

## *Retraction*

# **Retracted: Research on Acquisition and Tracking Algorithm of Global Satellite Positioning Receiver Based on UWB**

### **Wireless Communications and Mobile Computing**

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

### **References**

- [1] L. Yang, D. Sun, and H. Ruan, "Research on Acquisition and Tracking Algorithm of Global Satellite Positioning Receiver Based on UWB," *Wireless Communications and Mobile Computing*, vol. 2021, Article ID 9025086, 9 pages, 2021.

## Research Article

# Research on Acquisition and Tracking Algorithm of Global Satellite Positioning Receiver Based on UWB

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In order to overcome the problems of the traditional algorithm, such as the time-consuming execution of acquisition instructions, low signal tracking accuracy, and low signal capture accuracy, a global satellite positioning receiver acquisition and tracking algorithm based on UWB technology is designed in this study. On the basis of expounding the pulse generation method and working principle in UWB technology, this paper analyzes in detail the characteristics of UWB technology, such as antimultipath, low power consumption, and strong penetration. Then, on the basis of window function filtering, in the process of three-dimensional search of global satellite positioning signal, firstly, the satellite signal entering the GPS software receiver is processed by RF front-end mixing and AD sampling, and then, the signal tracking and navigation message solving are completed according to the relationship between the influence factor and Doppler frequency offset. The experimental results show that the execution time of the acquisition instruction of the proposed algorithm varies between 1129 ms and 1617 ms; the signal tracking accuracy ranges between 0.931 and 0.951, and the signal capture accuracy ranges between 93.3% and 95.6%, which proves that the proposed algorithm has achieved the design expectation.

## 1. Introduction

Global positioning system (GPS) has realized real-time, reliable, and accurate positioning services anywhere on the earth, and GPS receiver is the key to realize accurate and fast positioning [1]. Compared with the hardware receiver, the software receiver transplants all the signal processing process to the programmable microprocessor for implementation and has significant advantages such as high flexibility, strong expansibility, and convenient upgrade [2].

In general, GPS software receiver includes RF front-end module, ADC module, capture module, tracking module, and navigation message solving module. The capture module is the foundation of the following tracking module and the message solving module, which directly affects the performance of GPS software receiver [3]. The function of the acquisition module is to determine the visible satellite and roughly estimate the C/A code phase and Doppler frequency offset of the visible satellite GPS signal, which provides support for the follow-up signal tracking and position calculation.

With the continuous expansion of the application range of GPS technology, GPS positioning technology under weak signal conditions (tunnel, forest, indoor, etc.) has received extensive attention, and GPS signal acquisition with high sensitivity has become a hot research issue.

For a specific visible satellite, GPS signal acquisition is a two-dimensional search problem in the signal Doppler frequency domain and the phase domain of C/A code [4]. Early GPS receivers usually adopt sliding correlation acquisition algorithm, which has a large amount of computation and a long acquisition time. To improve the capture speed, in reference [5], a new parallel fast acquisition algorithm is proposed for C/A code acquisition of GPS software receiver under weak signal conditions. In this method, the average correlation technique is used to reduce the autocorrelation loss of C/A codes, and the cumulative error of C/A codes is reduced based on the carrier frequency error compensation technique. The superposition correlation method is used to reduce the complexity of coherent accumulation operation, and the time consumption of frequency stepping

search is reduced by cyclic shift. Experimental results show that the algorithm can effectively achieve GPS signal acquisition. The comparative simulation results show that this algorithm can capture weak GPS signals with moderate computation and is suitable for high sensitivity software receivers. In the research of reference [6], in order to make full use of the GNSS receiver in the processing process, the prior information of the navigation filter is used to assist the acquisition of the baseband signal, which improves the acquisition speed and sensitivity. In this method, the concept of "virtual path" is introduced to calculate the phase of the pseudo code, and the algorithm of directly calculating the phase of the received pseudo code by navigation filter is derived in detail. Then, the error source and propagation characteristics of the pseudo code phase and Doppler frequency are analyzed in detail. However, the above two methods have the drawback of long capture instruction execution time.

In reference [7], a fast satellite signal acquisition algorithm based on Sparse Fast Fourier Transform (SFFT) is presented. Combined with the strong autocorrelation of satellite signal pseudo random code, the original estimation of SFFT amplitude is removed. By using the time-domain serial acquisition method, the local pseudo random code corresponding to the large coordinate point output in SFFT algorithm is correlated with the received satellite signal, and then, the satellite signal is captured. In order to solve the problem that the Fourier transform of the traditional parallel frequency acquisition algorithm in the Beidou satellite receiver needs to process a large amount of data and thus affects the acquisition speed of satellite signals, a fast Beidou signal acquisition algorithm based on coherent drop sampling is proposed. By using FPGA+DSP (high speed digital signal processor + field programmable logic gate array), the coherent drop sampling module is added into the traditional parallel frequency acquisition algorithm. After carrier stripping and pseudo code stripping, the amount of data to be processed by Fourier transform is reduced by reducing the sampling frequency, and then, the satellite signal is searched in three dimensions. However, in the practical application, it is found that the above two methods have the problems of low tracking accuracy and poor capture accuracy.

Although there have been many research results in this field, however, the current research results still have some shortcomings, such as high algorithm computational complexity and time complexity, and the research results can not be applied to the actual system. In order to solve these problems of the traditional methods, this paper designs a global satellite positioning receiver acquisition and tracking algorithm based on UWB technology. On the basis of expounding the pulse generation method and working principle in UWB technology, this paper analyzes in detail the characteristics of UWB technology, such as anti-multipath, low power consumption, and strong penetration. Then, on the basis of window function filtering, in the process of three-dimensional search of global satellite positioning signal, firstly, the satellite signal entering the GPS software receiver is processed by RF front-end mixing and AD sampling, and then, the signal tracking and navigation

message solving are completed according to the relationship between the influence factor and Doppler frequency offset.

The main work of this paper can be concluded as follows:

- (1) We study the problem of acquisition and tracking algorithm of global satellite positioning receiver based on UWB, which is now a very hot research point
- (2) We proposed a new acquisition and tracking algorithm of global satellite positioning receiver. This new method is based on the UWB, and we analyze in detail the characteristics of UWB technology, such as anti-multipath, low power consumption, and strong penetration

The rest of this paper is organized as follows: Section 1 gives the relevant concepts. Section 3 gives the acquisition, and tracking algorithm of GPS receiver is designed based on UWB technology. Section 4 is the experiment and the result analysis. The conclusion is given in Section 5.

## 2. Relevant Concepts

*2.1. GPS Technical Analysis.* GPS, also known as the global positioning system (GPS), is a midrange circular orbit satellite navigation system that combines the technology of satellite and communication development and uses navigation satellites for time measurement and ranging [8]. GPS is a new generation of satellite navigation and positioning system developed by the United States from the 1970s, which lasted more than 20 years and cost 20 billion US dollars. It was fully completed in 1994 and has the ability to fully implement three-dimensional navigation and positioning in the sea, land, and air. After nearly ten years of use by surveying and mapping departments in China, the global positioning system has won the trust of surveying and mapping workers with the characteristics of all-weather, high precision, automation, and high efficiency and successfully applied to geodesy, engineering survey, aerial photogrammetry, vehicle navigation and control, crustal movement monitoring, engineering deformation monitoring, resource investigation, geodynamics, and other disciplines, so as to bring a profound technical revolution in the field of surveying and mapping [9].

The global positioning system is composed of a monitoring center and a mobile terminal, and the monitoring center is composed of a communication server and a monitoring terminal. The communication server is composed of the main controller and the GSM/GPRS receiving and sending module [10]. Among them, the mobile terminal is composed of GPS receiver, GSM transceiver module, main control module and external probe, etc. In fact, the GPS positioning system is a "3G" system composed of GSM, GPS, and GIS with high new technology. The structure of GPS receiver is divided into antenna unit and receiving unit. The global positioning system is shown in Figure 1.

The basic positioning principle of GPS is that the satellite continuously sends its own ephemeris parameters and time

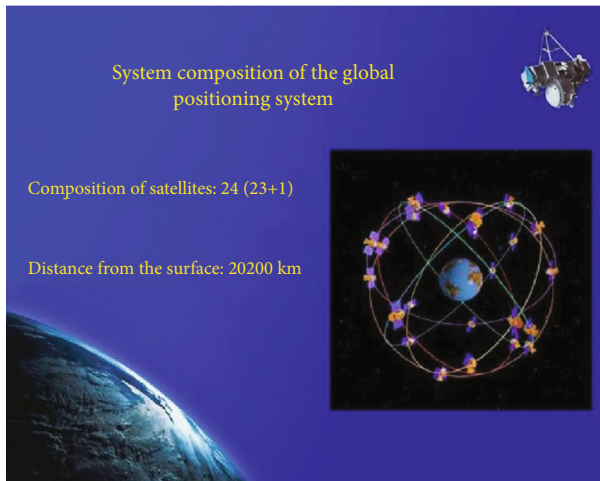


FIGURE 1: Composition of GPS.

information. After receiving these information, the user calculates the three-dimensional position, three-dimensional direction, and motion speed and time information of the receiver [11].

In recent years, China has built permanent GPS tracking stations in Beijing, Wuhan, Shanghai, Xi'an, Lhasa, Urumqi, etc., to carry out precise orbit determination of GPS satellites, provide observation data and precise ephemeris services for high-precision GPS positioning and measurement, and commit to the establishment of China's independent wide-area differential GPS (WADGPS) scheme. Participate in the preparation of the Global Navigation Satellite System (GNSS) and GPS Enhancement System (WAAS). At the same time, China has started to build its own satellite navigation system (binary satellite positioning system), capable of producing navigation GPS receivers. The application of GPS technology is developing at a deeper level [12].

**2.2. UWB Technical Analysis.** Ultrawide band (UWB) is a wireless carrier communication technology that does not use a sinusoidal carrier but uses narrow pulses of nonsinusoidal waves at the nanosecond level to transmit data, thus covering a wide spectrum. UWB technology has the advantages of low system complexity, low power spectral density of transmitted signals, insensitivity to channel fading, low ability of interception, and high positioning accuracy, which is especially suitable for high-speed wireless access in dense multipath places such as indoor [13].

UWB technology began with the rise of pulse communication technology in the 1960s. UWB technology uses extremely wide spectrum of ultrawide baseband pulse to communicate, so it is also called baseband communication technology, wireless carrier communication technology, mainly used in military radar, and positioning and communication systems with low interception rate/low detection rate. Instead of using a sinusoidal carrier, UWB uses narrow pulses of nonsinusoidal waves at the nanosecond level to transmit data, so it covers a wide spectrum and, despite wireless communication, can transmit data at rates of several hundred megabits per second or more [14]. UWB

technology can be used to transmit signals over very wide bandwidth, the United States Federal Communications Commission (FCC) regulations for UWB technology: in the 3.1 to 10.6 GHz band of 500 MHz or more bandwidth.

In essence, UWB is a carrier-free spectrum spreading technology using impulse pulse with very low duty cycle as information carrier. It directly modulates the impulse pulse with very steep rise and fall time. A typical UWB directly transmits an impulse train, which no longer has the traditional concepts of IF and RF. The transmitted signal can be regarded as either baseband signal (in terms of conventional radio) or RF signal (in terms of the spectral component of the transmitted signal).

The impulse pulse usually adopts a single period Gaussian pulse, and one bit of information can be mapped into hundreds of such pulses. Single-period pulses are nanosecond in width and have a wide spectrum. UWB has developed a new wireless channel with gigahertz capacity and the highest space capacity [15]. UWB pulse wireless transceiver based on CDMA generates a pulse sequence with a certain repetition period in the clock generator at the sending end. The information to be transmitted by the user and the pseudo random code representing the user's address are, respectively, or combined to modulate the above periodic pulse sequence in a certain way, and the modulated pulse sequence drives the pulse generation circuit. A pulse sequence of certain pulse shape and regularity is formed and then amplified to the required power and then coupled to the UWB antenna to transmit. At the receiving end, the signal received by the UWB antenna is amplified by a low noise amplifier and sent to one of the input ends of the correlator. At the other input end of the correlator, a locally generated pulse sequence modulated by the user pseudo random code synchronizes with the initiator is added. The receiving signal and the pulse train modulated by the local synchronous pseudo random code go through the multiplication, integration, and sampling and holding operations in the correlator together to generate a signal separated from the user's address information, which only contains the user's transmission information and other interferences, and then demodulate the signal [16].

### 3. The Acquisition and Tracking Algorithm of GPS Receiver Is Designed Based on UWB Technology

Based on the above analysis, this paper designs a GPS receiver acquisition and tracking algorithm based on UWB technology.

**3.1. Application of UWB Technology.** UWB communicates by sending an instantaneous spike wave or pulse wave. These pulses are limited to a width of less than 1 nm and emit pulses representing data in a very short period of time, enabling transmission rates of up to hundreds of megabytes.

There are two ways to generate a pulse source:

- (a) *Photoelectric Method.* The basic principle is to obtain pulse signal by using the steep rising edge of the



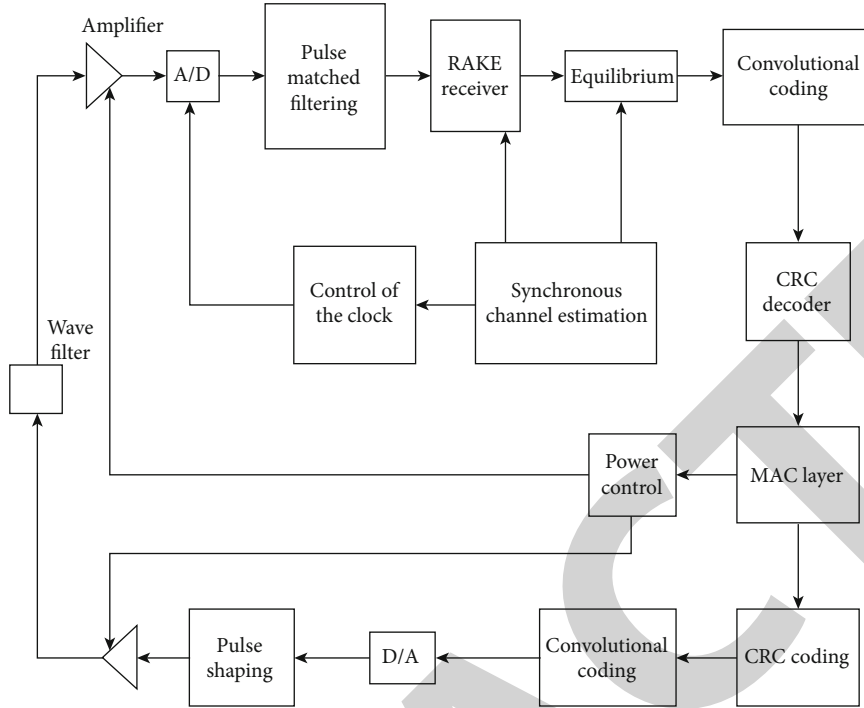


FIGURE 2: Structure diagram of UWB transceiver.

photoconductive switch. The pulse width obtained from the laser pulse signal can reach the order of picosecond (10-12), which is the most promising method [17]

- (b) *Electronic Methods.* The basic principle is to reverse charge the semiconductor PN junction, so that it reaches the avalanche state, and at the moment of conduction, take the steep rising edge as a pulse signal. The very short pulse obtained after shaping is the most widely used scheme at present, but due to the limitation of transistor voltage resistance characteristics, this method can only produce tens to hundreds of volts of pulse; pulse width can reach 1 ns below

There are a variety of UWB pulses, among which the typical one is the Gaussian mono-periodic pulse, whose time-domain and frequency-domain formulas can be expressed as follows:

$$v(t) = 6A \sqrt{\frac{e\pi}{3\tau}} \times \frac{t}{\tau} \exp\left(-6\pi\left(\frac{t}{\tau}\right)^2\right), \quad (1)$$

$$v(f) = -j\left(\frac{2f^2}{3}\right) \sqrt{\frac{e\pi}{2}} \exp\left(\frac{\pi}{6f^2\tau^2}\right), \quad (2)$$

where  $A$  is pulse amplitude,  $\tau$  is time delay length,  $t$  is time, and  $f$  is frequency. From the formula, we can know, center frequency  $f = 1/\tau$ , and half power bandwidth  $W = f \times 1.16$ . Thus, a single cycle pulse with a pulse width of 0.5 ns can

be obtained. Its center frequency is 2 GHz, and half power bandwidth is about 2 GHz.

As shown in Figure 2, the structure of the transceiver is divided into baseband part and RF part. Because there is no complex RF and IF transformation, the analog signal processing of the UWB transceiver can be simplified. When the data is sent, the signal sent is coded and interwoven by the digital signal processor. After the digital signal is converted by D/A, the pulse is formed, amplified, and then transmitted.

The received pulse signal is directly converted to A/D through antenna matching, filtering, and amplification, and the complex baseband processing such as demodulation, matched filtering, diversity receiving, channel estimation, and equalization is handed over to the digital signal processor for processing. The whole system can be done on a chip. Of course, the design of UWB system also faces some challenges, such as the UWB system used in the ultrawide band antenna, ultranarrow pulse generation, low energy narrow pulse detection, A/D and D/A transformation accuracy and speed, and accurate timing of pulse reception. All need to be further studied.

Global positioning system is a dense multipath system. Therefore, combined with the characteristics of UWB technology, its application advantages in GPS network are as follows:

- (a) *Multipath Resistance.* Multipath fading is a major obstacle to wireless communication. Traditional wireless technology is vulnerable to multipath interference, which makes wireless transmission characteristics worse, and it is difficult to accurately track the location with multipath dry disturbance. UWB signal has very high resolution due to its very high

frequency and very low duty cycle, and the resolution of different paths can be reduced to the order of ns, which is insensitive to channel multipath fading

For conventional wireless signal multipath fading depth of 10-30 dB, multipath environment for UWB signal fading less than 5 dB has an excellent antimultipath performance.

- (b) The low power consumption of the system is conducive to intrinsically safe design. The UWB system does not use carrier and has a very low signal duty cycle (as low as 0.5%). The system consumes only a few hundred  $\mu\text{W}$  to a few tens of mW during high-speed communication, which is only 1/10-1/100 of the power consumption of existing radio stations
- (c) *Strong Penetration.* The attenuation characteristics of UWB signal in the form of baseband narrow pulse are different from that of general wireless communication signal which carries information by sinusoidal carrier. The sinusoidal electromagnetic wave emitted by an antenna is a spherical wave whose attenuation in free space is inversely proportional to the square of the distance. However, the UWB transient pulse with appropriate waveform has strong orientation, and its attenuation is inversely proportional to or less than the distance. Therefore, at the same power, the UWB signal in the baseband narrow-pulse form can travel a longer distance than the ordinary modulated carrier signal
- (d) The transmission distance can be increased by increasing the transmitting power. According to the characteristics of UWB technology, the application of UWB technology in GPS network can reduce the transmission rate to achieve long distance wireless access service in many occasions

**3.2. Window Function Filtering.** The main mathematical tool in digital signal processing is Fourier transform. The Fourier transform deals with the whole time domain and the frequency domain. However, when engineering test signal processing is realized by computer, it is impossible to measure and calculate the infinite length of signal but to analyze the finite time segments. The method is to intercept a time segment from the signal and then use the intercepted signal time segment for periodic extension processing, to get a virtual infinite long signal, and then, the signal can be Fourier transform, correlation analysis, and other mathematical processing. When a signal of infinite length is truncated, its spectrum is distorted, and the energy that was concentrated at  $f(0)$  is spread over two wider bands (a phenomenon known as spectral energy leakage).

Window function is to realize the operation time reach the key steps of the linear, but using the traditional window function of truncation will cause the spectrum leakage, so in this paper, the window function by the Gaussian window function and the convolution of the rectangular window function make it in time domain and frequency domain

energy can be concentrated, thus use of window function to the UWB signal filter processing.

The flat window function constructed in this study is expressed by  $g$  in the time domain and  $G$  in the frequency domain, and its parameter is  $1/B, 1/2B, \delta, \omega$ .  $K$  is signal sparsity, window width is  $B = O(\sqrt{NK/\varepsilon \log(N/\delta)})$ , and  $\omega = O(B \log(N/\delta))$ .

Sequence  $y$  can be obtained by multiplying  $P_{\sigma,\tau}x$  and  $g$ . The process is as follows:

$$y = P_{\sigma,\tau}x \cdot g. \quad (3)$$

Different window functions have different effects on the signal spectrum, which is mainly because different window functions have different leakage sizes and different frequency resolution abilities. Signal truncation produces energy leakage, while FFT algorithm is used to calculate the spectrum and produces fence effect. In principle, these two errors cannot be eliminated, but we can suppress their effects by selecting different window functions. The main lobe of the rectangular window is narrow, the side lobe is large, the frequency identification accuracy is the highest, and the amplitude identification accuracy is the lowest. The main lobe of Blackman window is wide, the side lobe is small, and the frequency identification accuracy is the lowest, but the amplitude identification accuracy is the highest.

In the process of designing the filter, the given amplitude characteristic is usually piecewise constant, and there are discontinuity points at the frequency band boundary. The infinite impulse response (IIR) digital filter is needed to approximate this characteristic. In order to realize the finite impulse response (FIR), an appropriate and finite time wide window sequence can be selected to weight the infinite impulse response sequence, so as to constitute the finite impulse response digital filter to realize the given characteristics. Because the multiplication of two sequences in the time domain is equivalent to the convolution of the discrete Fourier transform of two sequences in the frequency domain, therefore, the convolution of the window function with a given filter property can achieve the goal of approximating the given property with a finite impulse response.

In order to improve the resolution, it is required to increase the length of recorded data when using the classical periodic graph to estimate the power spectrum, but the result will lead to the increase of the fluctuation of the periodic graph, that is, the increase of the estimation variance. In order to smooth the spectrum estimation and reduce the variance of the estimation, the data can be windowed, and then, the period graph estimation can be made to achieve the tradeoff between reducing the variance and improving the resolution.

**3.3. Tracking Capture.** The three-dimensional search process of global positioning signals is shown in Figure 3. According to this figure, we can get the search process of global positioning signals. In the capture range, we can use the code phase estimate and carrier frequency estimation to search the target.

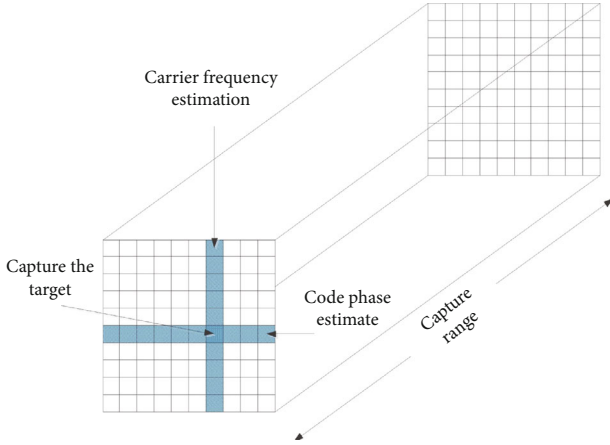


FIGURE 3: 3D search schematic diagram of global positioning signals.

After the RF front-end mixing processing and AD sampling processing of the satellite signal entering the GPS software receiver, the digital baseband signal can be expressed as

$$x(t_n) = qD_k(t_n)C_k(1 + \hat{\eta})(t_n - t_\tau) \cos((\omega_{IF} - \omega_D)t_n + \phi_0) + v(t_n). \quad (4)$$

Among them,  $q$  represents the signal amplitude,  $t_n$  represents the time series after sampling,  $D_k(t_n)$  represents the GPS navigation message data sequence with an interval of 20 ms, and  $C_k(t_n)$  represents the pseudo random coding of the satellite, namely, the C/A code to be captured.  $t_\tau$  represents the initial phase of C/A code,  $\eta$  represents the influence factor of the phase of Doppler frequency offset C/A code,  $\omega_{IF}$  represents the IF frequency output after mixing,  $\omega_D$  represents the Doppler frequency offset generated by the relative motion between GPS receiver and satellite,  $\phi_0$  represents the initial phase, and  $v(t_n)$  represents the additive white Gaussian noise.

Ignoring the influence of the ionosphere, there is the following relationship between the influence factor and Doppler frequency offset:

$$\eta = \frac{\omega_D}{2\pi \times 1575.42 \times 10^6}. \quad (5)$$

C/A code capture is to estimate the initial code phase and Doppler frequency offset  $\omega_D$  according to the sampled digital base band signal, which supports subsequent signal tracking and navigation message solution;  $\eta$  is the influence factor.

For example, to capture the signal of the  $j$ -th satellite, the codirectional and orthogonal components of the IF signal of the satellite's C/A code are, respectively, copied in the software receiver:

$$I(t_n) = C_k(1 + \hat{\eta})(t_n - \hat{t}_\tau) \cos(\omega_{IF} - \hat{\omega}_D)t_n, \quad (6)$$

$$Q(t_n) = -C_k(1 + \hat{\eta})(t_n - t_\tau) \sin(\omega_{IF} - \hat{\omega}_D)t_n. \quad (7)$$

TABLE 1: Experimental parameter table.

Parameter	The numerical
Intermediate frequency	1.40 MHz
Sampling frequency	5.71 MHz
Doppler frequency offset	1000 Hz
Code phase	900
Coherent integration time	5 ms
Window function parameter $B$	144
The sparse degree	4

In the formula,  $C_k(1 + \hat{\eta})(t_n - t_\tau)$  represents the C/A code of local replication,  $\cos(\omega_{IF} - \hat{\omega}_D)t_n$  and  $\sin(\omega_{IF} - \hat{\omega}_D)t_n$  represent the codirectional carrier and orthogonal carrier of local replication, respectively, and  $\hat{\eta}$ ,  $\hat{t}_\tau$ , and  $\hat{\omega}_D$  represent the estimated value of  $\eta$ ,  $t_\tau$ , and  $\omega_D$ , respectively. Because of the coupling relationship between  $\eta$  and  $U$ , the  $\omega_D$  code capture problem is a two-dimensional search problem about.

After correlating the locally replicated codirectional carrier and orthogonal carrier with the IF signal of GPS software receiver, the following can be obtained:

$$z_I(t_n) = \sum_{n=0}^{N-1} x(t_n)I(t_n), \quad (8)$$

$$z_Q(t_n) = \sum_{n=0}^{N-1} x(t_n)Q(t_n). \quad (9)$$

The two signals after correlation are composed of complex signals, and the process is as follows:

$$Z(t_n) = z_I(t_n) + jz_Q(t_n). \quad (10)$$

When  $\hat{t}_\tau = t_\tau$  and  $\hat{\omega}_D = \omega_D$ ,  $Z(t_n)$  gets the maximum value. Therefore, GPS signal capture and tracking can be achieved by traversing  $t_\tau$  and  $\omega_D$  and comparing the maximum value of  $Z(t_n)$  with the threshold.

## 4. Experiment and Result Analysis

**4.1. Experimental Design.** In order to verify the actual application performance of the acquisition and tracking algorithm for the global positioning receiver based on UWB technology designed in this study, the following simulation experiments are designed.

Experimental parameters are shown in Table 1.

In order to effectively solve the unilateral and one-sided problems of the experimental results, the paper compares the traditional GPS software receiver signal fast acquisition algorithm (algorithm of reference [5]) and the satellite signal acquisition algorithm based on the relevant SFFT (algorithm of reference [7]) and the fast acquisition algorithm of Beidou signal based on FPGA+DSP (algorithm of reference [8]).

TABLE 2: Statistical results of capture instruction execution time of different algorithms (ms).

Number of experiments/time	Algorithm of reference [5]	Algorithm of reference [7]	Algorithm of reference [18]	Algorithm of this paper
100	4240	3040	3799	1617
200	4421	3319	3842	1129
300	4325	3407	3695	1130
400	4021	4011	4005	1534
500	4217	4485	4016	1437

TABLE 3: Comparison of signal tracking accuracy of different algorithms.

Number of experiments/time	Algorithm of reference [5]	Algorithm of reference [7]	Algorithm of reference [18]	Algorithm of this paper
100	0.831	0.827	0.725	0.931
200	0.842	0.831	0.726	0.939
300	0.820	0.841	0.759	0.940
400	0.832	0.881	0.772	0.944
500	0.855	0.910	0.786	0.951

#### 4.2. The Experiment Indicators

- (1) *Capture Instruction Execution Time*. This indicator can reflect the working efficiency of different algorithms. The less time it takes to execute the capture command, the higher the efficiency of the algorithm, and the GPS receiver can capture the positioning signal in a shorter time. On the contrary, the more time it takes to execute the capture instruction, the lower the efficiency of the algorithm
- (2) *Signal Tracking Accuracy*. This index can reflect the reliability of different algorithms. The value range of signal tracking accuracy is [0,1]. The closer the signal tracking accuracy is to 1, the higher the reliability of the algorithm is
- (3) *Accuracy of Signal Capture*. this index can directly reflect the effectiveness of different algorithms. The higher the accuracy of signal capture, the higher the effectiveness of the algorithm, and the more effective the satellite positioning signal can be obtained. On the contrary, the lower the accuracy of signal capture, the lower the effectiveness of the algorithm

#### 4.3. Experimental Results and Analysis

4.3.1. *Capture Instruction Execution Time*. First, the capture instruction execution time of different algorithms was counted, and the results are shown in Table 2.

By comparing the results in Table 2, it can be seen that after the application of algorithm of reference [5], with the increase in the number of experiments, the execution time of capture instruction varies between 4021 ms and 4421 ms. With the application of algorithm of reference [7], the execution time of capture instruction varies between 3040 ms

and 4485 ms with the increase of the number of experiments. After the application of algorithm of reference [18], with the increase of the number of experiments, the execution time of capture instruction varies between 3695 ms and 4016 ms. However, with the application of algorithm of this paper, the execution time of capture instruction varies between 1129 ms and 1617 ms with the increase of the number of experiments.

Through the comparison of the above experimental results, it can be seen that the algorithm of this paper takes less time to execute the capture instruction, indicating that the higher the efficiency of the algorithm, the shorter the time the global satellite positioning receiver can capture the positioning signal.

4.3.2. *Signal Tracking Accuracy*. By comparing the signal tracking accuracy of different algorithms, the comparison results are shown in Table 3.

By analyzing the experimental results shown in Table 3, it can be seen that the signal tracking accuracy of the algorithm of reference [5] is between 0.831 and 0.855 with the increase of the number of experiments. The signal tracking accuracy of the algorithm of reference [7] is between 0.827 and 0.910. Algorithm of reference [18], whose signal tracking accuracy is between 0.725 and 0.786. The signal tracking accuracy of the algorithm of this paper is between 0.931 and 0.951.

Compared with the three traditional algorithms, the signal tracking accuracy of the algorithm of this paper is closer to 1. Therefore, it can be seen that the acquisition and tracking algorithm of global positioning receiver based on UWB technology designed in this paper is more reliable.

4.3.3. *Accuracy of Signal Capture*. The accuracy of signal capture of different algorithms was counted, and the comparison results are shown in Figure 4.



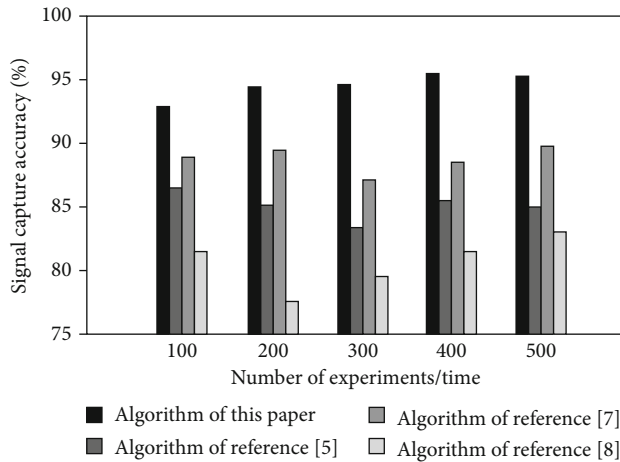


FIGURE 4: Comparison of signal capture accuracy of different algorithms (%).

By analyzing the experimental results shown in Figure 4, it can be seen that the accuracy of defect feature extraction by different methods keeps increasing. The accuracy of the signal capture for the algorithm of reference [5] ranges from 82.5% to 86.8%, and the accuracy of the algorithm of reference [7] ranges from 84.7% to 90.1%. The signal capture accuracy of the algorithm of reference [18] ranges from 77.5% to 83.0%, while that of the algorithm of this paper ranges from 93.3% to 95.6%.

Compared with the three traditional algorithms, the algorithm of this paper has higher signal capture accuracy. Therefore, it can be concluded that the acquisition and tracking algorithm of global positioning receiver based on UWB technology designed in this study can obtain more effective satellite positioning signals.

To sum up, the acquisition and tracking algorithm for global satellite positioning receiver based on UWB technology designed in this study has the advantages of less time consuming in the execution of capture instructions, high signal tracking accuracy, and high signal capture accuracy and is suitable for promotion.

## 5. Conclusion

In order to solve the problems in the traditional signal capture and tracking algorithm, this paper proposed a global satellite positioning receiver acquisition and tracking algorithm based on UWB technology. The main work of this paper is to design the window function filtering process after analyzing the multipath resistance, low power consumption, and strong penetration characteristics of UWB technology in detail. In the process of 3D search of GPS positioning signals, the satellite signals that enter the GPS software receiver are firstly processed by RF front-end mixing and AD sampling, and then, the signal tracking and navigation message solving are completed according to the relationship between influence factors and Doppler frequency offset.

After completing the algorithm design, this study also carried out experiments. The experimental results show that the execution time of the acquisition instruction of the pro-

posed algorithm varies between 1129 ms and 1617 ms, the signal tracking accuracy ranges between 0.931 and 0.951, and the signal capture accuracy ranges between 93.3% and 95.6%, which fully proves the effectiveness of the proposed algorithm.

In the future, we will continue to study other acquisition and tracking algorithm of global satellite positioning receiver and develop practical application systems as soon as possible.

## Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

## Conflicts of Interest

The authors declare that they have no conflict of interest.

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