

## Digital upgrade for parking zone, by parking assist system

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**Abstract.** This paper seeks to create a digital transformation plan for the traditional parking that has high demand for such spaces. It covers three main areas that include the inefficiency of traditional garage module, research of usable technologies and how these applications can be used to achieve digital transformation. It is set against the backdrop of the fact that traditional parking lots have low efficiency, high labor costs and occupy more space. Therefore, the system of the harbor and warehouse that the report comes up with uses a digital assist system backed by the relevant technologies. The paper also appreciates the fact that multiple technologies can be used to construct and improve the parking system, including technologies for locating vehicles and directing them to the desired destinations. After exploring the implementation for digital guidance system, it provides the concept that can be applied to achieve digital transformation. It applies a navigation app that easily assists the drivers to know the available parking lots and park within them. In addition, the digital transformation can be used to build, monitor and help in the navigation of vehicles to the parking lot based on the idea that a robust guidance system can enhance the efficiency of these parking lots. Eventually, conclusions are demonstrated that the employment of big digital platforms is key in creating an efficient parking system for drivers and their vehicles.

**Keywords:** Inertial Navigation, AI System, Route Mapping.

### 1. Introduction

By the end of 2020, the number of motor vehicles in China will have reached 363 million, and the number of civilian vehicles in China has been on the rise since 2006 and will continue to rise in the future [1, 2]. Therefore, in the face of such a huge parking market, the difficulty of parking motor vehicles will be a new livelihood problem to be solved, and the demand for parking management systems will increase year by year. With the rapid development of the Internet and the rapid improvement of intelligent terminal technology, the traditional parking management system cannot meet the market demand. Whereas, the intelligent parking management system carries the Internet of Things technology and uses the user's intelligent terminal, whose construction cycle is short, low cost, that can quickly meet the market demand. Therefore, it has a broad development prospect. The intelligent car park management system designed in this paper can allow car owners to grasp the situation of their vehicles in real time as well as grasp the situation of nearby parking spaces on the real-time positioning map, and design the remaining parking space prediction function, which effectively solves the problem of difficult urban parking and difficult to seek.

The development of the parking assistant system has been last for nearly 20 years. At first, it was just some discussion and technical validation in the first several years for the deployment of huge parking lots such as the parking lot of railway stations [3]. When the need for energy saving has risen, the energy saving part was added to the system. Now big data tech and AI are put into use in order to run the system swiftly [4]. However, the number of deployed systems is still a small number.

Previous researchers used STM32 as the main control chip of the system so that the vehicle navigation system is composed of a controller module and a parking space selection module, and each parking space is equipped with an ultrasonic sensor to judge the condition of the vehicle, so the system can control the situation of the vehicle in the garage at any time and guide the parking of the vehicle accurately [5, 6]. The researchers also optimized and upgraded the traditional parking lot management system based on Lab View platform, router network, and mobile phone APP, which makes full use of parking lot resources and improves parking lot service quality [7, 8].

## 2. Analysis of the inefficiency of traditional parking lot

The conventional mainstream type of parking system is the plane parking lots. It mostly uses an inductive IC card scanning technique, where the system can operate by just identifying the IC card. Most of these parking lots are on the structure's ground floor and are situated in somewhat enclosed areas. However, this typical parking lot system has certain drawbacks. Its effectiveness gradually declines as science and technology advance. It is a certain up-to-date parking system based on the principle of infrared sensors to detect the number plate and the change of displayed image. This parking system can be adapted to underground, above ground, and even those parking lots in between these two kinds. This kind of parking system has a traditional style columnar type on both sides of an entrance to protect the entrance when cars reverse out from a parking space. Nevertheless, this traditional technology does not have any high sensitivity features.

Firstly, because public parking lots tend to be wide, it can be challenging for drivers to find places during rush hour and they can only blindly hunt for scattered parking spaces. Hence, it not only adds to parking lot congestion but also wastes drivers' time. The parking lot infrastructure is also not set up to assist drivers in locating their cars. If the car owner parks the car in a big, multi-sectioned parking lot and forgets the parking spot, one may have to spend some time looking for the automobile.

Secondly, the conventional parking lot method is expensive and ineffective. Traditional parking lots have a high personnel cost and a high work load. During busy hours, parking attendants may have to conduct vehicles. It is challenging for employees of conventional parking lots to gather real-time traffic flow data in a timely manner, as they lack the means to comprehend actual vehicle operation and accomplish ideal arrangement. Besides, it is susceptible to charge management flaws during times of high traffic. The entrance and exit of the parking lot will encounter traffic congestion. Therefore, traditional parking lot needs a lot of management staff, causing high running costs.

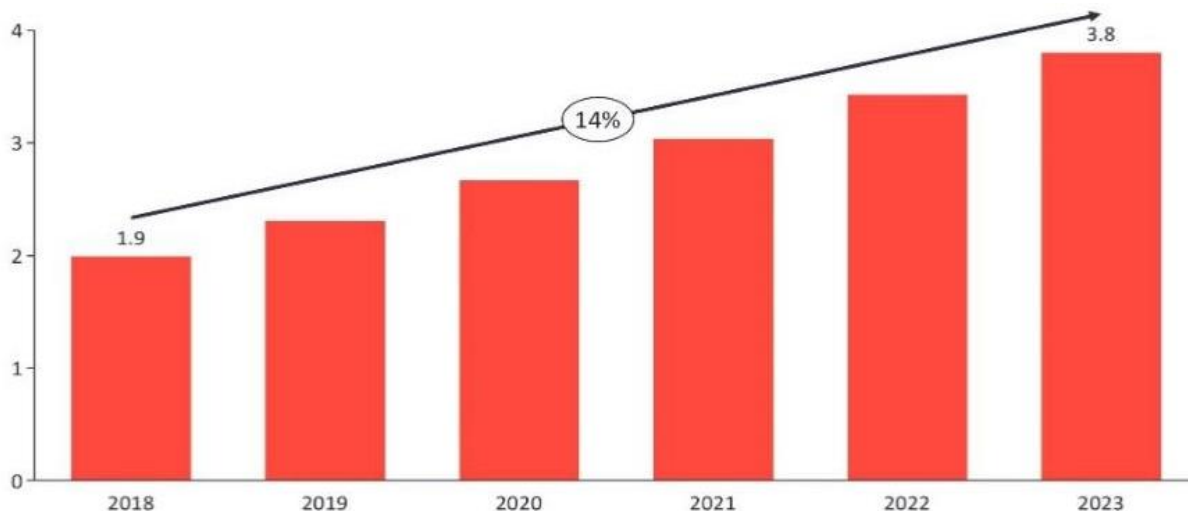
**Table 1.** Comparison of the parking spaces and their advantages

	East to Find	Easy to Use	Smart	Can Control	Waiting	Losing Fuel Consumption	Save Time
Traditional Car Park	×	×	×	×	×	×	×
Smart Car Park	×	√	√	√	√	×	√
Arduino Smart Car Park	√	√	√	√	√	√	√

Thirdly, large commercial buildings are always accompanied by sizable parking lots. For example, A typical Japanese retail mall's parking lot can accommodate 4,000 cars, and the parking lot of Tokyo Disney Resort can accommodate 20,000 vehicles. However, putting a lot of cars in particular spots in the parking lot might lead to traffic congestion problems, especially in the holiday. According to the research of [9], it is demonstrated that wasting drivers' time on parking could reduce their consumption desire. To save time, drivers may also park illegally. In many cases, illegal parking generates obstructions that further disrupt circulation within neighbourhood [3]. The issue of illegally occupied parking also affects public roads; drivers who do not have a place to park their vehicles illegally occupy public roads so they can reach their destination by car. These problematic spaces are also a waste of space. For example, many thousands of spaces in large cities such as New York, Los Angeles, and Paris are empty because drivers who rent parking spaces from government authorities

are not using them. Conventional parking lots also generate traffic congestion on the roads and streets so that people can have to move their cars more often. This leads to wasting fuel because people use their cars unnecessarily when they could reduce it considerably, if they took public transportation where they could catch public transportation options (e.g., buses, trains, and taxis.)

The shortages of these instances are considered as modifiable with application of certain guiding system. In comparing conventional garages and garage guidance systems, the development costs for garage guidance systems are lower than that of conventional garages. In conventional garages, personnel deployment is required to patrol, secure the car and divert traffic. While in a garage guidance system, there are fewer running cars and fewer persons in the garage, with minimum ventilation and smaller land area needed. Hence resulting in increased savings as compared to conventional garages [10]. Similarly, in garage guidance systems, only half of the space occupied by conventional garages is needed and the system can be built on top of a building, inside a building, overground and underground, conventional parking requires a search for vacant space which is exhaustive while in a guidance garage system, vehicles exit in a specified order [11]. These all show the advantages of parking assist system to increase parking effectiveness.



**Figure 1.** the projected global spending in the smart parking

As shown in Fig. 1, over the years, the amount of cash that people spend on smart parking has significantly increased. This growth trend is expected to hit higher figure as the people are embracing smarter parking solutions based on the inefficiencies identified which are associated with traditional parking lots. The rigidity of the traditional parking lots has made them impossible to accommodate the changes in population growth, traffic, and urbanization. The parking lots are not flexible to the changes in the population and urbanization, making it impossible to accommodate the changes in use [12]. The traditional parking lots also create a problem of safety and security. Parking lots cause traffic jams because they are crowded with vehicles, making it difficult to play and walk safely. The site where parking lot is in the most vulnerable area in the city because when there are a lot of vehicles parked, it becomes an easy target for criminals.

### 3. Analysis of usable technologies implemented in other circumstances

After the analysis of the inefficiency of traditional parking zone model, further research was taken to find out current technologies that are available to improve the system. Many technologies implemented in other aspects play a similar role to the envisioned construction of an improving parking system, which can locate vehicles and make the most efficient routes leading to the destination.

### 3.1. Working system of an automatic harbor

This system uses magnetic fields to let the unmanned vehicles know their position. The way of getting the position of the vehicles is since the strength of magnetic declines with distance growth and Faraday electromagnetic induction. So, with a group of magnets lined up at a certain distance from each other, the direction changing and strength changing of the whole magnetic field causes a current in coils. Censoring the currents can tell the terminals about the moving vectors [13]. Therefore, it is able to control all the vehicles in the port to reduce a lot of queues, such as picking up cargoes and transporting them to the rail or trucks. For now, there is an unmanned harbour located in Yang Shan, China. The deployment of the unmanned system in the harbour benefits the efficiency and safety of the harbour. With time passing, there will be more and more harbours using similar unmanned systems.

### 3.2. Parking lot energy-saving system

By using STC, LED running circuits, digital light intensity sensor circuits, and microwave sensor circuits to control the light keeping on or off by whether there is a car nearby a terminal [14]. It's somehow the basement of our project. This system can do a big part of the functions of our system including telling where the car is; and giving different feedback depending on where the cars are. Though there are not many examples that the writers can find now, the writers believe that the raising price of energy and the increasing need for environmentally friendly buildings will soon let many similar products to be deployed soon.

### 3.3. Simultaneous Localization and Mapping (SLAM)

The Hector SLAM algorithm system is composed of scanning matching and inertial sensing. As illustrated in Fig. 2, it is able to analyse the data scanned by lidar, and further process and extract the environmental features, thereby realising map construction, real-time positioning [15,16]. This system is suitable for building a consistent map for robot planning and navigation. In the design of AI Warehouse Handling Robot Based on Raspberry Pi [17], it is applied to build the map of warehouse and plan the optimal path towards the target point, which could be implemented similarly in the guidance in parking lots.

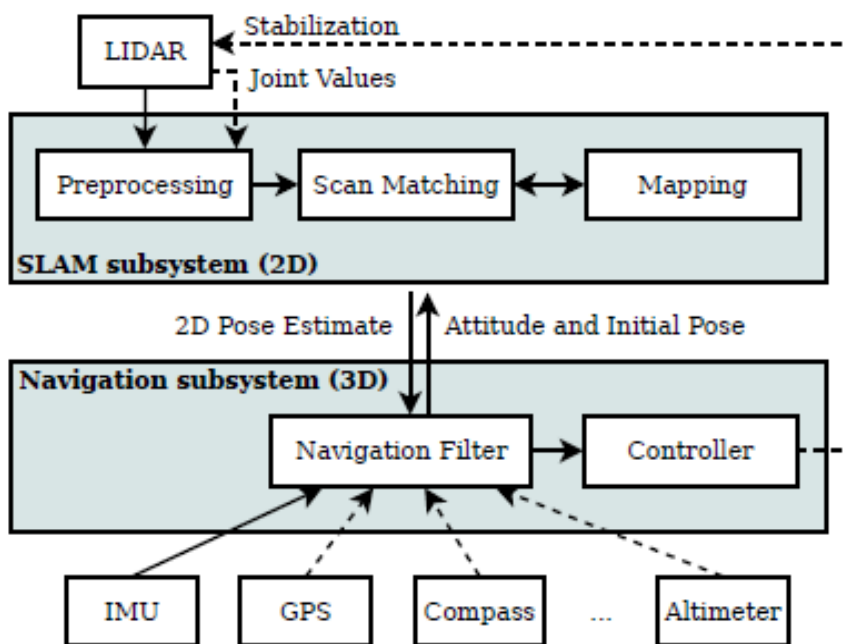


Figure 2. Overview of the mapping and navigation system (dashed lines depict optional information)

## **4. Application of possible technology into digital transformation**

After the exploration of technologies that may apply into the building of a digital guidance system of garage, further explanations of the concept and details of such digital transformation are provided.

### **4.1. Hardware**

Motion sensors and laser sensors are implemented for data collecting. Not only the laser sensor is a sensor that consists of laser, laser detector and measuring circuit, but also the linear performance of the laser is very good. It can obtain very accurate data by measuring the displacement of an object in a flat place. Moreover, the laser sensor can realize non-contact long-distance measurement and has the characteristics of high speed, large range and light resistance. In the parking lot, there is generally a relatively flat road surface, so the laser sensor can be used to measure the movement and access of vehicles in the garage. It can ensure that the terminal can quickly obtain accurate information.

Considering the need to save energy for garage operation and reduce the cost of the garage, the technology of Raspberry Pi could be applied. It is a small digital computer, which is widely used in the field of modern technology. Moreover, it is programmable to work as required. Compared with other devices, it is relatively cheaper for manufacturing automation systems. Therefore, Raspberry Pi could be chosen as the garage digital system. It can effectively complete the networking and control of sensors, software and hardware [18]. For instance, LED can be controlled and designed according to the selection and requirements of Raspberry Pi. Its module could decide which light to turn on for how long, or which light to blink. Another hardware is STM32, which can act as a terminal with the information collected by the sensors. It enables high performance to be realized with low cost and power consumption. STM32 can control the lighting system to guide the vehicle to park [19]. It meets the requirement of improving the efficiency of the traditional parking lot, while saving energy at the same time. Based on the above two points, kits from Raspberry Pi and STM32 are considered as the core of the terminal.

### **4.2. Working process**

After the garage navigation system is started, a single node can use a range finder to determine whether there is a vehicle below. When the vehicle enters the parking lot, the sensor will acquire the vehicle information and feed it back to the terminal. The computer connected to the server can play the role of a terminal. It has the information of the whole parking lot. By collecting and processing the data transmitted by the sensor, the terminal knows where there are vehicles and where there are empty parking spaces [4]. Then, the computer calculates the data and reasonably plans the route. This information will be fed back to the node and the LED light will guide the vehicle owner to find the correct parking space. This can save a lot of time for car owners to find parking spaces.

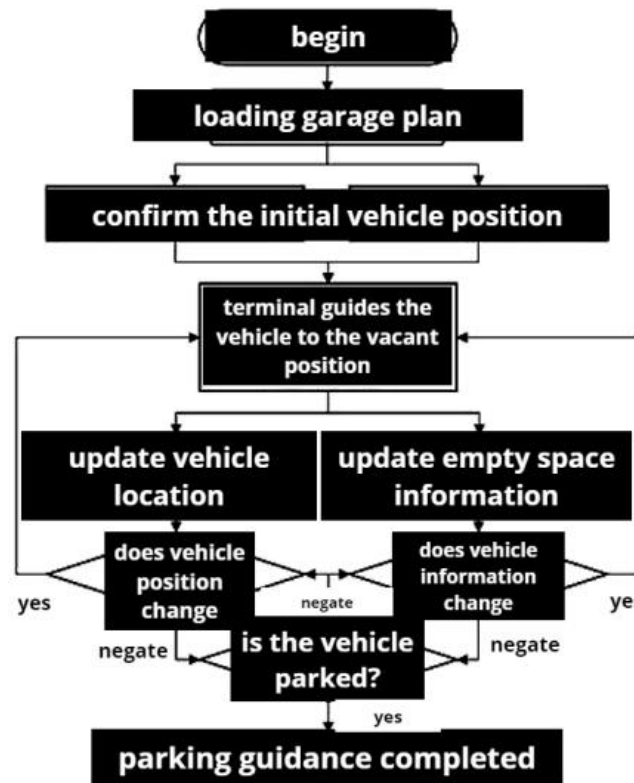


Figure 3. Operation program diagram of navigation system

### 4.3. Possible deployment methods

One possible method is to have an assistant for the monitor system do it. A further camera is hooked up alongside each monitor camera. The images sent back from the cameras are analyzed by machine learning to tell the driver whether a particular parking space is occupied or not. Through such cameras, the data of parking spaces in the car park is collected. The system collects information related to parking spaces in the car park and sends the information to the central control system through the data transmission network according to certain rules [4], where the central control system analyses and processes the information and puts it on the database server. Meanwhile, the data of each relevant processing is given through the information distribution system to each indication board and guidance board. The central control system analyses the information and puts it into the database server. For the parking space information in the database server, the system provides data query interface. The system enables parkers to park conveniently and quickly and to monitor parking spaces, making parking space management more standardized and orderly and improving the utilization rate of parking spaces: parking space detection in the car park uses ultrasonic detection technology to reliably detect the occupancy or vacancy status of each parking space. There is another cheaper way to do it, e.g., buying some huge screens and have them display the information sent back from the nearby monitors [20]. With the vehicle sensing function, the system automatically counts and calculates the vehicles entering and leaving the car park [21]. Based on the results, the system transmits the space information to the space display in real time and automatically displays the information about the remaining empty spaces in the car park on the space display and the software interface.

The information release screen can be divided into three types, i.e., entrance information screen, stratified information screen and partition information screen. The entrance information screen is used to display the overall information of the car park (how many parking spaces there are in this car park, how many parking spaces are left, etc.). The stratified information screen is used to display the information of the remaining parking spaces on this and other floors. The zoning information screen is used to display the information of empty parking spaces in each zone and to guide the driving direction. After the vehicle has entered, the parking space guidance system automatically detects the status of occupied or vacant parking spaces and sends the detected changes in parking space

conditions by the parking space guidance controller to the parking space guidance display in real time, which guides the vehicle to the best parking position and directs the vehicle owner to the empty parking space allocated by the system quickly.

## 5. Recommendations, Prospects & Limitations

As mentioned before the system is made up of a number of terminals and a server acted as a hive mind, the terminals are recommended to be deployed under the ceiling by adding an extra compartment which lies a few centimeters under the original ceiling in order to provide a surface for deployment and hide pipes hanged under the ceiling. Deploying terminals high means cutting costs for each terminal because the chance of being crushed by cars is nearly zero which means there's no need for providing every terminal with a durable shell to protect them. In addition, being deployed under the ceiling means the parking lot has no need to rebuild its floor which both cuts the cost and time for construction. When all the terminals are linked to the server, the system starts working, guiding the drivers to their nearest parking space. Moreover, the system may develop better with the cooperation with some navigation apps, such as Google Map. By collecting the parking conditions of nearby garages, the navigation app could match a more suitable parking area for drivers, which could be seen as one competitive advantage for those apps.

However, this system has some limitations. To be specific, its cost could be wasteful for smaller-size garages. Drivers don't need to circle around to find an empty parking space, as the parking situation would be obvious in a small area. On the other side, such technologies are available for those big navigation apps. They can develop the system by themselves and improve it as their own unique selling point (USP) without sharing information with other platforms. In this case, cooperation with big digital platforms would be difficult.

## 6. Conclusions

Considering the low efficiency, high labor cost and more space requirement of traditional parking lots, the concept of developing a parking assist system is proposed. In summary, this paper investigates possible digital development method based on working system of the system of the harbour and warehouse. Specifically, the opportunity of its digital transformation lies in building monitor and navigation system to assist drivers by machine learning calculation. By developing a suitable guidance system, there may be significant impacts, particularly in peak traffic period. According to the analysis, with better guidance system, the efficiency of parking may increase and cause less traffic jam. Moreover, with the deploying method mentioned before the cost shall not be too high to be accepted. Besides, the running cost in long run would contribute to covering the system installation cost. Nevertheless, the system requires the garage size of the target users. In the future, this digital assist system has the potential to be applied as a competitive advantage if cooperating with navigation apps. Overall, these results offer a guideline for the digital transformation of traditional parking zones.

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