Research on Intelligent Parking Space Design in Limited Space through Big Data

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Abstract. With the rapid development of urbanization and motorization in China, the problem of parking in the city becomes more and more serious. Due to a series of reasons such as spatial layout, insufficient parking facilities and lagging property management, the parking problem in old urban communities is difficult to be solved. Based on the perspective of big data, this paper analyzes the reasons for the parking difficulties in the old community, and designs a set of intelligent parking system to provide an effective solution to the problem of parking difficulties in the old community. At the same time, it proposes design strategies for the renewal of parking space in the old community.

Keywords: Big data, reconstruction of old community, intelligent parking.

1. Introduction
While the number of cars in urban areas is increasing, the demand of parking Spaces is increasingly tense. "Parking Difficulty" has become a hot spot and problem in the city. The increasing number of private cars and the relatively backward planning at the beginning of community construction have led to the increasingly prominent problem of parking in many residential communities, especially in the old communities built in the 1980s and 1990s without underground garages. Due to the lack of planned parking or the small number of parking spaces in the old community, the number of random parking vehicles on the road in the community is gradually increasing. At the same time, in a very limited space, the landscape is often squeezed. How to make use of the only remaining green space to make the ground parking fully integrated into the surrounding environment? The necessary landscape treatment of parking is imperative. For the convenience of the owner, accurately and quickly find a parking space, while increasing the community landscape environment, the author designed and finished a set in view of the urban old community parking information monitoring and led display system, using the radio frequency technology and mobile communication technology to realize the real-time monitoring of the old community parking, parking within the community landscape is optimized at the same time, owners rely on the parking guidance display system to understand the parking information of the community, so that the car owners can standardize parking, relieve the traffic congestion in the community, while beautifying the community environment.
2. System and technical analysis

In the design of the intelligent parking information inquiry system proposed in this paper, the system availability must be considered comprehensively, which includes fast response speed, high accuracy of results, high efficiency, strong adaptability, simple and beautiful operation interface, and low requirements for the operation environment. This paper uses Centos6.5 as the operating system, Mysql as the database system, Tomcat as the middleware, the hardware environment is Windows7, and the software environment uses Eclipse as the client development tool. The second part is about the security. Because the system involves important personal data such as customer name, ID number, mobile phone number, license plate number, etc., the system is designed to ensure the security of the system from the following three aspects: 1) user identity authentication and authorization; 2) prevent mismatching and malicious access to the system and information; 3) provide password strength check when the user registers. Passwords must contain uppercase, lowercase and numeric letters. In addition, the system in the development to have a clear division, in order to ensure the realization of the system functions. The specific division is shown in Figure 1. In order to meet the many requirements of the ground parking space design of the old community above, we must try our best to create landscape parking space. There are often narrow roads in old communities that cannot even meet the need for vehicles to make a U-turn. Based on this kind of parking space, route projection, intelligent light belt or sound-landscape elements can be added to remind the driver not to enter the narrow space to look for parking space when there is no vacant parking space. As an important parking place for cars, parking can not only consider the functional needs of parking, but also take into account the users' visual feelings and use feelings, the landscape effect formed by itself and the surrounding environment, and the convenient experience brought to users by parking behavior.

Figure 1. System module division diagram
(Image credit: drawn by author)

2.1. The system hardware

The parking space monitoring and guidance system in the old community adopts the tree-like Mesh topology structure to build the Internet of Things type parking space monitoring and guidance display in the old community of the city, including the parking space guidance and display control circuit and
N gateway circuits, which are connected in a tree way. There are m monitoring circuits for street parking Spaces, and the monitoring circuits for parking berths with ‘n’ less than ‘m’ are divided into ‘n’ groups. The community has n groups of parking lot space monitoring circuits and ‘n’ gateway circuits respectively connected through WIFI. Gateway circuits are connected with parking guidance display control circuit through GPRS network. The topology of the system is shown in Figure 2. In the layout of parking space, vertical, parallel and inclined column can be selected and planned according to the actual situation. Under the condition of satisfying the normal driving and parking of sufficient vehicles in the driveway, the parking space can be rationalized and the number of parking Spaces can be maximized. An electronic screen can be placed at the entrance of the parking space to remind drivers of the specific parking location of vehicles in the parking space, which can better ensure the order of the parking space.

Figure 2. System topology
(Image credit: drawn by author)

2.2. Software design

2.2.1. Terminal parking monitoring software. The terminal parking monitoring circuit can collect parking information and send and receive information as routing node when monitoring parking status. When a terminal node is networked, it searches for a gateway node that can be networked. If the gateway node is found, the network will start and the parking information will be collected and sent to the gateway node. If the terminal does not find the gateway node, it further searches for other terminal nodes near the terminal node. Once discovered, the network is established, and the parking information collected by the terminal node is forwarded by other terminal nodes and finally sent to the gateway. The design process of terminal parking monitoring software is shown in Figure 3.
2.2.2. Gateway software design. Parking guidance is divided into gateway software guidance and lighting guidance. In the design of gateway circuit software, it is necessary to constantly look for the terminal parking monitoring node nearby. Once the binding terminal parking space node is searched and networked, the gateway begins to receive the parking space data information collected from the terminal node, and forward it through the gateway, and finally send it to the parking space guidance display circuit. The software design flow chart of gateway circuit is shown in Figure 4. In the landscape design of parking space, the role of lighting cannot be ignored. Lighting facilities play a guiding role, including intelligent light belts, which can help users find parking spaces smoothly. At the same time, it should be both practical and ornamental.

2.3. The System hardware
In the choice of the intelligent system of the old community, they are more inclined to choose the hardware of Android system. The system is a special platform for mobile devices, including the
operating system, middleware and core applications of the device. Compared with other systems, it has
the following advantages: First, it is open, that is, the program source code of Android platform is
completely open, which is conducive to developers to master the details more quickly, improve the
technical level, and develop applications with more market prospects. The second is a rich choice of
hardware. Various device manufacturers have developed different solutions based on Android's open
programs, such as Samsung's Exons, Nvidia's Terga, etc. Although on the surface it is a competitive
situation, this does not affect data sharing and mobile device software compatibility. The ground
pavement of the parking space should be the same as other ground in the landscape. It should be
diversified in terms of material, form or color. Different materials and forms can make drivers have a
deeper memory of a specific place, so that it is more convenient and quicker to locate their own parking
space, and has a certain guiding role. It is worth pointing out that, no matter what kind of material shop
paste parking space, in the parking space and the municipal road part of the use of stone walking edge,
and fully left rain well.

3. Positioning system
During the construction of the positioning system, active Beacon tags are densely deployed on the aisles
or walls of the parking lot, and the device number and precise three-dimensional coordinates of each tag
are recorded. The Beacon tags broadcast their own device numbers periodically. This paper adopts a
data rejection strategy to compare the received power of all tags at the time of continuous measurement.
When a sudden change in the power of a tag is found, it usually means that the transmission channel of
this tag is blocked (or changed from blocked to non-blocked), and then locate it in the subsequence. This
label data is excluded from the calculation. Assuming that the actual coordinate of the terminal at time
it is \( (x, y, z)^T \), it is defined as a vector \( \alpha \). Suppose that the terminal receives \( N \) tags, and retains \( N \) tags
after being removed, and looks up the table to obtain the precise coordinates of each tag. Then sort the
\( N \) tags according to the received power to obtain the coordinate array \( \{ (x_n, y_n, z_n); n = 1: N \} \) and the
distance array \( \{ d_n; n = 1: N \} \). According to the relationship between distance and coordinates in the
positioning system:

\[
(d_n)^2 = (x_n - x)^2 + (y_n - y)^2 + (z_n - z)^2
\]

The paper organizes the coordinate array and distance array into the following matrix and vector
forms:

\[
r = \Phi \alpha + \omega
\]

Among them, the vector \( \omega \) represents the error vector that exists in the actual measurement process.
It is assumed that this error obeys a Gaussian distribution \( N(0;0, \sigma) \) with a mean value of zero and a
variance of \( \sigma \). Both the vector \( \alpha \) and the matrix \( \Phi \) are known and have the following form:

\[
\begin{pmatrix}
(x_1 - x)^2 + (y_1 - y)^2 + (z_1 - z)^2 \\
(x_2 - x)^2 + (y_2 - y)^2 + (z_2 - z)^2 \\
\vdots \\
(x_N - x)^2 + (y_N - y)^2 + (z_N - z)^2
\end{pmatrix}
\]

\[
\begin{pmatrix}
x_1 - x \\
x_2 - x \\
\vdots \\
x_N - x
\end{pmatrix}
\]

\[
\begin{pmatrix}
y_1 - y \\
y_2 - y \\
\vdots \\
y_N - y
\end{pmatrix}
\]

\[
\begin{pmatrix}
z_1 - z \\
z_2 - z \\
\vdots \\
z_N - z
\end{pmatrix}
\]

According to the least square’s estimation algorithm, we can get
\[ \hat{\alpha} = (\Phi^T \Phi)^{-1} \Phi r \]  

(4)

Where \( \hat{\alpha} \) is the least square estimation of the coordinate vector \( \alpha \) after N tags are observed.

4. System Test

The car drives to the three terminal parking space detection nodes in turn, which are marked as a, b, and c respectively. Open the platform software on the notebook and observe whether there is a vehicle on the on-site terminal parking space detection circuit and the three-level guidance screen in the parking guidance display circuit. Whether the situation is consistent or not, the result is accurate, and the number of tests is 50 times. The accuracy of the 50 parking monitoring data was monitored on the spot, and the accuracy rate was 100%.

5. Conclusion

According to the parking problem of the old community, this paper puts forward the transformation strategy to the parking system and parking space landscape. In the landscape of parking space, the transformation strategy is put forward from the aspects of ground pavement, greening plants, landscape structures, lighting and signs. In the parking system, according to the MVC mode, it uses HTTP Client as the communication mode and JSON as the data transmission format to connect the Android mobile terminal, Web server and MySQL database. C/S architecture realizes the goal that users can master the real-time dynamic information of parking lots and parking Spaces near the destination at any time. In addition, the navigation function provided by the system can provide users who are not familiar with the route with suitable driving routes and reduce the driving distance. Ground parking space design is an important part in the landscape of the old community. It is the key and difficult point in the landscape design of the community. When the parking system is upgraded, the same attention should be paid to the landscape renewal of the parking space. The system can also be further improved and studied in the aspects of function expansion and operation simplification, user information security management, system database resources and so on. In the renewal strategy of parking space landscape, we should pay more attention to the combination of reality, not blindly apply, according to local conditions of the landscape design.

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