# Chapter 59
# Positioning Method for Automated Warehouses Based on RFID

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**Abstract** In order to solve difficulty of AGV in accurately reaching destination in the material handling process in automated warehouses, the paper put forward a method based on radio frequency identification (RFID) technology. It utilizes the average distribution reference tags in room and the range of reader and then reads the reference tag's coordinates information and adopts the id algorithm of equilateral triangle and calculates the coordinate position of the reader. The result and simulation show that the method is more precise.

**Keywords** RFID · Indoor localization · Equilateral triangle

## 59.1 Introduction

Promote the rapid development of mobile location technology to mobile calculator development and the progress of the wireless LAN technology, triangulation, image analysis and beacon positioning, the three major auto-positioning technologies [1]. Positioning System (GPS) positioning the different environment can be divided into outdoor positioning system and an indoor positioning system. In recent years, GPS, cellular network positioning technology was developed very rapidly and gradually constitutes outdoor positioning system technology. Indoor environment in a large number of the block, the positioning accuracy of the positioning method is not enough, so the need to adopt new methods and techniques [2].

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At present, the common indoor positioning system is an infrared I EEE802, Ultrasonic and Radio Frequency Identification (RFID). In addition to these, there are many systems with other positioning technologies such as UWB, Bluetooth and so on. However, due to radio frequency identification (RFID) technology RF way non-contact two-way communication, in order to achieve automatic target recognition and access to relevant data, with high precision and strong ability to adapt to the environment, anti-jamming, operating fast, to identify fast moving objects, and can simultaneously identify multiple tags, and many other advantages, so much attention [3].

The use of RFID technology is a typical representative Spot ON. The system is based on signal strength, the development of an aggregation algorithm to locate the three-dimensional space. Spot ON system hardware label into a network-like distribution, without central control unit, the test signal strength through the label to characterize the geometric distance between the labels. However, complete Spot ON system had not yet been completed. It is worth mentioning that LANDMARC system through the introduction of a reference location tags and different labels between the residual weighting algorithms can obtain high positioning accuracy [4].

This paper discusses the use of RFID technology, setting the reader's read range, known location on the reference label layout, the use of the equilateral triangle centroid obtained the position of the reader and the relative coordinates of the reference label to realize their own positioning. The reader can be placed in a mobile cart or robots.

## 59.2 Basic Principles of Locate

Using RFID tags as reference coordinates, the role of the reference coordinates as the reader locates the reference point, placed in the position of the indoor known coordinates. The principle of selection of the label moves the car or a robot with a reader in the process of movement and will read the tags within its read range of the position calculation. In the reader's read range, for various reasons (such as interference, reflection, metal block, etc.) identification of the label, there will be some deviation. Under normal circumstances be able to read the three labels, read three, you can still be calculated in accordance with the established algorithms. Due to reflection or for other reasons, leading to read the label more than three, you can use the nearest neighbor data association method to elect the historical data and the prediction of the measured target location/nearest neighbor within the read range from 0 three labels to participate in the calculation. The so-called data association is to merge with the observations from one or more sensors or point trace Yi ($i = 1, 2, \ldots, N$) and $j$ already known or has confirmed that the event so that they belong to the $j$th a collection of events, that is to ensure that the probability of each event set contains observations from the same entity. Specifically, take the point of each batch of target trace the track matching with the database. Label in the room layout is shown in Fig. 59.1.

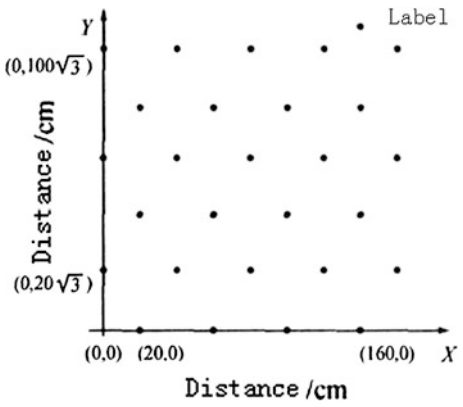


**Fig. 59.1** Label layout

Operating frequency is the RFID device 13. Length and width are dimensions of 56 MHz, the reader is 14.5 × 5 cm read range of 30 cm.

## 59.3 Positioning Algorithm

The coordinate information is written to the tag reader to read the label, according to the coordinates where the label information, the use of an equilateral triangle's centroid, label layout, you can calculate the coordinates of the location of the reader.

### *59.3.1 Average of the Label Layout Based on the Error Distribution*

First, the RFID tag layout into a grid constitutes a Cartesian coordinate system and records label in the label information (tag ID) and the absolute coordinates of the location information in each tab.

Secondly, the reader in front of the AGV car in the process of moving forward in the car, the reader reads a different label, and according to the different storage location information of these tags, analysis, calculation, draws the reader regional location in order to achieve the positioning of the car.

### *59.3.2 Positioning Methods*

**Definition 1** The reader lobe angle alpha, this article refers specifically to the horizontal lobe angle, fan-shaped region of the radiation in the horizontal plane, the reader antenna can point of view.

**Definition 2** The reader identifies the maximum identification range of the distance between the distance $r$, the reader can identify to the maximum distance label called reader.

**Definition 3** Tag spacing $d$ (this article assumes that unit 1), adjacent to the physical distance between the two labels.

**Definition 4** The reader label detection state S, when the reader can detect the label, the detection status of the reader of the label is denoted by S = True, otherwise denoted as S = False.

For a location bound to need a reference point for auxiliary judge a correct judgment of the reference point, which can positioning rules on the location, the environmental characteristics of the RFID and indoor positioning, and the car to walk the path of relatively simple, allowing this reference point selected to conform as closely as possible to the linear representation in order to simplify the calculation. The following from the lobe angle and identify the radius of the two positioning methods discussed.

Shown in Fig. 59.2 for AGV car in the region PMNQ positioning, setting the bit field four endpoint coordinates P $(x, y)$, M $(x + 1, y)$ of N $(x + 1, y + 1)$, Q $(x, y + 1)$, $\alpha$ is read-write device lobe angle, $r$ is the reader to identify the radius, $d$ is the unit length of the coordinate system, there are:

1. At $\alpha \in [2 \arctan 1/n, 2 \arctan 1/(n-1)]$, desirable to identify radius $r = \sqrt{n^2 + 1}d$, where $n \in N$, the geometric meaning of the interval $[0, \pi]$ is divided into $n$ parts.
2. When the reader detection of point B $(x + 1, y + n)$, then detection of point C $(x, y + n)$, but did not detect the point D $(x + 1, y + n + 1)$ and E $(x,$

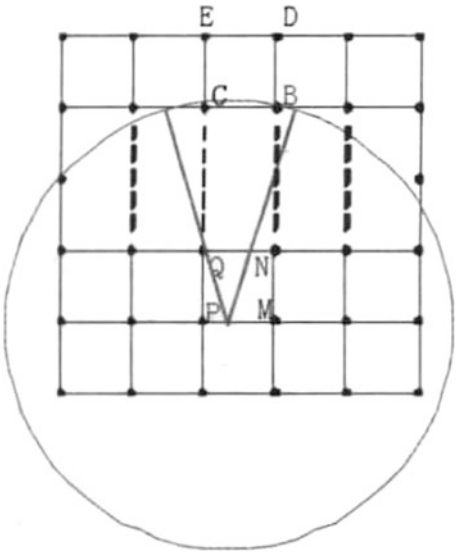


**Fig. 59.2** Positioning algorithm

$y + n + 1$), reader B, C, D, E four-point detection status of (Sb and Sc, Sd, Se), the change process (false, false, false, false) → (true, false, false, false) → (-true, true, false, false), you can determine reader in regional PMNQ, and even if in this process, the reader reads *B* and *C* in the same horizontal position, but also to determine the reader in the Regional PMNQ its error range in the M point, the error is 0, that is, to achieve accurate positioning.

3. When the reader detection of point C ($x$, $y + n$), detection of point B ($x + 1$, $y + n$), but did not detect the point D ($x + 1$, $y + n + 1$) and E ($x$, $y + n + 1$), the reader the process of change of B, C, D, E four-point detection state (Sb and Sc, Sd, Se,) (false, false, false, false) → (false, true, false, false,) → (true, true, false, false), you can determine the reader is located regional PMNQ, even if in this process, the reader reads and B, C are two points located in the same horizontal position, but also to determine the reader is located in the region PMNQ its error range, in which the P, the error is 0, that is, to achieve accurate positioning.

Below by it taking any one of $\alpha = 5/12\pi$ to verify the feasibility of the method of positioning.

1. After analysis, as shown in Fig. 59.2, decision rules, to make the reader at the critical point P can read about point C, the minimum recognition radius $r$ min = 2; radius $r > \sqrt{5}$, although the reader exactly the same time identify the B, C, two reference points, but quite far away from the judgment region, the large error, therefore the case take $r \in [2, \sqrt{5}]$ ideal, and because the selection of the radius to large principle, it can choose $r = \sqrt{5}$.
2. Identify the radius $r = \sqrt{5}$, is shown in Fig. 59.2, make the reader can read the critical point P, B, C, at this time lobe angle minimum $\alpha$ max = 2 arctan 1/2; but to $\alpha$ max then take the smallest angle, $\alpha$ max = 90, so when the identification radius $r = \sqrt{5}$ lobe angle can achieve the purpose of positioning.
3. In the method validation are given in the interval [2 arctan 0.5, 900], the positioning method presented in this paper is feasible.

## 59.4 Conclusion

This paper presents an effective and simple method—the use of passive RFID AGV positioning, RFID reader to read the location of the passive tags, resulting in the location of the AGV, the positioning method is in an ideal state deduced through the calculation, and analysis is to explore a kind of passive RFID tags locate, but in reality, the relative complexity of the indoor environment and walking on the path obstacle avoidance need to be considered, and this is the future work of the main problem of research.

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