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Research into Positioning of the Least Square Support Vector Machine based on Fisher Fishing in WSN

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Abstract

In order to improve the accuracy of positioning wireless sensor and aiming at optimizing the least square support vector machine's parameters, a sensor node positioning method based on fisher fishing optimization – the least square support vector machine is proposed. First of all, learning samples of the three-dimensional wireless sensor positioning model are established, and then the least square support vector machine is used to establish the three dimensional node positioning model and fisher fishing is used to find the optimal support vector machine's parameter. The results show that algorithm in this paper can effectively improve the accuracy of positioning sensor node and reduce positioning errors, so it has certain practical value.

Keywords*: Wireless sensor network; Three-dimensional node positioning; the least square support vector machine; Fisher fishing*

1. Introduction

Node positioning occupies an important role in wireless sensor network (WSN) and will influence the network efficiency, so how to improve the accuracy of node positioning is a hot spot in three dimensional sensor researches [1-2]. Domestic and foreign scholars have done a lot of research, literature [3] proposed a three-dimensional wireless sensor networks localization algorithm based on non-ranging distribution of Monte Carlo, and effectively improve the accuracy of positioning, but the positioning is closely related to the anchor node robustness is relatively poor. Literature [4] proposed using least squares support vector regression mechanism built a three-dimensional model of node location, and then use particle swarm optimization algorithm for least squares support vector regression kernel function parameters and rules of the parameter optimization, and achieved good results. Literature [5] proposed the introduction of Voronoi model based on particle swarm algorithm, by setting the model assigned to each node location. Literature [6] proposed an improved algorithm RSSI ranging, but anti-interference ability. Literature [7] proposed based on least squares support vector machine wireless sensor network node localization method, and achieved certain results. Literature [8] proposed a matrix mapping to estimate the distance from the matrix, and then use the mapping between the calculated distance vector, the position coordinates of the nodes of the final calculation on this basis, the disadvantage is it is unable to adapt to the three-dimensional space.

Fisherman fishing optimization algorithm (SFOA) is a new intelligent algorithm, mainly used to simulate fisherman fishing hunt process optimization algorithm, robust, easy to realize the advantages. LSSVM Preferences space is essentially a large-scale search of combinatorial optimization problems. This paper proposes a method for three-dimensional positioning WSN node SFOA Least Squares SVM-based optimization. Simulation results show that the positioning method herein improves the positioning efficiency, has some validity.

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2. Three Dimensional WSN Node Localization Method of the Least Square Vector Machine

2.1. Calculate the Average Distance of Each Jump

In three-dimensional WSN, the anchor node can estimate the average hop distance of the network by the position information and the hop count of the other anchor nodes, and then the anchor node will broadcast to the whole network, and the unknown node will be forwarded. The distance between the unknown node and anchor node is as the formula (1-2).

$$HopSize_{ij} = \frac{\sum_{j \neq i} \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2 + (z_i - z_j)^2}}{\sum_{j \neq i} hopS_{ij}} \tag{1}$$

In the formula, jis other anchor node number of the anchor node i in the data table, and hopSij is the amount of jumps between anchor node I and j.

$$L_i = S_i \times HopSize_{ij} \tag{2}$$

2.2. Modelling and Positioning of Nodes in the Least Square Vector Machine

(1) Suppose the coordinate of an unknown node is $S_l'(x_l', y_l', z_l')$, and the distance between $(l = 1, 2, ..., M)$ and the anchor node $S_j\,(j \in 1, 2, ..., M)$ is d_{ij}', then the distance between S_l' and each anchor node composes a vector set is: $R_l^{'} = [d_{i1}^{'}, d_{i2}^{'}, ..., d_{iL}^{'}]$. Use the distance vector R_l' of M unknown positioning nodes and its coordinate ($x_l', y_l', z_l^{'}$) to compose the training sample set $U_X = \{(R_l', x_l') \mid l = 1, 2, ..., M\}$, $U_Y = \{(R_l', y_l') \mid l = 1, 2, ..., M\}$ and $U_z = \{(R_l', z_l') \mid l = 1, 2, ..., M\}$.

(2) LSSVM is used to train the sample set U_x, U_y, U_z and get the optimal solution of the composition as formula (3).

$$\min_{\omega,\xi,b} \frac{1}{2}\|\omega\|^2 + \gamma \frac{1}{2}\sum_{i=1}^{M} \xi^2 \tag{3}$$

In the formula, ω is the weight value, γ is the regularized parameter and ξi is a random error.

Introduce the Lagrange operator a and b to transform formula (3) into a dual problem, that is

$$\begin{cases} \begin{bmatrix} 0 & \overline{1}^T \\ \overline{1} & \Omega + \gamma^{-1} I \end{bmatrix} \begin{bmatrix} b \\ a \end{bmatrix} = \begin{bmatrix} 0 \\ x' \end{bmatrix} \\ \begin{bmatrix} 0 & \overline{1}^T \\ \overline{1} & \Omega + \gamma^{-1} I \end{bmatrix} \begin{bmatrix} b \\ a \end{bmatrix} = \begin{bmatrix} 0 \\ y^{'} \end{bmatrix} \\ \begin{bmatrix} 0 & \overline{1}^T \\ \overline{1} & \Omega + \gamma^{-1} I \end{bmatrix} \begin{bmatrix} b \\ a \end{bmatrix} = \begin{bmatrix} 0 \\ z^{'} \end{bmatrix} \end{cases} \tag{4}$$

In the formula, $x' = [x_1', x_2', ..., x_M']^T$, $a = [a_1, a_2, ..., a_M]^T$, $\overline{1} = [1,1,...,1]^T$ and $\Omega(m, n) = K(R_m', R_n')$.

According to formula (4), a and b can be obtained and the decision function of LSSVM is

$$\begin{cases} \hat{x} = f_x(R) = \sum_{l=1}^{M} a_i K(R_i, R_i') + b \\ \hat{y} = f_y(R) = \sum_{l=1}^{M} a_i K(R_i, R_i') + b \\ \hat{z} = f_z(R) = \sum_{l=1}^{M} a_i K(R_i, R_i') + b \end{cases} \tag{5}$$

(4) the distance between the unknown node $S_l'(x_l', y_l', z_l')$ to each anchor node is to form the distance vector $R_i=[d_{i1},d_{i2},\ldots,d_{iL}]$ as the input vector of the decision vector f_x,f_y,f_z, and obtain the $\hat{x}_i$, $\hat{y}_i$, $\hat{z}_i$, that is ($\hat{x}_i, \hat{y}_i, \hat{z}_i$) is the estimated coordinate value.

3. Fisher Fishing Algorithm based on the Least Square Vector Machine

From the modeling process of the two vector machine, it is known that the normalized parameter's y value has a great influence on the performance of LSSVM. In this paper, the parameters of the vector machine are optimized by using the optimization algorithm to improve the positioning accuracy of the sensor nodes.

3.1. Fisher Fishing Optimization Algorithm

Fisher Fishing Optimization Algorithm (SFOA) is an optimization algorithm imitating fisher fishing behaviors or habits. Suppose D is the unit fish swarm region, $D = D_1 \times D_2 \times \cdots D_n$ is the fisher fishing region, $X = (x_1, x_2, \cdots x_n)$, $X = (x_1, x_2, \cdots x_n) \in D$, $F(x)$ are the target function of the region D (density function of fisher swarm). Suppose $x_i \in D_i$ and $x_i = [a_i, b_i]$, so fishers need to seek the place with the most density and the optimal region in the fish swarm (i.e. $F_{\max}(x)$ and $[a_{best}, b_{best}]$).

$$\begin{aligned} &\Omega_0^{(i)} = \{X^{(i)} = (t_1^{(i)}, t_2^{(i)}, \cdots t_n^{(i)}) \mid t_j^{(i)} \\ &\in \{x_{0j}^{(i)} - t_j^{(-)}, x_{0j}^{(i)}, x_{0j}^{(i)} + t_j^{(+)}\}, j = 1, 2, \cdots n\} \end{aligned} \tag{6}$$

In the initialization, there are k fishers randomly distributed in D. Suppose the initial position of the fisher i is $P_0^{(i)} = (x_{01}^{(i)}, x_{02}^{(i)}, \cdots x_{0n}^{(i)})$, and the fisher casts network from 4 directions, so the fishing network point set centered at the fisher's position is:

(1) Mobile search behavior. In fishing at the point $X_0^{(i)}$ where the density is greater than the current location $P_0^{(i)}$ of the fishermen, the fishermen move to a new location $P_1^{(i)} = X_0^{(i)}$, and for the new center $P_1^{(i)}$, continuous search to find the density of the largest location, after a number of steps, the location of the fisherman's trajectory is $P_0^{(i)}, P_1^{(i)}, p_2^{(i)}, \cdots p_{best}^{(i)}$, after the steps, the fisherman in the search area to find a local optimal location.

(2) Contraction search behavior. After a certain number of positions, the fisherman i's current position is $P_m^{(i)}$, if the density at the point $X_0^{(i)}$ is less than the current position $P_0^{(i)}$ of the fishermen, the fishermen remain unchanged at the current position. Then continue the nets in 4 directions of the current position, get a set of fishing nets.

$$P_0^{(i)} = (x_{01}^{(i)}, x_{02}^{(i)}, \cdots x_{0n}^{(i)})$$
$$\Omega_m^{(i)} = \{X_{m+1}^{(i)} = (t_1^{(i)}, t_2^{(i)}, \cdots t_n^{(i)}) \mid t_j^{(i)}$$
$$\in \{x_{mj}^{(i)} - t_j^{(-)}, x_{mj}^{(i)}, x_{mj}^{(i)} + t_j^{(+)}\}, j = 1, 2, \cdots n\} \tag{7}$$

Herein, $t_j^{(-)} = \alpha t_{j-1}^{(-)}$, $\alpha \in (0,1)$.

3.2. Steps of Algorithm

(1) Initialize the fisherman algorithm parameters, mainly including the number of fishermen, fishing zone length, contraction coefficient, algorithm of maximum number of iterations, set bulletin board.

(2) Generate n fishers at random, and the initial place of the i fisher is (γ_i, σ_i). The composition value of (γ_i, σ_i) is regarded as the parameter of the support vector machine for training and modeling and predicting samples.

(3) According to the formula (8) to calculate the fitness function, fitness function and select the maximum individual fishermen to enter the bulletin board.

$$FC = \sqrt{\frac{1}{M}\sum_{l=1}^{M}((f_x(R_l') - x_l')^2 + (f_y(R_l') - y_l')^2 + (f_z(R_l') - z_l')^2)} \tag{8}$$

In the formula, R_l' is the distance vector between nodes to each anchor node; fx,fy,fz is the estimated value of the recession model established by using the optimization model-establishing parameter.

(4) Conduct mobile search and narrowing search by fisher to get the new place of fisher.

(5) Compare the positions of fishers at the new place and in the bulletin board. If the new fisher is superior to that in the bulletin board, replace it and the iteration number adds another one.

(6) Decrypting individual fishers at the optimal position to obtain the optimal parameter(γ,σ) of LSSVM.

(7) Using the optimal parameters to establish the optimum sensor positioning model.

4. Simulation Experiment

4.1. Simulation Environment

This paper selects the Windows XP system, the hardware configuration for the CPU as the core i3500G hard disk, 4G memory. Simulation experiment was carried out in Matlab environment. Selection of 100 randomly distributed sensor nodes in length of 10m of three-dimensional space, the anchor nodes is known for 40, until the node localization for 60, selection algorithm in this paper, algorithms in literature [3] and [4] were compared.

4.2 Results and Comparison

4.2.1 Comparison of Positioning Results

From Figure 1 we can find that the algorithm of this paper is less than algorithms in the literature [3] and [4]. It is mainly because this paper introduces the least square support vector machine based on the fisher fishing optimization algorithm, which to a certain extent, reduces the three-dimensional space in the positioning of the defects, and improves the accuracy of the target positioning.

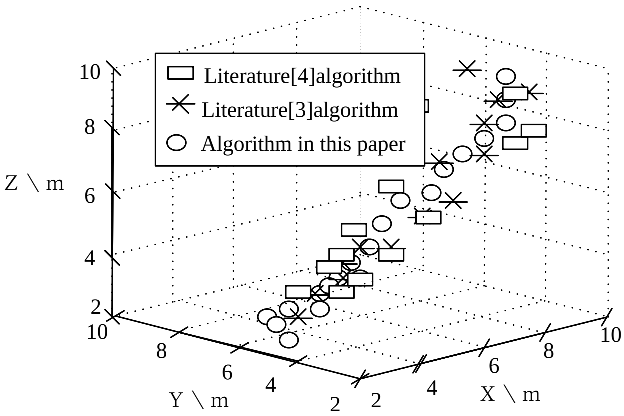

Fig.1 Comparison of Positioning Results of Three Algorithms in the 3D Space

4.2.2. Influence of Measuring Accuracy on Positioning Errors

Measuring error is a problem that cannot be ignored in positioning, in order to further verify the effectiveness of the algorithm, in different distance error, and the literature [3] algorithm, the literature [4] algorithm positioning error is compared. From Figure 2, with the increase of the distance error, the node localization accuracy of the three algorithms is gradually reduced, the algorithm is better than the other two algorithms. This shows that the proposed algorithm is optimized by the least square vector machine to optimize the sensor node localization model, so it has strong anti-interference ability, and get a better positioning effect.

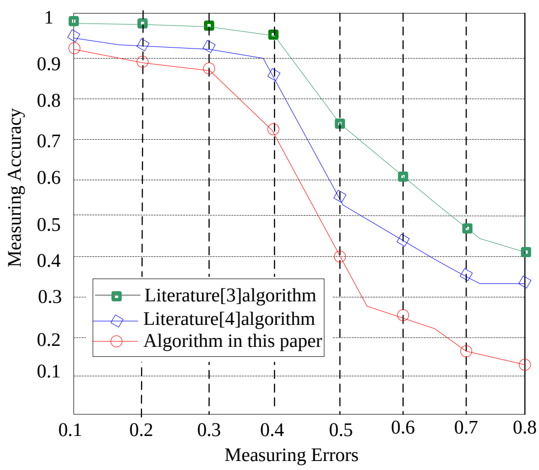

Figure 2. Influence of Measurement Accuracy on Positioning Errors

5. Conclusion

How to better carry on the node localization has been the research focus of wireless sensor network. In this paper, a method of 3D WSN node localization based on least square vector machine is proposed. The simulation results show that not only the positioning performance is improved, but also it can reduce the error of sensor node localization, which has high application value.

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