# Development of LBS-based Indoor and Outdoor Car Parking System

Fuan Tsai[1*], Jhe-Syuan Lai[2] and Yu-Ching Liu[1]
[1]Center for Space and Remote Sensing Research (CSRSR), National Central University (NCU),
No. 300, Zhong-Da Rd., Jhongli, Taoyuan, Taiwan 32001
[2]Department of Civil Engineering, National Central University (NCU),
No. 300, Zhong-Da Rd., Jhongli, Taoyuan, Taiwan 32001
*email: ftsai@csrsr.ncu.edu.tw

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**ABSTRACT:** This study develops a 3D-based indoor and outdoor car parking LBS system (smart phone APP) based on indoor building models and attributes, and Dijkstra's algorithm in order to provide users an intuitive location-based car parking service and to improve the efficiency of searching available car parking spaces. The example result demonstrates that the developed system integrated with the indoor building models and attributes can provide intuitive and realistic visualization of the environment for car parking assistance. It may be of interest for future research to apply the developed system in support of intelligent car parking management.

## 1. INTRODUCTION

The objective of LBS (Location-Based Service) is usually to combine GNSS (Global Navigation Satellite systems) and other positioning and navigation systems, digital maps and mobile technologies so as to provide the spatial information of POIs (Point Of Interesting) such as restaurants, entertainment places, disaster locations, traffic conditions, and so on. The traditional way to visualize the spatial relationship between POIs and user's locations is to overlap assorted related two-dimensional layers. However, the 2D-based visualization is not intuitive for most users to understand and sometimes can be difficult to explain the scenarios of requirements. In cities, car parking has become an annoying issue for drivers as the number of vehicles increases dramatically, but most car parking assistance systems cannot consider the indoor and outdoor environment at the same time as GNSS signals cannot be received inside buildings. Therefore, some studies have developed the indoor navigation systems based on wireless or communication technologies. Selecting a suitable algorithm for route planning is also a critical topic in the related applications, such as Dijkstra's algorithm (Dijkstra et al., 1959), A* algorithm (Hart et al., 1968), ACO (Ant Colony Optimization) algorithm (Colorni et al, 1991), and so on. Assuming that the wireless or communication technologies can solve the indoor navigation problem, this study develops a 3D-based indoor and outdoor car parking assistance system (APP in a smart phone) based on the LBS system, indoor building models and attributes, and Dijkstra's algorithm in order to improve efficiency of searching available car parking spaces, especially in a complex indoor parking garage.

## 2. METHODOLOGY

There are two modules in the developed APP. The first module, which integrates the outdoor digital map and parking attributes (e.g., business hours, toll, etc), is to search the available parking sites based on the Dijkstra's route planning algorithm and user's demand (e.g., cost, distance, etc). After inputting the requirements for searching the parking locations, the developed APP will search and identify the suitable candidates. User can select one of parking sites in the first module.

After that, the APP system will show the indoor parking information (second module in the study). The second

module combines the indoor parking map, attributes (e.g., elevators, entrance, exit, etc) and 3D models (e.g., parking space, pillar, etc), supporting 2D and 3D visualizations. The 3D models are constructed in accordance with the building map and OGC CityGML LoD-4 (Level of Detail) standard. Users can also browse the facilities (e.g., elevators) in the indoor parking site, and query or navigate the available parking spaces based on their requirements (e.g., the nearest distance to elevator, entrance and foothold).

## 3. RESULTS

The parking lots and garages at the Taoyuan station of Taiwan High Speed Rail (THSR) are selected as the study area. Fig. 1 shows an example to query the outdoor parking sites that the blue icons and upper part demonstrate the candidates of parking spaces and one of the parking attributes, respectively. Fig. 2 illustrates the spatial distributions of elevators in an indoor parking garage from a 2D point of view. Fig. 3(a) displays a 3D model in the indoor parking garage. Fig. 3(b) and (c) demonstrate the navigation function to guild the user to a suitable parking space according to the Dijkstra's route planning algorithm.


Fig. 1. Outdoor parking candidates and attributes

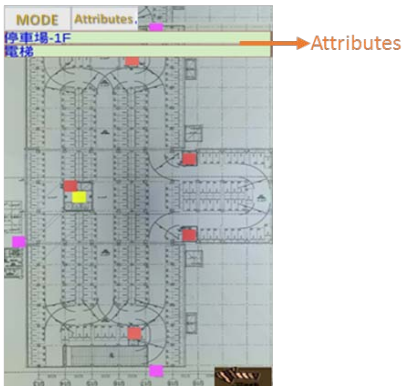
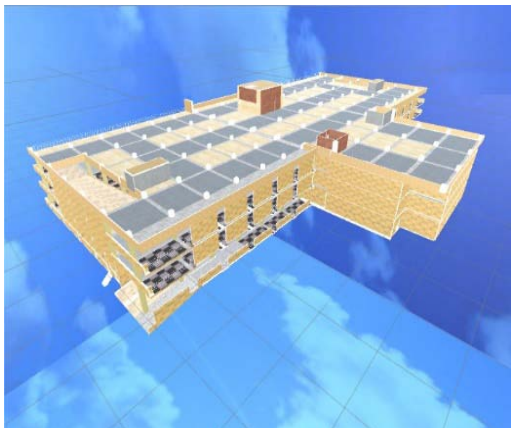



Fig. 2. 2D visualization to display the spatial distribution of elevators in the indoor parking site



(a) OGC CityGML LoD-4 model


(b) A guide direction


(c) The destination

Fig. 3. 3D visualization for searching an indoor parking space

## 4. CONCLUSION

This study integrates digital maps, 3D building models, and route planning algorithm to develop a 3D LBS-based indoor and outdoor car parking assistance system. The case study demonstrates that the developed system can provide intuitive and realistic visualization as well as the efficiency of searching available car parking spaces. It may be of

interest for future research to apply the developed system in support of intelligent car parking management. In addition, the IoT (Internet of Things) technology that can be used to sense the environmental information and task the interactive performance is a potential extension to be coupled with LBS-based system and 3D building models for extending smart city applications.

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