

Comparing LR, GP, BPN, RBF and SVR for Self-Learning Pattern Matching in WSN Indoor Localization

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ABSTRACT

It is a challenging issue to apply WSN (Wireless Sensor Network) to achieve accurate location information. PM (Pattern Matching), known as one of the most famous localization methods, has the drawback of requiring high initialization effort to predict/train MF (Matching Function). In this paper, the authors propose SPM (Self-learning PM) to improve not only the localization accuracy but also the initialization effort of PM. SPM applies a divide-and-conquer self-learning scheme to reduce the number of training patterns in training. Additionally, it introduces a Bayesian filtering scheme to remove the noise signal caused by multipath effects so as to enhance localization accuracy accordingly. This paper applies different training methods (linear regression, Gaussian process, backpropagation network, radial basis function, and support vector regression) to evaluate the performances of SPM and PM in a complicated indoor environment. Experiments show that SPM is better than PM for all training methods applied. SPM can use up to 72% fewer training patterns than PM to achieve the same localization accuracy. If the same number of training patterns is utilized, SPM can achieve up to 58% higher localization accuracy than PM.

Keywords: Indoor Localization, Matching Function, Pattern Matching, Self-Learning, Self-Learning PM, Wireless Sensor Networks

1. INTRODUCTION

Location tracing of a specific item has become an important problem and challenging issue for abundant LBS (Location-Based Service) applications. In past years, large numbers of studies have aimed at proposing location solu-

tions by WSN (wireless sensor networks) (or networks of other wireless RF devices), such as AOA (Angle Of Arrival) (Chen & Chou, 2008; Jazzar & Ghogho, 2009), TDOA (Time Difference Off Arrival) (Chen & Chou, 2008), TOA (Time Of Arrival) (Jazzar & Ghogho, 2009; Lau & Chung, 2007), RSSI (Received Signal Strength Indication) (Lau & Chung, 2007; Wann & Chin, 2007), and Proximity (Blumenthal, Grossmann, Golatowski, & Timmermann,

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2007; Bulusu, Heidemann, & Estrin, 2000). In these algorithms, PM (Pattern Matching) (Bahl & Padmanabhan, 2002; Ding, Meng, Gao, & Zhou, 2007; Kuo, Tseng, & Shen, 2007; Kuo & Tseng, 2008; Nerguizian & Nerguizian, 2007; Outemzabet & Nerguizian, 2008; Stella, Russo, & Begusic, 2007; Takenga, Xi, & Kyamakya, 2006; Takenga & Kyamakya, 2007; Villani, Le, & Battiti, 2002; Yeh & Peng, 2006; You, Chen, Chiang, Huang, Chu, & Lau, 2006) is known as the most important method applied in real-life applications.

Due to cost concerns, PM uses original communication chip and conduct calculation of localization upon strength of signal measured. It derives from RSSI of multiple beacon nodes to form SP (Sample Pattern) of each pre-specified location and establishes a FD (Fingerprinting Database). Just like personal fingerprinting, signal fingerprinting in FD reports a feature of uniqueness. A MF (Matching Function) can be applied to discover the most suitable target of a given fingerprinting. Although different approaches were proposed to improve PM in past years, they all emphasized on trying different training methods to predict a good MF and to improve the localization accuracy. However, to establish a good FD and its MF, excessive initialization effort would be required to collect massive fingerprinting in multiple locations. The installation hours will be extended along with site area and may lead to increase in computation of signal matching. It is unfavorable to immediate requests in real-life applications.

This paper proposes a SPM (Self-learning PM) algorithm to improve not only the localization accuracy, but also the initialization effort of PM. A self-learning system is proposed to use MF to figure out coordinate location to replace fingerprinting similar to those received by target nodes in FD. Different from the previous training/prediction scheme, the self-learning scheme will not apply all SP in MF. It can minimize the computation of signal matching. With the development of smart home, we consider the localization problem in indoor environments. Comparing to outdoor environments, indoor environments will subject to the effect of

indoor decorations. It will cause instability of signal strength in localization. For removing the noise signal caused by multipath effects, we apply a Bayesian filtering scheme in SPM to enhance localization accuracy. Experiments show that SPM is better than PM for different training methods (such as Linear Regression (LR), Gaussian Process (GP), Backpropagation Network (BPN), Radial Basis Function (RBF) and Support Vector Regression (SVR)) applied. It can use up to 72% fewer training patterns to achieve the same localization accuracy. If the same numbers of training patterns are utilized, it can achieve up to 58% higher localization accuracy.

The structure of this paper is organized as follows. Section 2 discusses previous works in localization of WSN. Section 3 describes the proposed SPM method. The experimental factors and results are shown in Section 4. Finally, conclusions are presented in Section 5.

2. RELATED WORKS

Bahl and Padmanabhan (2000) proposed the RADAR algorithm upon indoor environments, which is regarded as the ancestor of PM. RADAR reports two operating phases: training phase and locating phase. In training phase, the user will stand at some pre-specified locations and use a sample node (with a radio chip embedded on the sensor board) to collect the RSSI of beacon nodes. The signal strength collected in each location makes a unique vector (called SP in this paper) which is as unique as personal fingerprinting. Then, the sample node sends its SP along with the related location information to FD. In locating phase, the target node will use its radio chip to collect RSSI of beacon nodes as a vector called UP ("Unidentified Pattern" as its location is unidentified). The target node will send this UP to the base station where a calculation is then conducted on each SP (with identified location) in FD to figure out its Euclidean distance to this UP. The location of UP is assigned as the location of its nearest SP.

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