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Personal Positioning Method of Digital Community Monitoring System

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Abstract. Wireless network can be used to digital community monitoring system, personal positioning method is the important component of the digital community monitoring system. On the basis of studying the traditional personal positioning algorithms, we proposed a trilateral-weighted centroid localization algorithm. On a wireless network hardware platform we validated that this algorithm had Higher precision than traditional algorithms.

Introduction

China had already entered old-age society, by 2014, the Old-age people more than 60 years account for nearly 15.5 per cent of the population, which is about 210 million[1]. The development of community health service level represents the progress of a social level, correspondence the new medical technology such as modern network technology, communication technology, control technology and some medical equipment terminals, realize medical service and health care services, care services, emergency service, health education inside a family, build a digital community monitoring system is the the future of endowment trend[2,4]. Personal positioning method is the important component of the digital community monitoring system. Personal positioning method can carry on position location and position display for the aged at real time. The crucial of the Personal positioning method is to understand the health-status of the aged, and rescue them timely when they are in danger[5].

The topic researches on the key technologies of digital community monitoring system. Wireless network and embedded technology have been used in the system. On the basis of studying the traditional personal positioning algorithms, we proposed a trilateral-weighted centroid localization algorithm. We used trilateral-weighted centroid localization algorithm and trilateral-weighted centroid localization maximum likelihood estimation algorithm in Personal Positioning study. The results of test verify that the trilateral-weighted centroid localization algorithm had higher precision than traditional algorithms.

Positioning Algorithms

The existing wireless sensor network localization algorithms can be divided into 2 categorys: Range-based positioning algorithms and Range-free positioning algorithms[3,6]. Range-based positioning algorithms include RSSI, TOA, RTOF, TDOA, PDOA, AOA, NFEM[7]. Range-based positioning algorithms are rarely used in the existing positioning systems. Range-free positioning algorithms include Trilateration, Min-max, Triangulation, Maximum Likelihood Estimation.

Maximum Likelihood Estimation. Wireless network includes two kinds of nodes, one kind is the nodes know their position, known as the reference node; Another kind is needed by calculating for the location of the node, called the blind node. According to the distance between reference node and blind node, we can calculate blind node's coordinate[3,8]. Shown as Fig. 1, n known reference nodes' coordinates are (xi,yi)($1\leqslant i\leqslant n$, I is an integer), blind node's (D) coordinates is(x,y),there is:

$$(x-x_i)^2+(y-y_i)^2=d_i^2 \tag{1}$$

blind node D can be obtained by the method of least squares,

$$X = (A^T A)^{-1} A^T b \tag{2}$$

$$X = \begin{bmatrix} x \\ y \end{bmatrix} \tag{3}$$

$$A = \begin{bmatrix} 2(x_1 - x_n) & 2(y_1 - y_n) \\ \vdots & \vdots \\ 2(x_{n-1} - x_n) & 2(y_{n-1} - y_n) \end{bmatrix} \tag{4}$$

$$b = \begin{bmatrix} x_1^2 - x_n^2 + y_1^2 - y_n^2 + d_n^2 - d_1^2 \\ \vdots \\ x_{n-1}^2 - x_n^2 + y_{n-1}^2 - y_n^2 + d_n^2 - d_{n-1}^2 \end{bmatrix} \tag{5}$$

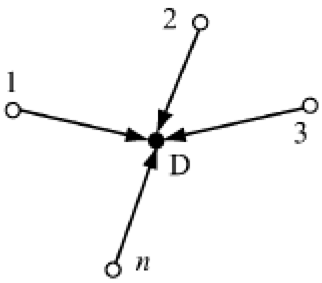

Figure 1. Maximum likelihood estimation method

Trilateral-weighted Centroid Localization Algorithm. 3 known reference nodes A, B, C, blind node and the reference node distances are RA, RB, RC, centered on A, B, C, RA and RB, RC for the radius of circle. The intersection of three circle area, intersection of two circles set to O1, O2, O3 coordinates to satisfy the following equations[3,9]:

$$\begin{cases} (x_{01} - x_B)^2 + (y_{01} - y_B)^2 = R_B^2 \\ (x_{01} - x_C)^2 + (y_{01} - y_C)^2 = R_C^2 \\ (x_{01} - x_A)^2 + (y_{01} - y_A)^2 \le R_A^2 \end{cases} \tag{6}$$

$$\begin{cases} (x_{01} - x_B)^2 + (y_{01} - y_B)^2 = R_B^2 \\ (x_{01} - x_C)^2 + (y_{01} - y_C)^2 = R_C^2 \\ (x_{01} - x_A)^2 + (y_{01} - y_A)^2 \le R_A^2 \end{cases} \tag{7}$$

$$\begin{cases} (x_{01} - x_B)^2 + (y_{01} - y_B)^2 = R_B^2 \\ (x_{01} - x_C)^2 + (y_{01} - y_C)^2 = R_C^2 \\ (x_{01} - x_A)^2 + (y_{01} - y_A)^2 \le R_A^2 \end{cases} \tag{8}$$

Obtained intersection O1, O2, O3 coordinates by equations(7) (8) (9),composed triangle by O1，O2，O3 as verticles. In $\Delta O_1O_2O_3$,we considered the weighted value as follow: for example, first, reference node O1 is made up $\odot B$ and $\odot C$ intersection, so the weighted value have RB and RC, secondly, blind node O is made up of OA, OB and OC, reference node O1 should be considered in the middle of the weighted variables influence of RA; Finally consider the distance between blind node and reference node is inversely proportional to the weighted value. So, the weighted value of O1 is: $\frac{1}{R_B+R_C}+\frac{1}{R_A^n}$, the weighted value of O2 is: $\frac{1}{R_A+R_C}+\frac{1}{R_B^n}$,the weighted value of O3 is: $\frac{1}{R_A+R_B}+\frac{1}{R_C^n}$, we obtained blind node's coordinate O (x,y):

$$x_i=\frac{x_{01}\cdot\left(\frac{1}{R_B+R_C}+\frac{1}{R_A^n}\right)+x_{02}\cdot\left(\frac{1}{R_A+R_C}+\frac{1}{R_B^n}\right)+x_{03}\cdot\left(\frac{1}{R_A+R_B}+\frac{1}{R_C^n}\right)}{\left(\frac{1}{R_A^n}+\frac{1}{R_B^n}+\frac{1}{R_C^n}\right)+\left(\frac{1}{R_A+R_B}+\frac{1}{R_B+R_C}+\frac{1}{R_A+R_C}\right)} \tag{10}$$

$$y_i=\frac{y_{01}\cdot\left(\frac{1}{R_B+R_C}+\frac{1}{R_A^n}\right)+y_{02}\cdot\left(\frac{1}{R_A+R_C}+\frac{1}{R_B^n}\right)+y_{03}\cdot\left(\frac{1}{R_A+R_B}+\frac{1}{R_C^n}\right)}{\left(\frac{1}{R_A^n}+\frac{1}{R_B^n}+\frac{1}{R_C^n}\right)+\left(\frac{1}{R_A+R_B}+\frac{1}{R_B+R_C}+\frac{1}{R_A+R_C}\right)} \tag{11}$$

Test Anlysis

Digital Community Monitoring System is made up for parts: reference node, blind node, gateway node and PC. We chose 18 reference nodes and 1 blind node, in an empty area, set 18 reference nodes to two rows, formed to 40 m long, for the positioning area of 5 m wide, and correction coefficient n = 3,the whole test steps as follows[10]:

(1) Open the power of the blind node, Blind node initialize, and then send its' ID information;
(2) Reference node receive RSSI;
(3) 18 reference nodes send RSSI to PC;
(4) Matlab simulates two Algorithms.

In 8 region obtained 8 test results.

Table 1 High and low settings of predictor variables

Reference node(X_i, Y_i)	（0,10），（5,10），（0,5）	（5,5），（5,10），（10,5）	（15,5），（15,10），（10,5）	（20,10），（15,10），（20,5）
Blind node ID	0xd1	0xd1	0xd1	0xd1
RSSI	0x32,0x33,0x34	0x2c,0x34.0x34	0x2f,0x33,0x36	0x2d,0x32,0x35
Reference node(X_i, Y_i)	（20,5），（25,5），（20,10）	（30,10），（25,10），（30,5）	（35,5），（35,5），（30,10）	（40,10），（35,10），（40,5）
Blind node ID	0xd1	0xd1	0xd1	0xd1
RSSI	0x32,0x33,0x36	0x31,0x33,0x32	0x32,0x35,0x34	0x31,0x33,0x34

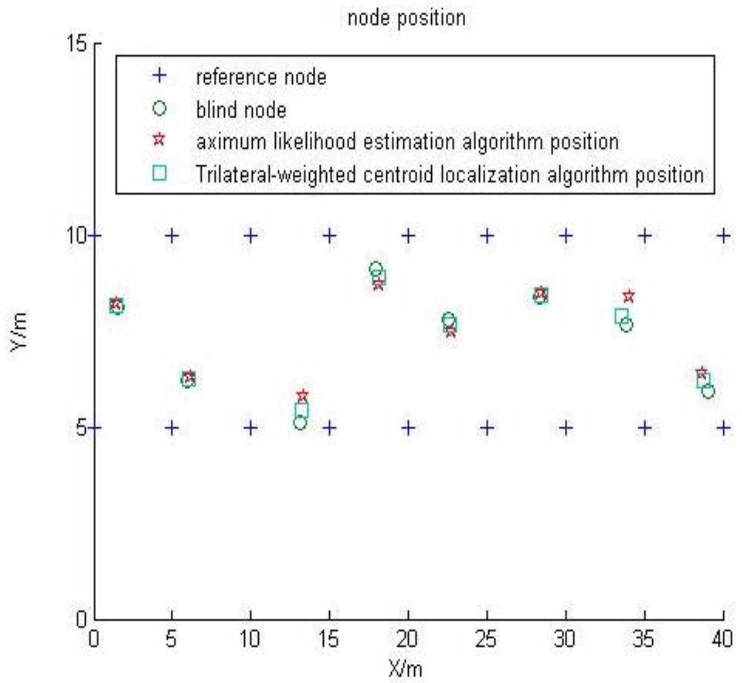

Figure 2. Matlab Simulate Result

Shown as Fig. 2, 18 reference nodes and 1 blind node, trilateral-weighted centroid localization algorithm has higher precision than maximum likelihood estimation algorithm.

Summary

In the topic, we proposed a trilateral-weighted centroid localization algorithm. We used trilateral-weighted centroid localization algorithm and maximum likelihood estimation algorithm in Digital Community Monitoring System . On a wireless network hardware platform we validated that this algorithm had higher precision than traditional algorithms.

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