INSTITUTE OF COMMUNICATION, INFORMATION AND PERCEPTION TECHNOLOGIES

Scuola Superiore Sant'Anna

Accurate RSSI Localization in dynamic unknown environments

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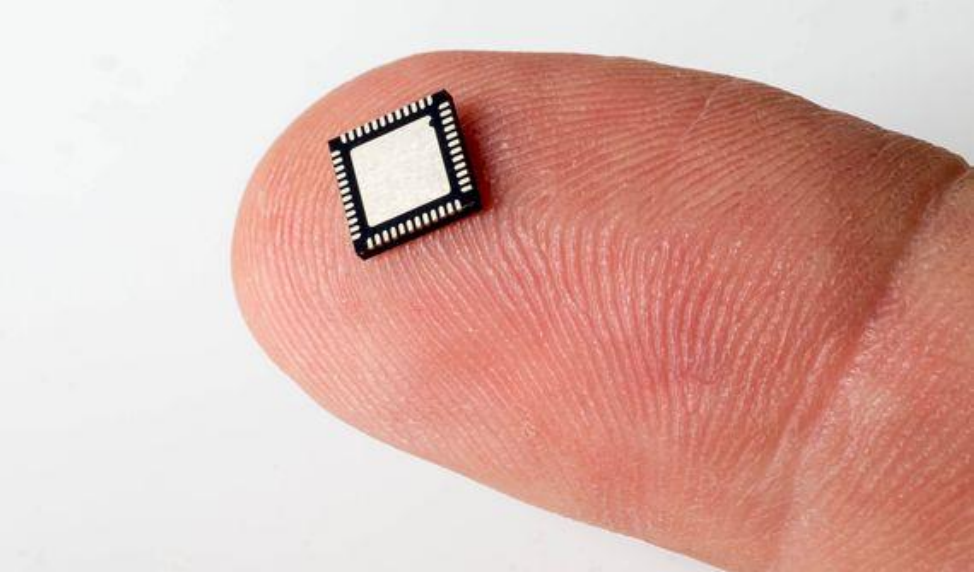
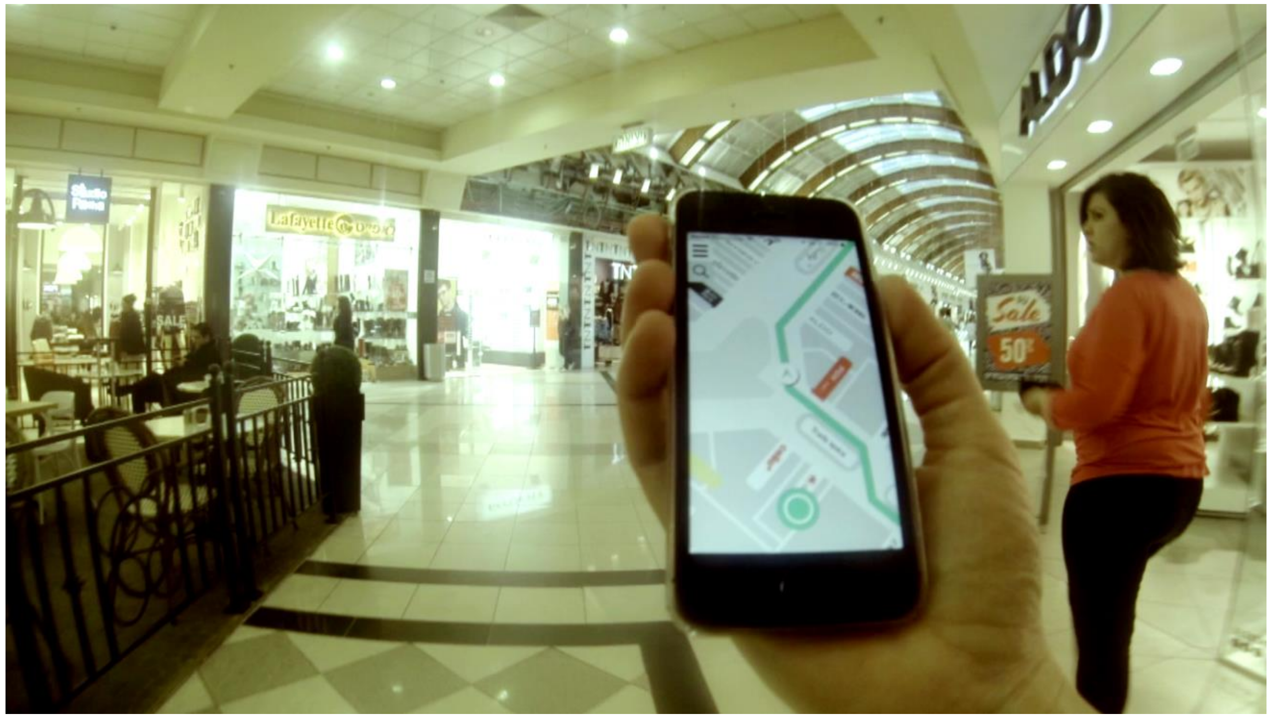
Retis
Real-Time Systems Laboratory

Indoor Localization

Embedded systems are pervasive:

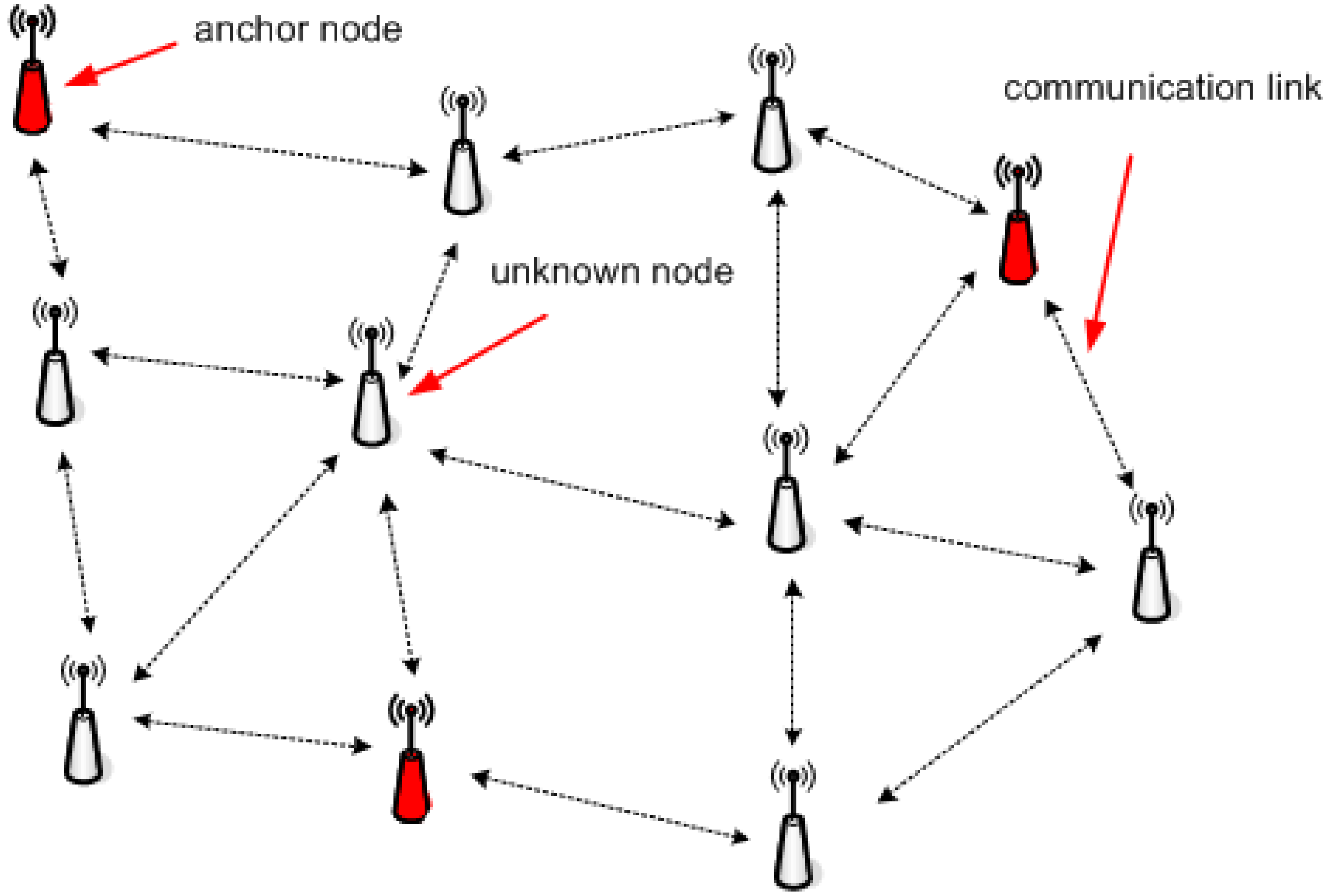
- Radio technology used to provide Localization
- Spatial information is important





Distance-based localization

Use Radio communication (RSSI,ToF, ToA) to compute the distance



Composed of two phases:

1. Ranging phase
2. Estimation phase

Ranging Techniques – Received Signal Strength Indicator(RSSI)

A receiver measures the distance from a sender by using the signal strength of a received message.

Features:

- Fast, no overhead
- Scalable
- Noisy
- Accuracy highly depends on the environment

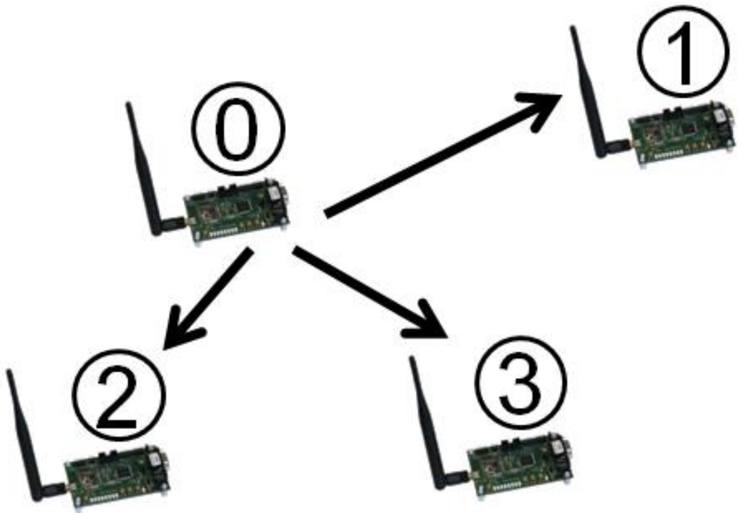


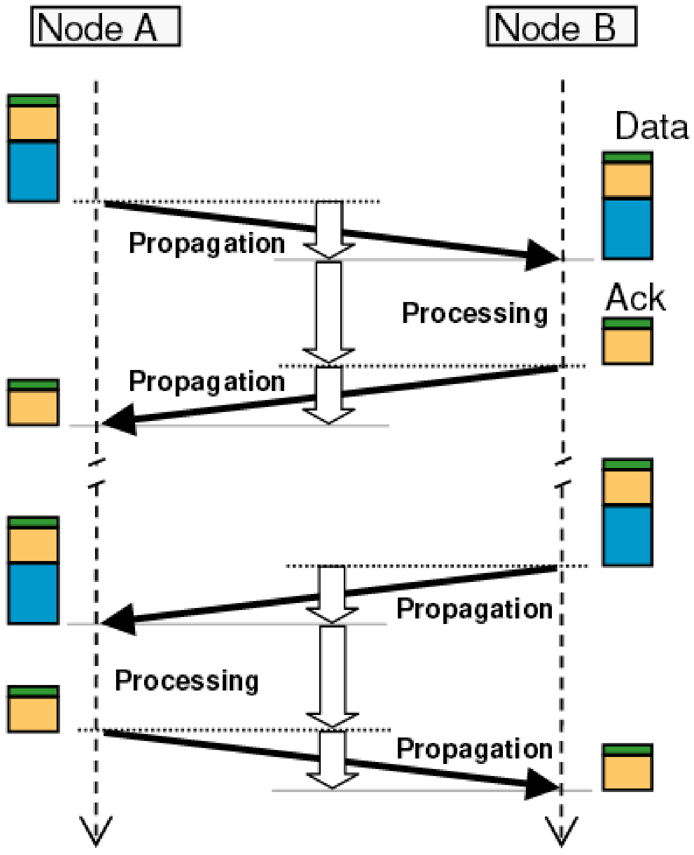
Fig. Node 0 broadcasts a message. Nodes 1,2,3 compute the distance

Ranging Techniques: Time of Flight (ToF)

Measures time needed for a packet to travel from a sender to a receiver and then compute the distance

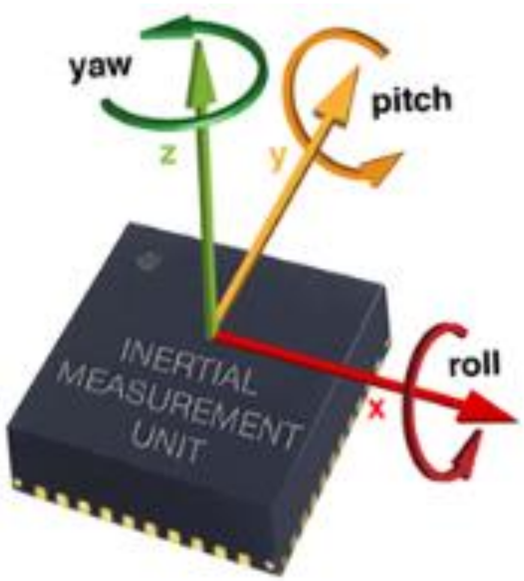
Features:

- No synchronization between nodes necessary
- Uses highly predictable hardware to generate acknowledgement packets and timestamps.
- Clock offset and drift compensation
- Long data collection period (~20 ms)



Inertial measuring units (IMU)

measures linear accelerations, angular speed, and sometimes the magnetic field surrounding the body, using a combination of accelerometers and gyroscopes, sometimes also magnetometers.



Motivation

We want a localization algorithm for team of mobile nodes that has:

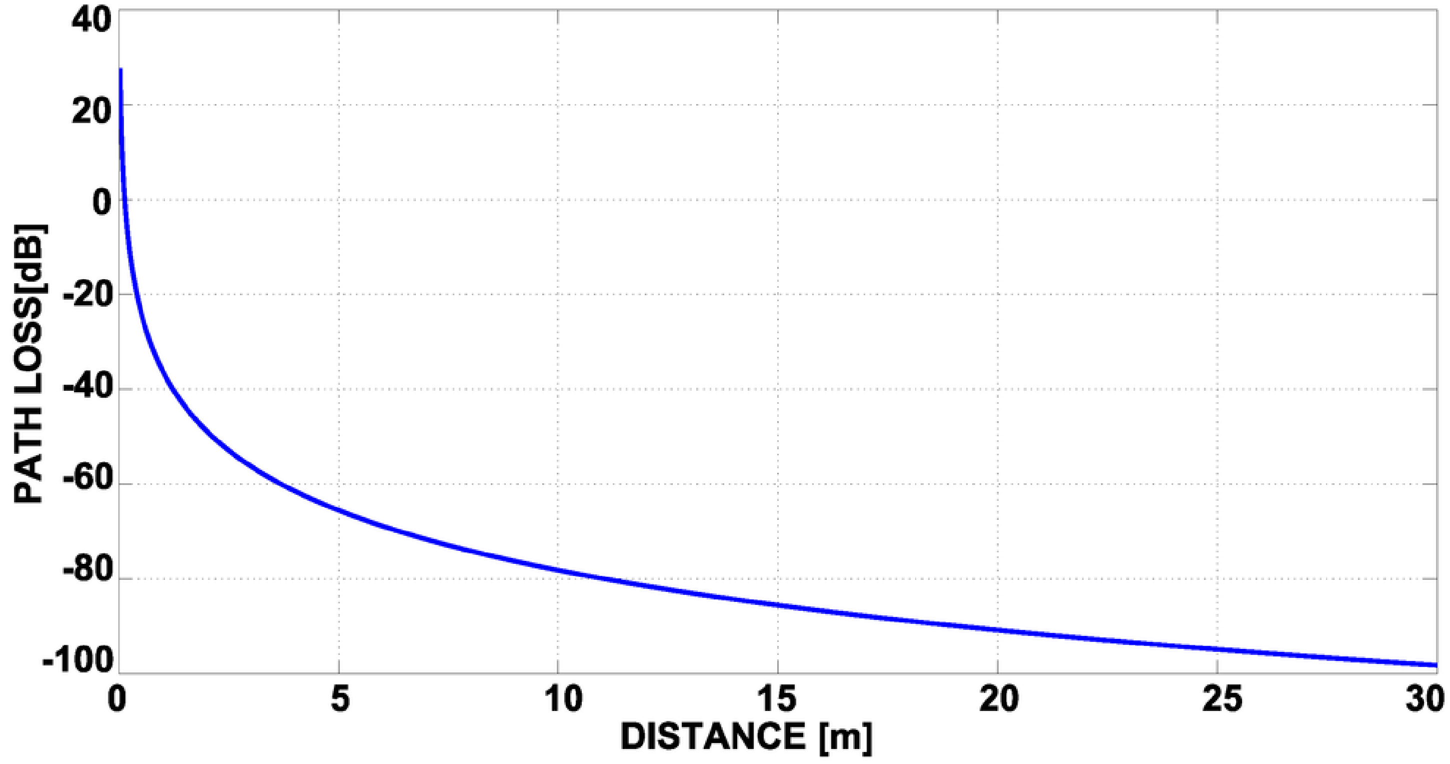
- Short data collection period
- **Scalable** (using RSSI)
- **No A-priori Calibration of the environment**
- **Adapts** to the environment

Channel model equation

The channel model is expressed by the following equation:

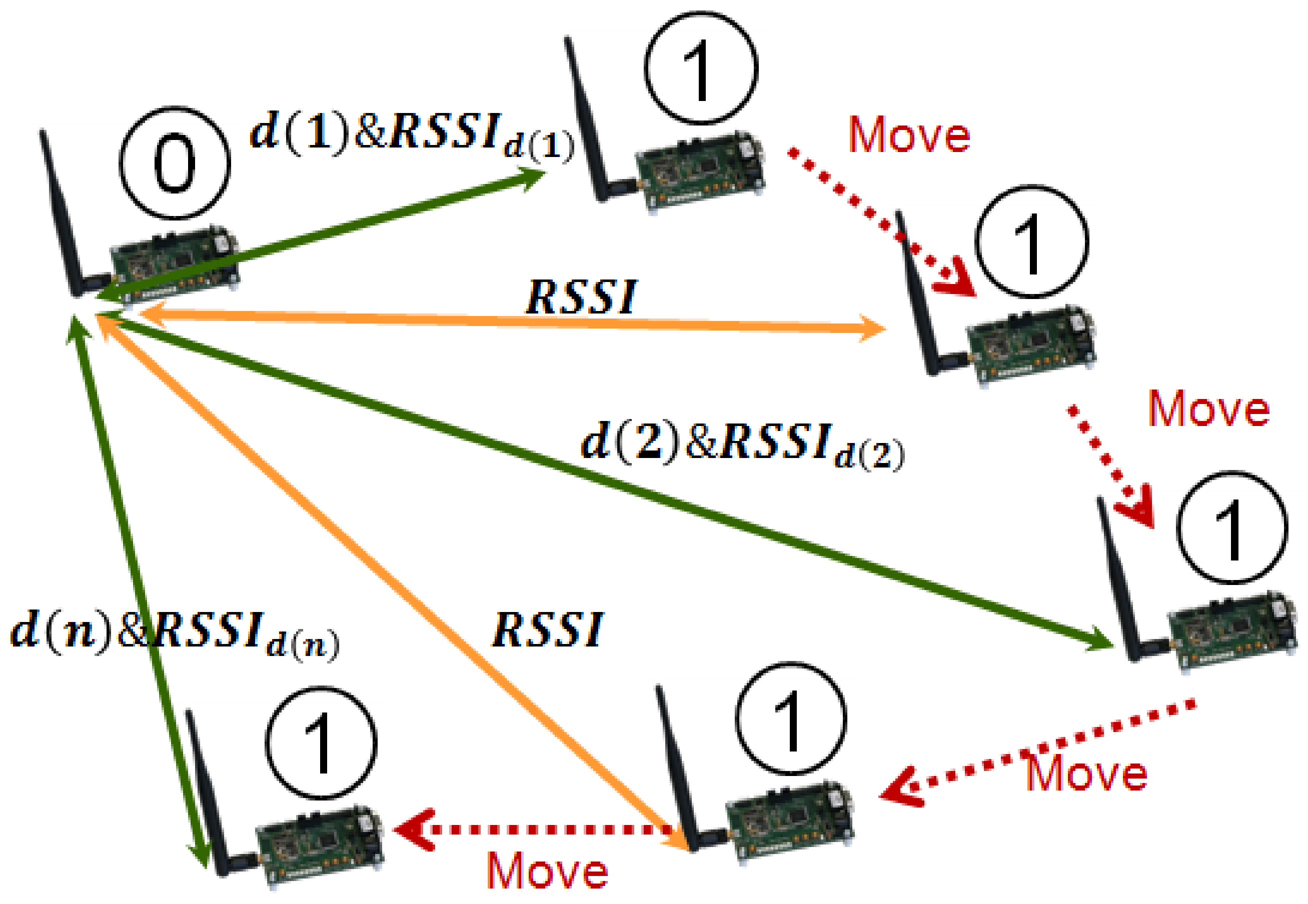
$$d = d_0 \times 10^{\frac{\rho_0 - \rho_d}{10\,\alpha}} \xRightarrow{if\ d_0=1} \rho_d = \rho_0 - 10\alpha \log_{10} d$$

Where ρ_0 is understood to be the power delivered from the transmit antenna (in dBm) and α is the path loss exponent

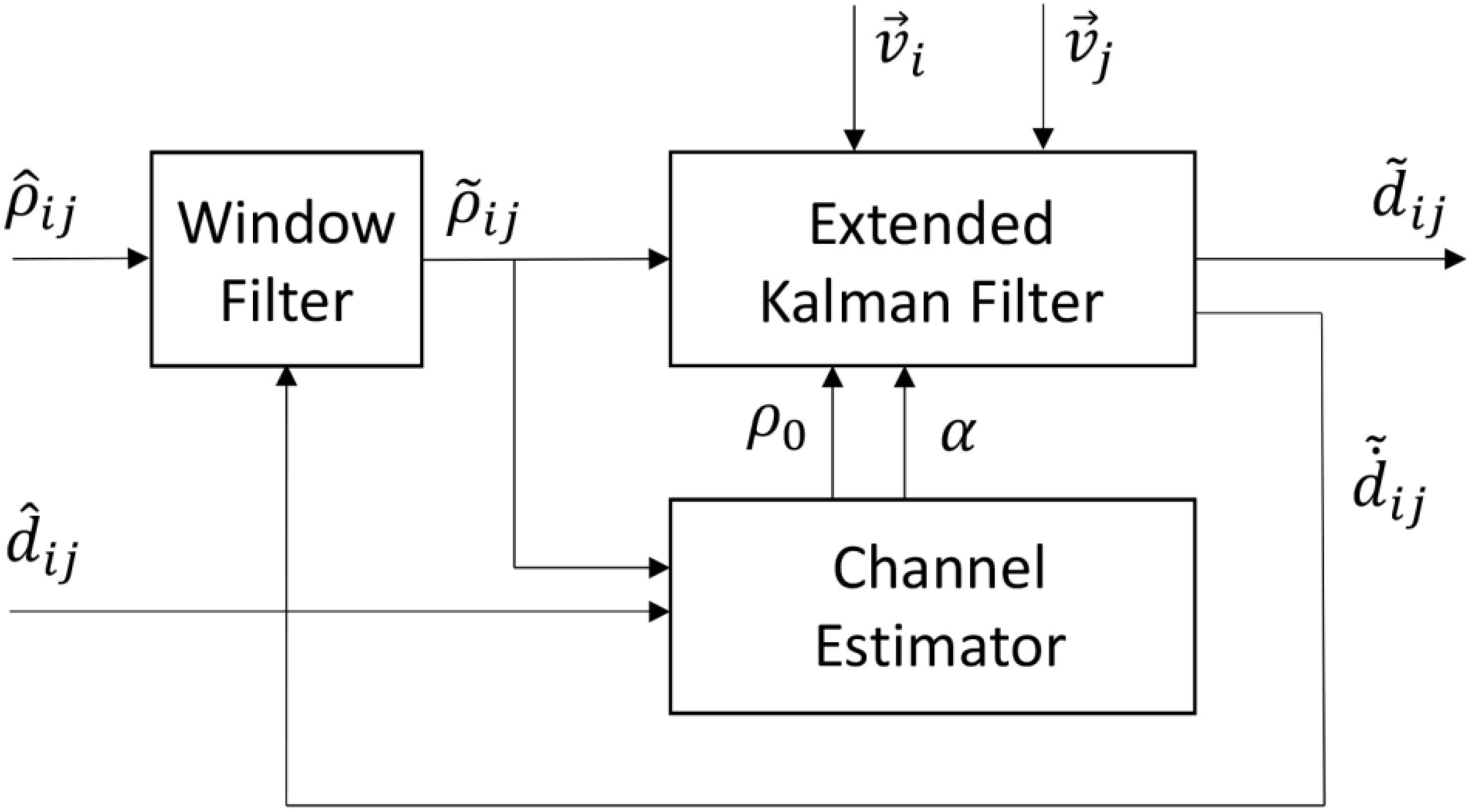


Adaptive channel estimatation

We use pairs of ToF and RSSI measurements to estimate the model

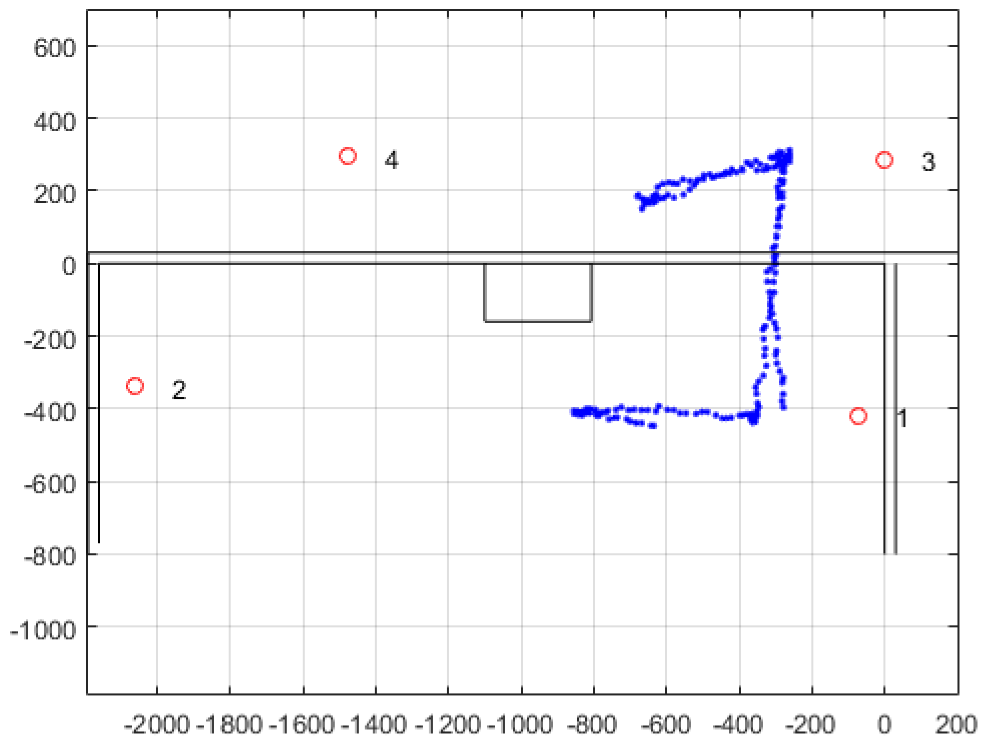


Adaptive Channel Model estimation

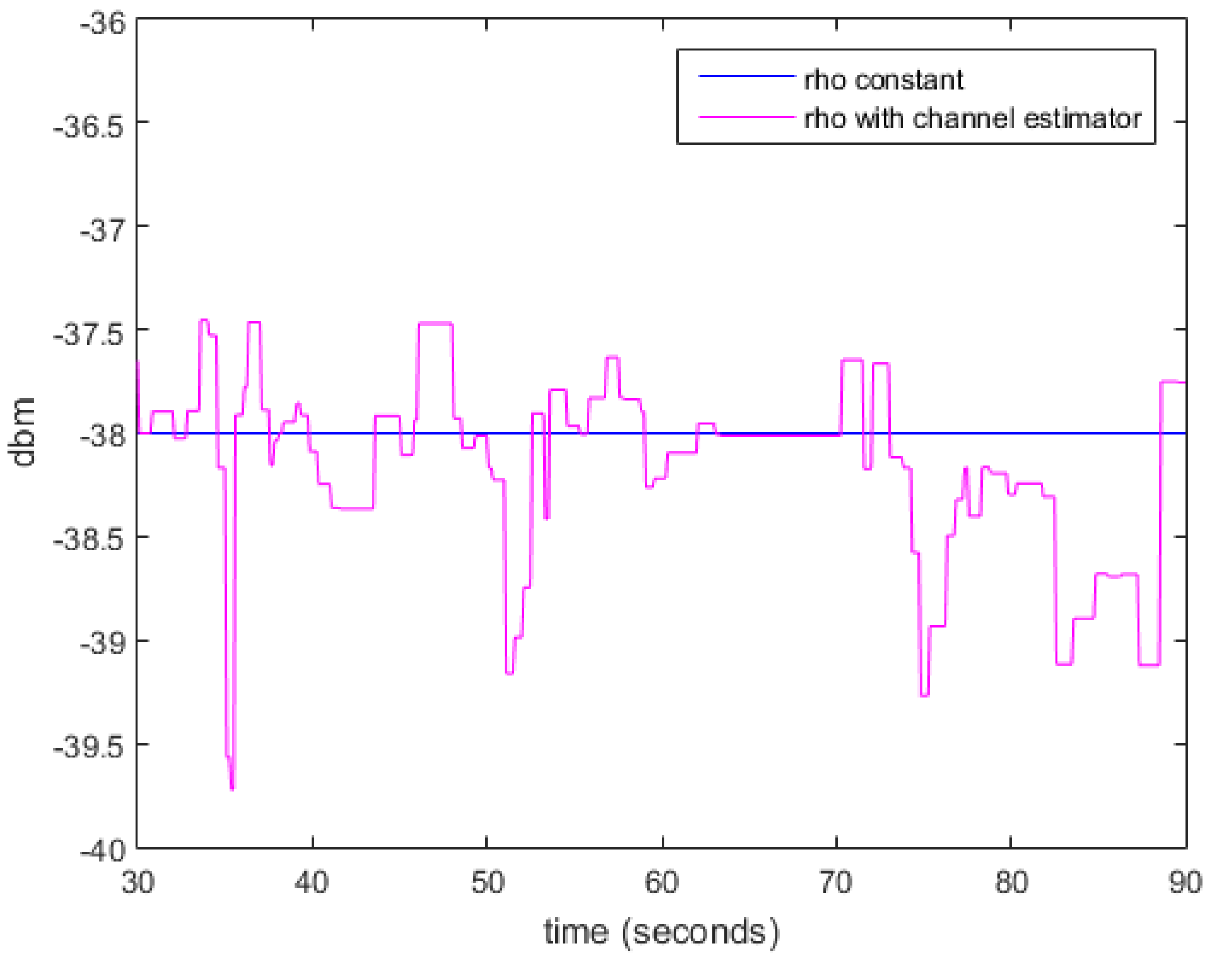


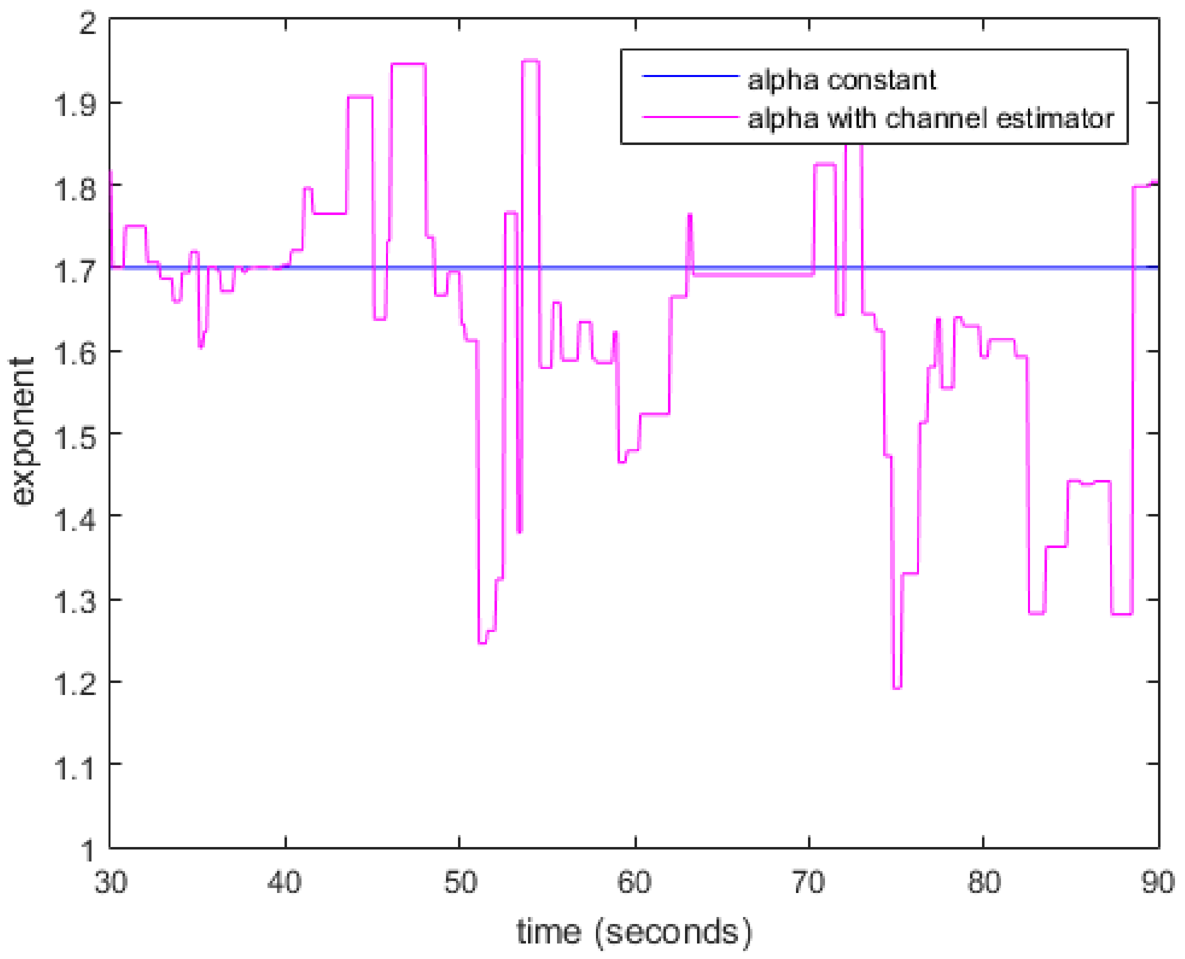
Experiment Setup in a multi-environment

The experiment has been recorder with a camera in order to provide ground truth

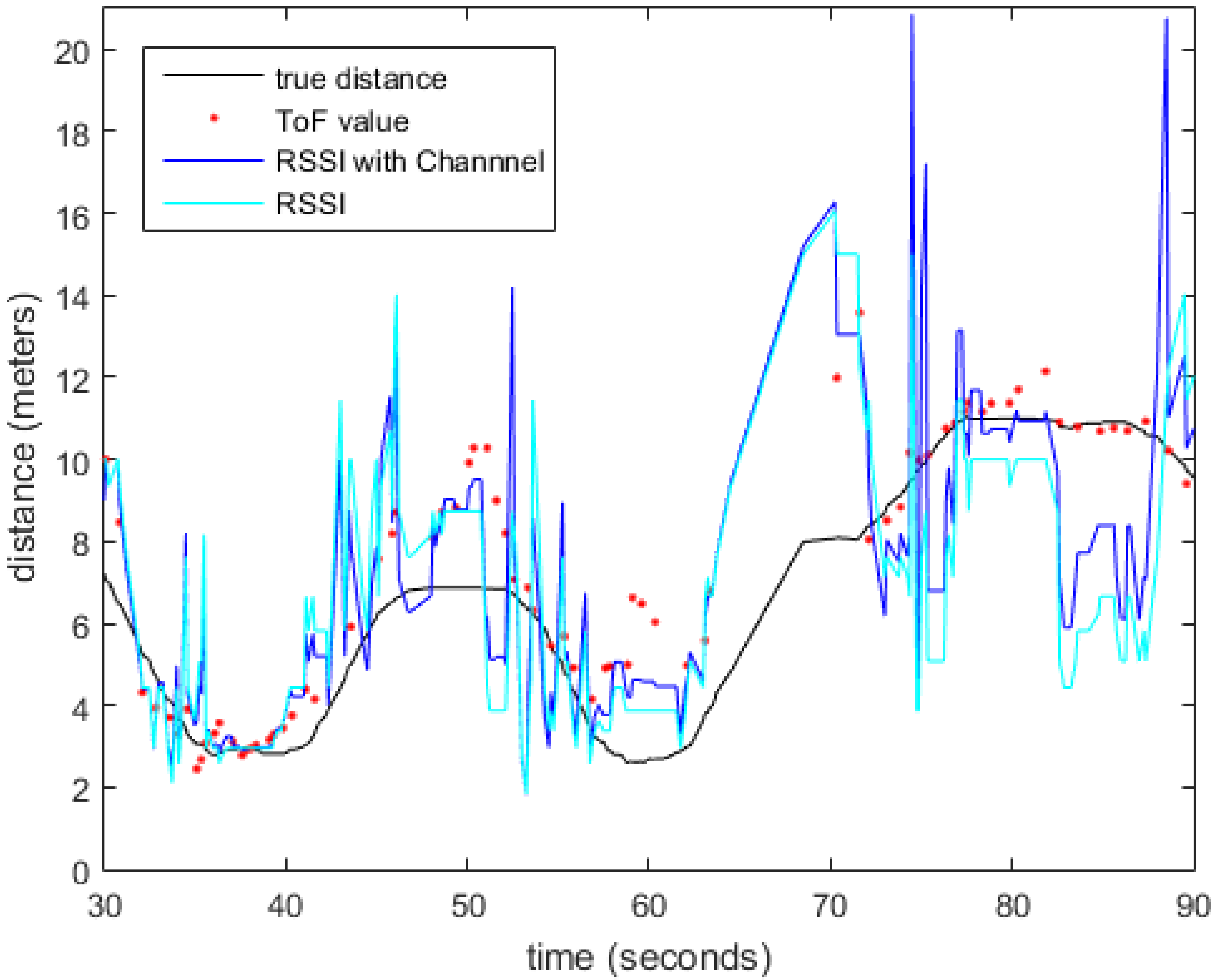


Adaptivity of the channel parameters





Distance estimation



Preliminary results

The channel estimator adapts the two parameters using ToF measurements (every 1 s) reducing the standard deviation of the error.

Error in the distance estimation	Mean	Standard Deviation
ToF	1,25 m	1,69 m
RSSI without Channel Estimator	0,61 m	3,85 m
RSSI with the Channel Estimator	0,65 m	2,53 m
Distance after the Kalman Filter	1,07 m	2,00 m

Conclusion

- In this preliminary work, we focused our attention to the ranging phase in order to improve the estimation of the RSSI distance.
- The results show that our channel estimator is promising in applications with fast dynamics when it is not possible use ToF due to its long measurement period (20 ms).

Next step will be to focus to the Estimation Phase

thank you!

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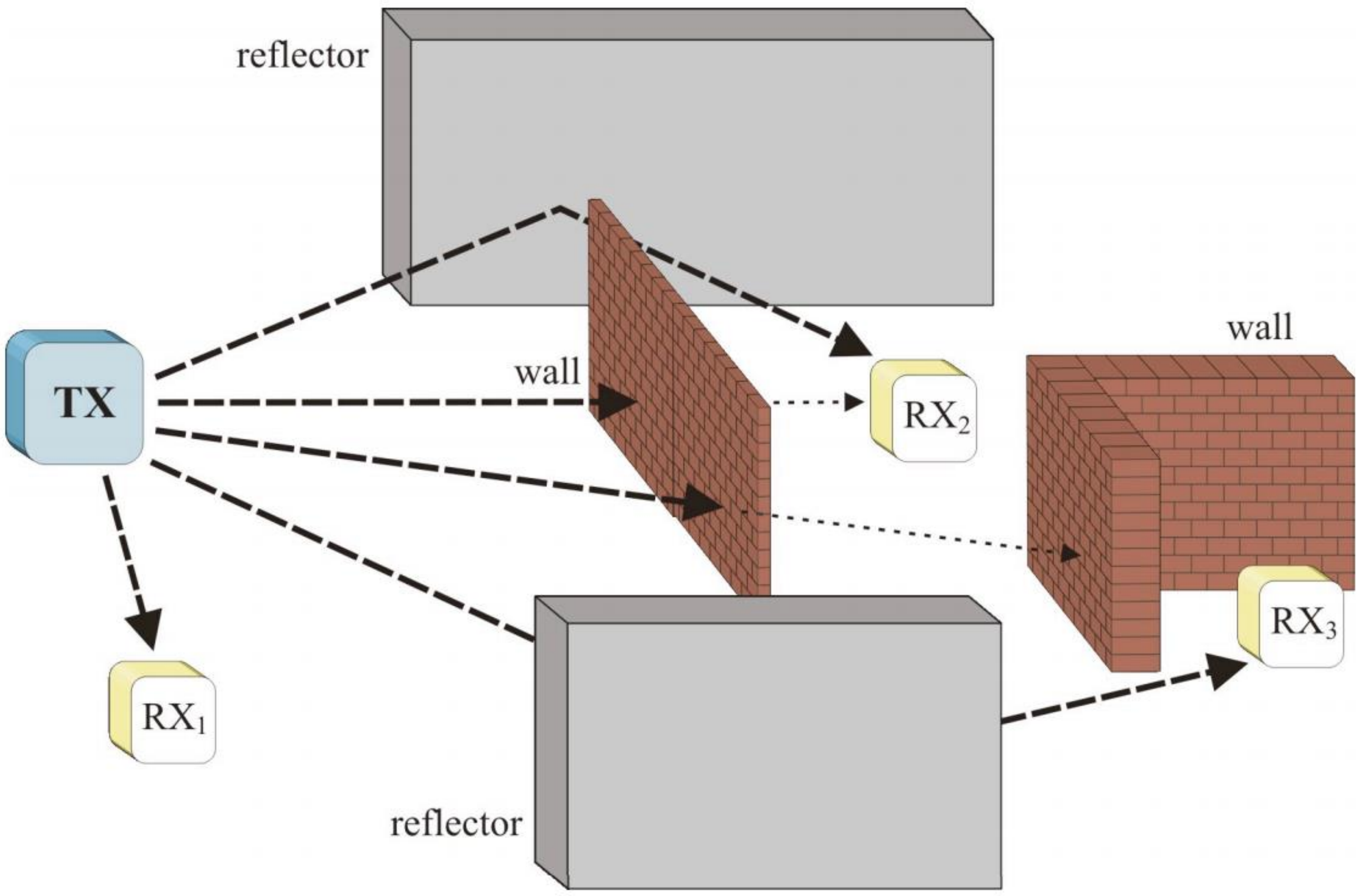
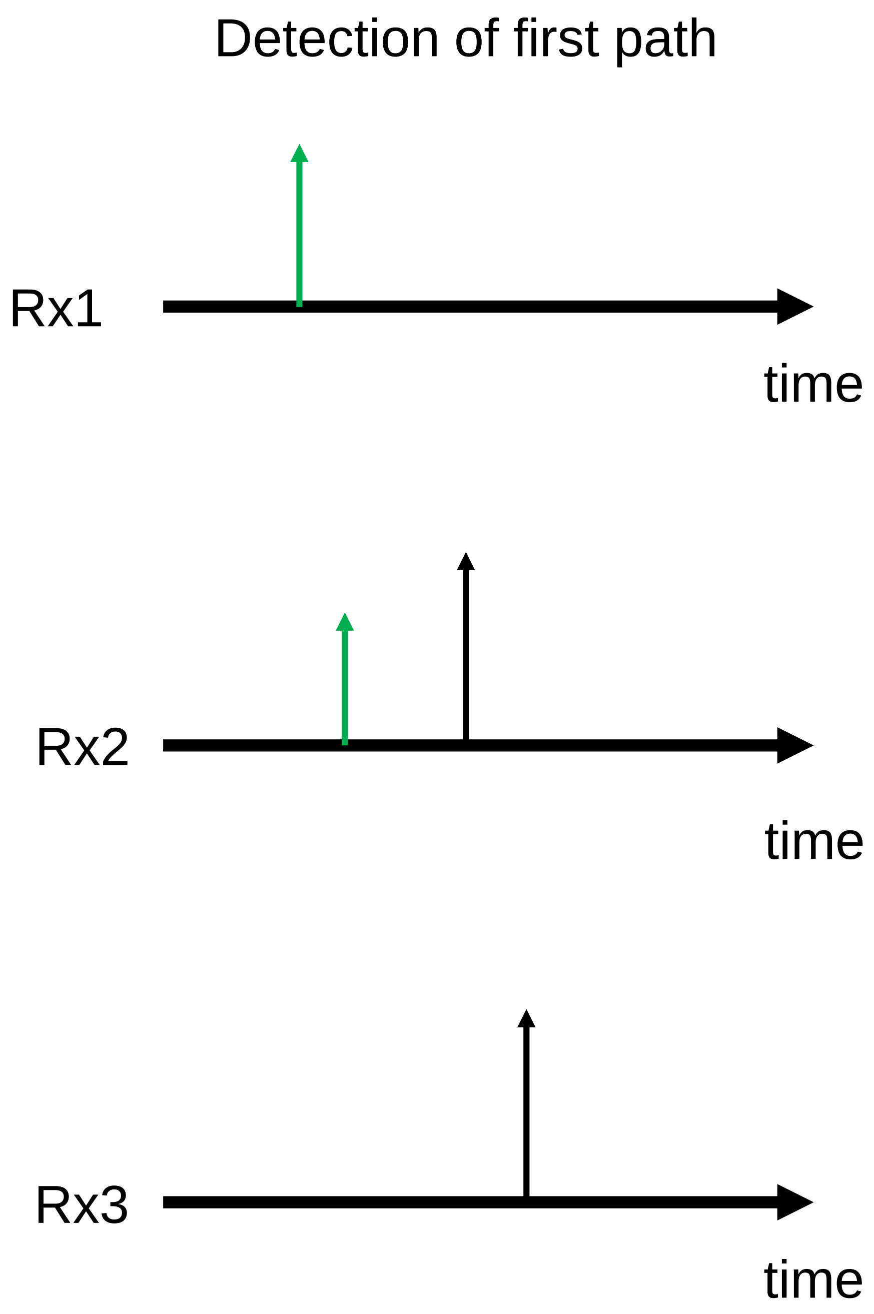
Time-based techniques: ToF, TDoA, ToA

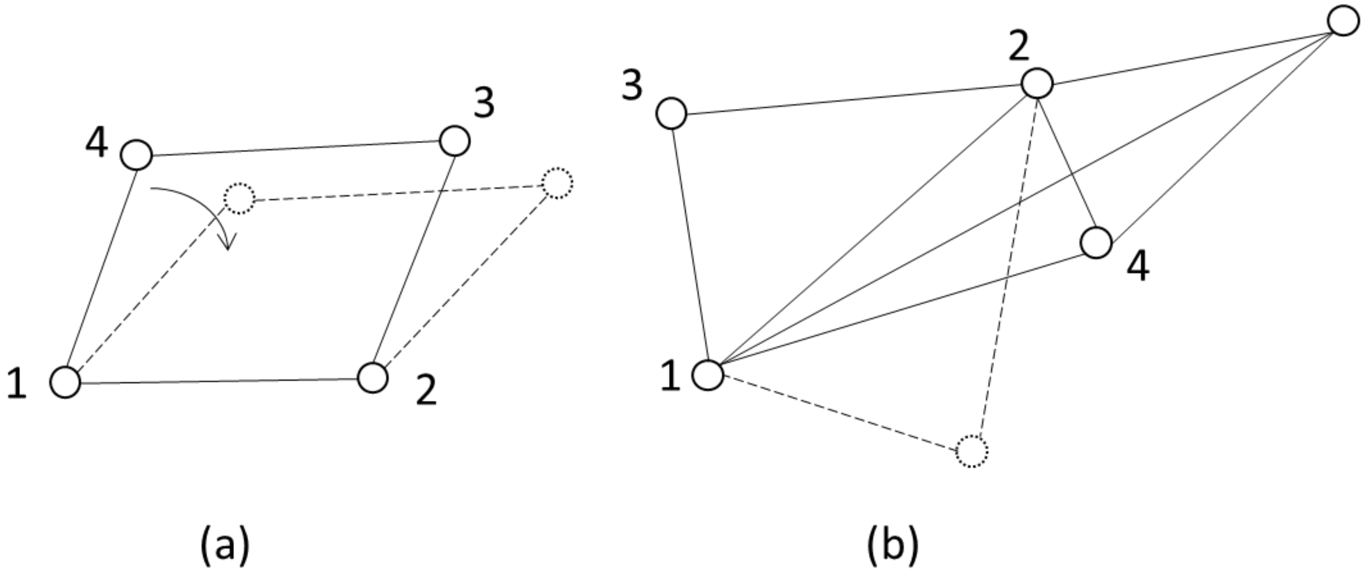




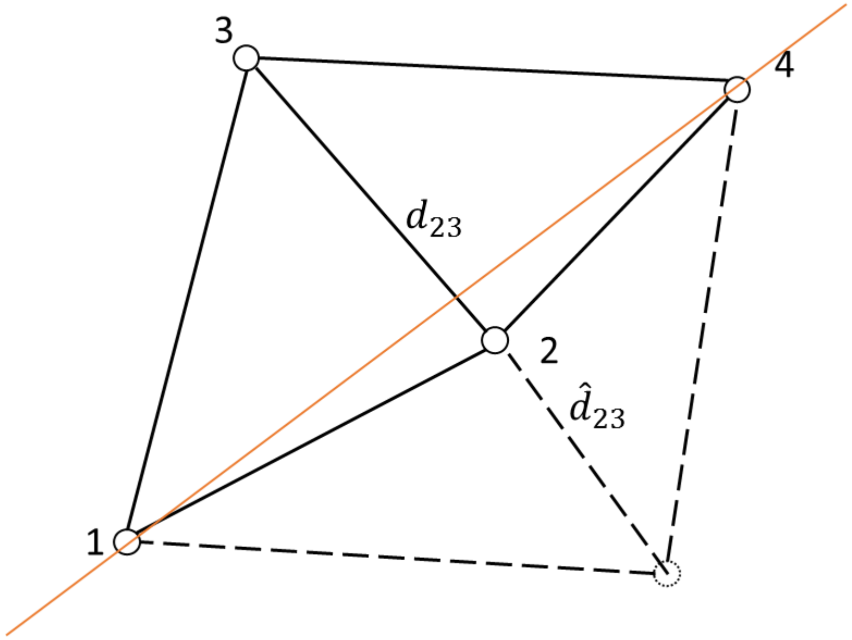
Estimation Phase

Use the measured distance to compute the node coordinates.

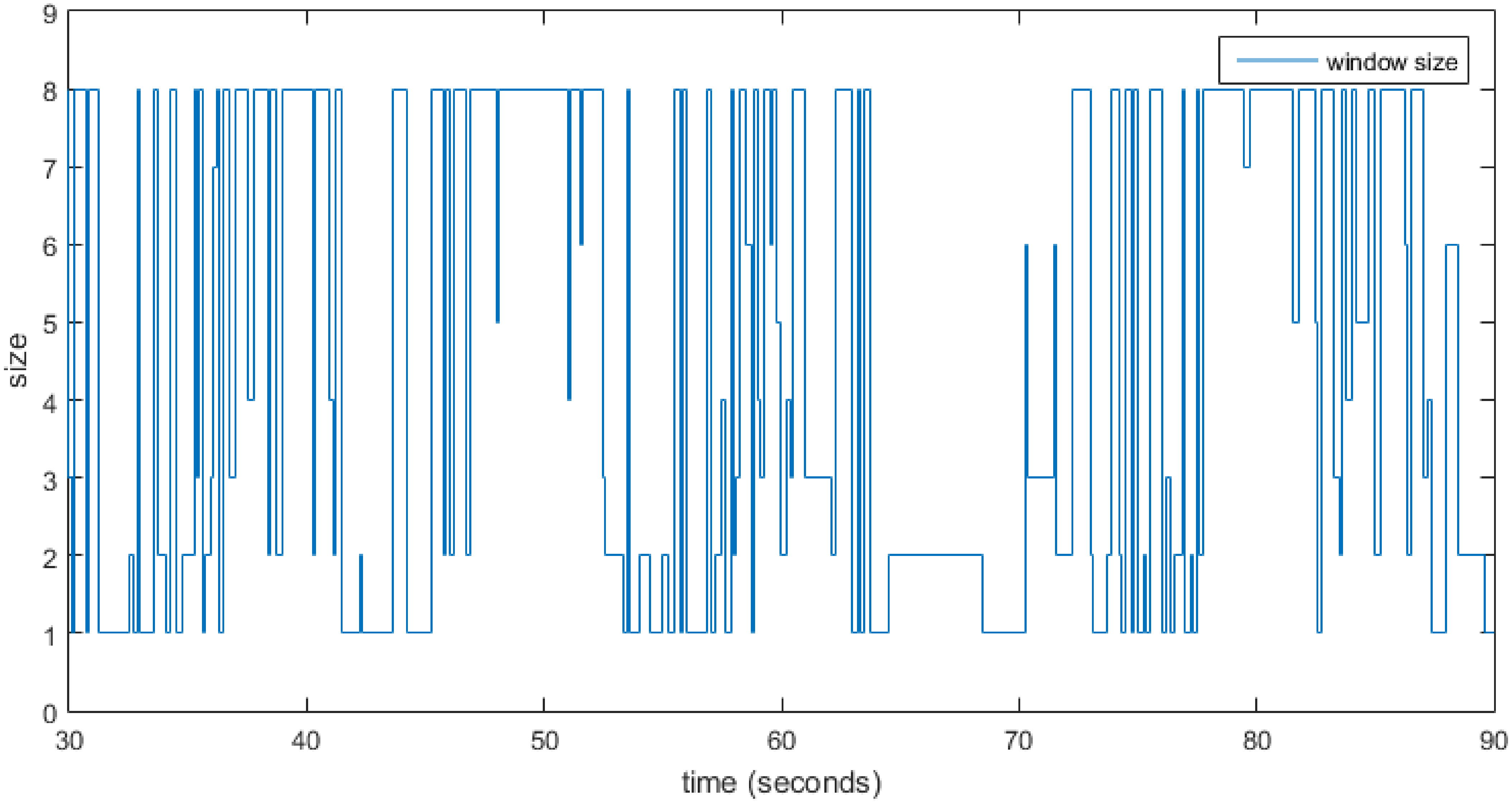
- Flex and Flips due to geometry



- Flips due to distance errors

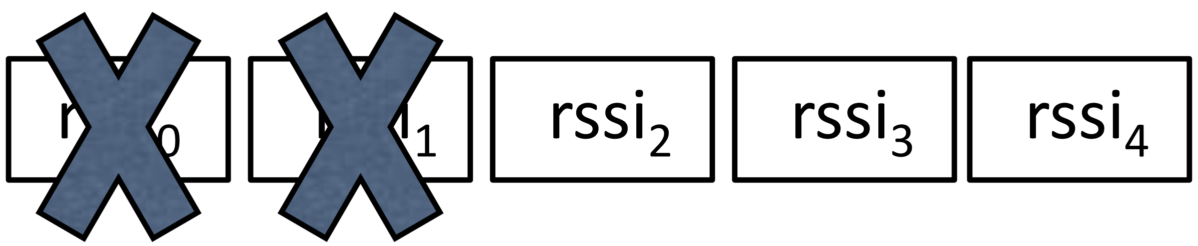


Adaptivity of the channel parameters



Dynamic window filter

However, if a node moves, the window filter will contain inside his window inconsistent values of RSSI measured at different positions



Number of elements K= 5

Dynamic window filter

We derived K as a function of the relative speed between two nodes. We bounded K with a maximum value K_{max} and a minimum K_{min}.

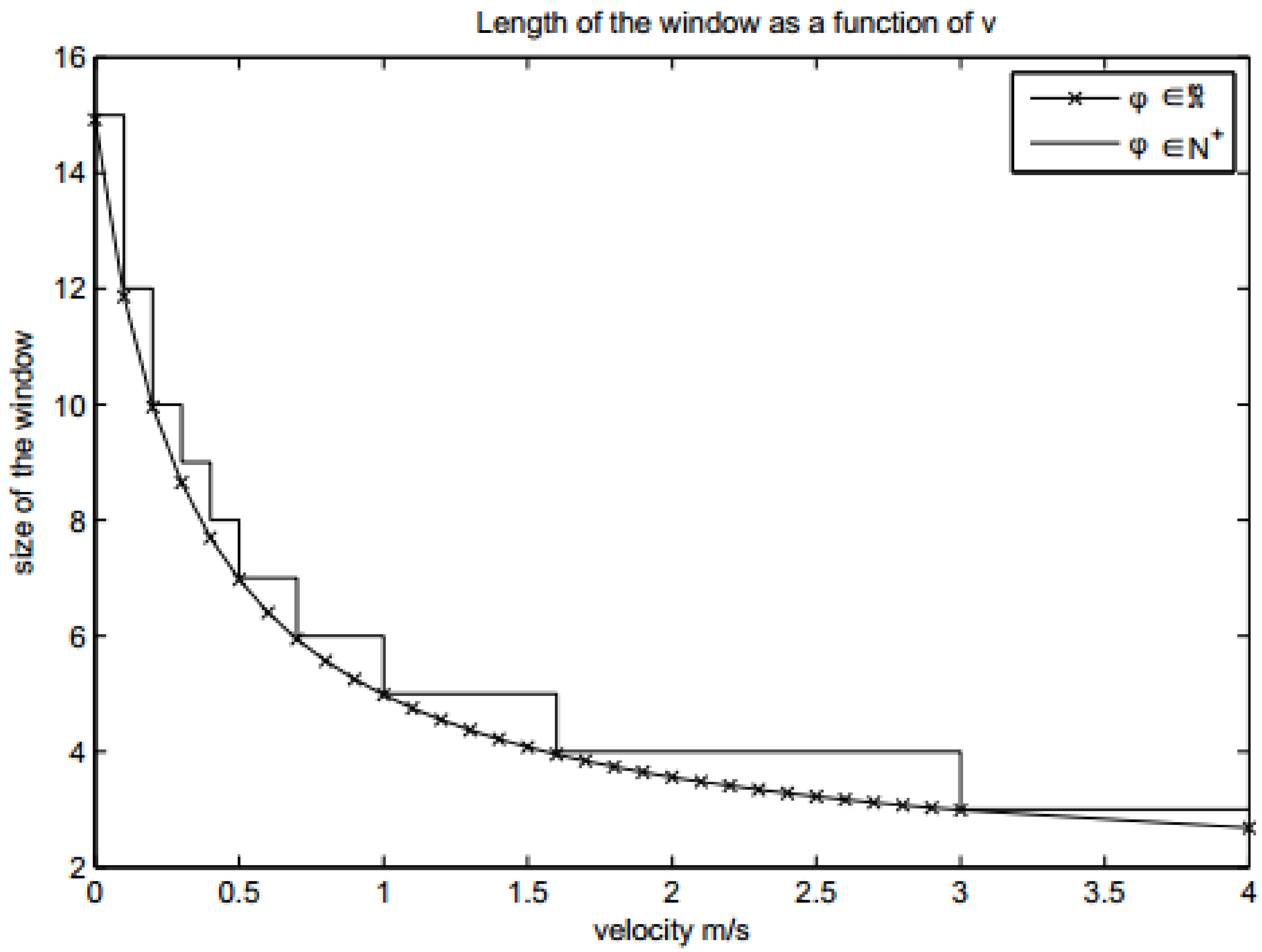


Fig. 3. Size of the median sliding window filter as a function of the speed.