RFID Location Algorithm

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Abstract. With the development of social services, people's living standards improve further requirements, there is an urgent need for a way to adapt to the complex situation of the new positioning technology. In recent years, RFID technology have a wide range of applications in all aspects of life and production, such as logistics tracking, car alarm, security and other items. The use of RFID technology to locate, it is a new direction in the eyes of the various research institutions and scholars. RFID positioning technology system stability, the error is small and low-cost advantages of its location algorithm is the focus of this study.This article analyzes the layers of RFID technology targeting methods and algorithms. First, RFID common several basic methods are introduced; Secondly, higher accuracy to political network location method; Finally, LANDMARC algorithm will be described. Through this it can be seen that advanced and efficient algorithms play an important role in increasing RFID positioning accuracy aspects.Finally, the algorithm of RFID location technology are summarized, pointing out the deficiencies in the algorithm, and put forward a follow-up study of the requirements, the vision of a better future RFID positioning technology.

1 Introduction

With the rapid development of radio frequency identification (RFID) technology, RFID technology already have important applications in many fields. RFID technology originated during the beginning of World War II, the Allies to analyze and judge the enemy and friendly ships or aircraft using wireless technology. However, due to relatively high cost of the technology ,after the war it just used in military strategic studies for a long time. In the 1980s and 1990s, is widely used around the world began to chip and electronic technology, RFID only began to enter the field of civilian production, but has not been effectively developed and applied in our country. Until February 2006, China promulgated the "China RFID Technology White Paper", it means that China began to develop RFID technology. Now, RFID applications have been explored in a number of aspects of identification, security, anti-counterfeiting and so on.

In the aspects of positioning technology, the prior art are more mature US-developed GPS global positioning system, commonly used in Europe's Galileo global positioning system, Russia is good at Green NASDAQ Global Positioning System and China's own development of the Big Dipper global positioning technology, This positioning technology has a relatively high accuracy, commonly used in military combat and nautical terms. But these technologies have positioned a short board, when the target is in the room, then positioning is compromised. Because the indoor environment is more complex, and easy to interfere with the absorption of the satellite signal, resulting in greater positioning system can not locate or error. To solve this problem, we need to find ways to quickly prepare targeted indoor new technology, so the radio frequency technology run into people's vision to become a scientific research institutions and scholars sought after star.

Radio frequency identification technology is a non-contact technology, the main principle is through electromagnetic coupling or electromagnetic coupling to the propagation and reception of signals, even in relatively harsh environments, the system can run stable, signal communication’s distance is also available may enter, can automatically identify the corresponding tags, can simultaneously identify multiple targets without human intervention. And it has a small, penetrating strong, convenient application features.

2 RFID technology summary

Radio frequency technology includes three aspects: the c ontrol chip, antenna tags and readers.

1, The control chip is the core component of the radio frequency system, equivalent to a host computer, controls the transmit electromagnetic signals, receiving, processing and judgment. For example, commonly used access control system, when a signal of the correct access cards, access control systems is to identify and determine the received signal, to open the action.

2, The antenna RF cards and tags essence of memory modules. Capable of storing identified items of information are transmitted RF card antenna related information. Depending on the article, the antenna can be made into a variety of label materials and shapes. It can be attached to the surface of an article to be implanted

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inside the article. According to the work principle,Tag antenna can be divided into active tags and passive tags. Internal affinity label containing a small battery to provide energy to provide power for the chip, which can be discriminated from the label is much greater than the passive; but the presence of short battery life, larger shortcomings, is not conducive to carry, in general for applications that require identification distance and special scene.

Internal battery is not passive tags provide energy, it is the use of electromagnetic coupling or electromagnetic coupling to an external reader generates a current work, although closer than active tags to identify short, but with better shape and more low plasticity prices are widely used in the actual production applications.

3, The reader is an important means to receive and identify electromagnetic signals.It emits an electromagnetic signal, when the electromagnetic signal coverage within the working area of the tag antenna, the receiving antenna is the automatic tag feedback signal, and then sends a signal to carry out comparative analysis and decoding chip, chip and then make the correct decoding and error analysis results decoding the corresponding action. The reader is to achieve recognition of information, which is the basis of RFID positioning technology.

3 the common base algorithm

In the field of RFID positioning technology, now commonly used positioning divided into three areas, namely: (1) to reach the positioning information, (2) positioning signal strength, (3) measuring the azimuth positioning. Let these three commonly used positioning method a brief introduction.

1, Positioning arrival information divided into two discussions:

(1) the arrival time of positioning.

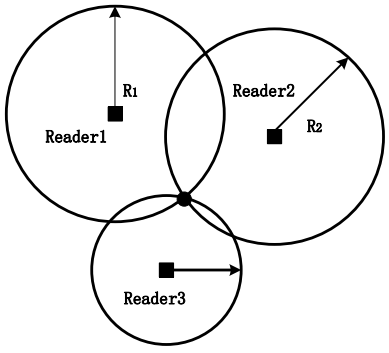

Figure 3-1 arrival time targeting method

The figure shows that there are three tag reader intersection is the sitting position. It is easy to locate a tag needs to know three readers to achieve, we know that the speed of propagation of electromagnetic waves in the air of C (3 * 108m / s), the coordinates of three readers also known (Xi, Yi), measured of electromagnetic waves from the target tag to the reader the propagation time t1, t2, t3, this way, they will know the distance of the target tag to the reader is Ri = C * ti, according to the mathematical method, can be assumed that the position coordinates of the target tag (X0, Y0), the following relation formula is as follows:

$$\begin{cases} (x_1 - x_0)^2 + (y_1 - y_0)^2 = R_1^2 \\ (x_2 - x_0)^2 + (y_2 - y_0)^2 = R_2^2 \\ (x_3 - x_0)^2 + (y_3 - y_0)^2 = R_3^2 \end{cases}$$

(2) Time Difference of Arrival Location

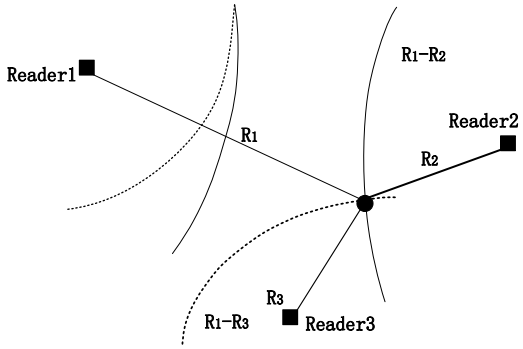

Figure 3-2 TDOA hyperbolic positioning method

3 or a known reader coordinates, as they are from the same distance from each part of the target tag, and electromagnetic wave propagation velocity is known, the time they received the target tag signal will be different. As shown, there is a time difference between the time t_{21}, through publicity R_{21} = C * t_{21}, the target tag certainly at the intersection of two readers, according to mathematical knowledge, the relationship can be written as follows:

$$\begin{cases} \sqrt{(x_0 - x_2)^2 - (y_0 - y_2)^2} - \sqrt{(x_0 - x_1)^2 - (y_0 - y_1)^2} = R_{21} \\ \sqrt{(x_0 - x_3)^2 - (y_0 - y_3)^2} - \sqrt{(x_0 - x_1)^2 - (y_0 - y_1)^2} = R_{31} \end{cases}$$

2, the signal strength of the positioning

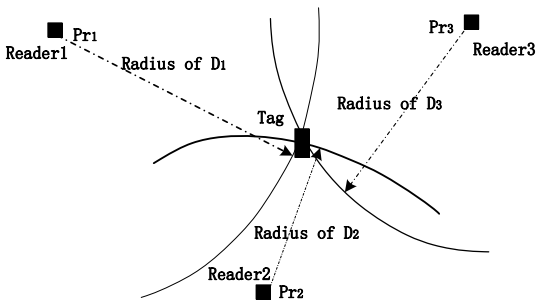

Figure 3-3 the signal strength of the positioning

In essence, is the energy of electromagnetic wave propagation, the spread will widen as the distance decreases, according to the theory of electromagnetic wave transmission, publicity can be listed:

$$P_{r_i} = \frac{P_t * G_t * G_{r_i} * \lambda^2}{4\pi * D_i^2}$$

As shown in FIG, P_t represents the transmission power of the target tag, the Pri reader represents the i-th power of the received signal shows the wavelength of electromagnetic waves, G_t, G_{r_i} said first target gain and the i-th label reader antenna, according to publicity to give the title to the first tag reader distance D_1, once on, you can also obtain the target tag to the other two readers distance D_2, D_3. The position of the target label is to the three readers radius circle intersection.
3, The direction of the measurement positioning.

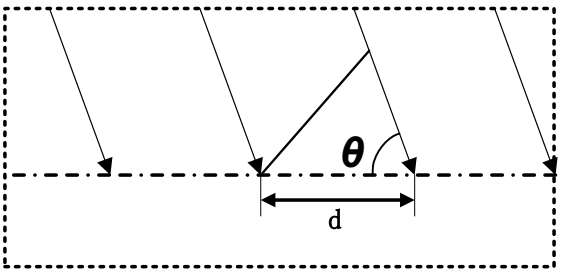

Figure 3-4 the received signal to determine the angle of arrival

Known coordinates of the three readers have been installed antenna array can be used to measure the tag to the reader emit electromagnetic wave angle, as shown, it can be listed according to the following formula known conditions:

$$\varphi = 2\pi * d * \cos\theta / \lambda$$

For different antenna arrays, we can measure the sign al has a different phase, so the angle can be calculated a tr ansmitted signal, can be calculated the same way three re ader receives the angle signal, thereby to obtain the locati on information of the target tag.

4 the topology of the network algorithm

In practice, often densely build RFID reader, when a label is placed where multiple readers will read the information and processing information, the process is a relatively complex process. We know RFID reader is a RS-232 serial port or Ethernet docking with the computer in order to transfer the collected information to a computer, make calculations and analysis by a computer.

The reader position is known, the calculation will be in the form of nodes, each node of the interconnected, it will form a network topology, as shown:

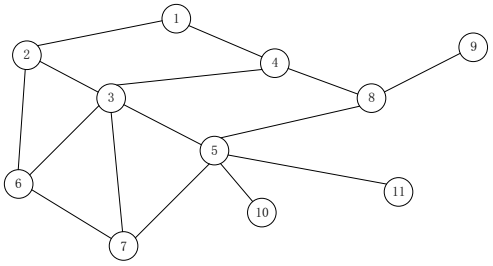

Figure 4-1 Reader topology

Read the entire topology map, each label and each reader has a unique identifier ID, so when the tagged item or person moves in the topology map, RFID reader will re-read the tag's location, It sends a signal to the computer in the background computing and storage, and finally all the information combinations reconstruction, reflecting the label walking paths. RFID reader topology can tell from the label very close, so the results will be measured more accurately. However, if the label in the topology map to move, space does not exist on two adjacent reader, then there will be a reader does not have access to information of the label, there is leakage reader to read, so the need to create new computer system to avoid this problem.

We can also locate to the original vector improve:

$$\langle TagID, T, \mathrm{Re}aderID, RSSI \rangle$$

Wherein TagID target represents a unique ID tag, T represents the tag reader signal reaches the moment and is detected, ReaderID represents the detected movement of the tag reader ID, RSSI indicates the received signal strength, to analyze in detail each of the following vector meanings.

(1) tag identification number TagID: This is a vector equation of the first variable, the label is a unique number within the chip, globally unique. During the movement of the tag, the reader will be real-time tracking of the received signal, consisting of a group targeting vector, then background computer systems start to realize the label positioning monitoring.

(2) Read time T: The vector equation is a second variable, which represents the time the label is detected. It is worth mentioning that the requirements of each reader clock to be synchronized, otherwise there is no meaning. When a label reader into a work area, just generate a targeting vector. But when the label reader returns back and forth movement of the edge of the area, it will produce multiple targeting vector, in this case is to be discussed separately, and do not here described.

(3) The reader identification number ReaderID: topology map reader corresponds to a different identification number, if they are to transmit signals to the computer, the computer system according to the signal reader sent a different identification number, by continuously reading the position, calculate the approximate location of the label.

(4)The signal strength RSSI: when the tag near the reader, to the signal is getting stronger, while the principle of the tag reader, the signal is in a slow decay process, by detecting signal strength, but also can help accurate positioning orientation coordinates of the tag.

Suppose a tag in the process of moving, there are two time information is submitted back to the computer syste m, according to the vector equation can be obtained:

$$\{\langle T_1, t_1, R_1, S_1\rangle, \langle T_2, t_2, R_2, S_2\rangle\}(t_1 < t_2)$$

Both vectored means: at time t_1, the tag T_1 signal is to capture readers R_1, then the signal strength of S_1; Similarly, at time t_2, the signal label reader R_2 T_2 is captured, This signal strength S_2. The computer system will calculate a route that information. Formula $t_1 < t_2$, so the second position from the first position in the past, so there is:

$$track = R_1 \rightarrow R_2$$

Easy to learn, improved topology calculation method is relatively simple, but the basic premise is to satisfy a condition that a label with an identification number must be the same. While many tags in the reader's mobile work area, the system must be based on the same identification number, filter out other labels, only the label to locate the target and monitoring.

5 LANDMARC Algorithm

Location technology based on signal strength, is the most commonly used method of LANDMARC, this algorithm makes use of different labels as a reference material, due to the different position of the reference material, the reader detects the signal strength is different, of LANDMARC way it is by comparing the different reference RSSI different labels, and then use the right to reuse the empirical formula to calculate the position coordinates of the label to be located.

LANDMARC nearest neighbor algorithm depending on the intensity of the signal, the reader will be divided into eight power level (1-8), and then assume a reader M, L reference tag, N a label to be located. This defines the signal strength of the matrix S: where Sij (i = 1,2 ... N, J = 1,2 ... M) represents the i-th reference values J-th tag reader to take.

$$S = \begin{bmatrix} S_{11} & S_{12} & \mathrm{K} & S_{1M} \\ S_{21} & S_{22} & \mathrm{K} & S_{2M} \\ \mathrm{K} & \mathrm{K} & \mathrm{K} & \mathrm{K} \\ S_{N1} & S_{N2} & \mathrm{K} & S_{NM} \end{bmatrix}$$

Signal strength matrix:

$$T = \begin{bmatrix} T_{11} & T_{12} & \mathrm{K} & T_{1M} \\ T_{21} & T_{22} & \mathrm{K} & T_{2M} \\ \mathrm{K} & \mathrm{K} & \mathrm{K} & \mathrm{K} \\ T_{L1} & T_{L2} & \mathrm{K} & T_{LM} \end{bmatrix}$$

Wherein, Tij for the first J-reader to get i-undetermined label values.

Refer to the label to be positioned with a tag associated matrix E:

$$E = \begin{bmatrix} E_{11} & E_{12} & \mathrm{K} & E_{1M} \\ E_{21} & E_{22} & \mathrm{K} & E_{2M} \\ \mathrm{K} & \mathrm{K} & \mathrm{K} & \mathrm{K} \\ E_{L1} & E_{L2} & \mathrm{K} & E_{LM} \end{bmatrix}$$

among them

$$E = \sqrt{\sum_{k=1}^{M} (T_{ik} - S)^2} \qquad (\mathrm{i} = 1,2,..,\mathrm{L},\ \mathrm{j} = 1,2,..,\mathrm{N})$$

It represents the j-th reference label to be associated with the i-th degree positioning tag. If the smaller the value of their degree of relevance, the more that the closer the distance between the two labels.

The position coordinates of a known reference coordinate position of the label, the label is to be located:

$$(x, y) = \sum_{i=1}^{k} w_i (x_i, y_j)$$

$$W_i = \frac{\frac{1}{E_{pi}^2}}{\sum_{j}^{k} \frac{1}{E_{pj}^2}}$$

Wherein, W represents the weight of heavy reference frame, the closer the distance, the greater the weight, K represents the tag to be located away from the nearest reference coordinate tag number, for a label to be positioned P, that is, (E_{P1}, E_{P2}, .. ., E_{Pn}) selects the smallest K value corresponds to a reference label by calculating the value of W, the positioning error is:

$$e = \sqrt{(x - x_0)^2 + (y - y_0)^2}$$

Wherein, (x_0 , y_0) is positioned to be the actual coordinates of the label, (X, Y) to calculate coordinates. Place a test tracking labels, 49 tag reference, four readers, can be obtained by calculating the difference between the maximum distance is 0.8M, the average error is 0.5M.

6 Summary

This paper describes several common RFID positioning technology algorithms and the other two advanced algorithms more accurate and efficient, overall grasp both tag and reader identification code, select the reader or the tag as a reference to establish the coordinates of each portion, It is obtained by positioning the label coordinate geometry mathematics calculations. But advanced algorithms can be more accurate, fast and stable to be calculated from the target location.

Of course, the existing RFID location there are still some technical problems to be studied and solved. For example,three-dimensional positioning technology,RFID technology and the fusion of things, would require further exploration. Under the new era of the new situation, RFID location technology is playing an increasingly important role for some breakthrough technology bottlenecks, can effectively promote the development of social production. Study more advanced RFID location algorithm is the key to break the technical bottlenecks.

References

[1] Li Fei high, Sun Remington. Analysis of RFID radio frequency identification technology [J]. Digital Technology and Applications. 2012 (05)
[2] Hae-Won Son, Hyuk Park, Kyong-Hee Lee.UHF RFID Reader Antenna With a Wide Beamwidth and High Return Loss. IEEE Transactions on Antennas and Propagation. 2012
[3] Yao-Lin Wang. RFID-based indoor localization of a movable object [D]. Nanjing University of Posts and Telecommunications 2015
[4] Tang Jun. Design and implementation of active RFID location system [D]. Southwest Jiaotong University 2014
[5] Yang Hang. Roadway precision personnel location system and data processing technology [D]. University of Electronic Science and Technology 2015
[6] Wang Xiaoyuan. RFID-based outdoor personnel positioning system research [D]. Lanzhou Jiaotong University, 2015