15th International Conference on Computers Helping People with Special Needs
July 13-15, 2016; Pre-Conference July 11-12, 2016
University of Linz, Austria

Kalman-based approach to bladder volume estimation for people with neurogenic dysfunction of the urinary bladder

Alessandro Palla[1], Claudio Crema[2], Luca Fanucci[1],Paolo Bellagente[2]

1:University of Pisa, Italy
2: University of Brescia, Brescia, Italy

UNIVERSITÀ DI PISA

Outline

- Introduction
- Bioimpedance based measurement
- Measurements Protocol
- Bladder Volume Estimation
- Results
- Conclusions

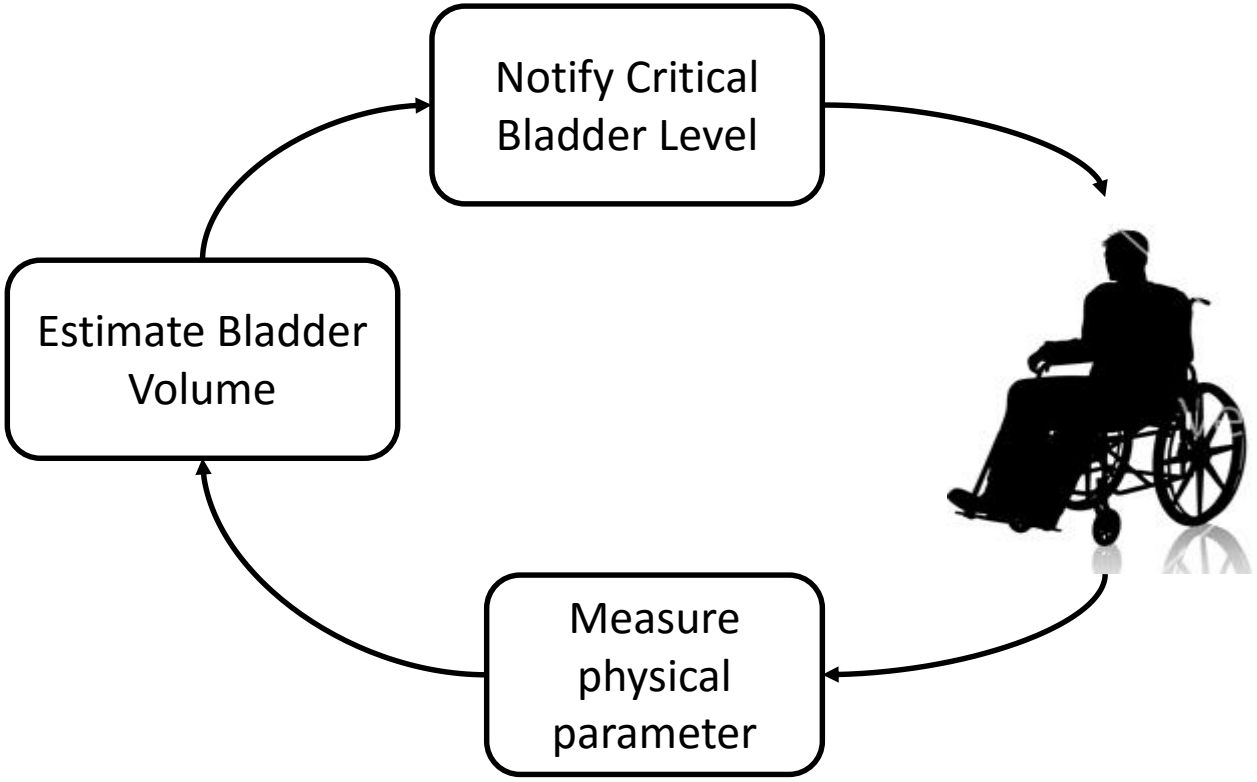
Neurogenic dysfunction of the urinary bladder

- Paralysis inhibits urinary bladder sensitivity

- Drawbacks:
  - Refluxes can damage patient's health and his psychological status
  - Frequent catheterishms increase reduce the risks of infection of the urinary tracts
  - Professional nursery increase overall medical system costs

The Idea

- Real-time bladder volume estimation



State of the Art

Ultrasound

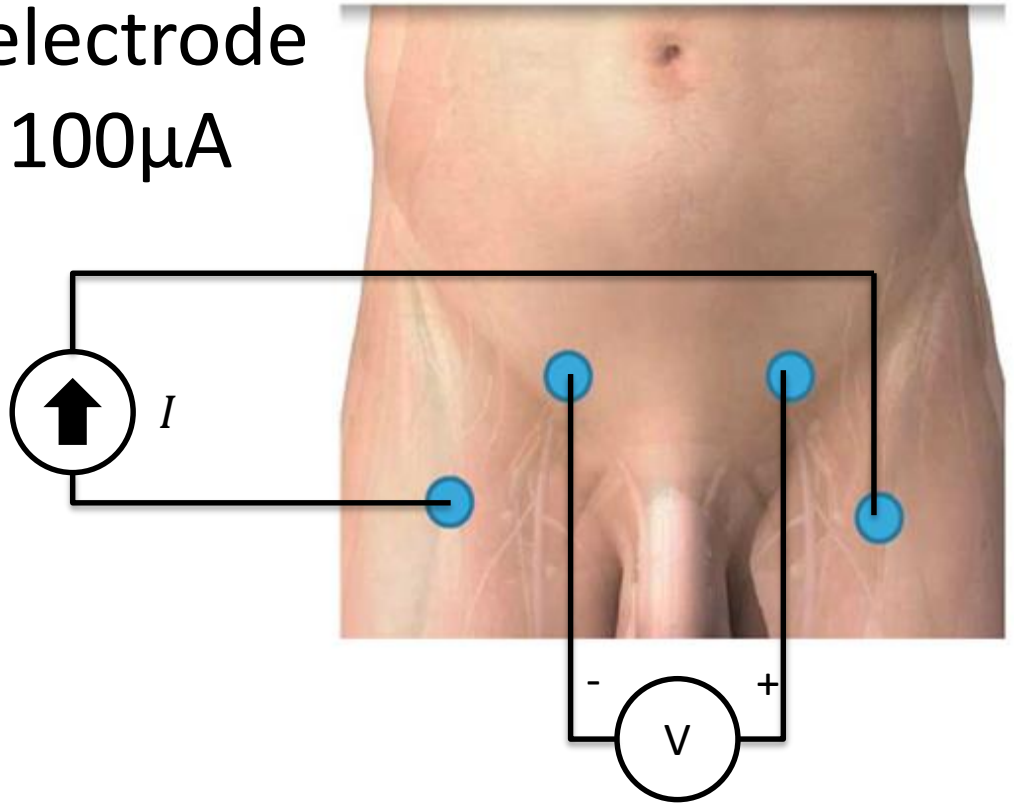
- PROs:
  - Very accurate
  - Standard medical diagnosis technique for bladder evaluation
- CONs:
  - Expensive and complex machines
  - Requires often a medic for data interpretation

Bioimpedance

- PROs:
  - Cheap and low cost
  - Wearable and battery powered
- CONs:
  - Less accurate than ultrasound
  - Artifacts in measurement decrease reliability

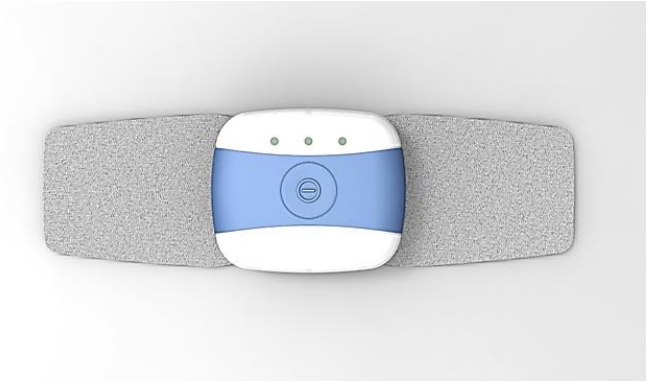
Bioimpedance: how does it works?

- Standard ECG electrode
- Sense current: 100µA @ 50 kHz

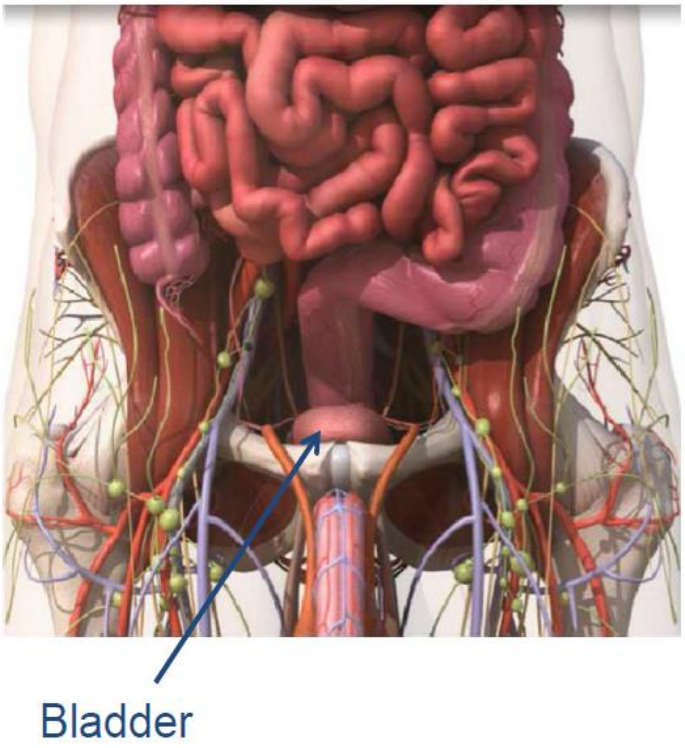


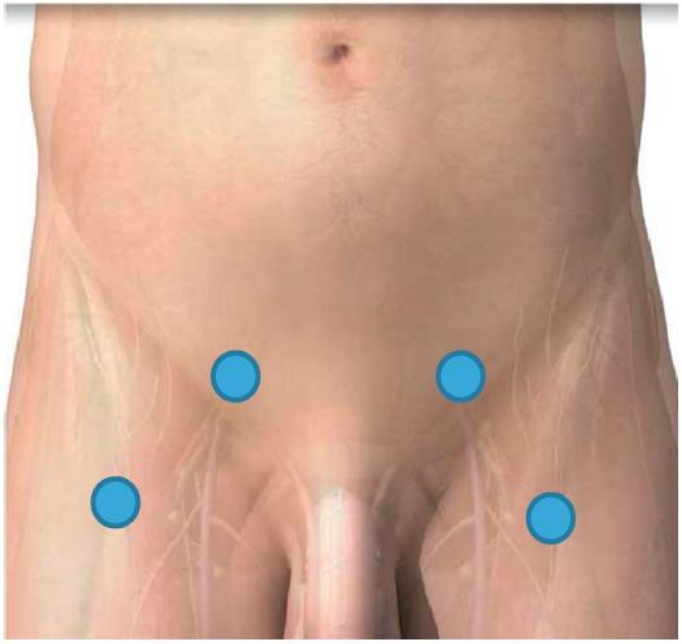
- $Z_0 = V/I$

STMicroelectronics BodyGateWay



Electrode Placements





4 Steps Test Protocol

T = 0

- Empty bladder
- Minimal/no movements

T = 0 to 1h30’

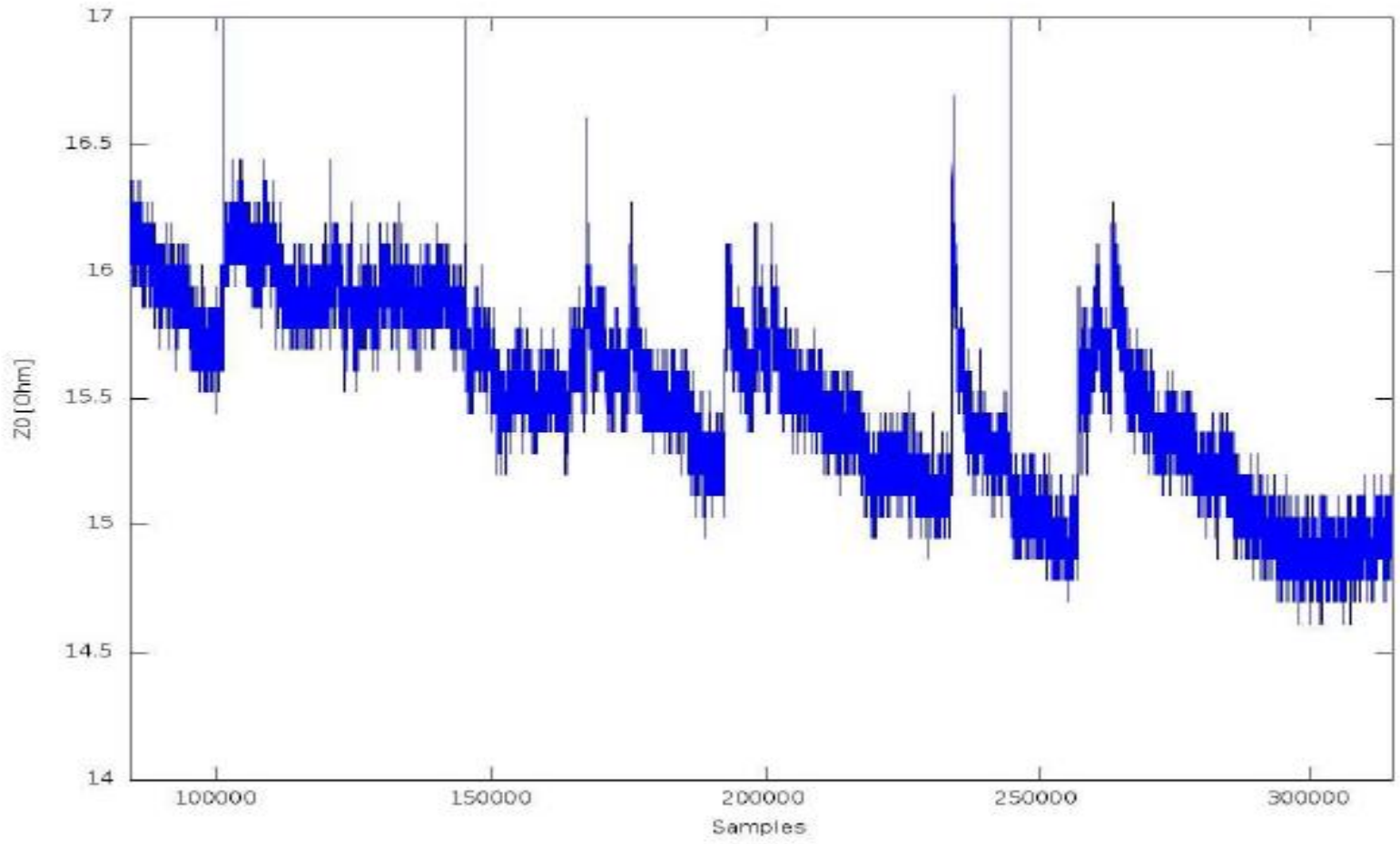
- Bioimpedance monitoring
- Drink 1.5L of water

- Empty bladder
- Measure urinary volume

- Measure again bioimpedance to check test consistency

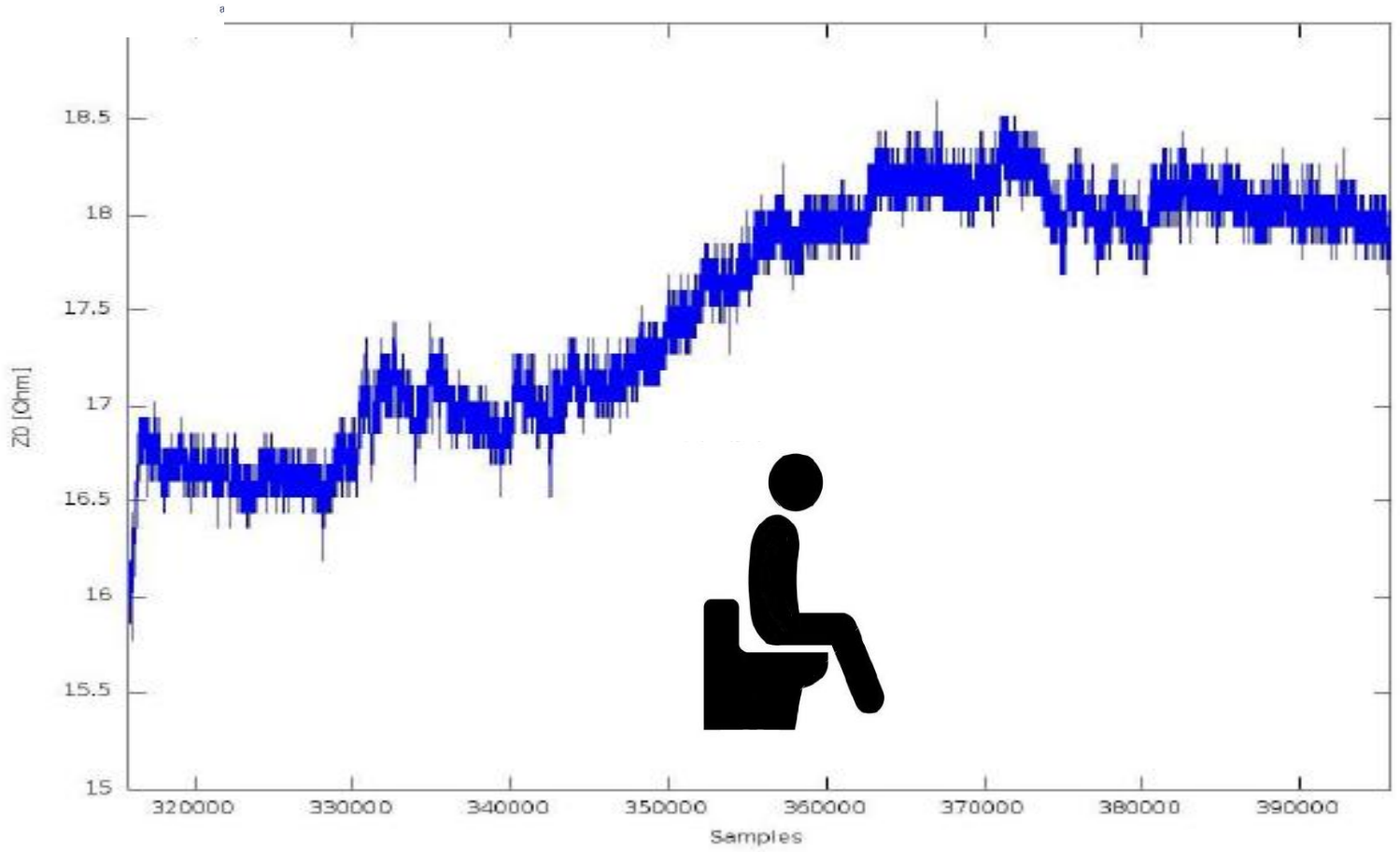
Results: Bladder Filling

13th AAATE Conference
9-12 September 2015,
Budapest, Hungary

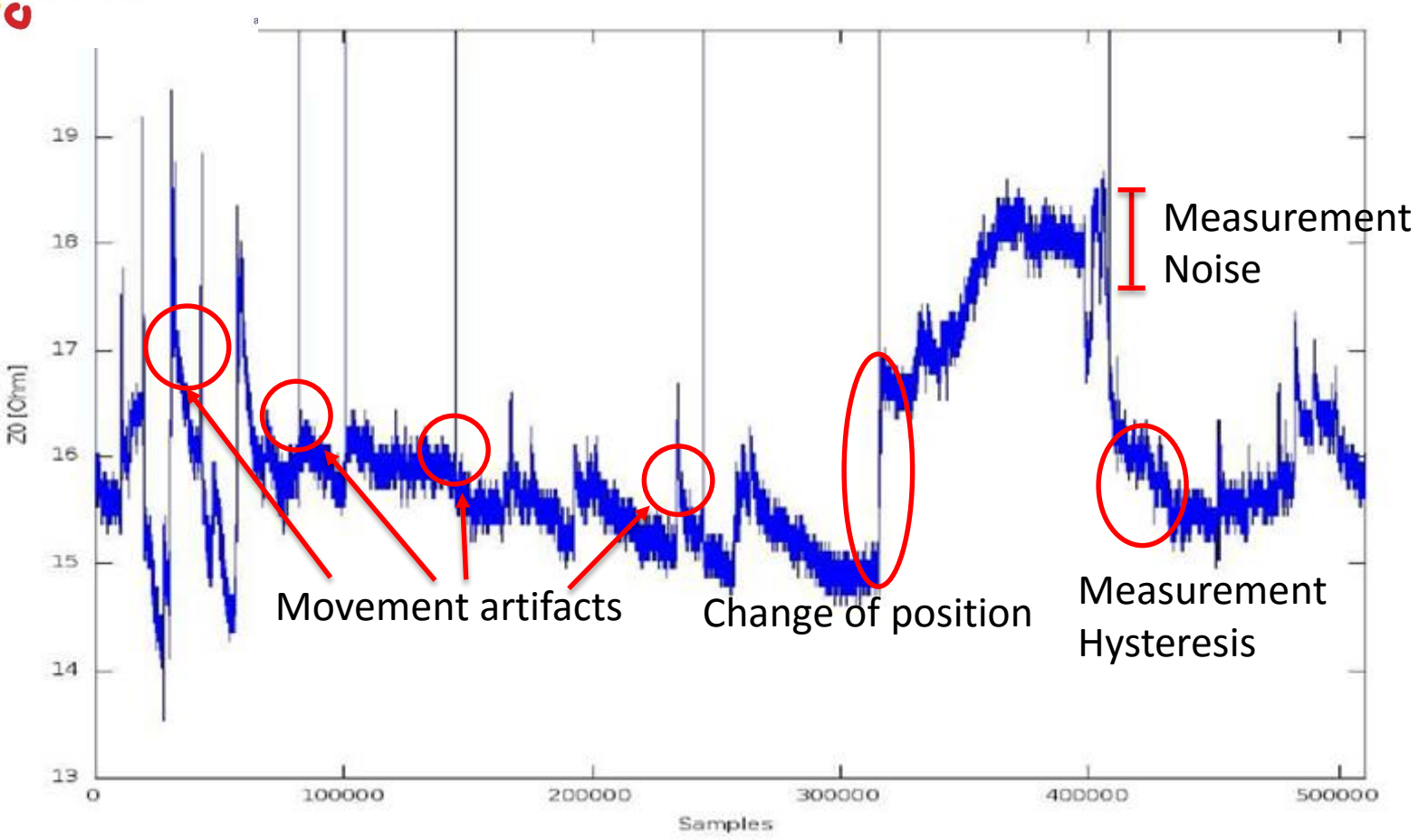


1.5 ohm

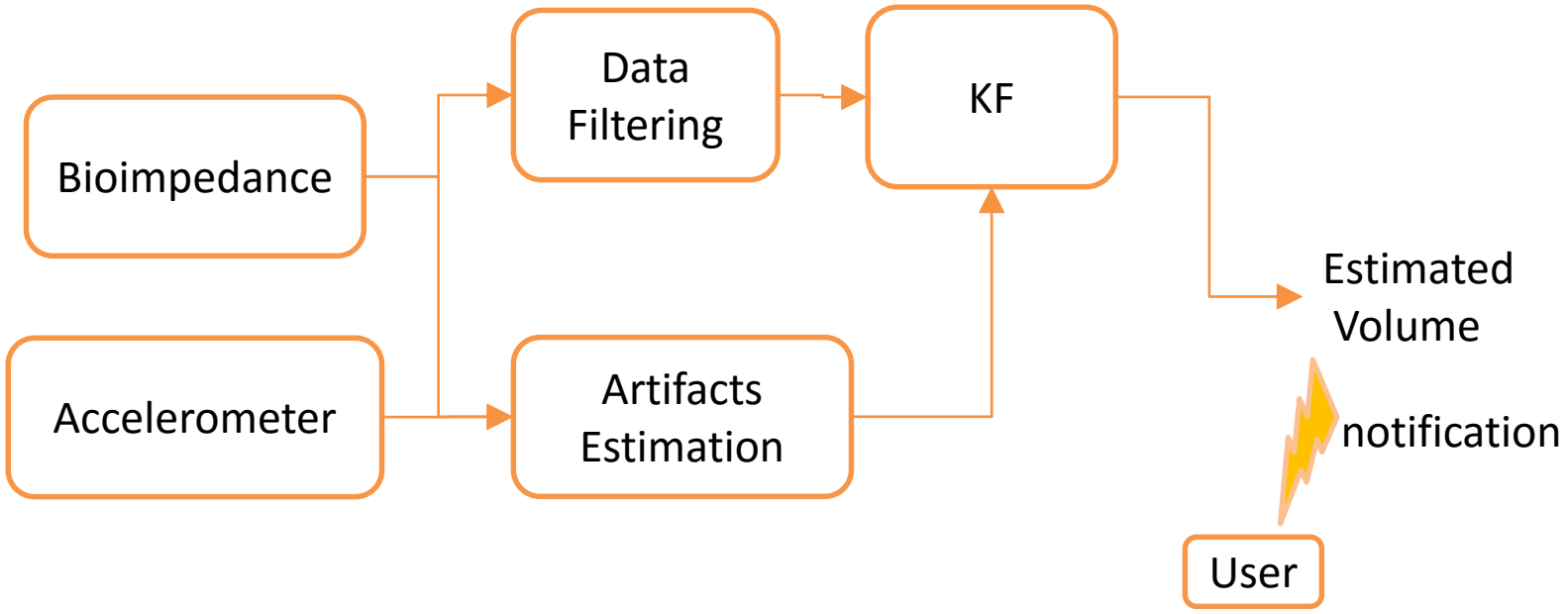
Results: Bladder Empting



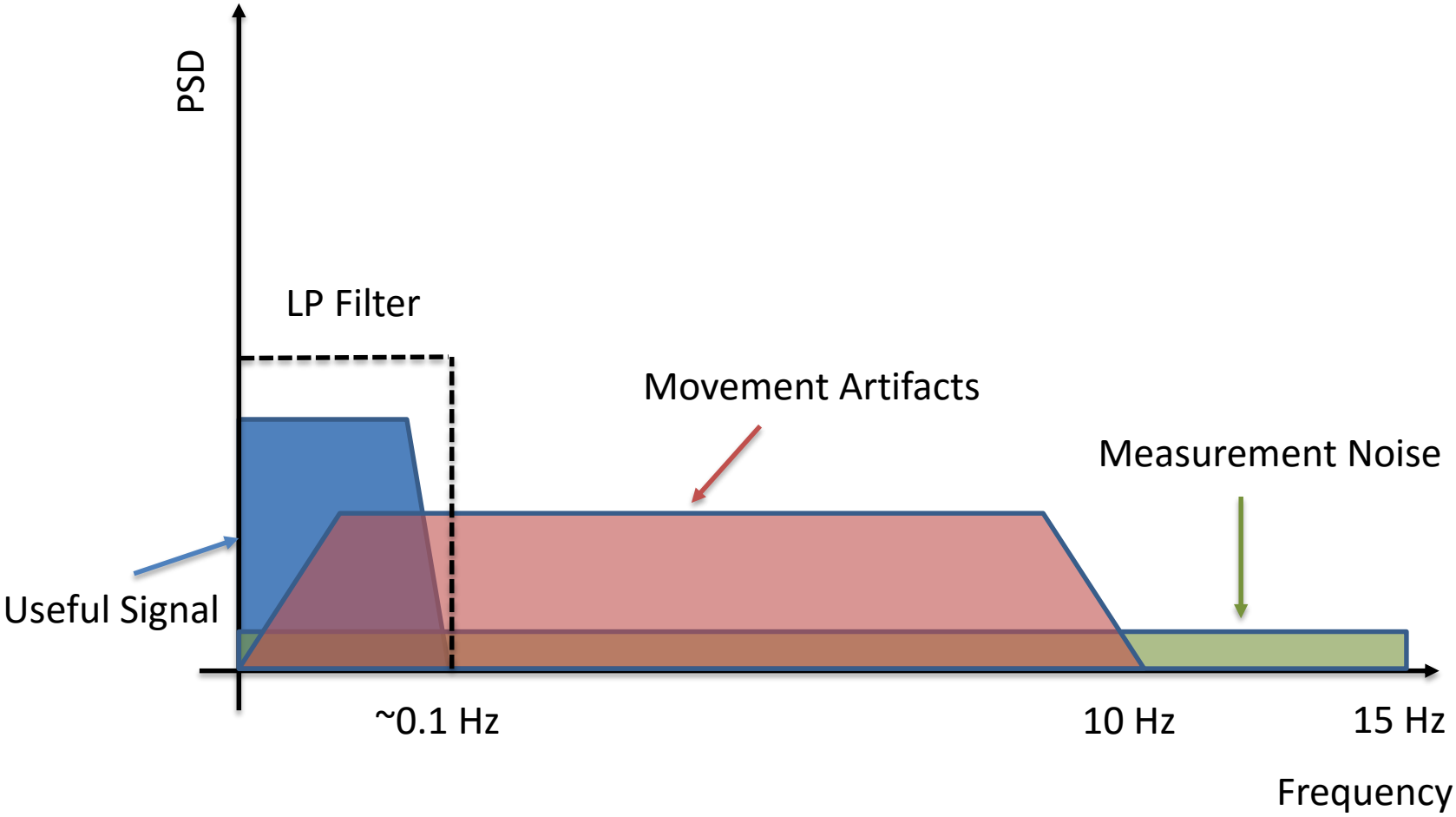
Measurements Artifacts



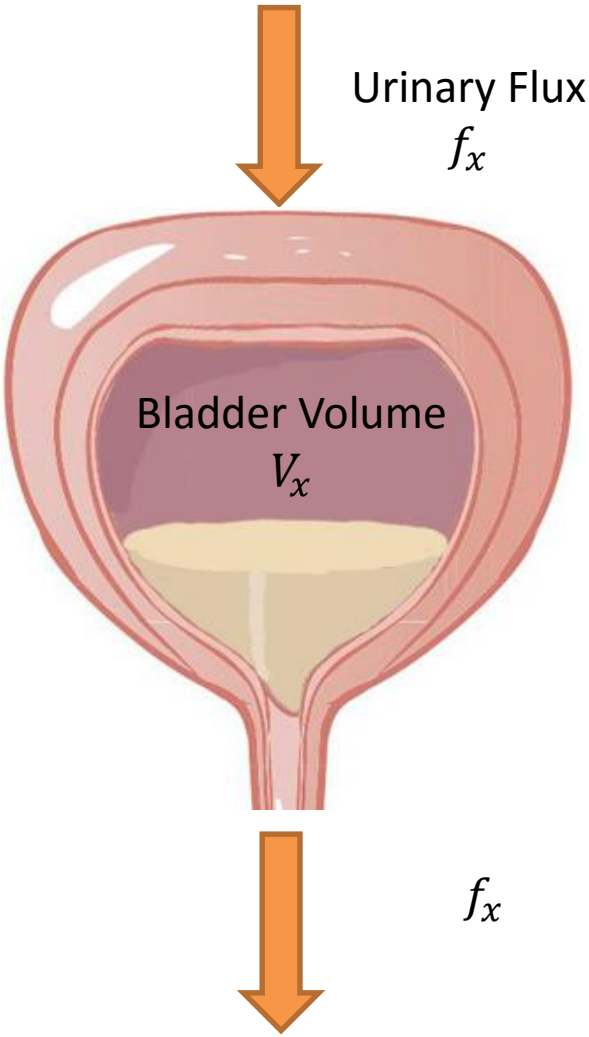
Bladder Volume Estimation



Data Filtering



Statistical Model



- Urinary flux is **not directly observable**
- Statistical model:

$$\frac{d}{dt} f_x(t) = n(t)$$

Gaussian Noise

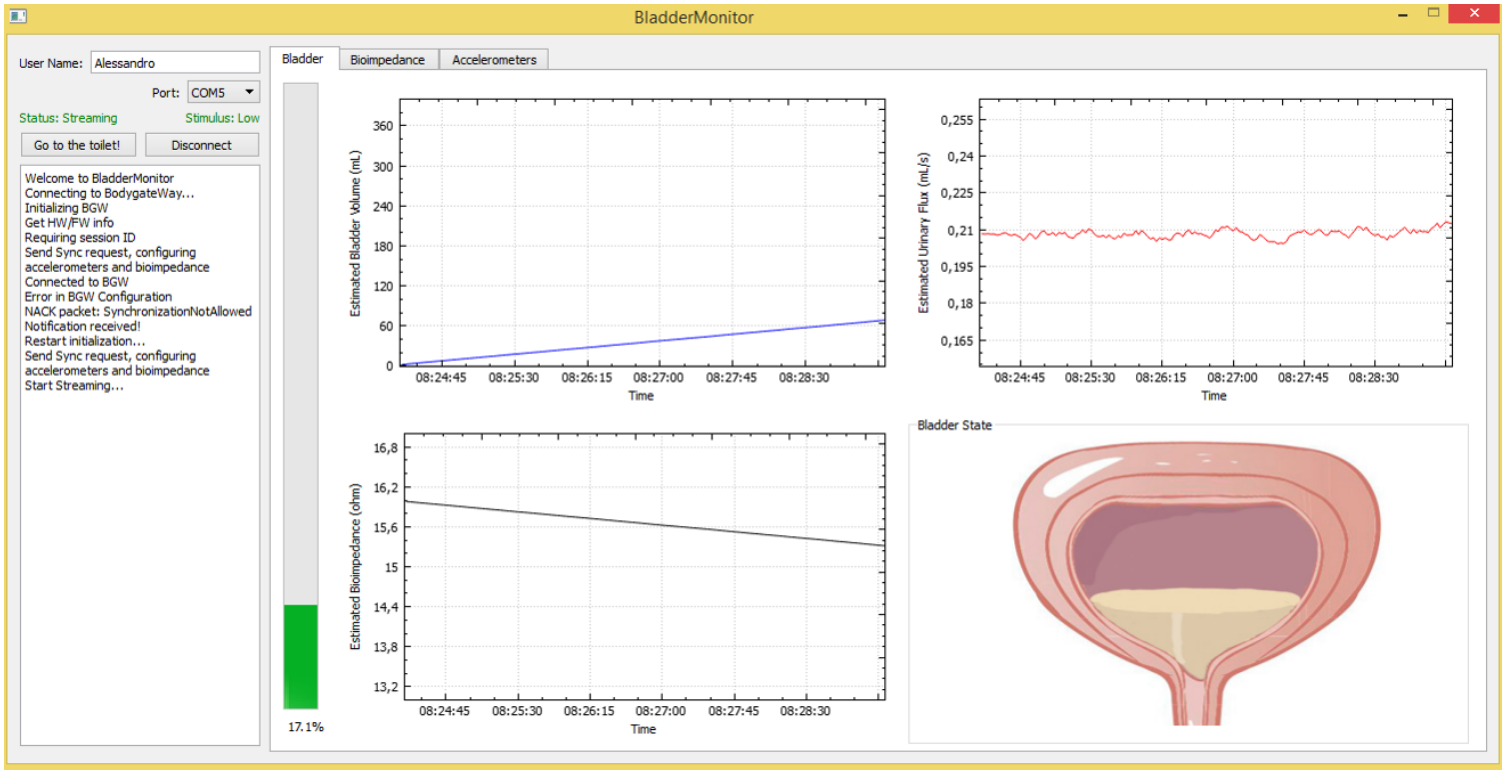
$$f_x = f_0 + B(t)$$

Average urinary flux

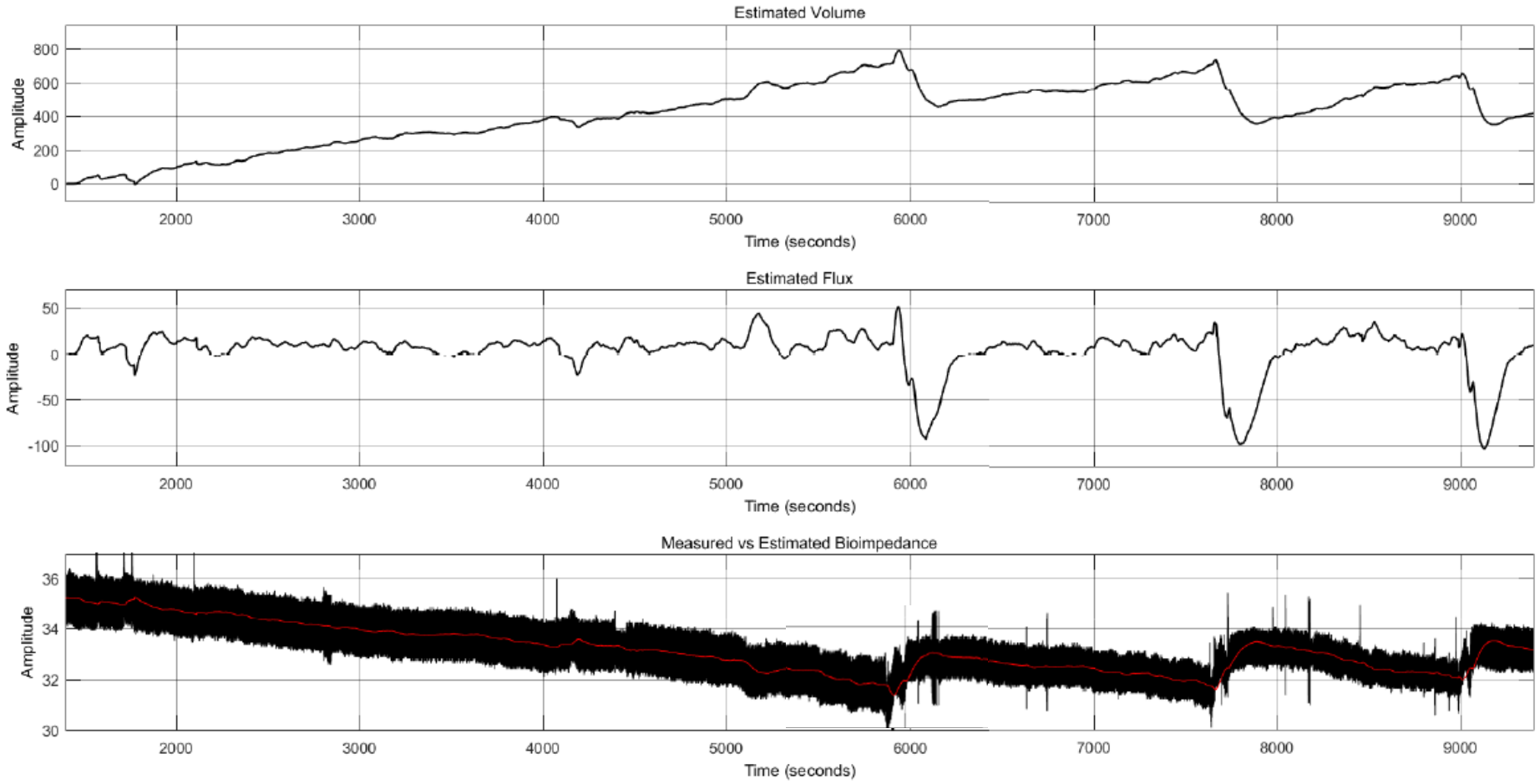
Random path

Kalman Filter

- Kalman Filter (KF): estimates state variables in presence of noise and artifacts.



Estimation Results



Conclusion

- Bio-impedance based bladder level estimation using statistical model and kalman filter
- Estimation can be used to send a warning to the patient

- Need collaborator to to validate system and algorithm with more users.

15th International Conference on Computers Helping People with Special Needs

July 13-15, 2016; Pre-Conference July 11-12, 2016
University of Linz, Austria

Thank you for your attention

Alessandro Palla, PhD

University of Pisa

alessandro.palla@for.unipi.it

+39 050 22-17-486

palla.ap

/in/alespalla

UNIVERSITÀ DI PISA