論 文 の 内 容 の 要 旨

論文題目　Practical wireless localization algorithms for IoT
（IoTシステムにおける実用的な無線位置推定アルゴリズム）

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Wireless localization is a fundamental task which refers to extracting geo-locating information of an object based on its wireless signals to multiple known devices. It plays important roles in the Internet of Things (IoT) due to its numerous important applications, particularly industrial applications, commercial environments, public safety settings, and everyday life and defense/security systems. Rapid technological development in IoT offers new opportunities for wireless localization. New network systems, applications, IoT equipped devices, etc. produce unconventional localization problems which remain mostly unexplored.

The main purposes of this dissertation are to propose and motivate new localization problems, as well as to develop practical techniques to resolve the problems. It focuses on a proposal of a new localization problem related to scenarios where the device positions are known a priori, however, the device IDs are not, and therefore need to be matched using radio frequency methods. The problem, called WLMP: the wireless localization matching problem, is motivated through various real-world applications including, but not limited to, disaster prevention wireless sensor networks (WSNs), indoor positioning, and smart lighting and heating systems. We propose several practical techniques to resolve the WLMP in different scenarios and network paradigms. Extensive computer simulations and real experiments in various environments validate that the proposed techniques can achieve high localization accuracy satisfied the requirements of real-world applications.

The dissertation consists of three parts. The first part investigates major wireless localization systems and techniques. It studies the properties and applicability of every technique to derive low-cost techniques that are most suitable for almost all IoT devices. The second part exploits low-cost localization techniques through two different prior studies. The first study illustrates that localization in multi-hop networks can produce coarse location of wireless devices, thus substantiating the validity of low-cost localization. The second study demonstrates that received signal strength (RSSI) based localization, which is one of the low-cost localization methods, can achieve satisfactory accuracy for some specific applications, thus validating the applicability of low-cost localization. The third part, which is the main part, therefore, proposes low-cost localization techniques to resolve the WLMP in different scenarios and network paradigms. It first proposes practical methods resolving the problem under mesh network paradigms. The proposed algorithms do not rely on propagation models, i.e. independent of wireless environments, thus being practical because they do not require a priori measurements. Besides, in the scenario that a priori measurements can be conducted, we propose a method to improve the accuracy of these localization algorithms. All of these techniques and algorithms are validated through extensive simulations and various real experiments in different environments. Consequently, the WLMP can be resolved efficiently using mesh network models. In practice, however, some sensor networks are not built as mesh networks, i.e. sensor nodes are not connected with each other. Instead, they are connected to a central unit, e.g. a wireless concentrator. Using a mobile central unit, we propose an alternative method to resolve the WLMP. The proposed method is validated through extensive simulations. In conclusion, the WLMP can be solved efficiently in the context of different network models.

This dissertation advances the state of art on wireless localization for IoT in several dimensions. First, it defines and promotes unexplored localization problems that are applicable in many real-world applications. Second, it bridges gaps between theory and practice by exploring features that are hard to get practically and exploring new features that can be obtained easily in practice for a certain network system. Replacing impractical features with new features, it proposed practical algorithms for resolving defined problems. Besides, the proposed methods are easily deployable in different environments because they do not rely on a specific environment/hardware. Third, the stability of the proposed methods is not only proved theoretically but also evaluated through various experiments. Last but not least, extensive real experiments in various environments illustrate that the proposed localization methods can achieve enough localization accuracy for real applications, thus validating the practicability of the proposed localization techniques.