Investigations on User Positioning Effects in a device-free Localization System for Smart Environments

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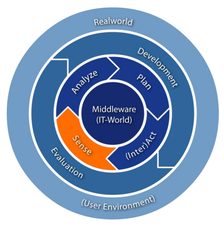
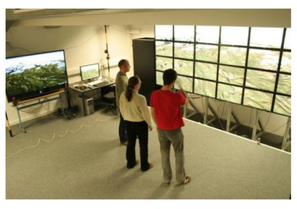
Abstract

Smart environments and their provision of spatial assistance for users with the help of randomly joined device ensembles is the central goal of the Multimodal Smart Appliance Ensembles for Mobile Applications Graduate School (MuSAMA). Basis for intelligent provision of assistance is the existence of data about the people acting in a smart environment.





Central attribute is the user position in a smart room. A new approach for device-free user localization with the help of ground mounted passive Radio Frequency Identification Tags (RFID) is subject to research in the graduate school MuSAMA. Recent work has shown the applicability in a proof of concept. In this work we dealt with the question: is it also possible to get information about the viewing direction of the user from the RFID field data.

Basics

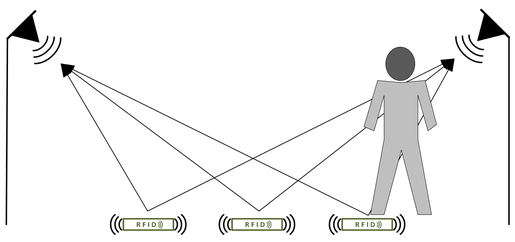
- Measured value: the **signal path loss**, power difference between transmitted and received radio signals

- Physical model: model of Lieckfeldt et. Al.[1]:

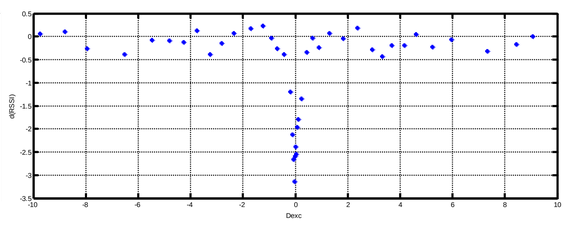
$$\Delta E(d_{exc}) = A d_{exc}^{B} \cos\left(\frac{2\pi}{\lambda} d_{exc} + \phi_{refl}\right)$$

with d_{exc} – Executive Path Length

- Parameter estimation: **least squares** approach based on the change of transmission power from a passive RFID-Tag to an active RFID-Reader in a **few tag scenario**.



Few tag scenario



Observed model

Modeling Observations

- Effect of the users direction on the change of RSSI is related to **multipath effects** of the tag-antenna-communication we considered the model formula (1) and add an **angle dependent term** (2).

$$(1) \qquad \Delta E(d_{exc}, \alpha) = A d_{exc}^{B} \cos\left(\frac{2\pi}{\lambda} d_{exc} + \phi_{refl}\right) f(\alpha)$$

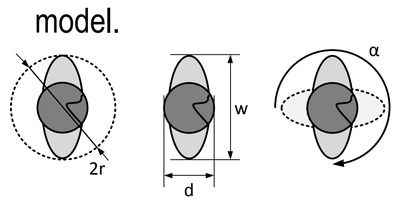
$$(2) \qquad f(\alpha) = \underline{C}\alpha \cos\left(\left(2\frac{\pi}{\underline{D}}\right)\alpha + \underline{E}\right)$$

- For parameter estimation consider observations from different tag readings.

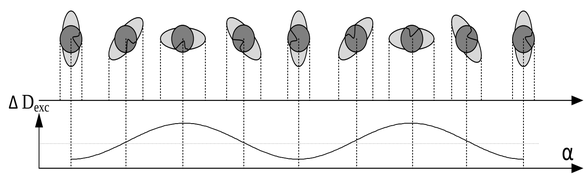
- Behaviour is varying duo to the position of the user due to the fact, that the scattering effect of the user is highest within the area of $d_{exc}/\lambda \leq 0.25$, the **First Fresnel Zone** [2].

- **Cylindrical** model of user body in former studies

- Assuming **elliptical shape** of the human body. Effective **reflection surface** and the position of the **reflection point** are changing with the user's directional movement with consequential effect within the known physical model.



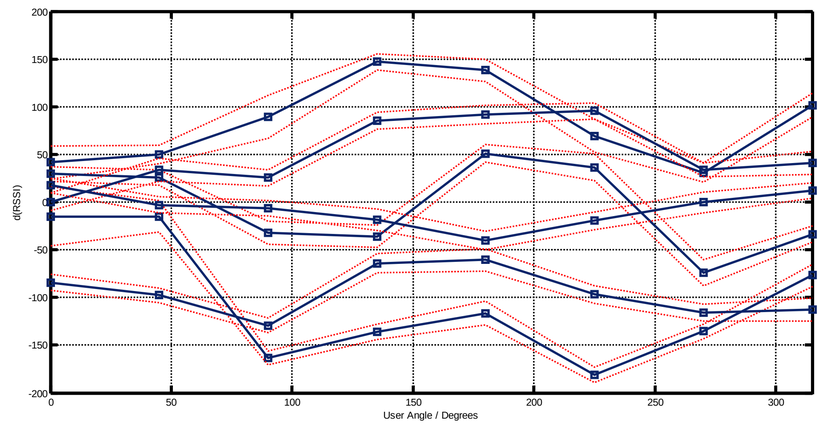
Shape model



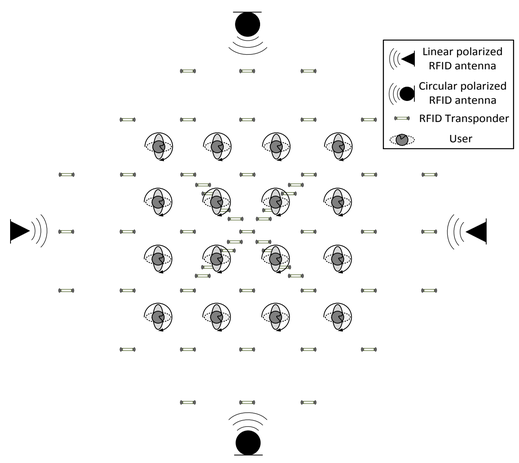
Influence on Path Difference

Simulation & Experiment

- First setup: **one-transponder-scenario** with scatterer on six positions turning on different directional angles.



- System setup: field setup with 4 **bistatic RFID antennas** and 57 tags in the middle of a conference room. On that field we defined **16 user positions with 9 view angles each**. We collected the data from every position-angle combination over the whole field.



References

[1] D. Lieckfeldt, J. You, and D. Timmermann, "Characterizing the Influence of Human Presence on Bistatic Passive RFID-System," *2009 IEEE International Conference on W ireless and Mobile Computing, Networking and Communications*, Oct. 2009, pp. 338-343.

[2] W. Lee, *Mobile communications engineering*. McGraw-Hill Professional, 1982.

[3] H. Liu, H. Darabi, P. Banerjee, and J. Liu, "Survey of Wireless Indoor Positioning Techniques and Systems," *IEEE Transactions on Systems, Man and Cybernetics, Part C (Applications and Reviews)*, vol. 37, Nov. 2007, pp. 1067-1080.

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