Study for Urban Multi-obstacle Environment Tracking by Wireless Sensor

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Abstract. With the digital information time coming, sensor is widely used in more aspects. The sensor becomes indispensable technology to a lot of applications. Wireless sensor RFID is one of advance sensor. This paper studies wireless sensor frequency phenomenon and characteristic, focuses on approach the combining frequency method in sensor, and provides a particular tracking system for multi-obstacle environment. This innovative approach can be introduced in most other aspects like environment monitor, object positioning, real time measure and so forth fields.

Introduction

As people’s eyes and ears, sensor is key tool for understanding and collecting things information in the world. Usually wireless sensor not only is of non-touch transmission property but also automatic measuring and sensing function. Furthermore wireless sensor has more advantages like different frequencies choice, little power consumption, near field communication, and radio features. As one of information sensing point, wireless sensors are composed of wide wireless sensor network. In environment field, by the sensor sensing object information capability, sensor network transfers this information into concrete and accurate data and delivers them to the monitoring header [1].

With mobile application widely development, the much business based on location message becomes key research. Hence wireless sensor node technology and measured moving object technology is critical necessary. Up to now, wireless sensor represents one of new generation intelligent collecting technology. For the urban environment measurement, moving things positioning, key object tracking etc. applications, it has grand meaningful to the world.

Analyzing Positioning Function

As far as moving things positioning, tracking and navigation method, Global Positioning System (GPS) and Beidou Navigation Satellite System are more well-known in the applications. It has, no doubt, many advanced functionalities in system [2]: Wide covering positioning area from land to mountain as well as to sky, nearly achieves 98%; Providing measurement speed function; Offering accurate time and time zone standard; Adopting L band frequency like 1575.42 MHz / 1227.60MHz for communication; Generally providing the location accurate is 100 meter around for civil application. While 10 meter or so for military which strictly limited by policy.

Of course there are some unavoidable disadvantages like: The entire system is correspondingly complicate; The end terminal has bigger cost; Information safety is critical issue especially for GPS; The positioning property is obviously decreased when moving object in multi-obstacle environment particularly for indoor. Moreover its location accurate is heavily weak [3].

How to search the tracking solution for the multi-obstacle occasion becomes one important research in the industry. Facing to this issue, the paper conducts deeply study and practice and provides relate tracking system by wireless sensor.

Wireless Sensor Analysis

In general, wireless sensor RFID is composed of radio frequency receiver and radio frequency tag. When tag (bonded with moving object) steps into the surveillance zone, tag delivers its signal
frequency with ID message etc, receivers gets this radio signal with messages. They complete their message exchange, thus it realizes the tracking purpose [4].

According to ISM standard, there are three frequency bands for wireless sensor frequency. This paper chooses 2.4GHz instead of 920 MHz UHF band because of it far away 3G frequency band comparing to later to 2G frequency band. While wireless sensor adopts 2.4GHz microwave frequency, the terminal tag is much cheap cost comparing to GPS terminal. The coverage radius reaches nearly 30 m, the data speed rate promotes 2Mbps. Hence this 2.4GHz wireless sensor is used for various fields. Especially that characteristic is suitable for monitoring moving object in wider area where without any much obstacle.

**Tracking Occasion Analysis**

In term of moving object, its moving direction is usually random or unforeseen in prior to behavior. There is a lot of different application environments [5,6]. For example, the monitored object, in some time, steps in wider square without any obstacle, and in other time goes into large buildings with many different obstacles and walls; There are also possibilities that monitored target roams in indoor area for long time, or is in indoor at some time and outdoor at other time etc. occasions.

Because of 2.4GHz characteristic closely depending on its used occasion, when being in multi-obstacle environment with many walls, metals, glasses, and dusts etc., there are some obstacles, non-sight distance and multi-path etc. negative factors for signal transmission. Meanwhile that produces harmful effect from other types of signal such as reflection, refraction, and diffraction etc. From point of practices view, at actual multi-obstacles occasion, it is highly necessary to consider choosing one better frequency characteristic.

**Combining Frequency for Multi-obstacle Situation**

Wireless sensor tracking system adopts the tag ID as monitored target which tag with undamaged, reliable data, long term using, and appropriate communication distance etc. functions. It is also the best choice to replace the bar code and infrared identification [7]. In surveillance area, receivers distributes in some key locations based to the environment physical location. The receiver nodes form many triangle field which covering the entire area, no matter anywhere object moves, the nearest node receiver automatically collects tag data, then realizes real time tracking.

**Studying Better Frequency Feature**

Obviously mentioned above, the signal is badly affected from negative factors when the object being in indoor multi-obstacle environment. It is proved that sole 2.4 GHz characteristic extremely becomes weak in this complex environment. By a great of approaches and experiments, it chooses one 125 KHz low frequency (LF) module respectively in receiver and tag. This LF module in receiver is as activating function when tag entering this monitored area. That produces better features comparing to 2.4GHz. As far as LF coverage, it is easier to sensing the RSSI and adopts fine accuracy in location [8], generally reaches 10 cm within. Thanks to LF 2500 m wavelength, it is of better signal penetration and diffraction properties and suitable for complex indoor environment. LF activating module in receiver with 4 antennas, each 2 orthogonal antennas activating radius reaches 3.5 m. If decreasing the LF transmitting power in receiver and tag receiving sensitivity, the activating radius is adjusted within 1 m. Thus it grandly promotes the flexible characteristic of coverage application. Design tag being passive work state, it greatly prolongs its navigation life [9].

<table>
<thead>
<tr>
<th>Freq. band</th>
<th>Penetration</th>
<th>Speed rate</th>
<th>Range distance</th>
<th>Activating speed</th>
<th>Central coverage</th>
<th>Power dissipation</th>
<th>Tag cost</th>
<th>Rece.RSSI accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>125KHz</td>
<td>Good</td>
<td>Low</td>
<td>Short</td>
<td>Good</td>
<td>Good</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>2.4GHz</td>
<td>Not good</td>
<td>High</td>
<td>Long</td>
<td>Normal</td>
<td>Normal</td>
<td>Little high</td>
<td>Normal</td>
<td>Low</td>
</tr>
</tbody>
</table>

The concrete comparison is as above table 1.
Combining Frequency Design

This paper designs an innovative combining approach for combining frequency in wireless sensor. The microwave is as carrier body for exchanging ID data; LF in receiver is as activating means for tag.

In general, the combining frequency receiver consists of several modules as the figure 1. LF activating module transmits LF signal containing receiver number, the tag is in receiving state. When the moving tag enters monitoring area and receives the activating signal, tag gets this receiver number and collects its RSSI, then triggers RF module in tag. This RF module transmits a strong signal including tag ID, receiver number, and RSSI data package, then receiver gains this data package. By communication module, data package is sent to monitor header. This center makes a calculation, comparison and judgment for the tag physical position. This combining frequency approach overcomes the sole 2.4GHz weakness and is better suitable for complex multi-obstacle environment in tracking application.

The Tracking System Mechanism

Triangle Area Design for Positioning

This system has combining frequency receiver and tag. In the surveillance area, the receivers distributes in each key physical triangle location as figure3. By the receivers receiving the signal strength from three physical dimensions, system judges tag concrete position [10]. Supposed X, Y, Z three positioning receivers as one group, their receiving ranges are same parameter. The tag is a gain type of tag as well. The signal gain circulates automatically from 0 to 3db. When the tag sends out its antenna signal gain, it transmits the data package in same time as Figure 2. The system relevant positioning judgment mechanism describes as following

When tag transmits maximum signal gain 3db, X, Y and Z completely receive signal strength. When signal gain is 2db, X and Z can get this signal while Y does not get it because of far distance. When signal gain becomes mini. 0db, only X collects this signal due to the nearest distance.

Hence system judges the tag is nearest to X node by calculation. Thanks to the intrinsic fine accuracy within a few dozens of centimeters in LF device, the system fixes the tag position is at X point instead of Y or Z.
In the same way, when moving object (tag) goes to other key place in surveillance area, the related receivers group measures this tag signal. System can judge this tag location. Thus entire monitoring network can definitely track the moving object in anywhere when it entering or exiting each area. Finally by this method, the system realizes the area tracking for the monitoring object.

Wireless Sensor Tracking System for Military Storehouse Application

The entire military storehouse occupies 40 k square meter and has four surveillance areas like figure 3. A and B are outdoor and indoor storehouse respectively, C is basement storehouse (about 28 k square meter) and G is guard area. In order to ensure all people and goods absolute safety, every people must wear wristband tag (with only global ID and banding one’s name) when entering this surveillance area. The tracking System keeps fully positioning at anywhere. The system consists of following part: tag which collecting data; receiver including LF activating module, RF module and interface module that transmits the data to concentrator; header-end intelligent tracking subsystem containing concentrator and server which conducts the related calculation, judges object position and displays moving trend. If necessary, it triggers the alarm and control order etc.

Combining Frequency Device

**RFID Combining Frequency Receiver.** There are two types of receivers with different antenna. One is directional receiver and other is omni-directional receiver. The former usually is located at the gate, sentry and bounding walls etc. specified zone to monitor these zones and read the signal data when tag entering these places. The later locates in the central area moreover three receivers forms one triangle group for object. The receiver distributed location is as Figure 3.

![Figure 3. Receiver Distributed in Surveillance Area.](image)

**LF Activitor.** There is two types, one is classified as gate trigger and another is surrounding wall trigger. (From engineering practice, the LF activator could be integrated into receiver or as discrete device. This solution provides both types of device regarding different using situations). Which is generally set at the door, gate etc. key positions. Its main function is to trigger tag, record the object entering and exiting time and judge the moving direction from one zone to another zone. It raises the positioning trend accuracy in system.

**Combining Frequency Tag.** Here offers wristband tag and card tag design. Wristband is anti-disassembly, waterproof and anti-impaction for peoples [11]. Its main function is to monitor for people at 7 x 24 hours. The card tag is for guard with alarm button function. It helps to give an alarm in time when guard discovers abnormal situation.

Header-end Intelligent Tracking Subsystem

This subsystem main equipment contains switch, sever, computer, concentrator, video wall and so on. All of these focuses on signal parameter calculation, data analysis, real time message display, and control order producing etc. functions.
Monitoring header operates not only these equipments, but also surveillance information both indoor area and outdoor fields in entire military storehouse coverage. Moreover it will send related control order to the next control subsystem when facing abnormal situation.

**Tracking Moving Object Mechanism**

The tracking system principle is same as above section introduction. When moving object (tag) goes to near X receiver in outdoor area, X, Y and Z respectively collect tag data based on the tag signal gain. Then transmit data package to System center. The server immediately calculates these data packages and judges tag position. In the same way, when object steps into C basement area, the related receiver group at the indoor gate and receiver group near C1 can adopt this tag data. The server can judge and track this moving object by different receiver groups in each location. Thus the system can automatically realize the entire surveillance area tracking. Furthermore the tracking system conveniently uses in the complex situation by combining frequency integrated technique.

**Summary**

This paper puts forward one integrated approach for wireless sensor RFID combining frequency technique and design; it mainly makes use of integrating each frequency characteristic advantages as well as designs tag signal gain circulating feature. Meanwhile provides an innovative study that advanced solution comes from technique characteristic and application characteristic integration. Moreover the study forms a perfect industry application approach in wireless sensor positioning and tracking field. This method and design can be extended to the other applications such as environment monitor, customs warehouse logistics, banking coffers, museum object as well as hospital care center etc. important aspects. It is of a profound significance in human work and life.

**References**


