

Navigation and Positioning Based on RFID in Local Scope

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Abstract. Recognition of orientation, occasion and mobility for visual impaired people is very difficult, especially in unknown environment. This paper describes an embedded pedestrian navigation system contained sensor that is an active Radio Frequency Identification (RFID) tag system. The navigation system based on active RFID is a new identification technology, judging direction and position of user by calculating in the tag net. Test results show that the positioning and navigating achieved by the method is effective at a local region area.

Keywords: Positioning; local navigation; RFID; tags; route planning.

1. Introduction

Navigation and positioning service has been paid more and more attention with science and technology rapid development. It is well known that Global Positioning System (GPS) is represented by navigation and positioning service. GPS has applied in many fields widely. The navigation and positioning service to a particular complex occasion or region, especially indoor navigation and positioning is necessary. The special local navigation has a large and growing trade prospect in the near future.

Based on GPS system, GPS user must contact with satellite system continuously, it is the maximum limiting, which is line of sight (LOS) environment. So the positioning accuracy won't reach to the required standard, if system out of working, the failure is attributed to the wireless signal transmission being restraint in room or building. The highest accuracy of GPS is about 6m, the accuracy can't satisfy the navigation requirements of one meter indoor. And some simple speech navigation and positioning systems, which are widely now in some scenic spots and venue, such as campus, museum, stadium, library, etc, but they can't be satisfied more complex region navigation demand.

Pedestrians, such as blinds and children, who need more information to show their orientation and position always. A new region navigation system based on RFID and speech technology meets the complex region navigation demand indoor.

RFID is an information technology, comparing with wireless identification and service, it has many advantages. RFID has been applied in many fields widely such as security, commodity production and sales, management and statistics, transportation etc in recent years. It's also a meaningful attempt to applied RFID tag and relevant chip in the tickets of Olympic game last summer. As a medium of intelligence paper tickets support quick check-in, accurate positioning, inquiring and management for tickets holder.

Speech navigation technology is a research focus in recent years, and RFID will make it popular on the market in the future. A few big companies have been researching speech recognition as a priority project. Because they believe speech recognition based on computer technologies will bring the quality of being useful and convenient for billions of people.

RFID technology and speech technologies have complementary advantages, they are interrelated and interdependent. Because RFID tag can provides entire information data, such as identification

code and time, so it also can assist us to confirm accurate position when the tags were fixed in special place or objects.

Actually, RFID system won't tell anyone how to walk if there isn't speech navigation and positioning system. If need better precision, integration speech recognition technology with RFID applications is more important in the region navigation system. At present, a guide system has been used in Europe. There is an automatic guide sensor be placed on the side of exhibition to transfer speech information. When the visitors come close the sensors of exhibition, their portable receivers will play prerecorded speech information of the exhibition. However, we can create a new information system through combining RFID technology and speech service technology for region navigation and positioning.

In addition, many scientific institutions and companies are researching RFID in a useful attempt. This paper will introduce a whole solution, speech service and regional navigation under PDA platform for mobile devices based RFID technology.

On this purpose a grid of RFID tags has been designed to provide information about the path the blind should follow in order to have a safe navigation. Such a grid, and the related acoustic signals, guide him along a route and alert him when the reader exits from the safe grid area. Actually when the user cannot easily perceive relevant points of reference, the designed system alerts the user via synthesized speech output, possibly also generating sounds to identify additional and useful reference lines.

2. Navigation System Construction

The system applied the RFID tag, compact handheld device as receiver to navigate and plan route for people in a special region when they travel or walk.

The system will load pre-corded speech navigation information. The identification tag will be installed the corresponding ground node. The pre-corded speech and the installed point can be changed according to the actual requirement.

When the bind or children travel through the routed nodes which installed identification tags, the reader of RFID built-in the handheld portable navigation device will access information from the tag, excite the vibrator or microphone to remind blind man in their route. A player will play the corresponding speech through blue-teeth connecting with handheld portable device. So the bind man and children will reach Specified Position followed the navigation speech. The system can also plan a reasonable route automatically except for positioning a single-node. Pedestrian can choice the shortest or the most reasonable route in a special region.

2.1 Developing Platform

The system will apply HP IPAQ h2100 PDA as intelligent terminal according some success projects in domestic. The platform is the software Visual C language based on Studio 2007 and wince operation system of mobile devices. The database is also constructed in the system. Considering the computing power and cost of mobile devices, data will be reserved as XML file instead of database file in the local mobile device too.

2.2 Key Technologies Development of system

There are three key technologies of the system, RFID positioning, path planning, speech service.

1) RFID Introducing

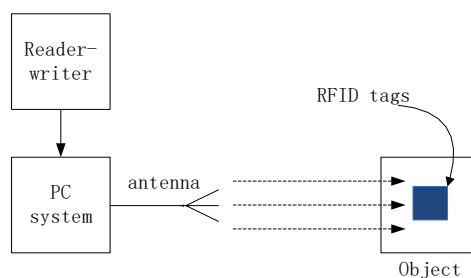


Fig.1 RFID tag read schmatic diagram

Radio Frequency Identification isn't the most advanced technology now. It just is a non-contact automatic identification technology which accessing data through exciting RF signal to the target. The RFID system works in a variety of bad Circumstances, their identification processing without manual intervention.

The fundamental theory of RFID technology is simple. A signal reader will send RF signal to the tags when the tags conduct the magnetic radiation, the passive tag will send memory information in the chip by the induced current, and the active tag can send a frequency signal by itself. The data information will be sent to the center processing system until the reader accessing the return information and decoding the information.

2) Route planning

The system algorithm includes two schedules, open and close. OPEN schedule in which to save all the nodes have been generated without excited, and the excited nodes will be served in the close schedule.

a) First, a nearest point to the initial point without being checked will be putted in the OPEN nodes group, then to be checked.

b) Finding out all the branch-nodes of the nearest point to the initial point, and put the point in the CLOSE schedule.

c) Research the branch-nodes and calculate the distance from the initial point of node, put the branch-nodes back in OPEN schedule.

d) Repeat step 2 and step 3 until the OPEN schedule cleaning up or target point appearing.

The system route planning algorithm is similar to the classic DIJKSTRA algorithm that is used to calculate the shortest path of a node to all other nodes. The shortest path algorithm can work out the optimal solution.

2.3 Speech Recognition

The system speech service including destination of the speech recognition, direction and position speech reminding real-time. The direction or position speech reminding real-time applied pre-recorded speech based on query results. Key-input is the usual choice for destination in the PDA, but key-input isn't suitable in moving process. The most convenient way is the user choosing the destination by speech commands. Hence, automatic speech-recognition is also one of the key technologies in the system. The target of automatic speech recognition is turns the speech signal into read-only words chain.

In actual, the Obtaining and Utilizing of acoustic features Parameter is input speech. Parameters will be combined with the acoustic model that has been trained in advance, language model, and dictionaries index to decode. At last, the text according acoustic wave will be presented. Acoustical model (HMM model) and other required models such as language model (LM) are obtained in the training of some Specific applications process early. In this system the main target language is mandarin, English and a little vocabulary speech recognition.

The main target vocabulary focuses on the spot terms and some objects name indoor. Navigation will be accomplished until the spot sequence accessed.

There aren't many speech recognition algorithm problems been solved, though the speech recognition technology has been put into real using step by step. Particularly medium and small vocabulary speech recognition system (<200 words) is close to accomplish, and it has widespread application market in mobile devices. That is also a dependable guarantee to system building.

3. Navigation Algorithm Research

3.1 Positioning Algorithm and Model Introducing

The whole RFID local net can be modeled as a connect undirected graph $G=(V E)$, V is a collection of all the data modules note, E is a collection of all the data module edges. We make a collection of $A (A \subset V)$ the set of all anchor nodes, the positions of all the nodes are known.

Search a point set of space, each point (x, y) in collection to meet the following conditions:

$$0 < L_{i-j1} \leq L_{i-j2} \leq \dots \leq L_{i-jk} \leq R$$

L_{i-jx} ($1 \leq x \leq k$) represent the distance from (x, y) to a anchor node, we assume that all nodes are the same type with the same communication radius. We use Voronoi diagrams inequality.

3.2 Estimation Positioning Error Comparison

According to the definition of Voronoi regions, we can know the start node in the Voronoi region. At this point, if removed from the set, you can know all remaining nodes in the node from the most recent data modules, so at this time in the Voronoi region, this process can be repeated until the K anchor-nodes of the Voronoi region all the calculations to complete, then calculate the intersection of Voronoi regions shall be the result of localization algorithm output.

4. Model subsystem structure

4.1 System Applicable Scenarios

Table 1 Applicable scenarios objects

Applicable scenarios objects dictionary		
XML-version	Door	TV
Location	Window	Radio
Latitude	Gate	Computer
Longitude	Road	Phone
Height	Floor	Refrigerator
Path	Stair	Washer
Sidewalk	Handrail	CD-player
Museum	Vending	Light
Cinema	Desk	Pot
Hospital	Bed	Dish
Restaurant	Chair	Thermostat
Toilet	Cabinet	Microwave
Bathroom	Pool	Stove
Kitchen	Stage	Sink
Bedroom	Curb	Guideboard
Faucet	Decelerating belt	Garbage can
Corridor	Direction board	Tree

The system plan shows in table I. Pedestrian can fetch a map on record and read whole information of RFID tags on some objects at any time, or choice related service by a RFID reading and writing device of intelligent mobile terminal.

B. System Structure

There are two parts developed in the system, which are PC system and PDA handed system.

PC system is used to edit the map and information. PDA handed-system is also important because almost all of the services are completed in it.

1) PC system

PC system is used to edit map information data. Some important nodes will be signed in a matching map that involves all sampling nodes data. All the information, such as object tag, name, positioning and sequence, will be stored as XML file in PC system. After reading data from tags, only one thing left to do is finishes loading the XML files by the PDA handed system.

2) PDA handed system

There are three modules in PDA handed operation system, RFID orientation MOD, map speech feedback MOD and planning MOD

a) RFID orientation MOD

Position and orientation information in detail can be shown on the PDA handed device. A main function of RFID MOD is to obtain scenes information and objects' character by RFID tags querying mode. Visitor can also query their position or orientation to navigate their route.

Orientation must be judge except for position, so the system can judge its orientation according previous tags. The flowchart to determining direction is shown in Figure- 7. When the robot is first placed anywhere on the edge of the grid, facing the center, the RFID microcontroller (the microcontroller tasked to direct the RFID reader to obtain tag information) obtains tag information

from reader. This tag information is the identification number found on the tag. The RFID microcontroller then matches the retrieved tag information to a pre-assigned list of where this particular tag will be found on the grid. The tag value from the pre-assigned list is the information that will be sent to the NAV microcontroller (the microcontroller tasked to perform the navigation algorithm). The converted tag information will now be labeled as the previous tag info and put into the navigation algorithm memory for use later in the process.

b) Map and speech MOD

PDA system will load edited map files in advance after the system starting up. A edited map files involve nodes position information will be loaded in memory. If user touches the screen of handed device, route text will be shown on the screen, and navigation speech will be played in time.

c) Route planning MOD

The main function of route planning MOD is querying for users' navigation.

The route planning and navigation system work well under normal circumstances. The response time of route query is not more than 2 seconds if the node doesn't exceed 300 in the map.

d) Tag selecting

According to the specification, the bit data rate is 64 Kbps which would be fast enough to communicate several hundred bits at a high velocity. Figure 3 shows the distance needed to read 64 bits at various data rates with respect to vehicle velocities. In the figure, the data rate is assumed to be the sole factor of RFID communication. Only the distance for 64 bits is drawn since the data size of a tag ID is 8 bytes in our program. The purpose of the experiments explained in this section is to measure the time that actually takes to complete a reading transaction.

e) Anti-interference Measures of tag

European Telecommunication Standards Institute developed a European standard based on RFID, it is a multi-reader associate work method, that named listen before talk.

It works mechanism is somewhat similar to CSMA technology. Before a reader will try to communicate with tags around it, the reader's communication channel is free, then the reader can query to the tags, other it must wait channel be free.

Listen before talk is an effect method that can be used between reader and another reader for anti-interference. But it can't control interference between reader and tags. Because mobile communications terminal of the hidden can be also interference each other if the channel is free.

f) Radiation standard

Adults is completely safe under the electromagnetic radiation environment when they stay in the largest power radiation scope of RFID UHF frequency channel, distance range of half meter to the antenna, and residence time is not over 6 minutes. The most power frequency is 6M till 30M. It is lower than China government standard.

g) Interference elimination of more reader-writer in one group

Interference is also happen in the same group at different points because interference scope is more than reading scope in the same group. It will seriously interfere with the progress of the work. So color-wave algorithm can be applied to eliminate interference more effectively in one group than others algorithm. Every point will be entrusts with a different color number, different color point will works in relevant slot channel if every neighbor points is different.

4) Database design

Database used client/server terminal and SQL Sorve7.0 management system. Any node can accesses this database if it has accessing privileges in net, and the node can serve as a reference terminal.

5. Compared with GPS System

The region navigation and positioning system has great advantage compared with the GPS system in a local range.

GPS system accuracy is more than two meters, but our system positioning accuracy can reach about 0.5 meter. The new system can also identify small objects and most obstacles; meanwhile it can be used in vertical navigation. If RFID net combines with GPS, they can excel in their pursuit.

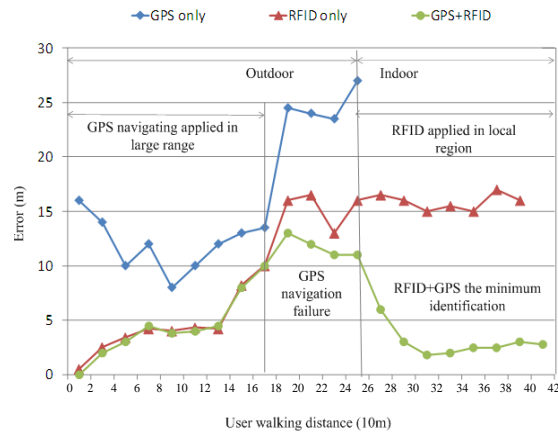


Fig.2 Error analysis with distance

6. Conclusion

This paper discusses a technology based on RFID, including system design and implementation Process of intelligence terminal device, the main function is speech service and navigation in a special region.

The new system not only gives effective help exhibition and large building, but also provides the users with more freedom and human services, especially for blind man or people unfamiliar with roads.

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