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Fusing Measured and Simulated Data for Radio Map Construction in Localization Applications

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Most localization algorithms can be classified into the geometrical approach, where the location of the target is determined geometrically using the estimated range of the target or the angle of arrival (AOA) of the target's signal at receiver sensors. Range and AOA estimation require the line-of-sight (LOS) between the target and sensors, which is unlikely in a dense urban scenario where the antenna heights are much lower than the building heights. It is expected that fingerprinting approaches, which do not require LOS, achieve higher localization accuracy than geometrical ones.

The fingerprinting approach requires the pre-construction of a fingerprint database, also called a radio map. Channel parameters such as the received signal strength (RSS) are mapped to their transmitting location coordinates and stored onto the radio map. Then, localization of the target is performed by comparing its measured RSS to those on the radio map. Although this approach may work well in non-LOS environments, one of the main drawbacks is the construction and maintenance of this radio map. Especially for outdoor applications covering an area of several square kilometers, the cost, time and effort to perform extensive measurements and collect fingerprints over a wide area is considerably high. Several approaches have been considered to reduce this burden of constructing the radio map, such as using a simplified propagation model, performing electromagnetic simulations such as ray-tracing, crowd-sourcing of measurements, or a hybrid of them. The use of ray-tracing simulations for indoor fingerprint-based localization was investigated in [1] using CIR fingerprints. In [2], the spatial correlation characteristics between neighboring RSS fingerprints obtained through simulations was exploited to perform localization without requiring the construction of the whole radio map.

In this paper, we shall consider radio map construction approaches where a large amount of RSS fingerprints obtained through ray-tracing simulations are used to complement a limited amount of fingerprints obtained through actual measurements. In general, a highly detailed model of the propagation environment is required in ray-tracing in order to accurately simulate the RSS. However, the construction of this model itself may be costly and time-consuming. We consider the case where a simplified model of an urban area is used in the simulations, and propose a method to correct the inaccurate simulated RSS radio map using several RSS measurements. Measurements were conducted in a university campus area [3], and ray-tracing was utilized to simulate the RSS. The spatial correlation characteristics of RSS was learned from the simulated data and was applied to the measured data through the Kriging algorithm [4]. The newly obtained radio map was utilized for localization of unknown targets, and localization accuracy was evaluated compared to conventional techniques which utilize only the measured or simulated RSS radio map.

References

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