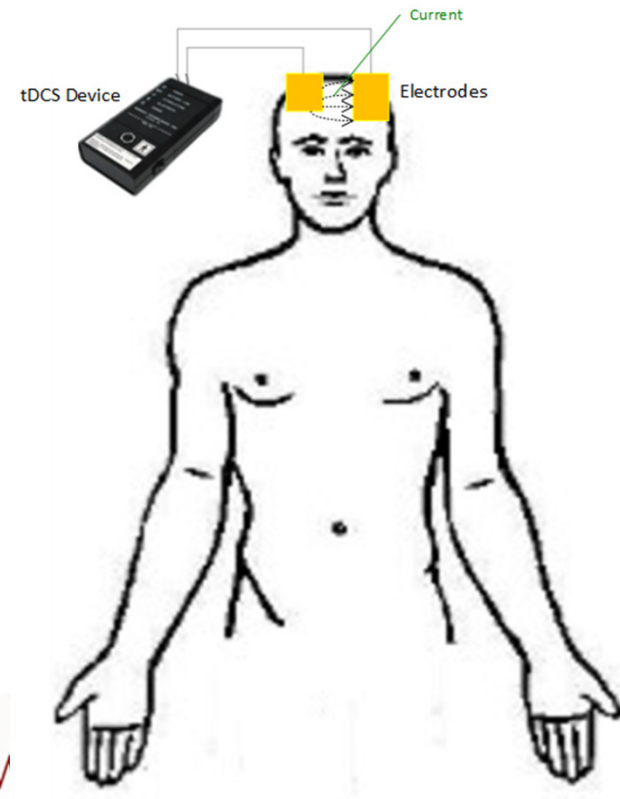
Non-Invasive Brain Stimulation

Applications

- Monitoring of health signs
- Localization, detection of activities and interactions
- Rescue
- Stimulation devices
- Assistive systems

Technologies

Transcranial direct current stimulation (tDCS)



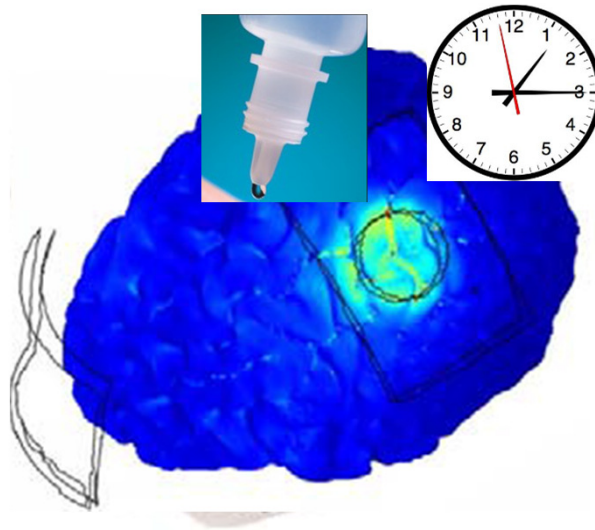
What is transcranial Direct Current Stimulation?

- Device
 - Current: 2 mA DC
 - Current delivery: 2 wet electrodes
 - Duration of session: 20 min
- Effect
 - Long lasting effect in modulating the neurons
- Applications
 - Depression
 - Pain relief
 - Recovery from stroke
 - Addiction treatment



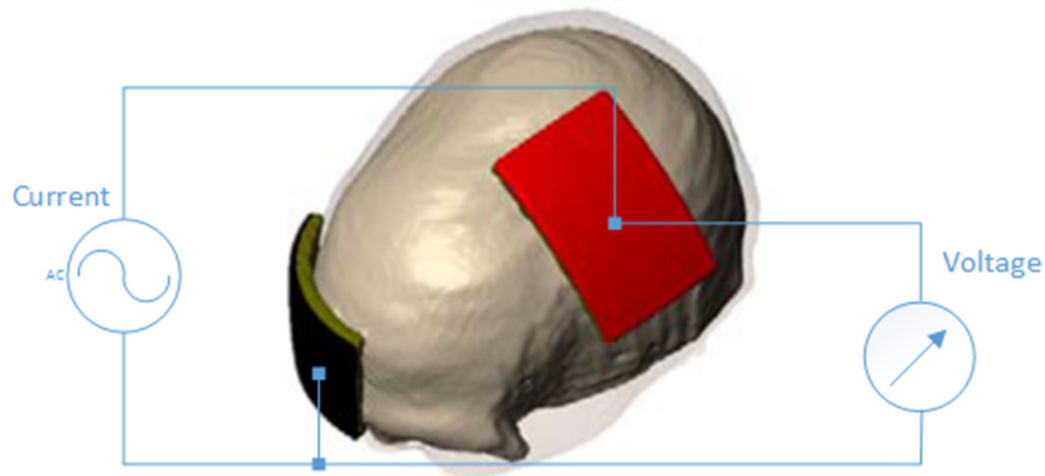
tDCS - Research #1

Problem	Approach	Method
Optimizing parameters of the stimulation	<ul style="list-style-type: none">• Determine<ul style="list-style-type: none">• Salinity• Stimulation time• Number of sessions• Electrode design	<ul style="list-style-type: none">• Developed electrode array board• Phantom• Simulation of current propagation



tDCS - Research #2

Problem	Approach	Method
<ul style="list-style-type: none">• Is patient responding?• Does patient need more sessions?• Non-responders?	Obtaining feedback during stimulation	<ul style="list-style-type: none">• Measuring bioimpedance• Clinical studies for opiate addicts



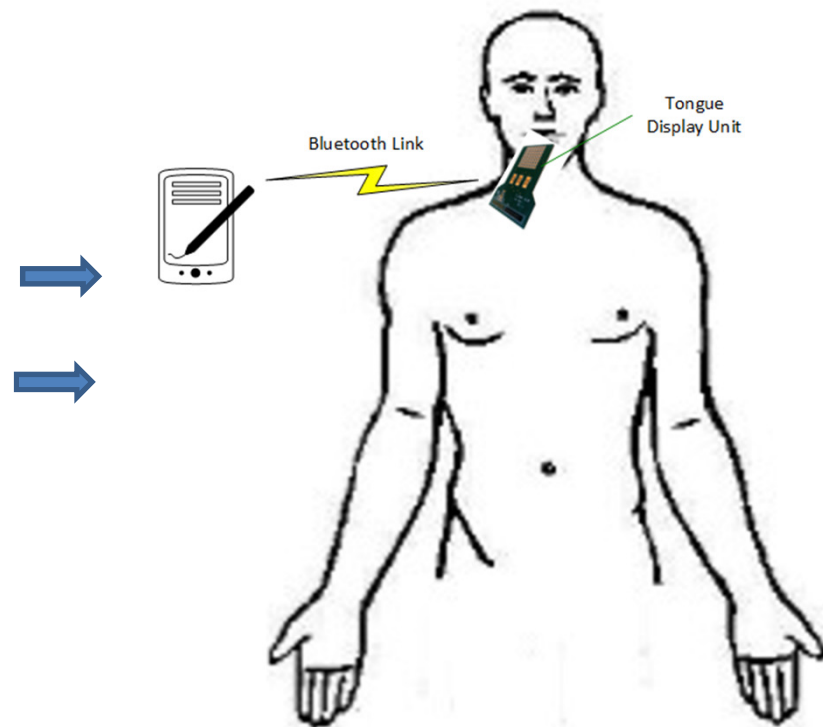
Tongue Display Unit

Applications

- Monitoring of health signs
- Localization, detection of activities and interactions
- Rescue
- Stimulation devices
- Assistive systems

Technologies

Tongue display unit



What is Tongue Display Unit?

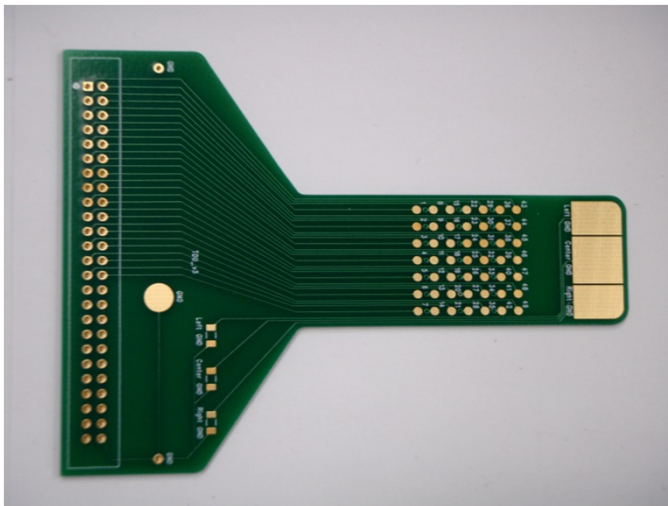
- Why Tongue
 - highly mobile
 - very sensitive to touch
 - It has a large representation in the brain
- Device
 - Electrode array that faces the tongue
 - We can selectively activate electrodes as well as measure their impedance
 - Wireless communication
 - Smartphone control
- Applications
 - assistive devices
 - for diagnosis
 - for rehabilitation



Tongue Display Unit - Assistive Device

Problem	Approach	Method
Translation of tongue gestures into mouse cursor movements and clicks	Detect contact between the tongue and the electrodes – transfer the map to PC	Bioimpedance measurements of the each electrode

Electrode Array

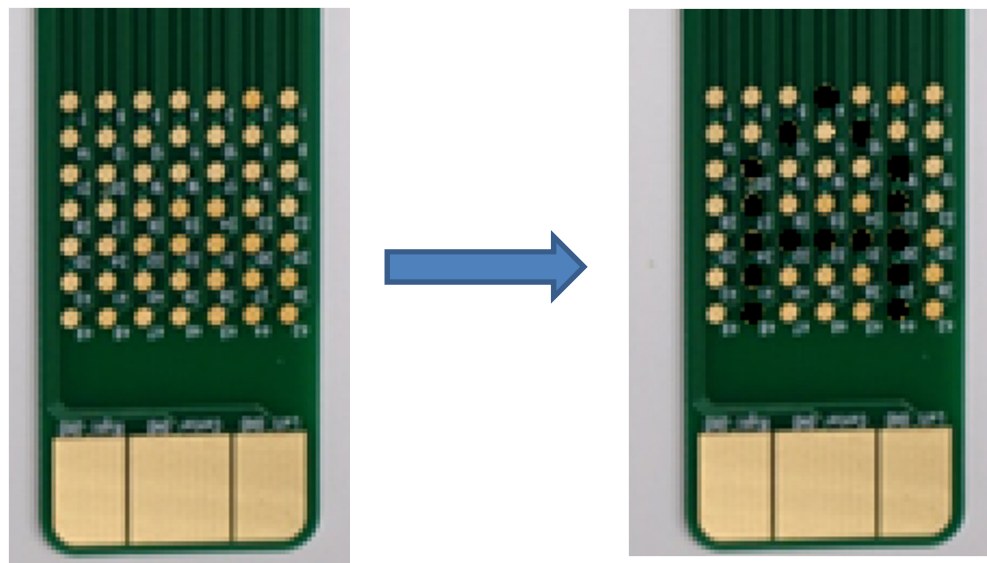


Display of the electrode contact map



Tongue Display Unit - Rehabilitation

Problem	Approach	Method
Tongue stimulation <ul style="list-style-type: none">- Stroke rehabilitation- Gaming	Turn on electrodes selectively to simulate desired patterns	Several applications/games have been developed.

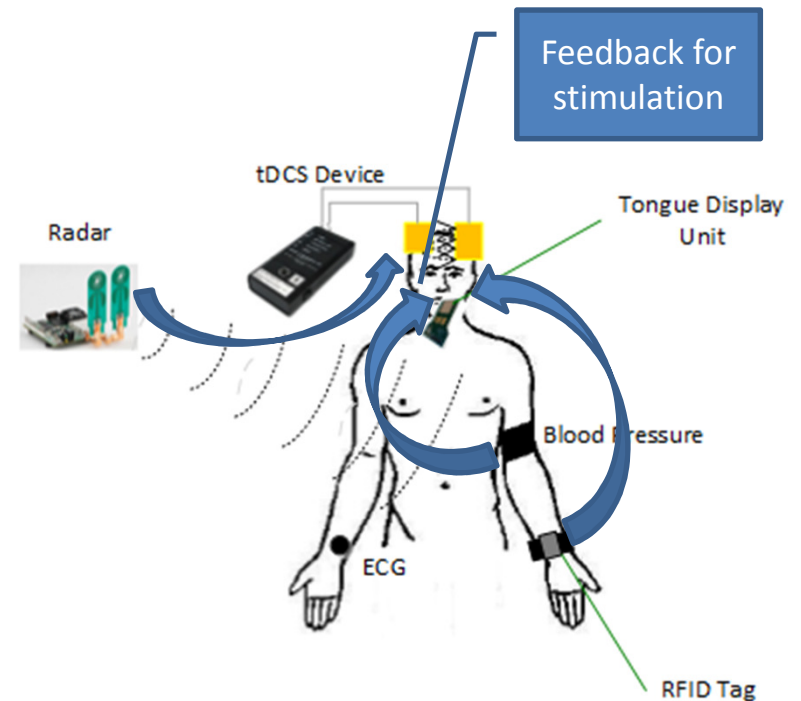


Concluding thoughts

- Home healthcare monitoring requires
 - Inexpensive, maintenance-free, reliable sensors and electrodes
 - Ways to express confidence in the measurement
 - Knowledge of situation awareness
- Stimulation and treatment requires
 - better understanding and utilizing feedback from the human body
- Combining everything together
 - based on sensing information, location and user actions

↓

 - adaptively determine parameters of treatment/stimulation



Acknowledgements

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- Thank you for your attention