論文 / 著書情報
Article / Book Information

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Title(English)	Fingerprint-based Localization of Unknown Radio Emitters in Outdoor Urban Environments
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種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

専攻： Department of	国際開発工学　専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　（　工学　）
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Chapter 1, "Introduction", gives an explanation regarding the background and main motivation for conducting this research. Localization has many applications in a wide range of fields, but in this thesis, emphasis is given on applications of localization for radio surveillance. The recent situation of illegal radios in Japan is presented, including a concise description about the localization system currently employed by the Japanese government. Then, main objectives of this thesis is presented, which is to propose a novel algorithm for localization of unknown radio emitters in dense urban environments. Several requirements for the system are identified considering the harsh conditions in the assumed scenario.

Chapter 2, "Overview Of Localization Techniques", presents a brief summary of existing localization techniques. The basics of operation for several conventional techniques is explained, and the limitations of each technique is highlighted. Localization techniques are divided into range-based techniques such as multilateration, and range-free techniques such as triangulation and location fingerprinting. This chapter focuses more on the fingerprinting technique, considering its advantages over other techniques in non-line-of-sight environments. A literature review on the types of fingerprints previously proposed by other researchers is conducted, and several conventional pattern matching algorithms is summarized briefly. In Sect. 2.5, the main challenges faced when performing localization on unknown emitters in urban environments is explained in detail, and the necessity for a new algorithm which overcome these challenges is emphasized.

Chapter 3, "Localization utilizing Channel Impulse Response as Location Fingerprints", proposes a novel localization technique which employs the channel impulse response (CIR) as location fingerprints. Although it may difficult to realize this technique due to lack of knowledge regarding the transmit signal of the unknown emitter, its possibility is explored in this chapter. Firstly, the proposed fingerprint model is explained in detail. In Sect. 3.4, a detailed description regarding the proposed system architecture is provided, followed by explanation regarding the training phase. Then in Sect. 3.5, algorithms to perform interpolation of the fingerprint in the bandwidth (delay), frequency and spatial domains are newly proposed. These interpolations are necessary in order to gain flexibility to support a wide range of possible parameters used by the unknown emitter. Evaluation of the proposed technique is performed through Monte Carlo simulations, and the radio propagation channel in the area surrounding Shinjuku station (Tokyo) is simulated using a commercial ray-tracing simulation software. The results indicate several practical issues when dealing with CIR fingerprints including sampling offsets, and methods to compensate such errors are also discussed.

Chapter 4, "Localization utilizing Cross-Correlation of CIR as Location Fingerprints", proposes another novel localization technique which utilizes the cross-correlation of CIRs between several receiver (Rx) sensors as location fingerprints. This fingerprint is able to overcome most of the requirements of the system, which was previously identified in Chapter 1. The fingerprint model is presented, followed by details of the training phase. In Sect. 4.5, algorithms to perform interpolation of fingerprints in the bandwidth, frequency and spatial domains are proposed, which are a modification of those proposed in Chap. 3. Section 4.6 presents the evaluation results of the proposed technique in a comprehensive manner. Results indicate the effectiveness of the proposed technique compared to conventional ones, in particular the robustness against the unknown emitter's parameters.

Chapter 5, "Localization utilizing Phase-difference between Antenna Elements as Location Fingerprints", proposes another novel localization technique which utilizes the phase-difference between elements of

an antenna array as location fingerprints. This fingerprint is able to exploit the angular information of the propagation channel by employing an array antenna at each Rx sensor, unlike the fingerprints proposed in the previous chapters. The fingerprint model employed in this chapter is described, and interpolation techniques in the frequency and spatial domains are presented, together with an angle-of-arrival estimation algorithm for the dominant multipath. Localization accuracy is examined under similar conditions with those used in the previous chapter for easier comparison, and results indicate promising results compared to conventional techniques.

Chapter 6, "Hybrid Localization Algorithm Combining Proposed Techniques", introduces a hybrid algorithm which combines the proposed techniques in Chapters 4 and 5. A probabilistic approach is applied to the pattern matching, and the joint likelihood function of the hybrid algorithm is derived under several simplifying assumptions. In Sect. 6.3, simulation results which compare the localization accuracy of the hybrid algorithm with those of the individual techniques is presented, and the results reveal how the strengths of each individual proposed technique may be maximized to achieve an even higher localization accuracy.

Chapter 7, "Near Real-time Tracking of Unknown Emitter using Particle Filters", discusses the application of particle filters, which is a recursive Bayesian estimation technique, in order to realize near real-time dynamic tracking of the unknown emitter which may be moving. In Sect. 7.2, the effect of various system parameters on computation load is analyzed, which revealed the necessity of reducing the search space in the pattern matching algorithm. Section 7.3 introduces a technique to narrow down this search space by utilizing Voronoi diagrams with overlap and the rank of the received signal power at several Rx sensors. Section 7.4 proposes a novel implementation of the particle filter which may help reduce the computation load of the localization technique while performing dynamic tracking of the unknown emitter. Results indicate that the computation load can be suppressed significantly without sacrificing much accuracy in localization.

Chapter 8, concludes the thesis with a summary of important findings, as well as possible research topics for future work.