TECHNISCHE UNIVERSITÄT WIEN
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Institut für Computertechnik
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Towards an Evaluation Framework for Indoor Localization using Directional Antennas

Rupkatha Hira, Rahul Indra
Indian Institute of Engineering Science and Technology, Shibpur, India
Stefan Wilker
TU Wien, Institute of Computer Technology, Vienna, Austria

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Introduction

- PinPointIoT
  - Novel Received Signal Strength (RSS) based localization system

- Project goals
  - Improve localization accuracy
  - Develop an innovative fingerprinting method
  - Improve computation time by quickly determining initial position estimates
  - Efforts into Evaluation Framework for Indoor Localization

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Indoor Localization Overview

- Many applications, industrial and private
  - Robots / components in factory of the future
  - Finding lost items
- No "GPS for indoor localization"
  - Interference from different transmitters
  - Reflection / absorption on walls / objects (multipath effects)
- From current market developments:
  - IPhone 11 will support UWB for indoor localization
  - Tile / Apple want to save the search for small items

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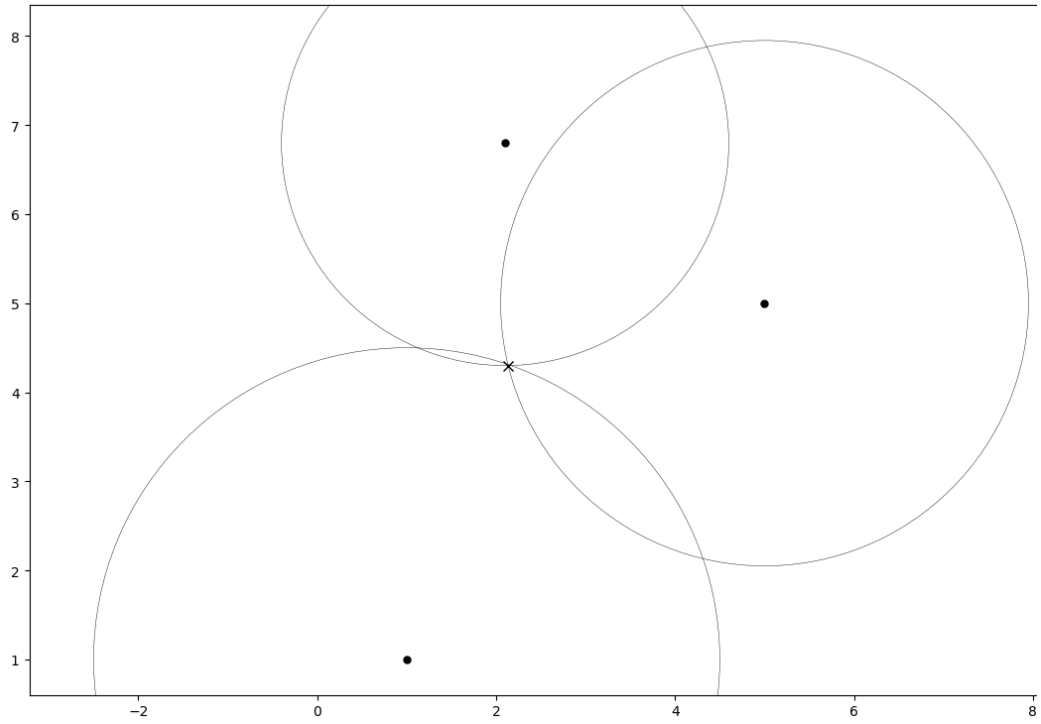
Techniques for indoor localization

- Signal Medium
  - WiFi
  - WPANs (Bluetooth, UWB, Zigbee)
  - sound
- Signal Metrics
  - Signal propagation time
  - Signal strength - RSS
  - Angle of Arrival
- Methods
  - Geometric mapping
  - Fingerprinting



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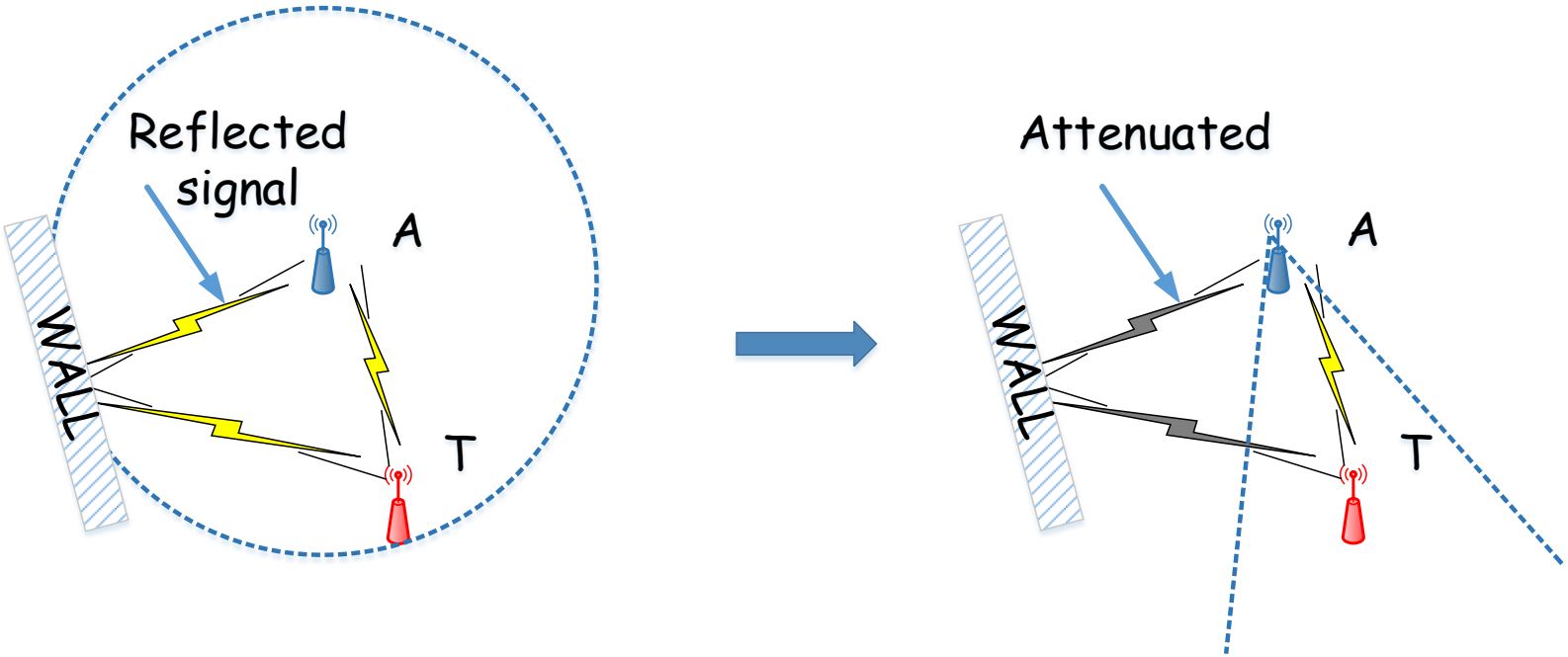
Need of directional Antennas

- RSS is highly affected by various physical effects
- Directional antennas for RSS to mitigate disturbances



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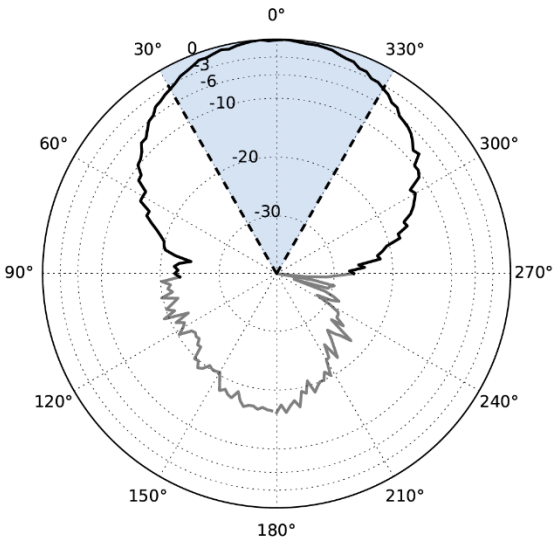
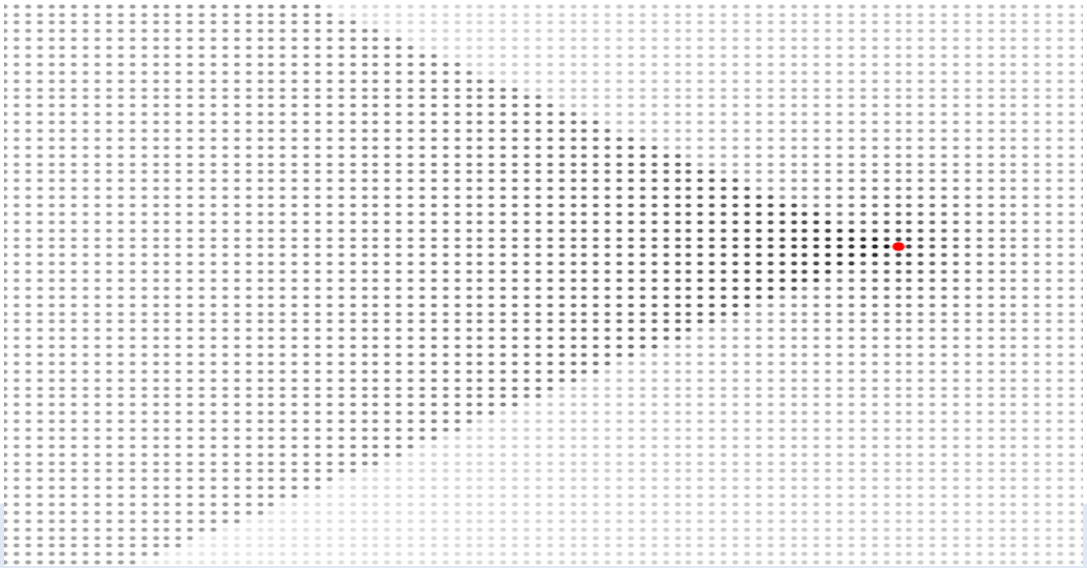
RSS fingerprinting with directional antennas

- Directed antennas
  - Transmission / reception cone
  - Real antennas mostly with directional characteristic
  - Previous work only with angle of arrival
  - Problematic with geom. mapping
- Fingerprinting with directional antennas





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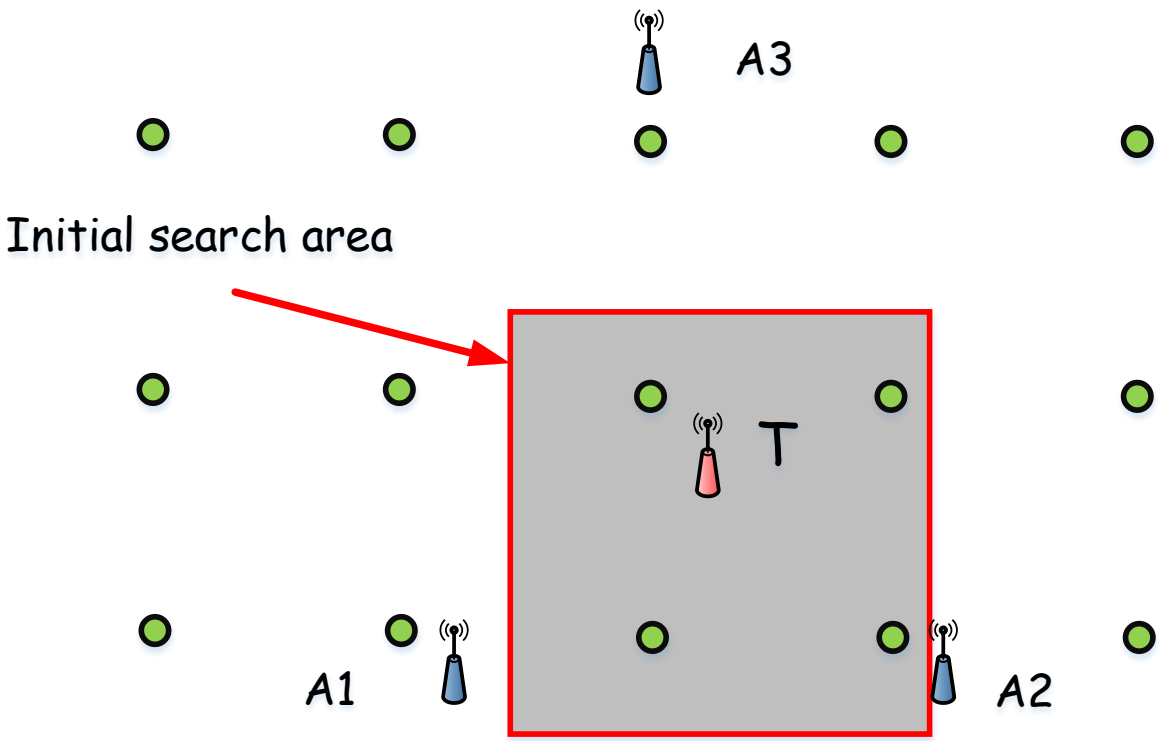
RSS Fingerprinting Optimization

- Algorithm to reduce the number of RSS fingerprint matches
  - A gradient field can be calculated that can be followed to the global minimum.



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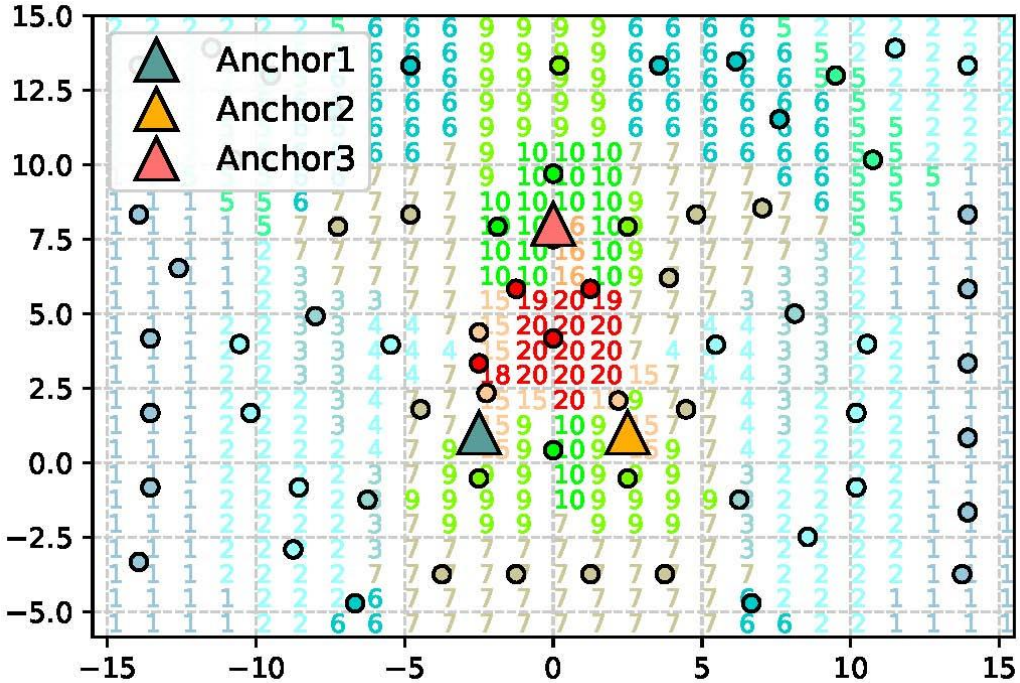
Initial Solution Estimation

- Dealing with the initial solution (area) definition
- Basic idea: characterization of the RSS map
  - Partitioning of the RSS Map using the clustering algorithms



Mean-Shift clustering algorithm result

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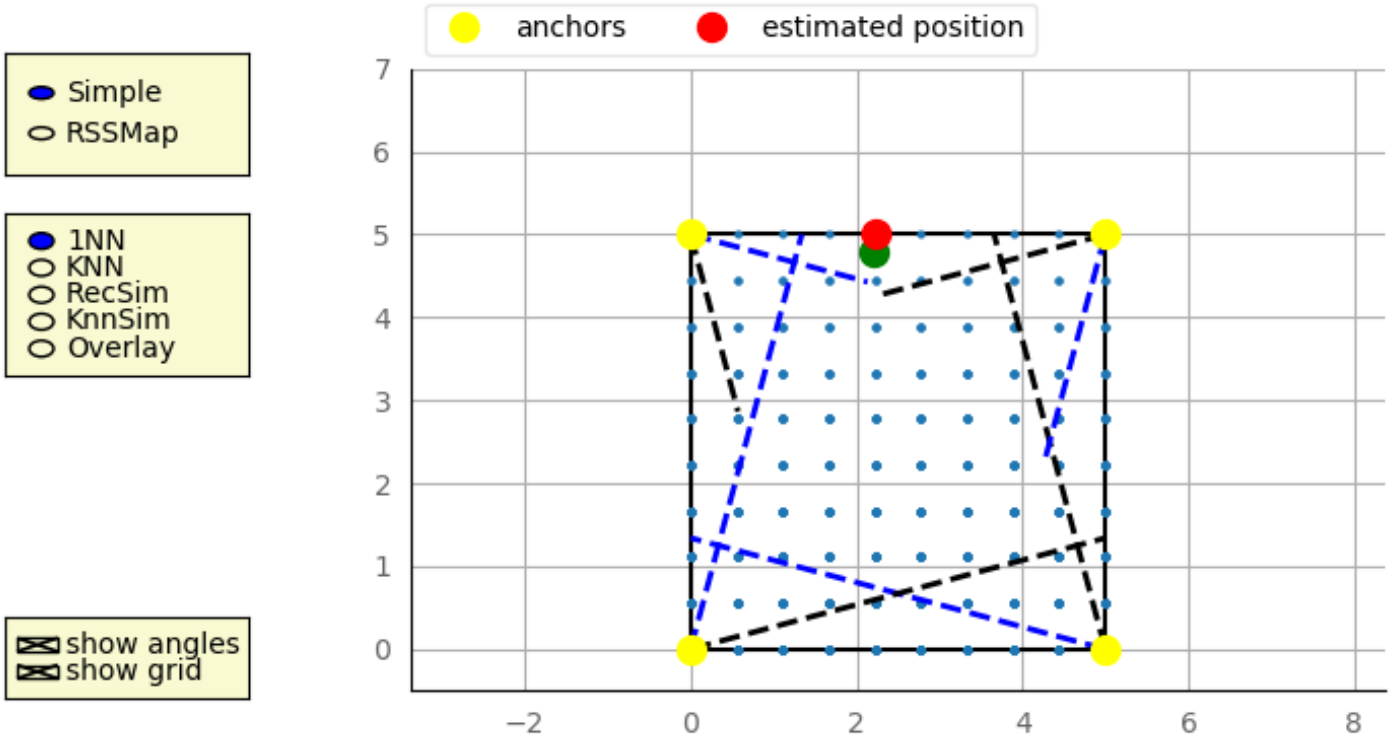
Rooms and Scenario

Class: Room, represents a room in which anchors can be placed, rotated and changed per mouseclick.



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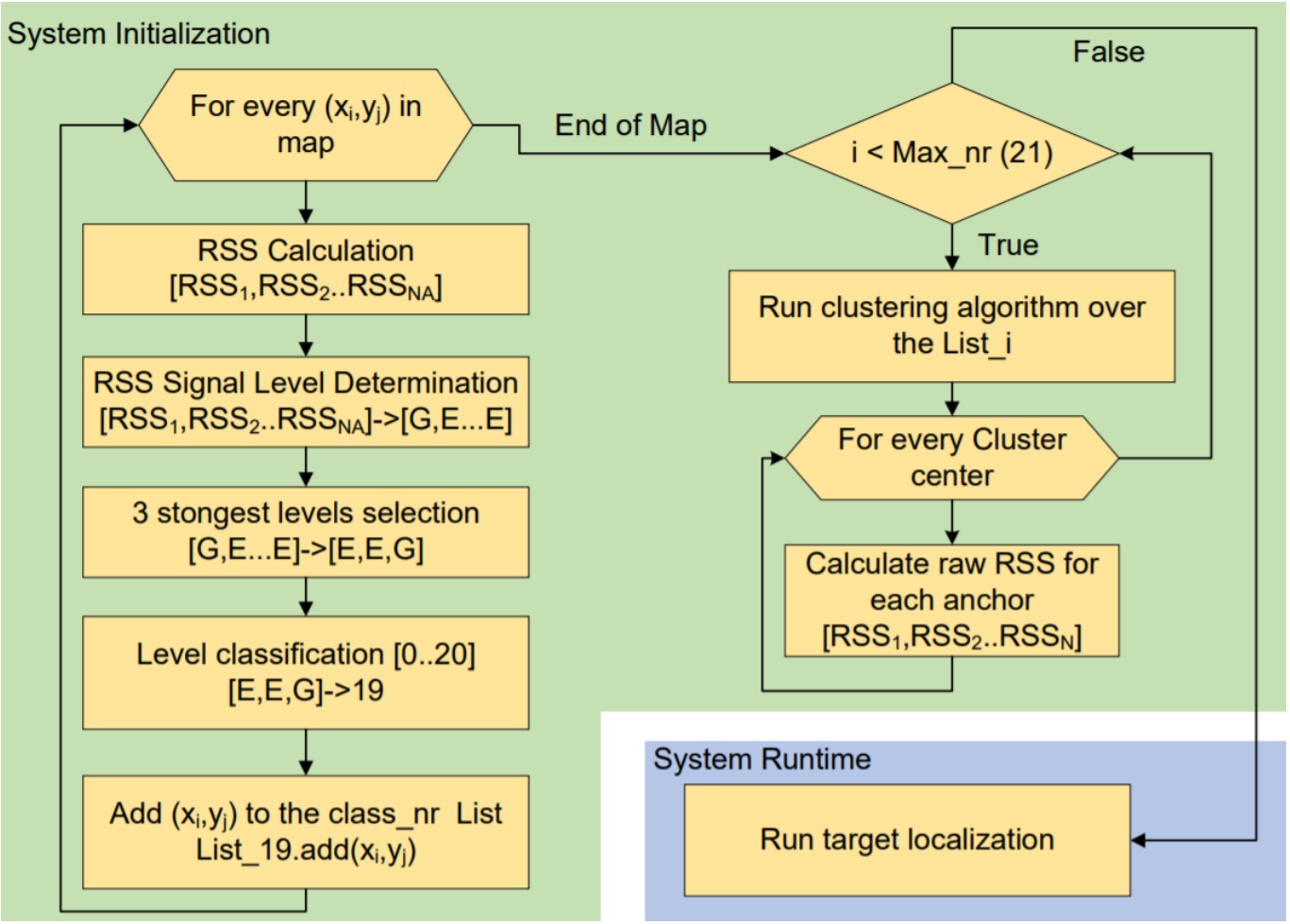
Flowchart general PinPoint localization



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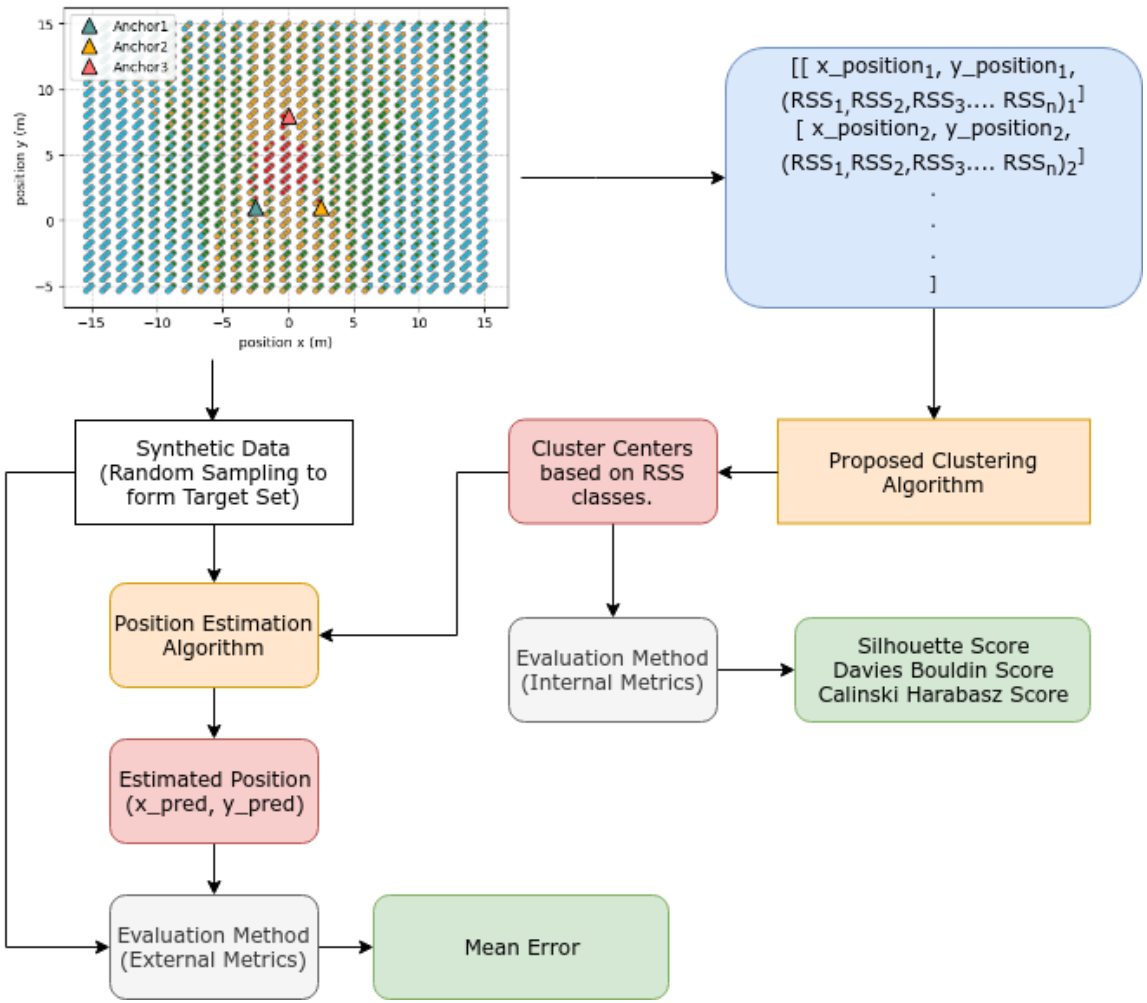
Flowchart for evaluation approach



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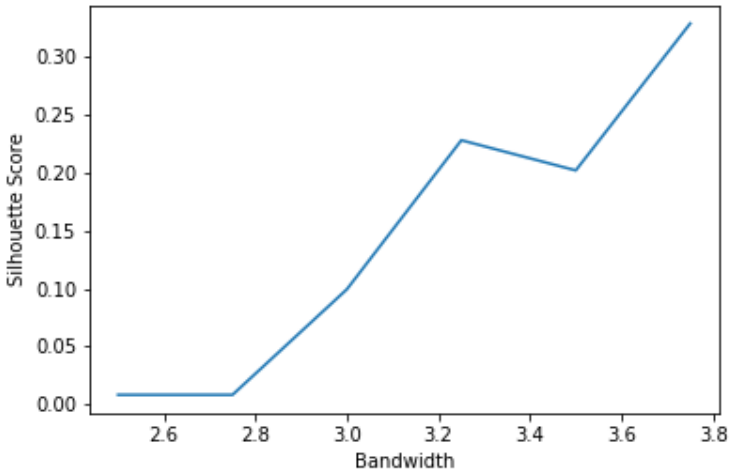
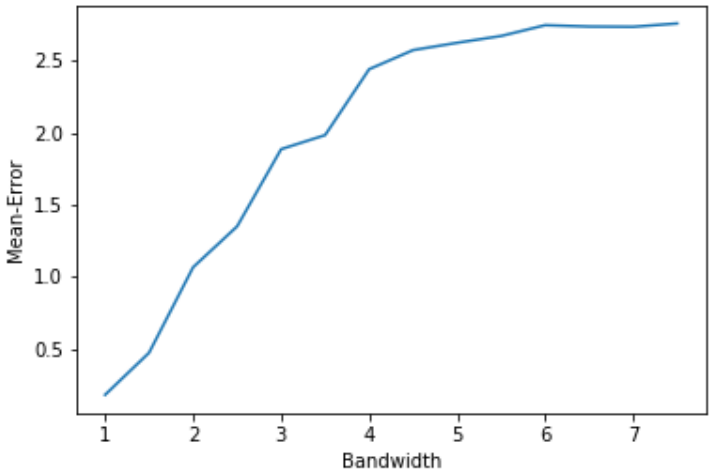
Graphs for Evaluation Method

Internal Metric



External Metric



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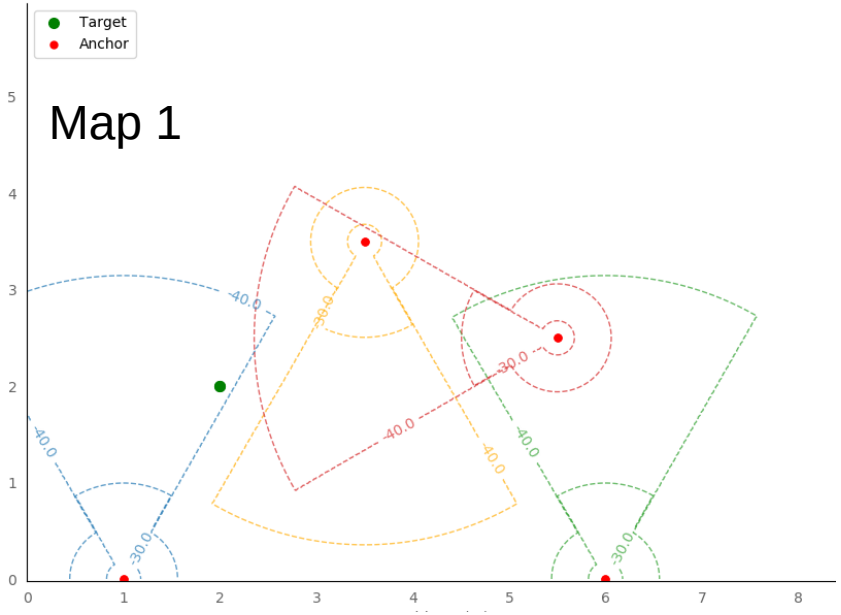
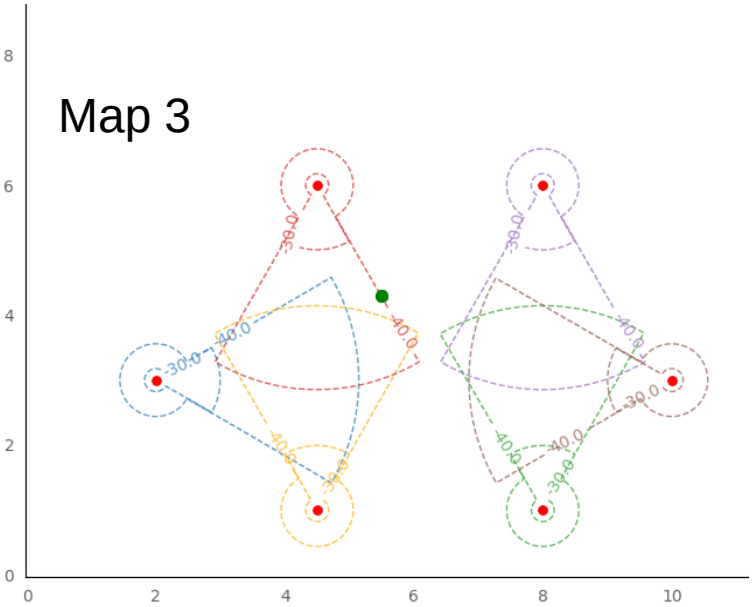
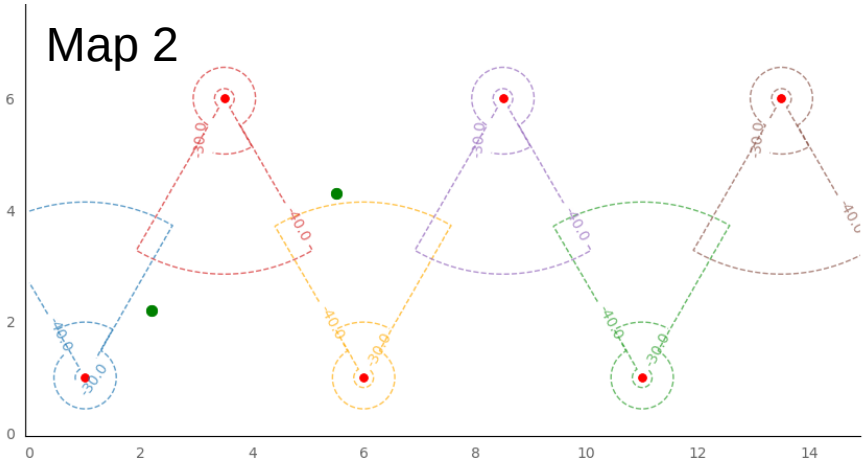
Some exemplary maps (without rooms)







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Clustering Algorithms investigated

- K-Means
- Mean-Shift
- BD-Scan
- Kalman Filter Expectation-Maximization
- Particle filter / sequential Monte Carlo algorithms
- Kernel density estimation
- linear/polynomial regression
- Regression tree
- Sliding-Window Average/Median

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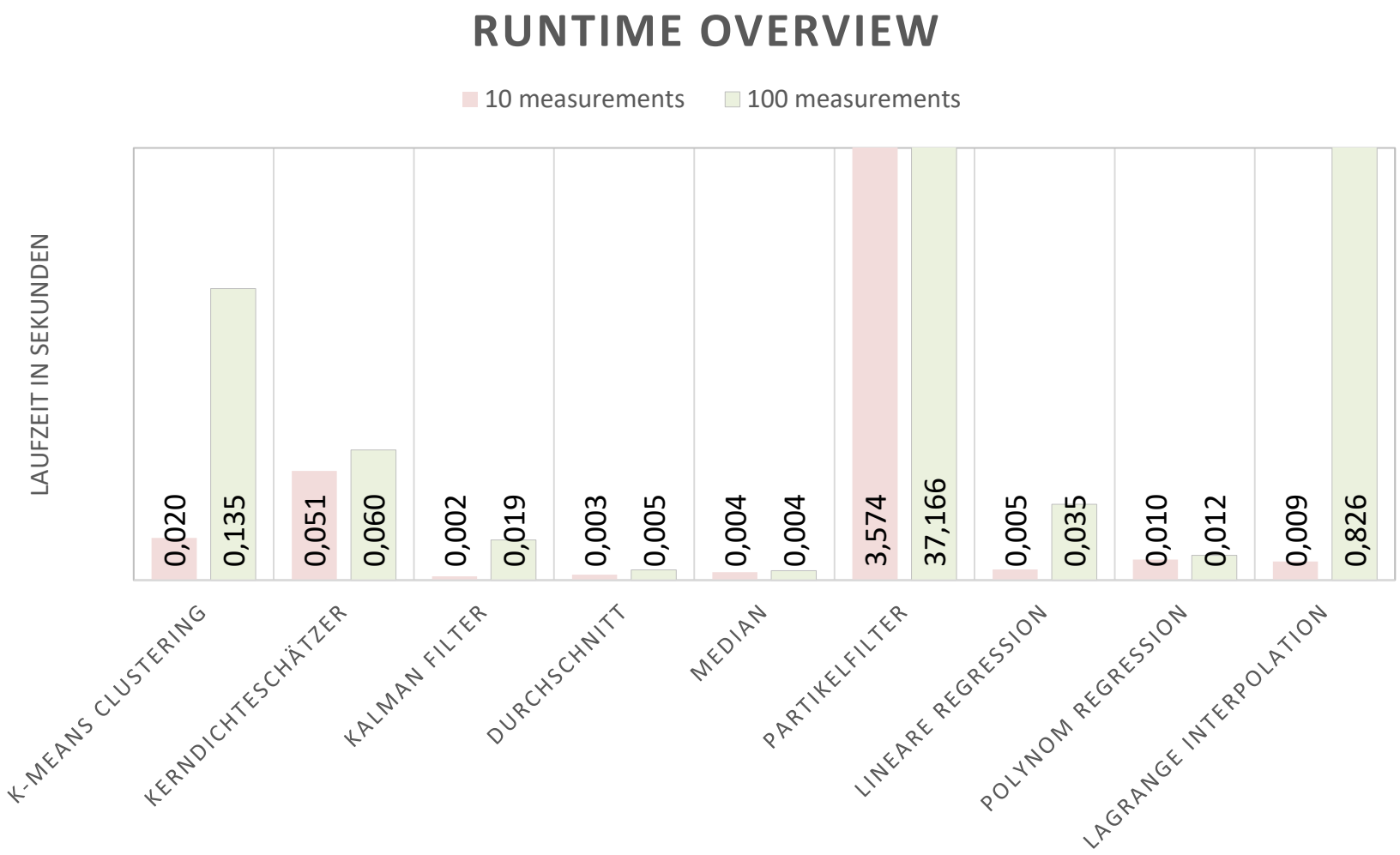
Run times visualized



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Outlook and next steps

- Test szenario automatisation
- Detailed comparison tables based on szenarios
- Enhance reflection behavior in room settings
- PinPoint IoT related references:
  - A. Nagy, T. Bigler, A. Treytl and T. Sauter, "A Radio-Map clustering Algorithm for RSS based Localization using Directional Antennas," *2019 15th IEEE International Workshop on Factory Communication Systems (WFCS)*, Sundsvall, Sweden, 2019, pp. 1-4. doi: 10.1109/WFCS.2019.8757938

    URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8757938&isnumber=8757867

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Viktor Kaplan Straße 2
A-2700 Wiener Neustadt

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