BoWI:
Body World Interaction

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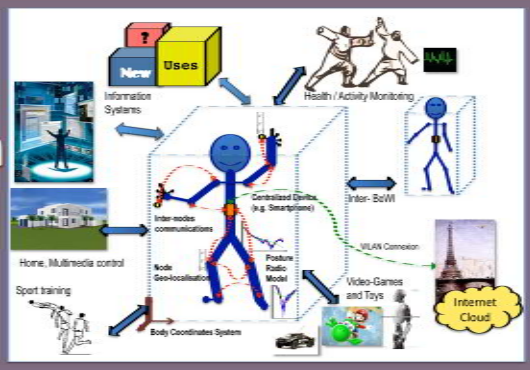


Summary

- New wireless, low cost & wearable solutions for MoCap and gesture recognition
- In- or out-door, everyday environment, without additional equipment
- Cross-layer approach combining techniques (antennas, wireless protocols, mutual)

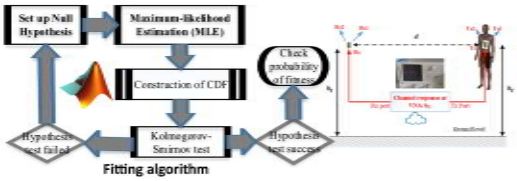
Achievements: 1) First demonstration of the interest to use radio signature to improve posture identification 2) Development of two hardware prototypes (Zyggie V1, V2) and a simulator 3) Proposition of a posture library and 3 main application scenarios 4) Channel propagation modeling at 2.4GHz and millimeter-wave 5) Energy efficiency of distributed precoding for BAN-BS communications 6) First results distributed power management and energy-aware control architecture 7) On-body propagation studies in the 60-GHz band.

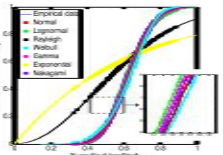
Usage

- Processing of an a priori set of postures
  - Head, Arm, Back, Legs: > 2000 postures
- Three uses cases
  1. Static postures: posture recognition game
  2. Gestures = timed sequence of postures: Therapeutic rehabilitation exercises
  3. Motion capture: sport game, etc.

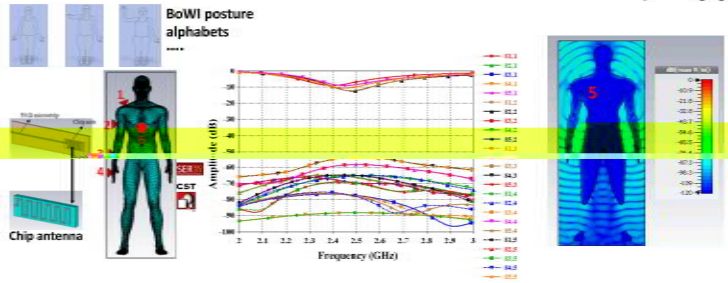
Radio

- Off-body diversity channel analysis: delay profile, delay spread, channel capacity
- A robust fitting algorithm to find the optimum channel model applied to various off-body and on-body channel measurements using Zyggie
- **Numerical channel simulator** using commercial tool (**FOSER**) with **CST**
- Miniature **chip antenna** design + impact of antenna polarization/pattern



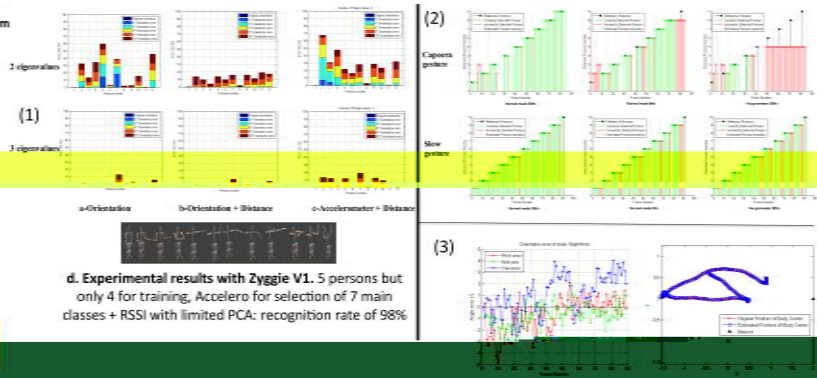


Normal distribution for LoS off-body channel detected by the **fitting algorithm**



Algorithms

- Case 1 "Static Postures": RSSI matrix used as a signature, data fusion based on
a. Acc + Mag: node orientation M[3x3] => Local basis + PCA + orientation ref. (e.g. manager)
b. Node orientation (Acc + Mag) M[3x3]+RSSI => Improved results or reduced PCA basis
c. If Mag NOK (environment perturbation): Acc + RSSI raw data => No orientation ref. close to a.
d. Two Steps: 1) Acc-based pre-selection 2) reduced PCA
e. Work-in-progress: comparison PCA vs. Artificial Neural Networks vs. K-means
- **Case 2 "Gesture":** linear acceleration => Acc + Mag and Acc + RSSI not usable as in case 1
  - EKF => quaternions => PCA inputs and controlled use of Gyro
  - Classification + timing analysis
- **Case 3 "Motion capture":** orientation + avatar + fixed beacons for geolocation



d. Experimental results with Zyggie V1. 5 persons but only 4 for training, Accelero for selection of 7 main classes + RSSI with limited PCA: recognition rate of 98%

Cooperative communications

- **Why choosing distributed MIMO precoding?**

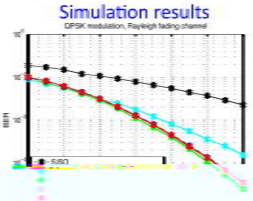
1) Reduce transmission power thanks to the adaptation to the channel
2) Compensate for rate loss (2-slot) with symbol combination (spatial multiplexing)

- **Challenges**

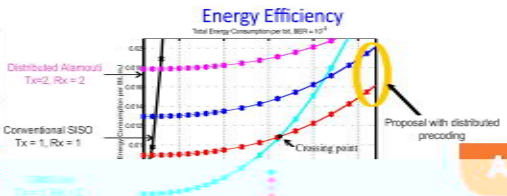
- Take into account the cooperation aspect for the precoder solution
- Design a dedicated MAC protocol
- Deal with the BAN channel characteristics for the local transmission

Distributed precoding via the Amplify-and-Forward protocol

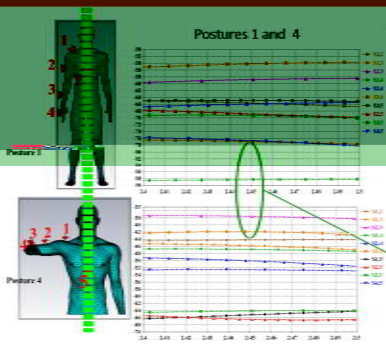
Simulation results



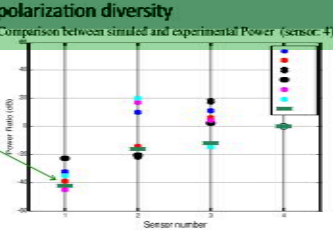
Energy Efficiency



Radio numerical results / Algorithms



- Training PCA with theoretical values, use PCA eigenvalues in real conditions
- Perspectives: More postures, Design of adaptive antenna for BoWI, Pattern/ polarization diversity



Architecture

Zyggie Prototype

- ASIC specification (post-BoWi)