DOCTORAL THESIS

Enhanced signal propagation models and algorithm selector for providing location estimation services within cellular radio networks

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Date of Award:
2007

Enhanced Signal Propagation Models and Algorithm Selector for Providing Location Estimation Services within Cellular Radio Networks

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A thesis submitted in partial fulfillment of the requirements
for the degree of
Doctor of Philosophy

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Hong Kong Baptist University

January 2007

Abstract

Mobile location estimation or mobile positioning is a crucial technology for mobile computing and ubiquitous computing. In this research, our purpose is to provide the estimation of the location of the mobile station (MS) under the GSM network, which is one of the dominant cellular radio networks in Hong Kong. Furthermore, our designs of models and algorithms are required to apply to different kinds of cellular radio networks, like the CDMA network, for real applications. We have designed our location models and algorithms based on the common attribute of all cellular radio networks—the Received Signal Strength (RSS). So our proposed models and algorithms in the thesis can be applied to all kinds of cellular radio networks in theory.

A geometric model, the Ellipse Propagation Model (EPM), has been proposed to provide the estimation of the location of the MS. It is a geometric model which considers the directional transmission property of the antenna. We present two algorithms based on EPM: the Geometric Algorithm and the Iterative Algorithm. We also present a data fusion method, the Statistical Estimation, with EPM to estimate the location of the MS. It uses the information of more than one snapshot to provide the estimation of the location of the MS. It can reduce the effect of the signal fading and fluctuation to the estimation, thus, it can provide an accurate estimation for location services. We then extend this geometric model into a 3D space in order to provide a 3D estimation of the location of the MS in applications.

Although EPM is simple and efficient to provide the estimation of the location of the MS, it is a simple approximate relationship between the RSS and the MS-BS distance. EPM is too simple to describe the complex surroundings factors. In view of that, we

present a probabilistic model, the Modified Directional Propagation Model (MDPM), to describe the relationship between the RSS and the MS-BS distance. MDPM is derived from the Directional Propagation Model (DPM), and combines the merits of DPM, EPM and SPM—the Statistical Propagation Model. We also propose an iterative method, not Expectation-Maximization (EM) algorithm, to provide the estimation of the model parameter, which can reach the global maximum of the likelihood function about the model parameter. We then provide the estimation of the location of the MS based on MDPM with the Bayes Estimation of the model parameter. Although our experiment provides a 2D solution in this thesis, our method of MDPM can be easily extended to the 3D space. Namely, we can provide a 3D estimation the location of the MS with our method without any major changes.

After we have presented a geometric model, EPM, and a probabilistic model, MDPM, it is natural to combine these models and gets the best out of these algorithms, since each algorithm mentioned in this thesis has its own advantage over different regions. We have presented three algorithm selectors making use of the LDA Classifier Model and the Bayes Classifier Models to combine the merits of these models and algorithms we have proposed in our previous work. For the Bayes Classifier Models, we propose two variations: the Naïve Bayes Probabilistic Model and the Bayes Probabilistic Model.

With the technical support from the local mobile phone operator, we have constructed and conducted several real world experiments in different kinds of environments in Hong Kong for our investigation. Experimental results show that the algorithm selector is effective and can provide an accuracy better than by any single algorithm alone in all kinds of terrains and environments in Hong Kong.

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