IC1301 -WiPE

Wireless Power Transmission for Sustainable Electronics

Object Tracking Using Commercial RFID Technology

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Motivation: Stock-taking and Human intervention

Motivation: Happy Boss Day

I want
1.less Errors
2.more Efficiency
3. Speed up stocktaking

…then you should
reduce human intervention to
control labor hours and **costs**

Solution: Efficient Automated RFID Robot Inventory

"With the help of a robot, stocktaking can be conducted more often so that data on the availability of goods is always highly up to date."

Advan robot by Keonn technologies (Spain)

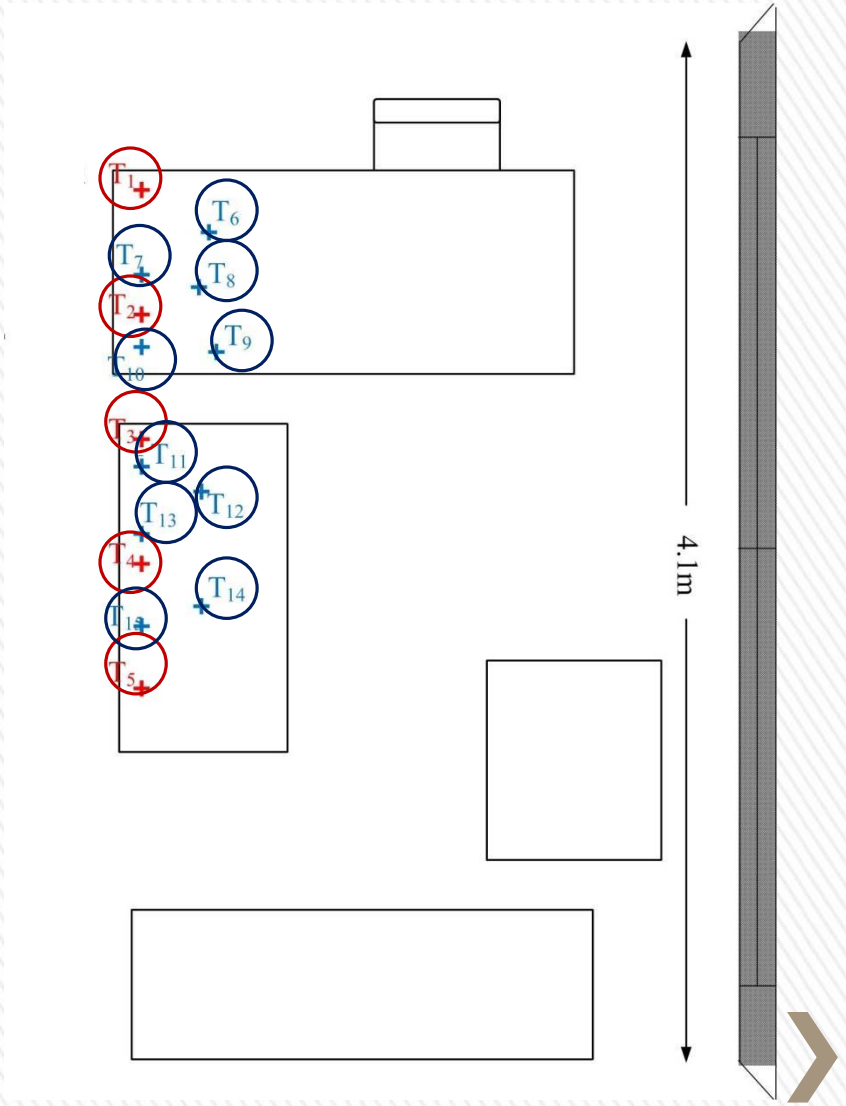
Metralabs Tory (Germany)

Contribution

- Object Tracking Using Commercial RFID Technology
  - Localization of Passive RFID Tags Using a Mobile Cart
  - **WHERE IS EVERYTHING**
- What do we need?
  - RFID Tags
    - reference
  - Reader Antenna
  - Mobile robotic platform
  - …and an efficient localization algorithm
- How?
  - We exploit RSSI, Received Signal Strength Information, from reference and target tags

Example

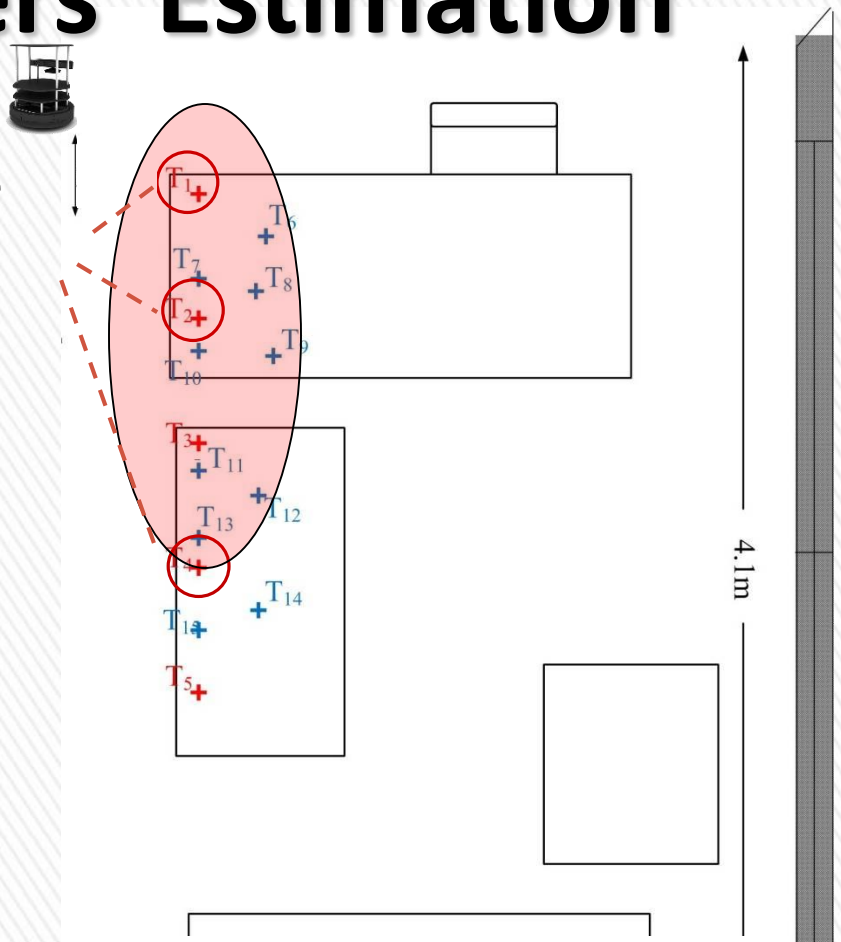
- 5 reference tags are placed in predefined positions +
- target tags are placed in the office +
- a mobile cart starts to move



Example- Readers' Estimation

- Reader moves across a line
- ***N=3*** reference tags send their **RSSI**

  P_1=-49dBm, P_2=-51dBm, P_4=-57dBm
- the **set P** of received **RSSI** is, **P={P_1,P_2,P_4}**
- if **p(P|r)** the *Likelihood conditional probability* of the **set P**, given that the true position of the reader is **r** then



$$p(P|r) = \prod_{i=1}^{N} p(P_i|r)$$

Example- Readers' Estimation

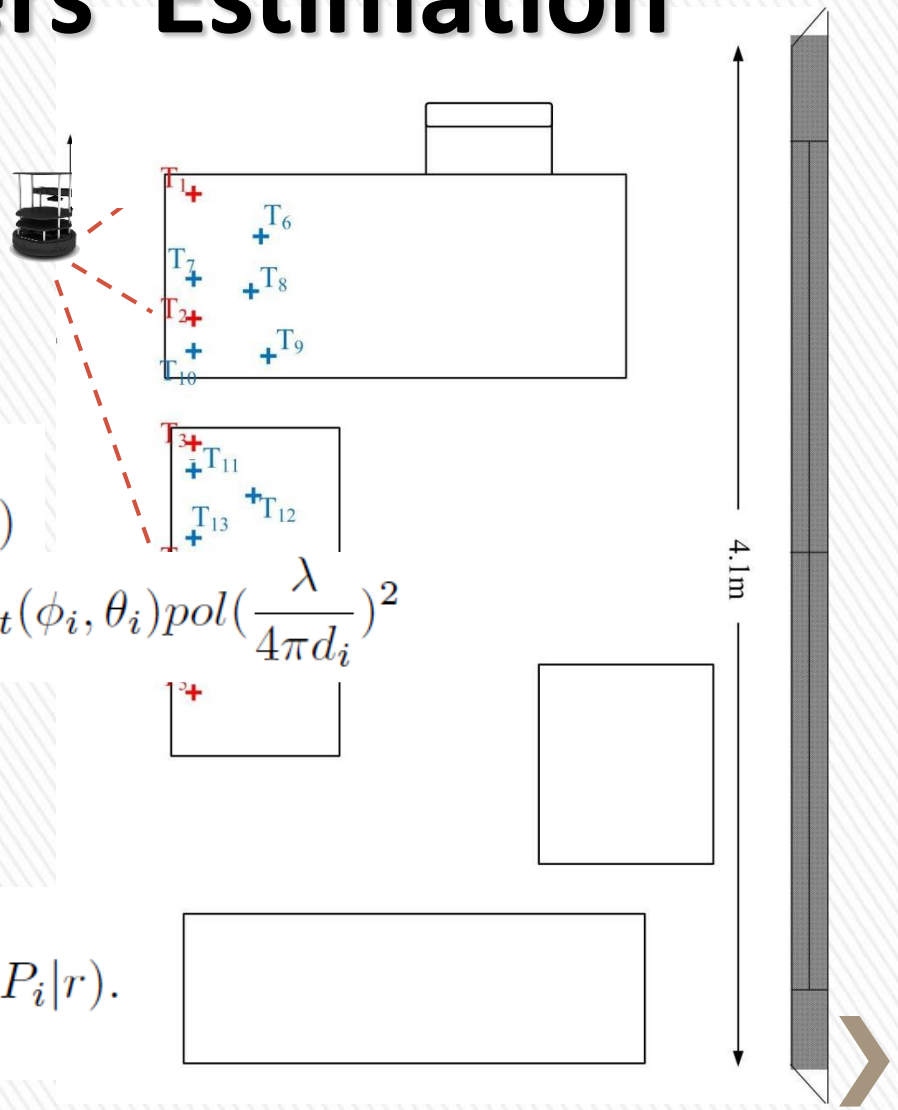
» ….the probability density function of the received **RSSI**, **Pi**, given position **r** is

$$p(P_i|r) = \frac{\sqrt{P_i}}{\sigma^2} e^{-\frac{P_i+\mu_i^2}{2\sigma_i^2}} I_0\left(\frac{\sqrt{P_i}\mu_i}{\sigma^2}\right)$$

$$\mu_i^2 = P_{tagi}\tau(P_{tagi})G_{tagi}(\phi_i,\theta_i)G_{ant}(\phi_i,\theta_i)pol\left(\frac{\lambda}{4\pi d_i}\right)^2$$

» …the entire room is searched to estimate the position r* of the reader

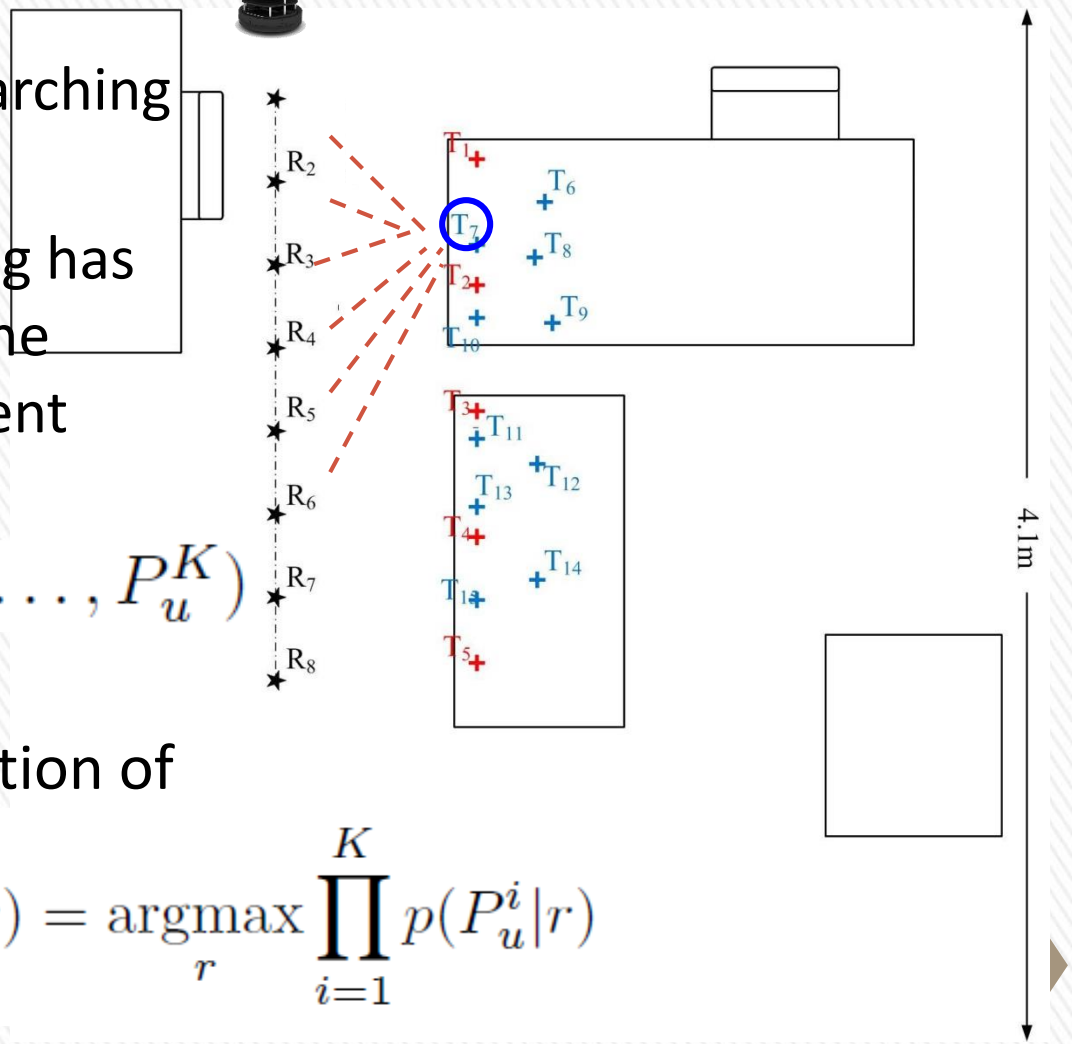
$$r^* = \underset{r}{\operatorname{argmax}}\, p(P|r) = \underset{r}{\operatorname{argmax}} \prod_{i=1}^{N} p(P_i|r).$$



Example-Location of tags

- …assume we are searching for tag ***u=7***
- Consider that this tag has been identified by the reader at ***K=6*** different locations
- If $P_u = (P_u^1, P_u^2, \ldots, P_u^K)$
- then r_u^* is the position of

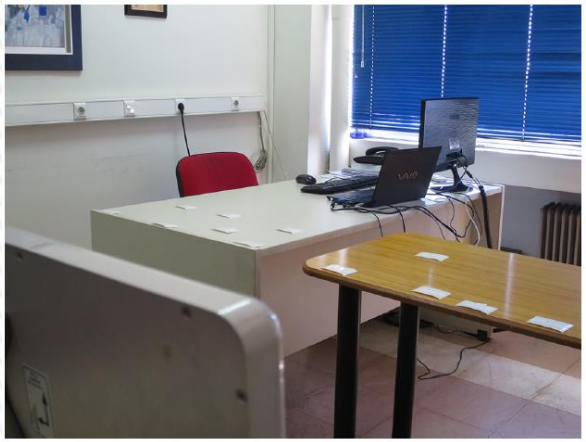
$$r_u^* = \underset{r}{\operatorname{argmax}}\, p(P_u|r) = \underset{r}{\operatorname{argmax}} \prod_{i=1}^{K} p(P_u^i|r)$$

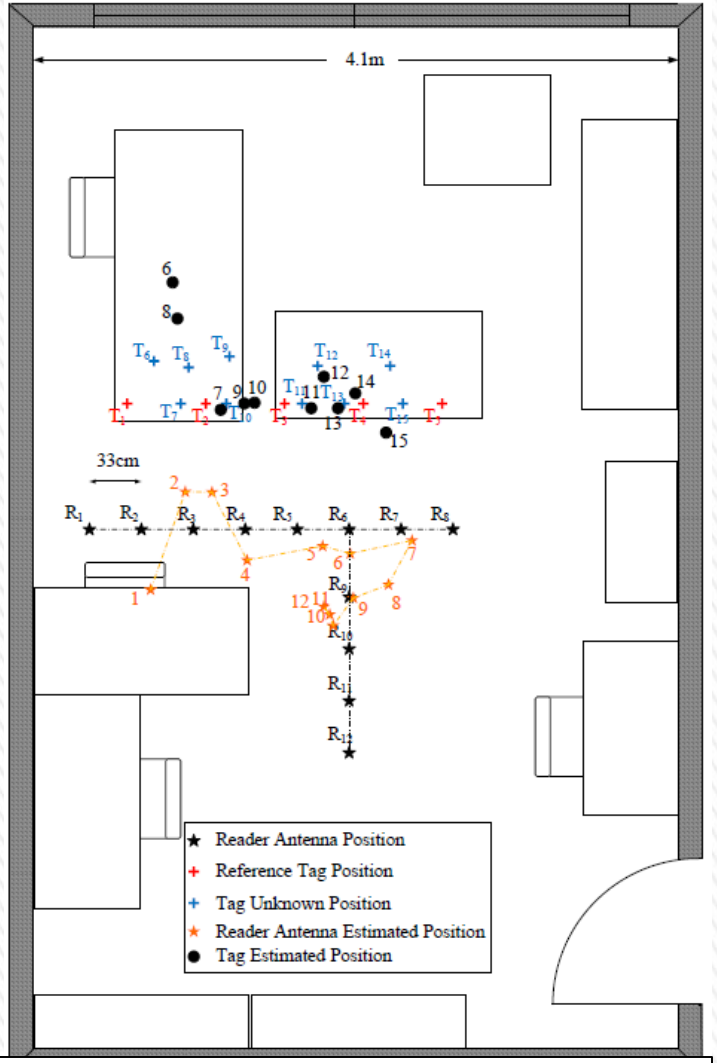


Measurements

Office Environment

- Reader trace estimation error = 33.4cm (σ=24cm)
- Tag error = 25.3cm (σ=12.4cm)





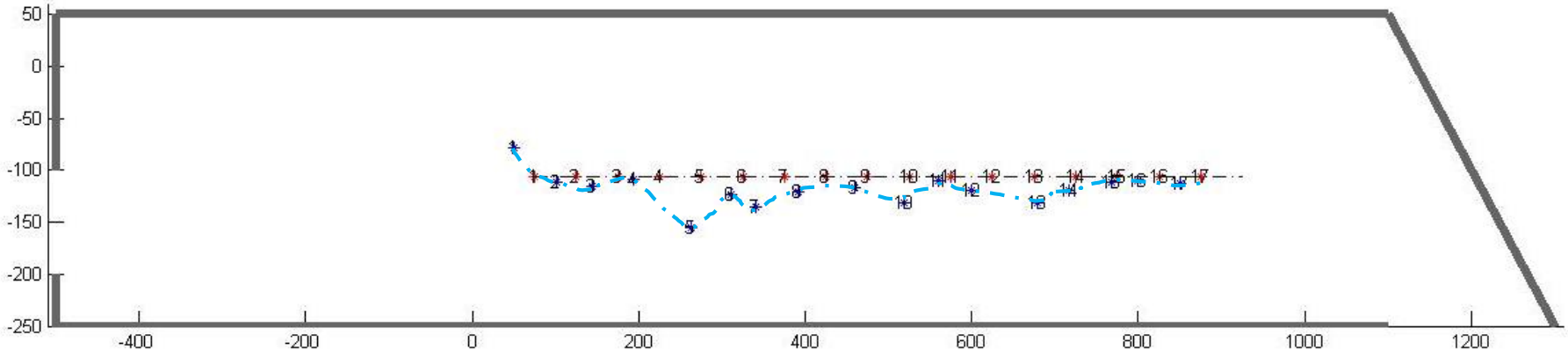
S. Siachalou, A. Bletsas, J. N. Sahalos and A. G. Dimitriou, "*RSSI Based Maximum Likelihood Localization of Passive RFID Tags Using a Mobile Cart*", **IEEE WPTC 2016**, Aveiro, Portugal, May 2016.

Retail-like Environment

- 47 reference tags spaced every 20cm
- 38 “target” tags
- 2 reader antennas (radiating in different time-slots – reader-antenna diversity is investigated)
- Assume that the map of the area is unknown
- **Only the locations** of the **reference tags are known**.

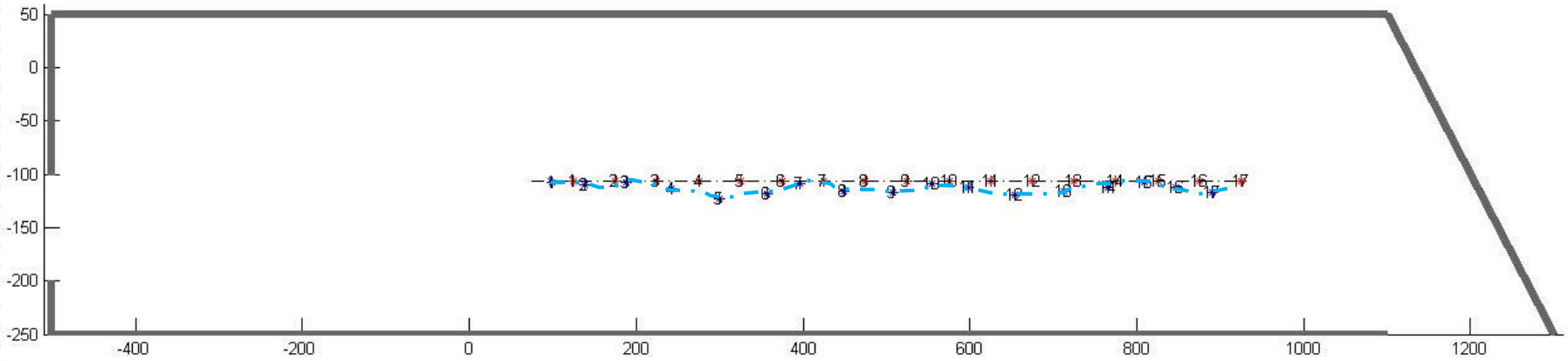
Reader Trace

- Mean error: 27.7cm (σ=10.3cm) - 35.6cm (σ=13.7cm)
  - Reference Tag Spacing = 20cm (dense)
- Source of error: Multipath
  - Improve: Increase the number of samples



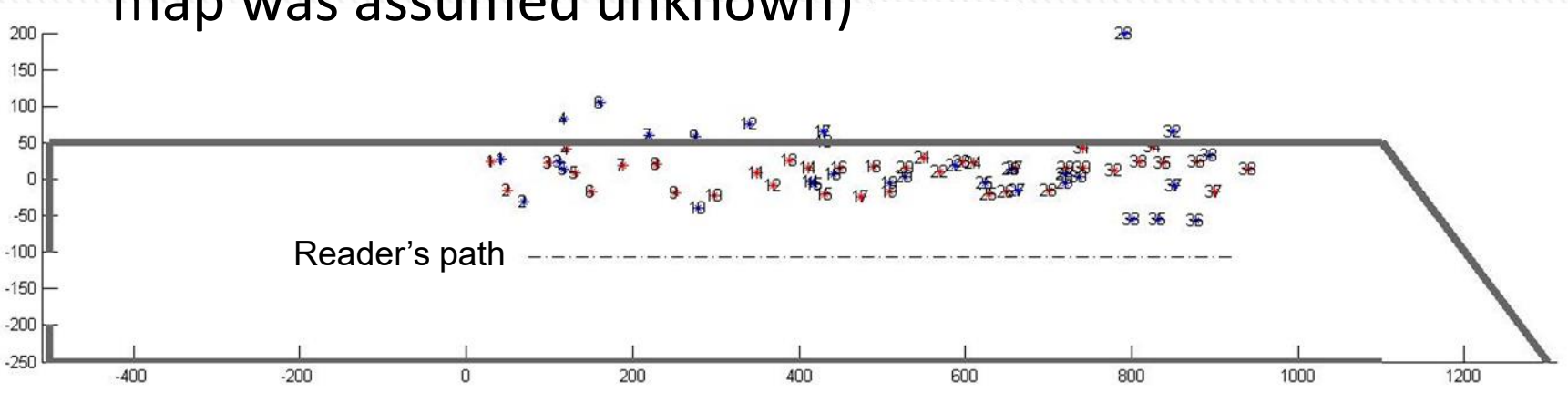
Reader-antenna diversity

» Mean error: 26 cm (σ=7.3cm)



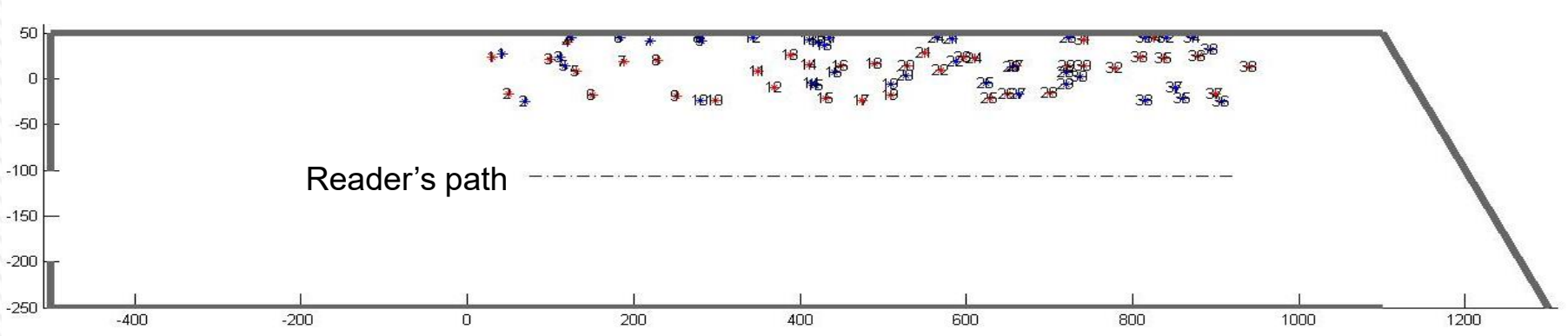
Tags' Localization

- Mean error: 42.7cm (σ=32.7cm) - 43.9cm (σ=31.9cm)
  - + Measurements were collected every 50cm (denser grid is needed)
  - + **Some tags backscattered less power than reference tags (due to aging, or detuning from attached objects)**
- Tags were found outside the walls of the area (the map was assumed unknown)



Exploiting Map Information (SLAM in robotics)

» Mean error: **33.4cm** (σ=22.6cm)



Conclusions

- RSSI localization for passive UHF RFID tags, using only reference tags at known location, seems promising for retail and logistics apps.
- It can be applied with commercial RFID equipment.
- Sub-wavelength accuracy can be accomplished by deploying fading-resistant techniques, combined with visual information, typically used in robotics.

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