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Intelligent Supermarket Shopping Guide System Based on UWB

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Abstract: *With the continuous development of society, people's shopping needs and consumption levels are constantly improving. Supermarkets tend to be large and multi-layered. The convenience of consumers' shopping is not enough, which reduces the shopping experience of consumers and cannot meet the shopping needs of most consumers. We designed a supermarket indoor shopping guide system based on UWB positioning. The system uses UWB technology to locate supermarket trolleys, and then sends the positioning information to the mobile phone through the server to navigate for customers. The system terminal intelligently generates recommendation messages through consumers' specific shopping behaviors, so that consumers can obtain more convenient and effective shopping methods.*

Keywords: *Smart Supermarket, Indoor Positioning, UWB*

1. Introduction

UWB technology began with the rise of pulse communication technology in the 1960s. UWB technology uses ultra-wide baseband pulses with extremely wide spectrum to communicate, also known as baseband communication technology and wireless carrier communication technology. It does not use a sinusoidal carrier, but transmits data using nanosecond non-sinusoidal narrow pulses [1]. Therefore, it occupies a large spectrum range, and although wireless communication is used, its data transmission rate can reach hundreds of megabits per second or more. Signals can be transmitted over a very wide bandwidth using UWB technology, which is mainly used in military radar, positioning, and low-intercept/low-detection communication systems [2]. Because UWB technology has high data transmission rate (up to 1Gbit/s), strong anti-multipath interference ability, low power consumption, low cost, strong penetration ability and low interception rate. And it shares the characteristics of spectrum with other existing wireless communication systems. UWB technology has become the preferred technology of wireless personal area network communication technology (WPAN).

Compared with foreign advanced countries, my country's UWB research and development started relatively late. Since 1999, Chinese researchers began to pay attention to the development of UWB technology [3]. With the initial emergence of the indoor positioning business model and the vigorous promotion of mainstream chip manufacturers, location service providers, and integrators in all aspects of the industry chain [4], UWB technology currently has a large number of industry application cases in the domestic and even the global market [5].

In order to solve the problem that consumers cannot find products during shopping, and the actual effect of shopping guides, paper leaflets and shopping guides is poor, a supermarket indoor navigation system is designed. Based on UWB indoor positioning technology, this system aims to improve the shopping efficiency and shopping experience of consumers. The system realizes the positioning of users and the guidance of commodities. The client is positioned through the shopping tag. APP realizes the guidance to the user; The supermarket side processes the real-time information of the user uploaded by the positioning tag, and generates a 2D/3D model to guide the user in real time.

Therefore, the problems to be solved are: (1) The establishment of the 3D model of the supermarket. (2) Supermarket navigation requires high precision. How to arrange the anchor points to maximize the advantages of UWB's high precision. (3) How to make full use of the characteristics of UBW's strong anti-interference ability and fast data transmission speed. How to use an algorithm to implement TWR ranging method to measure the distance between the tag and each anchor point, and calculate the

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current position of the tag according to the distance. (4) How to make the user operation simpler and more convenient, lower the operation threshold, and improve the user's shopping experience.

UWB technology has the advantages of strong penetration, low power consumption, good anti-multipath effect, high security, low system complexity, and can improve precise positioning accuracy to accurately locate customers. Navigate the customer to the product nearby. In this way, the shopping experience of customers can be greatly improved, and at the same time, it can save the time of supermarket shopping guides and save labor costs.

2. System Design

The positioning part uses three anchor points to locate the label that needs to be measured. Labels represent user locations. Two-way ranging (TWR) is used to measure the distance between the anchor point and the tag, and then the tag position is calculated from the distance. When the label position is measured, anchor 1 will send the position information to the server through the serial port. The server then sends the anchor point and label information to the client through TCP. After the client receives the data sent by the server, the user's location is depicted on the map, and the navigation algorithm is used to draw a trajectory according to the destination and the user's location, and guide the user to the target point.

The system uses STM32F401 series single-chip microcomputer. The microcontroller integrates functions such as ADC, rich timers and I/O ports. It's low power consumption, stable performance, high pin count, reliable, with up to 64K bytes6 of built-in SRAM. It can realize the multi-function control of the system, can carry out high-speed data acquisition and processing, and control the motor, which fully meets the requirements of this system. Taking into account comprehensively, the STMF401 series single-chip microcomputer in the second scheme with better processing performance is selected as the main control chip produced in this work.

In the design and construction of the hardware circuit, we place the positioning base station in the corner of the room for more accurate positioning, and this does not affect the placement of indoor items. Figure 1 is the physical location of the base station, and Figure 2 is the simulation of the supermarket environment to build the base station layout.

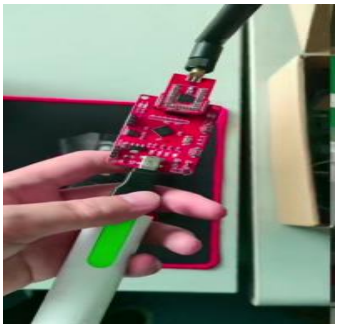

Figure 1: Positioning the physical object of the base station

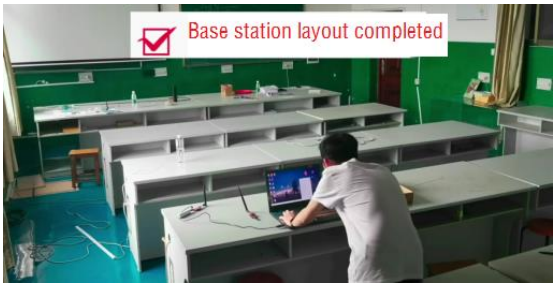

Figure 2: Layout of base station

3. MCU and Server-Side Software

The anchor point and label positioning process of the software part of the microcontroller. First the anchor sends a packet to the tag. The tag records the timestamp and replies to the anchor to receive the

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message. After the tag receives the message, it calculates the distance through the timestamp returned by the anchor point, and then transmits the calculated distance back to the anchor point, and the anchor point uploads it to the server through the serial port.

In the server-side software section, first select and open the serial port of the link anchor. When the serial port data is received, the tag position is calculated and the result is sent to the cache. Then start the TCP server and wait for the client to connect. When receiving a TCP request, wait for the client to enter the account password. If the account password is correct, put the client into the TCP connection pool and wait for the input to be sent. If the password is wrong, disconnect. When the calculation result of the serial port program is received, the data is sent to the corresponding connection of the TCP connection pool.

The supermarket can modify and determine the location of the base station through the server, and can visually display the specific location of the base station in the form of a map, which is convenient for debugging and future maintenance. Not only that, supermarkets can also push commodity information to users through the function of editing announcements on the server. For example: special price reductions, new arrivals, etc.

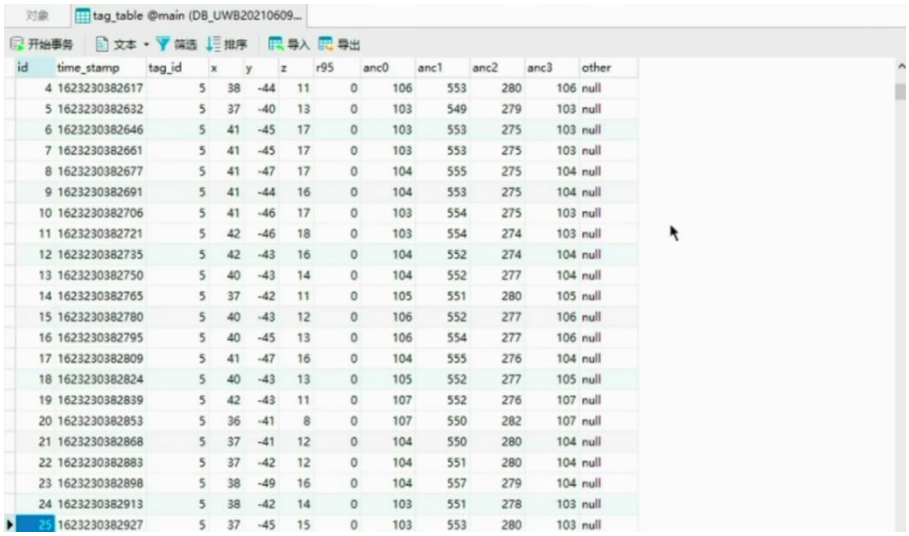
4. Mobile Software Part

In the mobile phone software program, open the program first enter the account password, and then connect to the server through TCP. When the server connection fails, re-enter the account password. After the connection is successful, the user inputs the navigation destination and the server sends the location information. Then plan and display the navigation route according to the user's current location, anchor location, and destination location. During the navigation, it is repeatedly judged whether to reach the destination, and if the destination is reached, the navigation ends.

The user can obtain the current IP address and port number by scanning the code, and then input the account password to enter. After the user enters the destination, the system will automatically generate a trajectory from the user's current location to the destination, guiding the user to go there. Of course, considering that some elderly people or children may not be able to understand a two-dimensional plan, you can click to switch to a three-dimensional view and convert it to a 3D view to guide users more intuitively and better enhance the user's shopping experience.

5. Data Testing and Analysis

After completing the production and debugging of the software and hardware systems, and confirming that the server and client can use and transmit data normally, we test the mobile APP and positioning tags respectively. Calculate the relative position of the positioning tag and use the mobile APP for navigation. After confirming that the mobile phone APP has logged in the account, calculate the coordinates of the label. The test results are as follows, as show in figure 3:



id	time_stamp	tag_id	x	y	z	r95	anc0	anc1	anc2	anc3	other
4	1623230382617	5	38	-44	11	0	106	553	280	106	null
5	1623230382632	5	37	-40	13	0	103	549	279	103	null
6	1623230382646	5	41	-45	17	0	103	553	275	103	null
7	1623230382661	5	41	-45	17	0	103	553	275	103	null
8	1623230382677	5	41	-47	17	0	104	555	275	104	null
9	1623230382691	5	41	-44	16	0	104	553	275	104	null
10	1623230382706	5	41	-46	17	0	103	554	275	103	null
11	1623230382721	5	42	-46	18	0	103	554	274	103	null
12	1623230382735	5	42	-43	16	0	104	552	274	104	null
13	1623230382750	5	40	-43	14	0	104	552	277	104	null
14	1623230382765	5	37	-42	11	0	105	551	280	105	null
15	1623230382780	5	40	-43	12	0	106	552	277	106	null
16	1623230382795	5	40	-45	13	0	106	554	277	106	null
17	1623230382809	5	41	-47	16	0	104	555	276	104	null
18	1623230382824	5	40	-43	13	0	105	552	277	105	null
19	1623230382839	5	42	-43	11	0	107	552	276	107	null
20	1623230382853	5	36	-41	8	0	107	550	282	107	null
21	1623230382868	5	37	-41	12	0	104	550	280	104	null
22	1623230382883	5	37	-42	12	0	104	551	280	104	null
23	1623230382898	5	38	-49	16	0	104	557	279	104	null
24	1623230382913	5	38	-42	14	0	103	551	278	103	null
25	1623230382927	5	37	-45	15	0	103	553	280	103	null

Figure 3: Test chart

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We have conducted many tests, and the above table is only a small part of ours. According to the test results, the client APP runs normally and can provide 2D/3D navigation services normally. The positions of the positioning labels displayed on the server side are all normal, and the navigation of the user's location is successfully implemented.

6. Conclusion

The test results show that the system runs smoothly, responds quickly, locates and navigates accurately, and realizes the query of the user's current location information and the navigation of the destination. And the navigation map can be freely switched between 2D and 3D, which lowers the threshold for using the system and makes shopping easier and faster for users.

The next step is how to improve the system and hardware, and arrange more sensors to make the positioning more accurate. In terms of software, the algorithm program is improved to make the operation of the system more stable and the scope of application wider. Hospitals hope to locate medical equipment in real time, so that it can be quickly called when needed; It is hoped that positioning monitoring of special patients can be performed to prevent accidents. High-risk chemical plants need to locate and manage personnel to prevent safety accidents. Therefore, the indoor positioning has shown broad market prospects in retail, catering, logistics, manufacturing, chemical, electric power, medical and other industries.

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