

# Review and prospect of research on indoor positioning methods

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**Abstract:** With the rapid development of Internet technology, location-based services are increasingly entering the field of mass applications and public services, and people's demand for indoor positioning is gradually increasing. Nowadays, outdoor positioning has been basically solved systematically, and indoor positioning technology has become a research hotspot at home and abroad in recent years due to its complex environment and other factors. This paper analyzes and summarizes the principles, advantages and disadvantages of the existing indoor positioning technologies and methods, and discusses and prospects the indoor positioning methods with higher precision in the future.

**Keywords:** Indoor positioning; Positioning algorithm; Positioning technology; Location-based services.

## 1. Introduction

The Internet of Everything (IoE) has spawned a wide range of indoor positioning services, and there is a growing demand for location-based services (LBS), such as indoor positioning and navigation, smart warehouses, disaster relief and management, location-based marketing, and more. At present, high-precision location acquisition in outdoor conditions mainly relies on Global Positioning System (GPS) and base station positioning. However, GPS signals are hardly available in indoor environments. Therefore, indoor positioning, as a key technology in LBS, has become a very popular research field at home and abroad in recent years, and has also become a very important direction for the development of IoE and smart cities.

At present, common indoor positioning technologies mainly include WiFi positioning technology, Bluetooth positioning technology, ultra-wideband (UMB) positioning technology, geomagnetic fingerprint positioning technology, radio frequency identification (RFID) positioning technology, 4G/5G mobile communication network positioning technology, and radar positioning technology. Wait. The indoor positioning methods mainly include ranging-based method and pattern matching-based positioning method. This paper investigates, analyzes and summarizes the existing commonly used indoor positioning technologies. By comparing the advantages and disadvantages of various technologies, the future higher-precision indoor positioning methods are discussed and prospected.

## 2. Review

### 2.1. Research on Indoor Positioning Algorithm

#### 2.1.1. AOA positioning algorithm

Based on the angle of arrival (AOA) measurement method, also known as triangulation method, this method needs to know the positions of at least two different access points (AP) in advance, and estimates the angle to be measured by measuring the angle between the smart terminal and the two APs. the location of the target. As shown in Figure 1, when the target under test receives signals from two different APs, it will form a triangle with the target under test as the vertex. The position of the target to be measured can be calculated by

knowing the positions of the two APs and the measured angle.

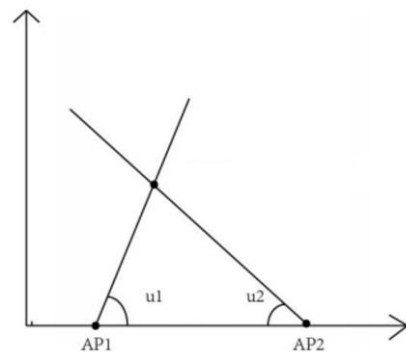


Fig. 1 Principles of Triangulation

#### 2.1.2. TOA positioning algorithm and TDOA positioning algorithm

The time-of-arrival-based method (TOA) and the time-difference-of-arrival-based method (TDOA) estimate the position of the target based on the distance from the target to the reference point, and are also collectively referred to as trilateration. As shown in Figure 2, the positions of AP1, AP2 and AP3 are known. The TOA method is to measure the propagation time of the wireless signal between the reference point and the smart device, and solve a set of circle equations to obtain the distance between the reference point and the smart device. , so as to obtain the position of the target to be measured.

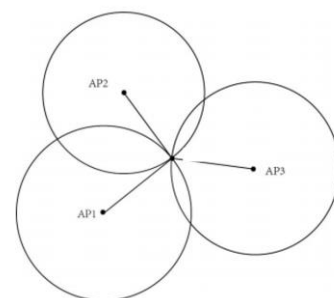


Fig. 2 Principles of TOA Measurement

TDOA is an improvement to TOA, which calculates the distance between a reference point and a smart device by measuring the time difference of arrival. As shown in Figure 3, the positions of AP1, AP2 and AP3 are known. The main

idea of TDOA is to use the arrival time difference to determine two hyperbolas, so as to obtain the position of the target to be measured.

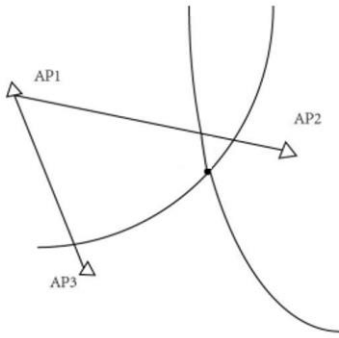


Fig. 3 TDOA measurement principle

### 2.1.3. RSSI ranging and positioning algorithm

Ranging based on RSSI value is an important means to obtain the location information of wireless network nodes. The commonly used wireless signal propagation loss model is shown in the formula:

$$R_d = R_{d_0} - 10 * a * l_g \left( \frac{d}{d_0} \right) + b \quad (1)$$

$R_d$  is the RSSI value of the receiver when the distance between the transmitter and receiver is  $d$ ;  $R_{d_0}$  Indicates the RSSI value when the transmitter and receiver are close to each other (generally  $d_0=1m$ );  $a$  (generally 2~4) represents the path loss coefficient, which depends on the surrounding environmental factors;  $b$  represents the noise, It fits the  $N(0, \delta^2)$  normal distribution,  $\delta^2$  generally takes the value 4~10. When the unknown node receives the signal transmitted by the beacon node, the distance between the beacon node and the unknown node is estimated by comparing the strength of the transmitted signal and the received signal, and the estimated coordinates of the unknown node are obtained by trilateration.

### 2.1.4. RSSI Fingerprint Matching and Localization Algorithm

The RSSI fingerprint matching positioning algorithm is to extract the signal characteristic information of a specific position in the measurement environment, establish a fingerprint database, and realize the positioning of the target to be measured by matching the real-time signal with the characteristic information in the fingerprint database. The method is mainly divided into two stages: offline data acquisition stage and online positioning stage. In the offline data collection stage, the signal strength (RSS) equivalents are collected to construct a signal fingerprint database; in the online positioning stage, the real-time RSS equivalents collected at the test point are compared with the information in the fingerprint database, and the relevant matching algorithm is used to estimate the User's location.

## 2.2. Indoor positioning technology

### 2.2.1. Wi-Fi positioning technology

Wi-Fi positioning technology is a positioning method based on wireless signals. Because Wi-Fi technology is relatively mature and widely used, Wi-Fi positioning technology has the characteristics of easy implementation, low cost and high precision. The method is a feature matching-based positioning technology. The principle of realization is to first extract the signal feature information of a specific location in the measurement environment, establish a fingerprint database, and then match the real-time signal of

the smart terminal with the feature information in the fingerprint database. The positioning of the target to be measured.

### 2.2.2. Bluetooth positioning technology

The Bluetooth positioning technology is based on the signal strength and uses the principle of multilateral positioning to estimate the position. In this method, the Bluetooth beacon needs to be installed and arranged indoors in advance, and a corresponding Bluetooth module is required on the user's device. First, the RSSI value sent by Bluetooth is measured by the smart device, and then the position of the target to be measured is estimated through its built-in positioning algorithm. The Bluetooth positioning technology is easy to implement and has a high degree of integration. However, the cost of Bluetooth devices is relatively high, and the positioning accuracy is easily affected by the surrounding environment, and the stability is not high.

### 2.2.3. Ultra-wideband (UWB) positioning technology

Ultra-wideband (UWB) positioning technology is a wireless technology based on extremely narrow pulses. It transmits data by sending and receiving extremely narrow pulses with nanoseconds or microseconds below, and uses triangulation or fingerprint positioning to locate. . UWB technology can have better anti-multipath effect, and has the advantages of high transmission speed, strong penetration, and low transmit power. However, this technology requires special equipment and solutions, which is costly and difficult to implement.

### 2.2.4. Mobile communication network positioning technology

With the advent of the 5G era, technologies represented by millimeter-wave communications have received increasing attention. 5G NR is a global 5G standard based on a new air interface design based on OFDM (Orthogonal Frequency Division Multiplexing) . Based on extensive and extensive analysis, experiments and comparisons, the best and most popular indoor positioning scheme based on cellular mobile communication systems is OTDOA (Time Difference of Arrival Positioning). But in general, the current research on 5G positioning is still relatively small, and the research on 5G positioning has great application value.

## 3. Conclusions

There are various positioning technologies, each with advantages and disadvantages. At present, a lot of research has been done on indoor positioning at home and abroad, but there is still no set of relatively mature and high-precision indoor positioning solutions. Due to its own limitations and uniqueness, a single positioning technology is difficult to achieve high-precision indoor positioning. Therefore, how to effectively integrate multiple positioning technologies is the key to research. And with the continuous introduction of 5G standards, it has also brought new vitality to indoor positioning research. In the future, high-precision, mature and reliable indoor positioning will surely be achieved.

## Acknowledgments

This work was supported by Natural Science Project of Guangdong University of Science and Technology (GKY-2021KYQNK-5).

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