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U-valet System for Smart Parking Information

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Abstract: Rapid increase in automobile ownership led to an increasing demand for an efficient parking management system. In response, smartphone-based smart mirroring service or application-based automobile control technologies are developed and these are getting favorable responses from consumers who are highly interested in quick and convenient systems that are easy to install. In response, this study developed a "U-Valet Parking System" which identifies parking status for efficient utilization of parking space and sends parking status to the smartphone for efficient parking management. This system will relieve traffic jams, reduce parking time, and reduce fuel expenses by providing real-time information on empty parking space.

Keywords: *U-valet system, Smart parking, Parking management, Real-time*

1. Introduction

Due to a significant increase in automobile ownership, there has been chaos for parking at large grocery stores or department stores. Therefore, drivers waste a significant amount of their time to secure a parking space. To secure parking space for the convenience of customers, they have parking agents serve customers with parking control. However, it requires much personnel expense. Several large-sized parking structures provide a quota for parking vehicles in the space, but they are unable to suggest the accurate location of available parking space but only provide a very limited function due to inflexible installation and operation of the system [1].

The parking control system has been developed by using a sensor network. Sensor nodes installed at every parking space dynamically form a network, and extracted data are conveyed to a server following the pre-formed network route [2]. Collected parking area information is saved in the server making it feasible to secure empty parking space by confirming current situations at parking space with a smartphone or device. Therefore, not many parking agents are required for the parking control, saving much of personnel expenses and making it convenient to install and use sensors as an advantage [3]. Also, as various sensors and sensor nodes related to sensor networks have recently been developed, it is feasible to install a sensor network at an affordable price. Furthermore, as they consume only a small amount of energy according to their characteristics, the cost for the maintenance will continue to decrease [4-8]. In this study, the "U-Valet System" is developed for efficient parking control to identify whether it is available to park a vehicle for the efficient use of space at a parking lot and make users confirm the parking status by sending it to a smartphone.

2. Related Researches and Necessity

Global companies such as BMW or Bentz in the parking industry in Europe and North America have been expanding joint investment with parking control companies, related application providers, car sharing companies, or city governments in a strategic partnership to provide specialized driving experience services. Companies such as Streetline, ParkatmyHouse, and GottaPark in the U.S.A or Europe have been promoting the emergence of companies providing innovative parking application services including real-time information at parking space and lot, parking reservation, and online parking payment. Streetline is providing service to find and reserve parking space in connection with mobile technology and IoT. Also, the wireless sensor of Nedap AVI has realized smart parking and relieved traffic conditions while reducing environmental pollution[9].

The city of San Francisco has implemented the 'Flexible Fare Parking System (SF Park)' project to replace existing parking meters with new smart meters equipped with various supplementary

functions to relieve inconvenience of drivers from traffic congestion when finding a place to park[9].

'SF Park' is a flexible fare system to classify 'congested parking space' if the proportion of vehicles parked at the space is over 8 out of 10 while increasing the hourly fare from 2~4 dollars to 6 dollars (about KRW 6,500). With a decreased number of vehicles parked at the parking space for a long time in congested areas, it is anticipated to have a higher parking circulation rate. At the same time, it is expected to reduce wasted time on the road and illegal driving or parking by using smartphone application for other cars to find a place to park[9].

Figure 1. SF park system components and applications(Server, Web, Mobile)

Developed by Frogparking Company in New Zealand, a smart parking control system makes it feasible for drivers to find space with sensors installed at parking spaces in the city that operate with sunlight in connection with a mobile application. When a driver does not use a mobile application, it is available to know how many empty spots are available for parking through electronic display installed on the road. Mobile application users do not need to have parking tickets issued and can make payment as much as they want with a mobile application. At the same time, sensors installed at the parking space detect a vehicle transmitting entrance time and total parking hours to the cloud server. Parking agents are also able to detect illegally parked vehicles or whether a certain vehicle not left with a parking ticket on the front window uses Frogparking service by holding a smart phone[9].

Figure 2. Parking Management Service System Incorporates Cloud Computing

Paper-ticket was a major means of parking payment in the domestic parking system in the 1990s. However, an automatic license plate identifying system and empty parking space displaying features were adopted in the mid-2000s. Korea is still at the beginning of real-time integrated parking control, and only parking inducing control system has been implemented. The domestic smart parking control system has just started. At the same time, no control system deserves to be called 'smart' as IT infrastructure planned as a part of an intelligent traffic system from the Ministry of Land, Infrastructure, and Transport is not completed yet on the road. With multiple large outlet malls opened in the railway station spheres in Korea, it has been requested to improve the parking control system in the buildings and allocate parking agents and even add more of them. Therefore, an intelligent parking control system is required more than ever[9].

Figure 3. Mobile admission and approval tickets and smart parking system with NFC technology

3. Parking Detecting Sensor Internally Installed Stopper

To identify whether it is available to park in the parking lot, a device internally equipped with the detecting sensor is required. In this study, a parking stopper internally equipped with an optical sensor has been designed to identify whether it was available to park. To minimize interference from fluorescent light, modulation wire has been realized in the lighting emitting part to have certain frequencies, while modulation frequency was set to be 60Hz or above followed by current consumption to be 30mA or lower and distance measurement to be up to 1m. At the same time, the window detection technique was used for selecting light reception at a certain frequency. Stopper structure has been designed and modeled in consideration of commercialized product specifications, sensor inserting methods, and impact diffusion. Figure 3 represents the light-emitting and receiving method of an optical sensor, and Figure 4 shows how the parking stopper is modeled.

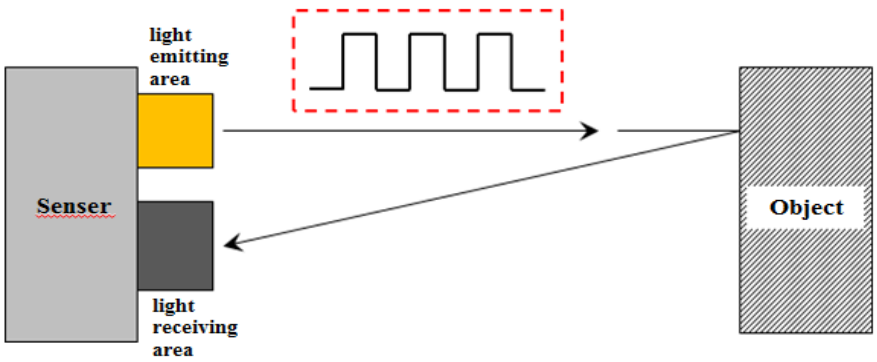

Figure 4. Light-emitting and receiving method of the optical sensor

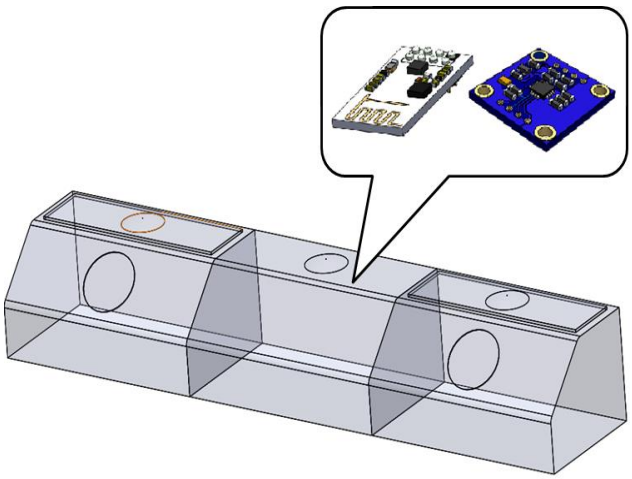

Figure 5. Parking stopper internally equipped with a detecting sensor

4. Wireless Parking Information Transmitting Device

To efficiently manage parking space in the parking lot, parking space was grouped in multiple sectors according to the size of the parking lot, while connecting parking detection sensor with wire in each sector and collecting information as to whether it was available to park in each sector. Collected data from each of the sectors were delivered through wireless communication devices such as Bluetooth or Zigbee and replayed by installing routers at a certain distance in the parking lot. Encoder wire was manufactured to collect data transmitted from the stopper in 8 to 32 units, and the transmitting data frame was designed. Fig. 3 shows how to index parking information, and Figure 7 represents how to wire-connect stoppers internally equipped sensors.

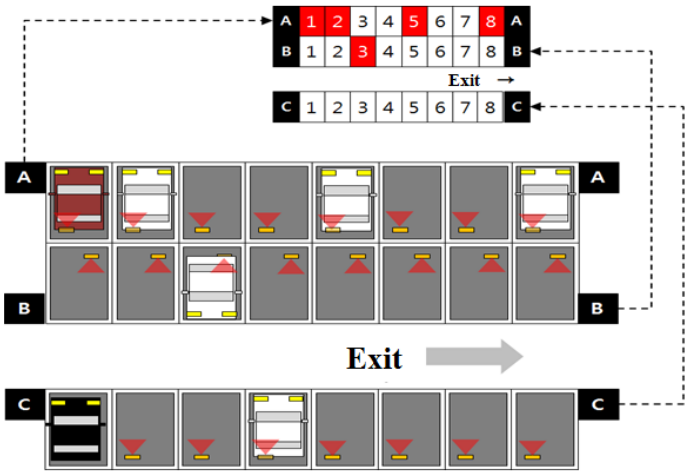

Figure 6. Flowchart of how to send parking status information

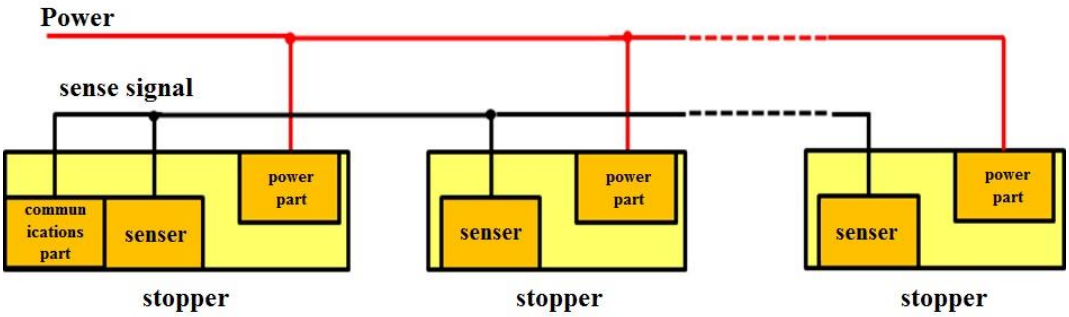

Figure 7. Wired connection method between sensor embedded stoppers

5. Parking Status Information Confirming Application

This application is comprised of the server PC collecting and processing information at each parking space so that users can utilize the service, applications to be provided to users, and beacon transmitting data to pop up parking information with a smartphone at the entrance of each parking lot. Figure 8 represents a flow chart about how to transmit parking status information.

Figure 8. A flowchart about how to transmit parking status information

Application is organized operating to access the server from a smart device available with data communication while having parking status information updated and designed to make reservations available after confirming the parking status. Also, when a vehicle approaches from the entrance of a parking lot, a smart device equipped with an application receives data from the beacon that parking status is popped up. Node.js was used for the server, and MongoDB was used for the database. Fig. 7 represents an example of a parking lot applied with the U-Valet system.

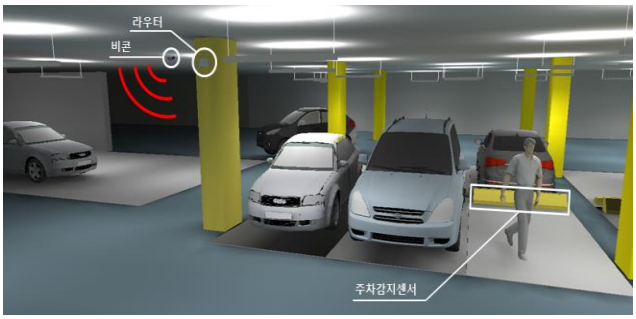

Figure 9. Example of parking lot applied with U-Valet system

6. Conclusion

In this study, the "U-Valet System" is developed for efficient parking control to identify whether it is available to park a vehicle for the efficient use of space at a parking lot and make users confirm the parking status by sending it to a smartphone. In the use of this system, it is expected to save time consumed for parking, improve convenience, and promote efficient management parking lot with guidance at parking space and area.

As many customers visit department stores and marts located in downtown, modern civilization involves an old social problem where parking takes over 15 minutes on average due to narrow entrance and confusion of parking staff. This system helps in relieving such issues. The system reduces time loss and economic loss by preventing confusion caused by the narrow parking space or inexperienced parking staff in advance. By solving parking difficulties in downtown areas, the system contributes to reviving the small merchants and traditional markets on issues. Users of smart parking information, U-Valet, can utilize the application without financial expense by downloading the free application. The system provides real-time information on the empty parking space to allow the users to reserve the parking space directly. It has a huge economic ripple effect by relieving traffic jams in surrounding areas, reducing parking time, and reducing fuel expenses.

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