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RESEARCH ARTICLE

A NOVEL OPTIMIZATION MODEL FOR LOCATING INDOOR ACCESS POINT USING POPULATION BASED ALGORITHM

T.Thirumurugan

Assistant Professor, Department of Electronics and Communication Engineering, School of Engineering & Technology, Surya Group of Institutions, Anna University Chennai, Villupuram, India.

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ABSTRACT

Now ever days positioning system of Wireless indoor Access Point have become very popular. These method have been used in many area like asset tracking, location fingerprinting and inventory management. The optimization of location of access point is to improve the accuracy of positioning due to complexity of indoor radio propagation environment. The first method introduce the indoor radio propagation and recently developed optimization method Euclidean for access point location, where the Euclidean metric of received signal strength array among all sample points have to maximize, hence it increase the diversity of signal strength array. So it improves the position accuracy of location fingerprinting method. Then Population based algorithm was used to optimize the proposed problem, and the examines the various experimental result. The result proves that the proposed model for access point location optimization proves the positioning accuracy. Finally, the paper concludes the possible future direction for access point.

INTRODUCTION

Now ever days there is rapid development of wireless network, wireless indoor positioning systems have become very important and attractive. The model has been successfully used in much area such as asset tracking and inventory management. The knowledge of user positions along with user profiles will significantly help in planning network, in load balancing, caching of information closer to the user and radio resource management.

The position location of a mobile device can be obtained by two methods, firstly by using a special infrastructure for positioning like (GPS), secondly by improving the existing communication infrastructure to identify the location of user. GPS method cannot be applied for indoor area due to lack of coverage. Hence it is possible to employ the existing wireless communications infrastructure to determine the location of user with in the network. In indoor areas, the wireless communications infrastructure is based on wireless local area networks (WLANS) [1]. So indoor positioning systems mainly depend on either IEEE802.11b or IEEE802.11g WLAN.

In existing communications, there are three basic methods for determining the location of user: (i) triangulation that requires at least three different estimates of the distance of the mobile device from known fixed locations,(ii) using the angle of arrival (AOA) of at least two different signals from known locations and (c) employing location fingerprinting schemes. Due to the harsh multipath environment in indoor areas, techniques that use triangulation or angle of arrival are not very attractive and often can get erroneous results [2-4].

* Corresponding author: + 91
E-mail address: thiru0809@gmail.com

Location fingerprinting refers to techniques that match the fingerprint of some characteristic of the signal that is location dependent. The fingerprints of different locations are stored in a database and matched to measured fingerprints at the current location of a mobile device. In WLANS, the finger printing method user the early available signal characteristic which is received signal strength (RSS).

Optimizing of the location of access point is to improve the position accuracy, which can be still a challenging and difficult one due to complexity of indoor radio propagation environment [10]. Population based algorithm is a Differential evolution (DE) algorithm [11,12] is new approach which has advantages like: finding the true global minimum regardless of the initial parameter values, fast convergence, and using few control parameters. In this paper, the normal indoor radio propagation model and proposed a novel optimization model for access points location optimization in which the Euclidean metric of received signal strength array among all the sampling points should be maximize in order to increase the differentia and diversity of the signal strength array, and thus improve the positioning accuracy of location fingerprinting schemes. Then Differential evolution algorithm is to optimize the proposed model. Experimental results show that the proposed model for access points location optimization can improve the accuracy positioning.

This paper is organized as follows. In Section 2 , we mainly concentrate on the access points location optimization using a model. Section 3 reviews the DE approach and shows how it is used to search for the one of the best solution. Section 4 discusses the experimental test method, results and analysis.

Finally, Section 5 summarized the paper and gave possible future development for research on access points location optimization for indoor environments.

ACCESS POINTS LOCATION OPTIMIZATION USING A MODEL INTRODUCTION

Indoor Radio Propagation Model

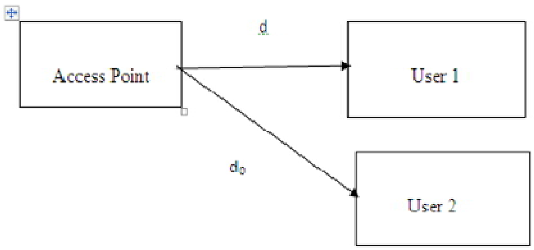


Fig. 1 Indoor propagation model with access Point and user

Due to severe shadowing and multi-path fading present in the indoor environment,here is cannot be an accurate indoor radio propagation model. In this paper, a path-loss model [10] is used to describe the characteristic of indoor environment which is as follows.

$$P = P_0 - 10 \cdot \eta \cdot \lg(d / d_0) + \zeta \quad (1)$$

In the formula (1), the P is the received signal strength of users when the distance between users and access points is d. And P_0 is the received signal strength of users if the distance between users and access points is d_0 (d_0 is equal to 1 meter). The parameter η is the path-loss index which depends upon the indoor propagation environment. ζ is the shadowing factor which is a random variable

Model for Access Points Location Optimization

In this paper, we proposed a optimization model for access points location optimization in which the Euclidean metric of received signal strength array among all the sampling points should be maximize in order to increase the differentia and diversity of the signal strength array, and thus improve the positioning accuracy of location fingerprinting schemes.

The proposed optimization model was described as follows:

$$\textbf{Maximize: } f = \sum_{i=1}^{N} \sum_{j \in D_i} r_{ij} \quad (2)$$

$$D_i = \{ j \,/\, \text{distance } i, j \le d \} \quad (3)$$

$$r_{ij} = \sqrt{\sum_{k=1}^{M} [rss_i(k) - rss_j(k)]^2} \quad (4)$$

$$\text{Subject to: } (x_k, y_k) \in S \quad (6)$$

In the formula (2), f is the Euclidean metric sum of received signal strength array among all the sampling points, and f should be maximized. N is the number of sampling points. And in the formula (3), i D_i is a sampling point set in which the distance between i and j should be smaller than d.In the formula (4), r_{ij} r is the Euclidean metric of received signal strength array between sampling points i and j , and M is the number of access points. In the formula (5), rss_i (k) is the received signal strength of sampling point i from access point k. And (px_i , py_j) is the location coordinates of sampling point i , and (x_k, y_k) is the location coordinates of access point k .

Finally, S is the area where the access points location should be optimized.

In this paper, the parameters of optimization model were defined as follows:

N (the number of sampling points) = 18
M (the number of access points) = 1, 2, 3, 4, 5, 6, 7, 8

$d = 18.0$
$p_0 = -28.0$
$\eta = 2.2$
$x_k \in [0, 12]$
$y_k \in [0, 6]$.

APPROACH USING DIFFERENTIAL EVOLUTION ALGORITHM

The population based algorithm is like Differential Evolution (DE) algorithm using the similar operators: crossover, mutation and selection [11]. The main difference in constructing better solutions is that genetic algorithms depend on crossover while DE depends on mutation operation. This main operation is based on the differences of randomly sampled pairs of solutions in the population.

The algorithm uses mutation operation as a search mechanism and selection operation to direct the search toward the corresponding regions in the search space. The DE algorithm also uses a non-uniform crossover that can take child vector parameters from one parent more often than it does from others. By using the components of the existing population members to construct trial vectors, the crossover operator efficiently uses information about successful combinations, enabling the search for a better solution space.

An optimization task consisting of D parameters can be represented by a D-dimensional vector. In DE, a population of NP solution vectors is randomly created at the start. This population is successfully improved by applying mutation, crossover and selection operators. The details of the mutation, crossover and selection operators were described in literature [11].

In this paper, the parameters of Differential Evolution were list as follows:

Population size = 200
Mutation rate (or scale factor) = 0.5
Crossover rate = 0.2

$$rss_i(k) = p_0 - 10 \cdot n \cdot \lg\left(\sqrt{(px_i - x_k)^2 + (py_i - y_k)^2}\right) \quad (5)$$

Strategy = DE/rand/2/exp

Maximum Generation = 1000. Figure 2 .is the GUI interface when Differential Evolution Algorithm is running in which the number of Access Points is equal to eight

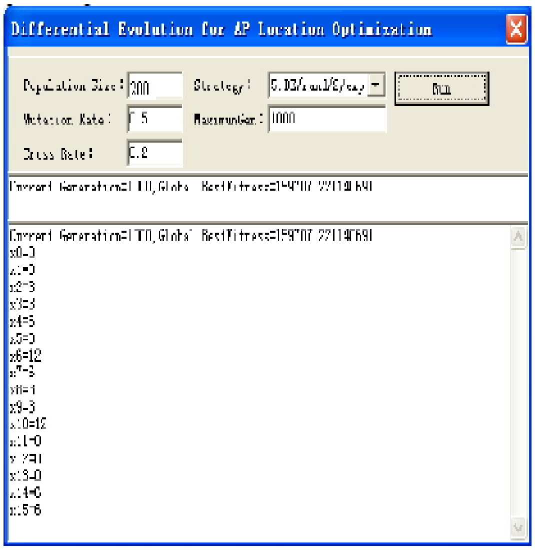


Fig. 2 GUI interface for Differential Evolution Algorithm when Number of Access Points is 8

RESULT AND ANALYSIS

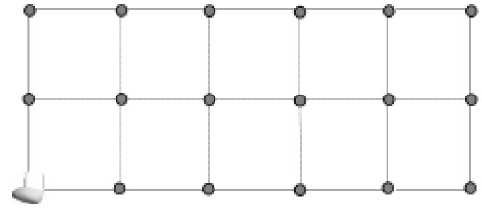
The experimental test is located in a typical office room. The office room has dimensions of 6 meter by 12 meter. In this work, it is chosen the TP-LINK TL-WA501G as our experimental APs due of its low cost. The WLAN consists of eight access points, and the name and operating channel of these access points are listed in

Table 1 Name and channel of experimental access points

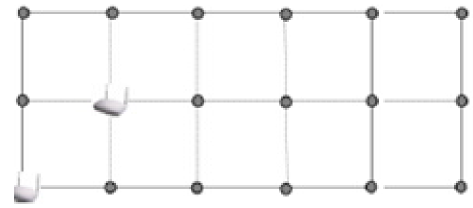
Name of Access Points	Channel of Access Points
Indoor – A	12
Indoor – B	1
Indoor – C	2
Indoor – D	4
Indoor – E	15
Indoor – F	7
Indoor – G	9
Indoor – H	5

The optimized results for access points location optimization (the number of access points = (1, 2, 3, 4) are shown in Figure 3

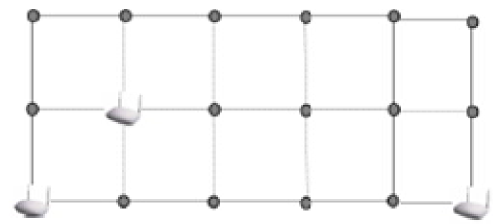
From Figure 3, we can see that the optimized locations and placements of access points are highly asymmetrical.



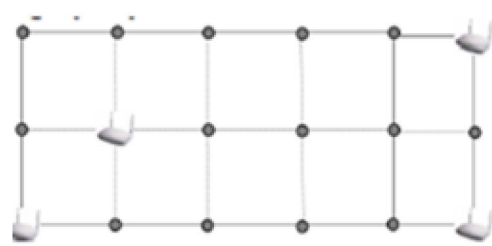
Number of Access Points=1
Best Fitness=47555.6675



Number of Access Points=2
Best Fitness=61220.5707



Number of Access Points=3
Best Fitness=87857.4274



Number of Access Points=4
Best Fitness=93619.0011

Fig. 3 The optimized results for access points location optimization

Furthermore, it is also compared the optimized solutions and the usual solutions when the number of access points is equal to 2, 3 and 4, and the comparison results. It can be seen that the symmetrical and usual placements of access points are worse than the optimized placements, and thus the placements of access points can be improved drastically.

When the access points number increases, the placement of access points cannot always obtain improvement. For example, when the number of access points is equal to 7 and 8, the optimized experimental results show that some access points should be placed together to increase the diversity of the signal strength array. These solutions are not reasonable because access points will disturb each other when the distance between them is too short

The experimental results show that the access points should be scattered asymmetrically and should be placed around the site in a "zigzag" pattern rather than placing several APs close together or placing them on a straight line. Furthermore, when the number of access points increases too much, the placement of access points cannot always obtain improvement.

The proposed optimization model to real indoor positioning system which is based on location fingerprinting in wireless networks [13], and the indoor positioning results and comparison among different number of access points.. In this experiment, the k-nearest-neighbor method was used to identify the user's location. When the number of access points increases from 3 to 6, the positioning precision can obtain improvement. However, when the number of access points rises from 6 to 8, the effect of number of access points on positioning performance is less. These results show that the proposed model for access points location optimization is useful, and it can improve the positioning accuracy drastically.

CONCLUSION

Firstly discussed the indoor radio propagation model and proposed a optimization model for access points location optimization in which the Euclidean metric of received signal strength array among all the sampling points should be maximize in order to increase the differentia and diversity of the signal strength array, and thus improve the positioning accuracy of location fingerprinting schemes. Then we presented the algorithm which was used to optimize the proposed problem, and the experimental test setup, experimental results and analysis were discussed. The results show that the proposed model for access points location optimization can improve the positioning accuracy remarkably. Future directions for research on access points location optimization are as follows: (1 Continue to improve the proposed optimization model, and add more constraints in real life, for example, the distance between two access points should not be less than 5 meters, and the effect of walls and doors should be considered.2) Number footnotes separately in superscripts (Insert | Footnote).

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T.Thirumurugan has received his both the U.G and P.G Degree from Pondicherry University in 1999 and 2002.He is at present working as Assistant Professor (Sr.G) in Surya Group of Instittuions..He is a life meber of ISTE and Published 5 International Journals.

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