

Master Thesis on Unsupervised Weighting for Improved Positioning Accuracy

1. Duration & Start Date

The duration of the study is 6 months including writing the master's thesis. The candidate is expected to start as soon as possible.

2. Requirements

The candidate is required to have knowledge on:

- Unsupervised learning methods (e.g., k-means, gaussian mixture models).
- Time-based positioning methods (e.g., linear least squares, weighed least squares).
- Basics in wireless communication theory (wireless channels, channel impulse response).
- Python and/or MATLAB programming skills to implement the studied algorithms.

3. Topic

Location information is vital for many applications across various domains where some of the applications, such as industrial asset tracking, autonomous driving, and process automation, require highly accurate position estimation [1]. Positioning can be conducted by various approaches including time-based, angle-based and fingerprinting techniques using radio signals.

This study will focus on widely used time-based positioning where multiple time-based measurements associated with a target device are utilized for positioning. However, such measurements do not have the same reliability since they propagate through different radio channels. As a result, some of the measurements carry accurate positioning-related information while some others may be inaccurate due to challenging radio conditions such as non-line-of-sight (NLOS) or multipath propagation. When such inaccurate measurements are used for positioning, they degrade the accuracy of the position estimate. Thus, an investigation is required on how to mitigate such inaccuracies to deliver an improved positioning accuracy.

Existing methods of detecting NLOS measurements and excluding them from the positioning solution, i.e., only utilizing line-of-sight (LOS) measurements, [2-3] are suboptimal solutions. Such classification might be insufficient to describe propagation environment fully leading to an information loss. Moreover, discarding NLOS measurements might lead to a poor positioning performance when the number of available measurements is low. In addition, such hard classification mechanisms cannot distinguish between the reliability of the measurements classified in the same group.

Although ranging error estimation [3-4] and reliability estimation through likelihood ratio tests [5] have been proposed that can be used for weighting the positioning measurements, such methods require labeled data or known probabilistic distributions that can be costly to obtain or might differ across different scenarios.

This thesis will investigate unsupervised mechanisms evaluating the reliability of positioning measurements. This evaluation, in turn, will be used to weight the measurements accordingly to deliver an improved positioning accuracy. Furthermore, the performance of the proposed method will be compared with state-of-the-art methods.

[1] 3GPP, "Study on NR positioning enhancements," TR38.857, V2.0.0, 2021.

[2] M. Stahlke, S. Kram, C. Mutschler, and T. Mahr, "NLOS Detection using UWB Channel Impulse Responses and Convolutional Neural Networks," in *Proc. of International Conference on Localization and GNSS (ICL-GNSS)*, pp. 1-6, 2020

[3] K. Bregar and M. Mohorčič, "Improving Indoor Localization Using Convolutional Neural Networks on Computationally Restricted Devices," *IEEE Access*, vol. 6, pp. 17429-17441, 2018.

[4] H. Wymeersch, S. Marano, W. M. Gifford, and M. Z. Win, "A Machine Learning Approach to Ranging Error Mitigation for UWB Localization," *IEEE Trans. Commun.*, vol. 60, no. 6, pp. 1719-1728, 2012.

[5] I. Guvenc, C.C. Chong, and F. Watanabe, "NLOS identification and mitigation for UWB localization systems," in *Proc. IEEE Int. Conf. Wireless Commun. Networking (WCNC)*, pp. 1571-1576, 2007.