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Research on Group Location Technology of Indoor Dual- Source Combination

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Abstract

Aiming at the situation that the positioning accuracy is affected by the single-hand interference of complex environment from UWB ranging results in non-visual-range environment, the indoor UWB/IMU collaborative positioning based on particle filtering algorithm is proposed. The distance between the locator and each reference base station is obtained through UWB, and the east and north positions of the locator are calculated by the UWB position solving unit. The three-axis acceleration, three-axis angular velocity, and three-axis magnetic field intensity during walking are obtained by IMU, and the step length, eastward step speed, northward step speed, walking time and attitude Angle are calculated by IMU calculation unit. The results of UWB system and IMU system are fused by particle filter algorithm. Finally, it can reduce the influence of complex environment and improve the positioning accuracy.

Keywords

Indoor navigation; Dual-source positioning; Cooperative navigation; Particle filtering.

1. INTRODUCTION

With the development of GPS satellite navigation and positioning technology, it is difficult for GPS technology to accurately track and position in indoor and underground environments due to the closed and complex environment characteristics of indoor and underground environments. Thus, indoor positioning technology arises at the historic moment. Among all kinds of indoor positioning schemes, most of them focus on the research of single positioning technology. The relatively better wireless positioning technology is UWB indoor positioning technology, but UWB positioning is easily affected by the environment. If the indoor environment is empty and there is no interference of obstacles, that is, the positioning accuracy of UWB is higher in the line-of-sight environment. When the indoor environment is complex, that is, in the non-line-of-sight environment, the UWB signal is affected by multipath effect, resulting in the target cannot be accurately and continuously located. IMU positioning technology is not easy to be affected by the environment, it can continuously locate and track the target. However, IMU positioning technology has accumulated errors, which requires continuous position correction. The indoor positioning technology based on UWB/IMU can not only improve the average positioning accuracy of the system, but also realize the long-term continuous positioning and tracking of the target.

In this paper, particle filter algorithm is used to integrate IMU measurement data and UWB ranging information. The IMU data is taken as the prior information of particle filter, and the UWB ranging value is taken as the observation value of particle, and the node position information is predicted and updated to improve the accuracy of navigation and positioning. Experimental results show that the positioning accuracy of the particle filter fusion IMU and

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UWB indoor positioning system is significantly higher than that of the single IMU inertial navigation system.

2. IMU NAVIGATION AND UWB RANGING MODEL

2.1. IMU Positioning Model

Inertial measurement unit (IMU) is a unit to measure the angular velocity and acceleration of three axes of object motion. In this paper, Pedestrian Dead Reckoning (PDR) algorithm is used to calculate the three-axis angular velocity and three-axis acceleration of mobile nodes collected by IMU. Acquisition without auxiliary equipment wear innovative marketing under the environment of sports personnel in the process of marching acceleration and angular velocity data, and use these data to step length and direction of travel personnel, get a mobile node coordinates and azimuth, so as to achieve the aim of fixing the personnel tracking, mainly involved in the process of gait detection, step length and direction is calculated.

Initial conditions of PDR: Given the initial position S0(X0,Y0), the built-in accelerometer in IMU detects the pedestrian's gait, and then the gyroscope monitors the pedestrian's Angle in real time, so as to calculate the path by using the following formula.

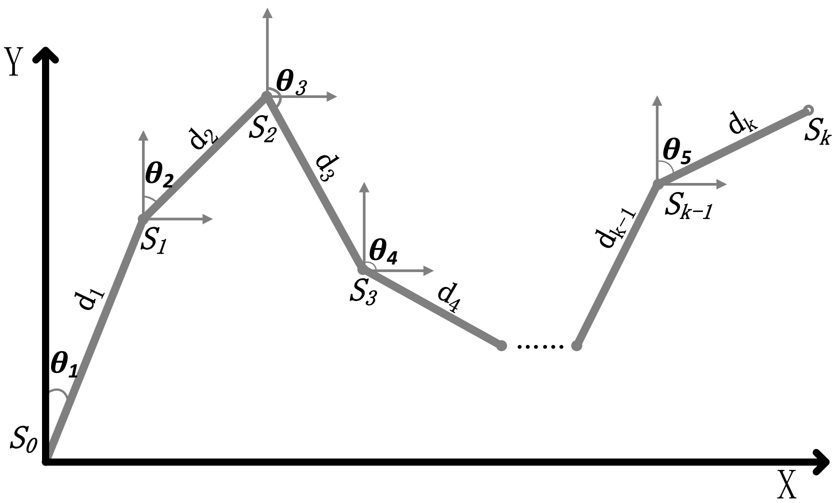

Figure 1. PDR algorithm diagram

$$\begin{cases} X_k = X_0 + \sum_{n=1}^{k} d_n \sin\theta_n \\ Y_k = Y_0 + \sum_{n=1}^{k} d_n \cos\theta_n \end{cases} \tag{1}$$

According to the above PDR calculation formula, the position of k at any moment, $S_k(X_k,Y_k)$, can be obtained.

2.2. UWB Positioning Model

Ultra-wideband (UWB) ranging has the advantages of strong penetration, low power consumption, strong anti-multipath ability and high safety performance. In this paper, two way-time of flight (TW-TOF) method is used to complete UWB ranging. The main two asynchronous transceivers (Transceivers) between the signal time of flight to ranging. A separate timestamp is generated for each transceiver startup. The transmitter of module A transmits A request-nature pulse signal at T_{a1} on its timestamp, which is received by the receiver of module B at its

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timestamp T_{b1}.Module B sends A response signal at the time T_{b2}, which is received by Module A at its own time stamp T_{a2}.From this, the flight time of pulse signal between two modules can be calculated to determine the flight distance S.

$$S = c[(T_{a2} - T_{a1}) - (T_{b2} - T_{b1})] / 2 \quad (2)$$

We denoted the time between the packet sent by the sender and the response received by the receiver as, and the time between the packet received by the receiver and the response sent by the receiver as, then the one-way flight time of the packet in the air can be simplified as:

$$T_{TOF} = c(T_{TOT} - T_{TAT}) / 2 \quad (3)$$

3. UWB/IMU COLLABORATIVE NAVIGATION MODEL

In this integrated navigation model, we take the IMU measurement inertia data carried by each node as the state quantity of the system. When each mobile node receives the IMU data, the state transition equation is used to update the current system state.When the UWB ranging data between nodes in the team area is received, the ranging data is used as the observed value, and the two are integrated into a probability framework to obtain the joint posterior probability distribution of the current position. The state estimation is output after updating the particles according to the information of the IMU.Finally, the problem of particle attenuation is mitigated by resampling.

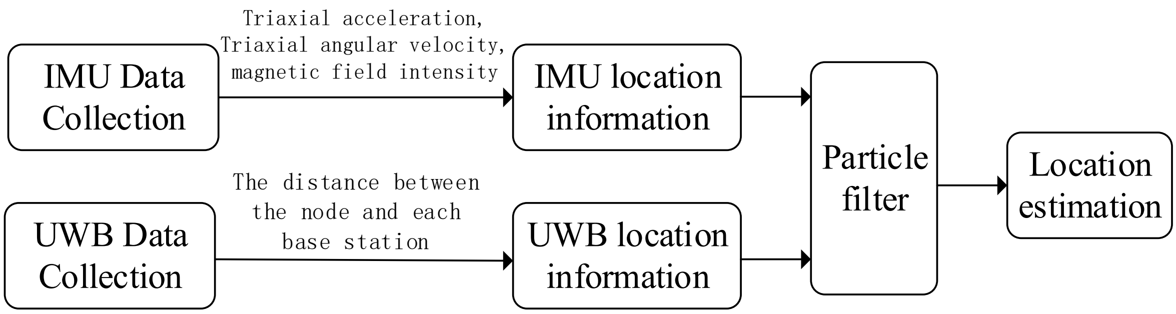

Figure 2. Collaborative Navigation Flow Chart

The equation of state of the filter is:

$$\begin{bmatrix} E(t+1) \\ N(t+1) \\ V_E(t+1) \\ V_N(t+1) \end{bmatrix} = \begin{bmatrix} 1 & 0 & S(t) & 0 \\ 0 & 1 & 0 & S(t) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} E(t) \\ N(t) \\ V_E(t) \\ V_N(t) \end{bmatrix} + \begin{bmatrix} \frac{1}{2}S(t)^2 & 0 \\ 0 & \frac{1}{2}S(t)^2 \\ S(t) & 0 \\ 0 & S(t) \end{bmatrix} * \phi(t) \quad (4)$$

Among then $[E(t+1) \ N(t+1) \ V_E(t+1) \ V_N(t+1)]$ and $[E(t) \ N(t) \ V_E(t) \ V_N(t)]$ is he position in the east direction, the position in the north direction, the step speed in the east direction and the step speed in the north direction obtained by the measurement and calculation of UWB equipment and IMU equipment at the time t and the time t+1 respectively. $S(t)$ is the step time of the team members at the time t, and $\phi(t)$ is the system noise at the time t.

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The observation equation of the system is:

$$\begin{bmatrix} E(t) \\ N(t) \\ K(t) \\ Y(t) \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & h_1(t) & h_2(t) \\ 0 & 0 & 0 & h_3(t) \end{bmatrix} \begin{bmatrix} E(t) \\ N(t) \\ V_E(t) \\ V_N(t) \end{bmatrix} + \gamma(t) \tag{5}$$

$$h_1(t) = S(t) * V_E(t) / \sqrt{V_E(t)^2 + V_N(t)^2} \tag{6}$$

$$h_2(t) = S(t) * V_N(t) / \sqrt{V_E(t)^2 + V_N(t)^2} \tag{7}$$

Among them $\left[E(t)\ N(t)\ K(t)\ \mathrm{Y}(t)\right]$ is t time UWB positioning system with IMU inertial measurement system of position, the position of the north east direction, step length and the attitude Angle, b t time UWB positioning system with system navigation calculation of IMU inertial measurement system get the east, north direction location, north east direction pace, pace, c t moment system observation noise.

According to the above matrix and the process of particle filtering, we can divide it into the following steps:

Prediction: We plot a new set of particles $X_k^i \sim q(X_k \mid X_{0:k-1}^i, Z_{1:k})$ based on the motion model of the node, which is measured by the IMU carried by the node itself. The weight of the filter is $w_k^i = w_{k-1}^i \dfrac{p(Z_k \mid X_k^i) p(X_k^i \mid X_{k-1}^i)}{q(X_k^i \mid X_{k-1}^i, Z_{1:k})}$.

Update: When the measurement between the node and its neighbors is worth it, we assign a new weight $w_k(X_{0:k}^i) = \dfrac{w_k(X_{0:k}^i)}{\sum_{i=1}^{N} w_k(X_{0:k}^i)}$ to each particle according to the UWB's ranging model.

Resampling: According to the size of the normalized weight $w_k(X_{0:k}^i)$, the particle set $X_{0:k}^i$ is copied and eliminated, and reset the weight $w_k^i = 1/N$, a posterior distribution:

$$p(X_{0:k} \mid Z_{1:k}) \approx \frac{1}{N} \sum_{i-1}^{N} \delta_{(X_{0:k}^i)}(dX_{0:k})$$

Final team member position estimation output: $X_k = \int X_k p(X_{0:k} \mid Z_{1:k}) dX_{0:k}$

4. EXPERIMENTAL VERIFICATION

Based on the above theory, in order to verify the rationality and positioning accuracy of this method, a test scheme was designed to compare the combination of UWB and IMU with a single IMU. The IMU equipment used in this study is the IMU equipment developed by the laboratory, and Pulson440 of Time Domain Company is selected as the UWB module. The test site was a complex indoor environment in the Indoor Gnasium Center of Chongqing University of Posts and Telecommunications. The walking range of the test was set as a rectangular path 50m*60m. Three people wore navigation and positioning devices to walk indoors. The experimenter fixed the IMU device on the waist and fixed the UWB device on the head in order to avoid blocking the UWB signal by the human body. In this experiment, two laps were walked around the

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rectangular path. The three mobile people started from the starting point 1 meter apart and kept the distance during the experiment.

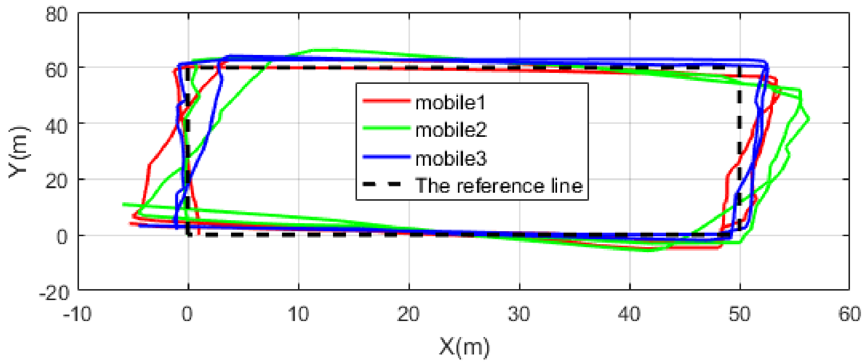

Figure 3. Single IMU route

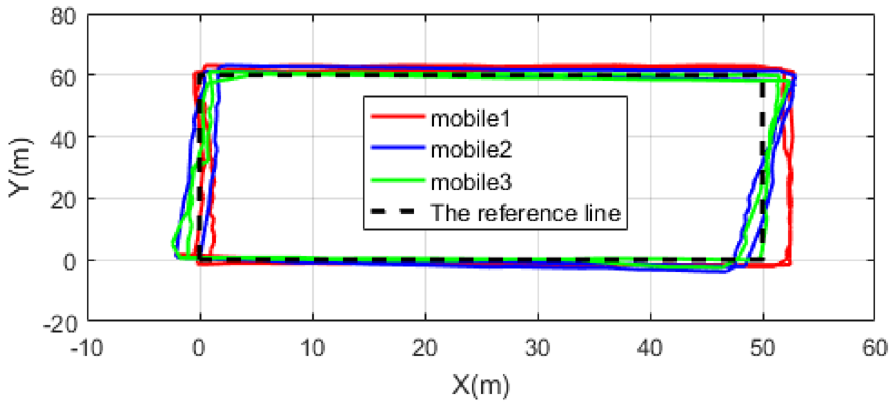

Figure 4. UWB/IMU route

5. SUMMARY

Single IMU inertial navigation long-endurance cumulative error can lead to orientation deviation, this paper puts forward the need of the auxiliary signal source, the IMU inertial information and team in the area of UWB range information combination of navigation and positioning method, relative single IMU inertial navigation, increased the precise distance measurements, using particle filter two kinds of data fusion, in order to improve the precision of navigation and positioning. Through the test verification, after the combination of IMU and UWB, the actual walking track of the team is more coincident with the reference track, and the navigation and positioning accuracy is significantly improved.

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