Implementation of Smart Parking Guidance System based on Parking Lots Sensors Networks

Wenyu Cai, Dong Zhang, Yongjie Pan
Electronic Information College, Hangzhou Dianzi University, Hangzhou 310018, China

Abstract: This paper designs a parking guidance system based on parking sensor network. The system consists of parking lot sensors and sink node and parking manager. The system builds the parking sensor network by ZigBee communication protocol, where the real-time parking information of all parking sensors is transmitted to the sink node. The sink node sends information of all parking lots to the parking manager by manner. In the parking manager, there will display the information and position of the parking spaces. Moreover, this paper uses Dijkstra optimization algorithm to obtain the optimal parking router.

Key Word: Smart Parking guidance, Sensor network,Dijkstra algorithm, Parking Router

1 Introduction

With the development of economy and society, the promotion of urbanization process, and the improvement of living standards, the number of the cars was increasing rapidly, which has resulted in the situation of shortage of parking space [1]. The problem of parking has become a major problem that constraints the development of urbanization and this problem is also growing concerned by persons. At present, there are few studies on parking guidance, parking optimization and other aspects of parking lot at home[2]. Some guidance of parking only displayed the numbers of empty parking lots to driver and didn't indicate the specific location and parking routing, which reduced the efficiency of parking, spent a lot of time, and gave inconvenience to people.

For the technology of parking guidance, there were some researches at home and abroad. In theoretical research, *Russell G.Thompson* did some researches on the theory and method of the Design and development of Parking Guidance Systems[3-4]. *Yasuo Asakura, Masuokashiwadani*[5-6] also made some studies on how to reduce traveling time and improve the efficiency of traveling in the case of the period of the peak time. At home, considering the problem that the dynamic information of VMS in parking guidance system is monotonous, Chen Qun, Guan Hanfei presented the display method [7] of the traffic guidance information board based on fuzzy control in 2007. Ji Yanjie, Wei Wang established the optimal model [8] based on Grey entropy by the analysis of parking behavior characteristic in 2009.

This paper builds a new system to make parking guidance based on sensor networks. The system combines sensor technology, wireless communication technology, and positioning technology, which makes data transmission stable,and this has certain innovation and science.

2 System Model

2.1 Principle of system

As shown in Figure 1, system of parking guidance system [9] mainly includes data acquisition module, data transmission module, data processing module and data sending module. The main function: the sensors detect parking lot real-time information in each parking lot, and will transmit the real-time data to the information center, information center will deal with the data and sent to the user, and make the relevant instructions. The working process: Firstly, install the parking sensors in each paring

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space and build the sensors network by using ZigBee. The sensors collect the information of parking lots, and transmit the real-time data to information center. When the car enters into the park, the system will locate the position of the car by Bluetooth. According to the vehicle location, the system will choose the best parking and optimal parking route.

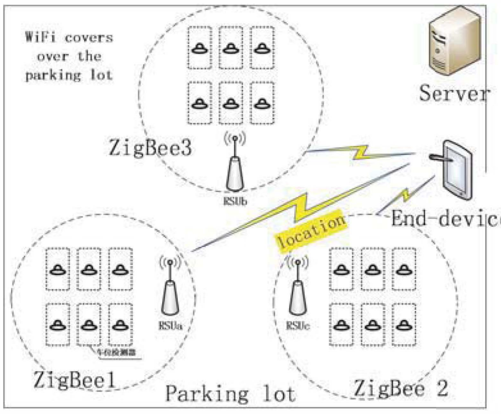

Figure 1 The system framework

2.2 Sensor nodes

In this system, parking sensor needs to make the real-time detection of parking information, the data will be transmitted to the main controller by the parking detector, so the system needs to install a parking detector in every parking space, and make networking communication for each sensor by ZigBee. Each parking detector is looked as a network terminal. In this system, ultrasonic sensor is used for detecting parking spaces. The principle of ultrasonic detection is to calculate the time difference between ultrasonic transmitting and receiving, by the time difference, the distance is measured. Ultrasonic principle diagram is shown as Figure 2.

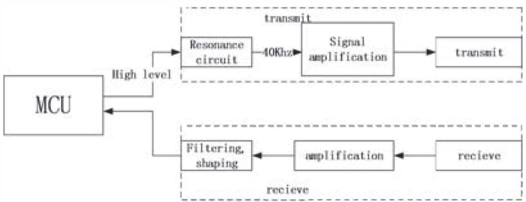

Figure 2 Ultrasonic circuit

The CC2530 is a true system-on-chip (SoC) solution for IEEE 802.15.4, Zigbee and RF4CE applications. It enables robust network nodes to be built with very low total bill-of-material costs. So CC2530 is used as MCU.The diagram of parking detection system is shown as Figure 3.

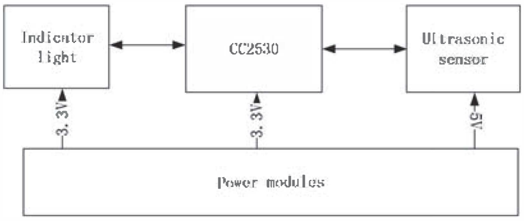

Figure 3 Parking detection sensor

2.3 Sink node

Information center includes three parts: ZigBee coordinator, Bluetooth station and WiFi part. Zigbee coordinator is used to collect the information of parking spaces from every end-devices, and those information will be transmitted to parking management menu by WiFi. Bluetooth station is used to get parking vehicle on its location. Considering too many end-device, the system needs to establish three sensor networks, so the system has three information centers. As follows in Fig 1. The real-time data of parking spaces in Zigbee coordinator will be sent to WiFi part using UART. The information center diagram is shown as Figure 4.

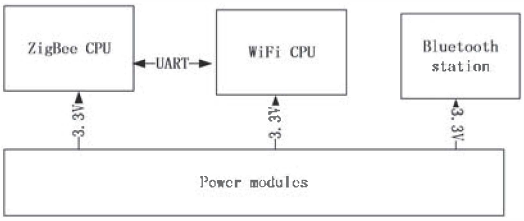

Figure 4 Sink node

3 Shortest path search algorithm

3.1 Optimization model

This paper chooses Dijkstra algorithm for parking optimization. Dijkstra algorithm [10-11] mainly calculates the route from single point to other all nodes. This traditional algorithm has large computation and low efficiency. In this paper, a constrained optimization condition is used to optimize the algorithm, and the computational quantity is greatly reduced.

It supposed that *'E'* is as the entrance of parking lot, *'Pi'* is as spare parking, *'O'* is as the exit of parking lot. *DistanceEntrance[i]* is a set of distance that from *'E'* to *'Pi'*.*DistanceExit[i]* is a set of distance that from *'Pi'* to *'O'*. *'S'* is a set of route that begins at the point *'E'*. Adjacency matrix *'LengthEntrance[i][j]'* is the set of weighted value for path, if the path from one point to other point is none, the value is ∞ .*'Parking[i]'* is a set of spare parking that minimum of *DistanceEntrance[i]* and *DistanceExit[i]*, *PathEntrance[i]* is a set of optimal route from *'E'* to *'P_i'*. The steps is as follows:

(1) Detect all the spare parking spaces, called *P*, each spare parking space called P_i, $i \in (1, n)$.

(2) calculate the distance from P_i, to entrance of lot, called *DistanceEntrance[i]*, and the distance from P_i, to exit of lot, called *DistanceExit[i]*.

(3) calculate the sum of two sets(*DistanceEntrance[i]*+ *DistanceExit[i]*).

(4) Repeat the step (3), Search all the spare parking space.

(5) Compare the different value(*DistanceEntrance[i]*+*DistanceExit[i]*)) for each spare parking space '*Pi*', choose the minimum value, put the corresponding space into set *Parking[i]*.

(6) Initialize the optimal route set (*PathEntrance[i])*. Look entrance of parking lot as source node, look across road as vertex, look the linear distance between each two vertices as the weight value, look the spare parking space in the set *parking[i]* as end node, make the optimal path, put it into the new set (*PathEntrance[i]*).

(7) Repeat step(6), Search all the spare parking space in the set *Parking[i]*, put the corresponding path into the new set *PathEntrance[i]*.

(8) Compare the weighted value of all the route in the set *PathEntrance[i]*. Select the minimum value, come to a new set *Min{PathEntrance[i]}* $i \in (1, n)$.

(9) The parking space corresponding optimal path is the best space. Determine the number of the sets *Min{PathEntrance[i]}* $i \in (1, n)$ .if number was only one, the path is the optimal route, if more than one , According to the parking process as far as possible to go straight line, find the path of the least inflection point, at this time, the path of the best parking optimal path for the entrance.

The improved algorithm flow chart is as follows shown in Figure 5,

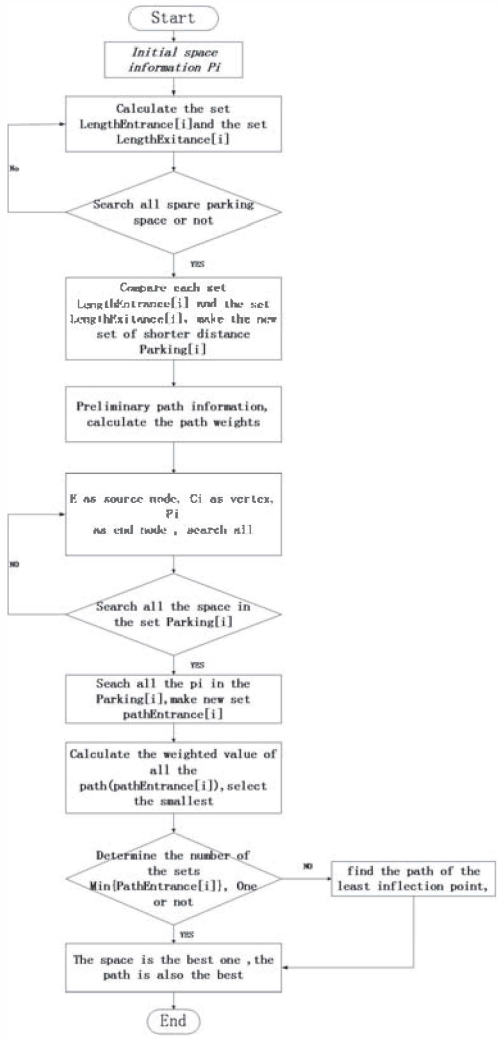

Figure 5 Improved algorithm flow chart

3.2 Optimization algorithm

In order to verify the rationality and the implementation of the optimization algorithm, we can select different parking structures. In fact, the sketch map of parking spaces are different from the ideal, so, we choose the parking door as a reference point, and draw the weighted diagram of parking lot. Figure 6 is a sketch of a certain underground parking lot. Figure 7 is a weighted map of this parking lot.

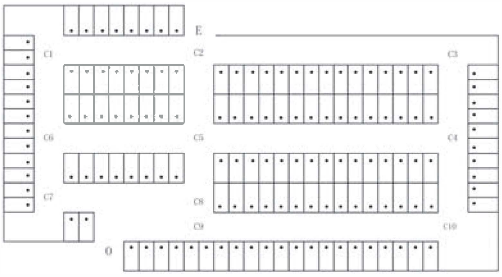

Figure 6 Sketch of underground parking lot

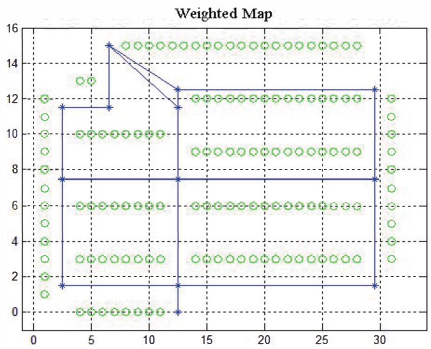

Figure 7 The weighted map of parking lot.

Choose spare parking space by parking sensor as shown in Figure 8.

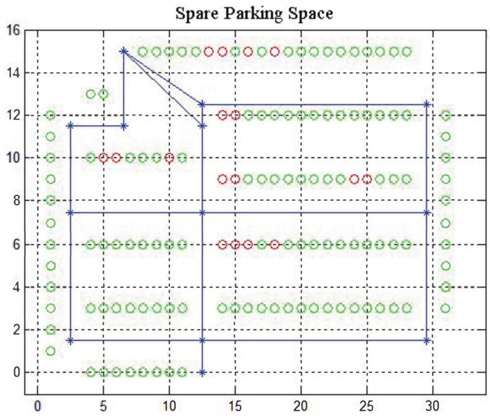

Figure 8 the sketch of spare parking spare

Through the optimization of this paper, the optimal path of parking optimization is obtained As shown in Figure 9

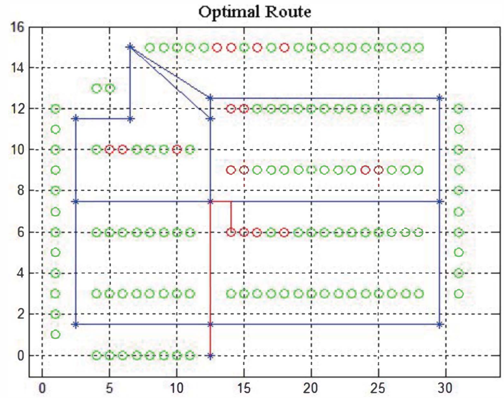

Figure 9 Optimal parking router

4 Debugging

Because of the limitation of the test environment, the system is tested in the laboratory environment. Three sensor networks, nine parking detection nodes, and PC software consist of a small test system. The parking detection node is shown as Figure 10, the information center is shown as Figure 11, and the management menu is shown in Figure 12.

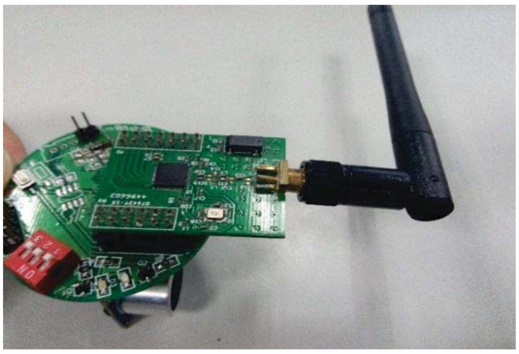

Figure 10 Parking detection node

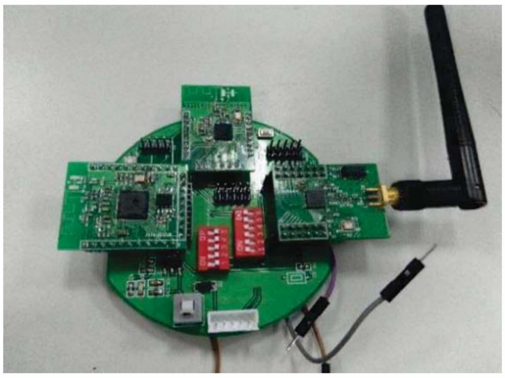

Figure 11 the sink node

Figure 12 Parking lots manager

5 Limitations and future work

Intelligent parking guidance system is a very complex and huge system, so it is difficult to carry out the system of testing. Therefore, the system is only testing in the simulation of the parking environment, and achieves the desired results. The limitation [12]of this system is that the sensor nodes are few, and the map of parking lot is simple.

The future work [13] is to increase the number of sensor nodes, to find some of the relatively small parking in the test experiments, while continuing to beautify and improve the parking management interface, which can further test the practicability of the system.

6 Summary

Although this system has not been used in real life, the ideals of the this system have something innovative and feasibility in real life..Optimization Dijkstra algorithm concerned in this paper is easier computation and higher efficiency than traditional Dijkstra algorithm. This system has some practical value in intelligent parking fields.

Acknowledgements

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