Intelligent and efficient parking solutions

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Abstract. The high demand for mobility around the world means a constant increase in road traffic and a deterioration in parking spaces. The paper focuses on the issue of automatic parking systems in the Czech Republic. It defines automatic parking, functionality and also informs about the possibility of using BIM. It describes in detail the systems located in the city of Ostrava.

1. Introduction

The deficit of parking spaces is large all over the world. Newly built parking spaces in housing estates and in the central parts of cities are, of course, welcome by motorists, but given the development of motoring over the last 17 years, the construction of 100-200 new parking spaces per year is not enough. Of course, the construction of new parking spaces is becoming more and more investment-intensive. In addition to lost time and overpayments, most people say they are stressed when looking for a parking space, almost half missed an appointment, one third left or avoided it due to parking problems, and a quarter say they are furious due to parking problems. roads [1]. In the Czech Republic, the current parking situation, especially in residential areas, is very chaotic. This problem stems from the ineffectiveness of the responsible institutions, which maintain the current situation or solve it only with minor building modifications, while increasing a few new parking spaces. Due to the fact that there are relatively few projects for the development of automatic parking systems or online parking zones in the Czech Republic, people are forced to look for a solution themselves and thus end up parking on lawns or playgrounds or sidewalks. In areas with collective housing (housing estates) there is a lack of parking spaces for parking vehicles, in areas with the aim of transport there is a lack of mainly unpaid parking spaces for parking vehicles during working hours. In housing estates, the solution is parking houses, where the capacity of parking houses should relieve the excess demand for parking over the possibilities of street space. Another possibility is to regenerate housing estates, which often include an increase in the number of parking spaces or changes in the organization of transport. As there is a lack of parking spaces and space, it is necessary to find a solution to this problem. One possible solution is to design automatic parking systems, where these systems offer larger capacities, are more environmentally friendly and faster. Robotic parking systems help us create space for the development of a greener city while reducing pollution, traffic jams and the carbon footprint.

There are things that machines do better than humans. From vacuuming the floor (Roomba) to welding the vehicle chassis (every car manufacturer), machines dominate repetitive, quantifiable tasks. When you divide parking into its individual parts, you will find that it has a lot in common with some of these other automated tasks [2]. There are two completely different approaches to automatic parking: The first is to modify the systems in the vehicle so that it can be parked in a conventional parking space. The car is intelligent, but the parking spaces are not. Many car manufacturers have done this and there are dozens of brands and models with some form of "parking assistant". The second approach is the opposite of the
first: Adjust the parking spaces and welcome all the cars. This approach relies on smart parking spaces, not smart cars.

The Czech Republic has several manufacturers of automated parking systems, which produce systems not only for the domestic market, but also abroad. Most of these manufacturers are based in Prague. There is also a manufacturer of these systems in the city of Ostrava, which has two automated parking facilities built in the city.

2. History of automatic parking systems

The first parking system for 824 cars is located in the shopping complex in Sarojini Nagar (India), which was put into operation in early 2012. The average volume of services is 178 cars / h, the system is capable of holding 104 cars and each emits 74 units. Parking is on average 80% full and during rush hour a line of incoming cars is built far behind the car park [3]. In Canada, the construction of a second fully automated parking system for modular vehicles is planned at 57 parking spaces in the country, which, according to the representation of the Canadian construction company Windmill Development Group, will save up to 65% of the parking space. This company is one of the first to introduce electronic communications for car management inside a parking system. Today, China is the undisputed leader in parking systems. A city program to increase parking spaces is being implemented in Xiamen, and the first complex of mechanized tower-type parking systems for 285 storage spaces has been officially put into operation near the Sheraton Xiamen Hotel. At the loading level, vehicles are transferred to mechanized equipment that moves them, without any involvement of people in the storage areas, the time required to complete this process does not exceed 2 minutes. In addition, the construction of 16 other similar facilities with a total capacity of 6,500 cities located in different parts of the city where the entrepreneurial activity of the population is increased is planned. At the beginning of 2015, the data in the Guinness Book of Records were updated on the largest fully automated parking system in the world. This system is Tower 2, located in Wolfsburg and is one of the tourist attractions of the city. Each tower is a 25-storey, fully automated building, 48 meters high, capable of holding up to 400 cars simultaneously. Cars park and leave the building with two special elevators. In 2014, the automatic towers were included in the Guinness Book of Records as "the fastest automatic parking system in the world" due to the elevator speed - 2 m per second. The new car climbs from the entrance to the highest parking space in 1 minute and 44 seconds. The experience of foreign scientists, designers and technicians is undoubtedly useful in planning parking spaces, designing and arranging parking systems [4]. The largest automated parking system is installed in Al Jahra Kuwait and was supplied by Robotic Parking System Inc.

3. Automated parking and BIM

3.1. What is automatic parking?

Automated parking is a computer-controlled system of equipment that parks and hauls vehicles without human intervention. Automatic parking reduces the floor area and cubic volume of the garage, increasing the sales or rentable square footage of the building while protecting patrons and vehicles, as no one ever enters the actual storage safe and the vehicle's engines are switched off, so there is no risk of damage to the vehicle. The automated parking garage does not need aisles, lifts and stairs, lighting, ventilation and many other components that are located in a typical parking garage [5].

3.2. How does it work?

The parking process is simple, safe and convenient for the driver. The driver enters the entrance cab, switches off the engine and leaves. The sensors measure the height, length and width of the vehicle and confirm that no person is left in the entrance cab. The vehicle is moved to the parking space specified by the computer using the parking device. During the entire parking and towing process, the vehicle is never touched and the vehicle's engine is switched off [5].
3.3. **BIM solution for parking systems**

Building Information Modeling is the name of a planning method that displays the entire project life cycle in a model and provides support to the construction industry in improving communication between planning participants. The BIM building model provides all relevant information digitally and up-to-date, enabling goals to be achieved with higher speed and accuracy. The demand of the construction industry for an innovative method of planning, which can be used to implement projects faster and more accurately, is growing. With BIM models, individual companies expand their services for designers and architects, which means the incorporation of a digital 3D model of a building and an important step towards the future and digitization. The model file should provide the designer with a parametric model containing all the possibilities of variations, e.g. the length and width of the parking space, the profile of the vehicle to identify possible collisions with the building when parking. The designer should see the technical information of the parking systems at a glance. The manufacturers of these systems have started to use BIM, and the customer can download the model directly from the website and try to configure it according to their place of design.

![Fig. 1. BIM - model [6].](image)

3.4. **Mobile application**

U-tron is proud to be the first automated parking provider to offer a mobile application to control the entire parking and loading process. U-tron shares real-time parking status and load time estimates. With this application, users can call their vehicle while they are still at home / in the office, obtain an estimate of the loading time and schedule the pick-up time accordingly. To further reduce latency, U-tron allows users to schedule loading times in advance. Users choose their preferred pick-up time and the automatic parking system delivers their car as needed. With the U-tron application, users can also pay for parking and further save time and effort [7].

4. **RING automated parking system (Ostrava - Svinov)**

The RING automated parking system was one of the first such projects in the Czech Republic. It is a sophisticated system of rings that turn and store cars in spiral sequences, taking into consideration the load distribution of the building. This system has been operated since 2006; however, with regards to the long parking time and high energy consumption, it is no longer being built anywhere. The currently designed systems are much smarter and more sophisticated. The building is used to automatically park passenger cars and has a capacity of 105 spots. The average time for parking is 219s and 218s for leaving. A part of the building is leased for commercial purposes. The hall is made of a steel structure and has seven above-ground floors. The parking is done by a fully automated system. It has a cylindrical body made of floors set in independently turning rings, to which cars are parked using lifts. The building foundation is made of reinforced concrete bands mutually connected to the foundation grate. Due to the high groundwater levels, the internal tub is designed to withstand hydrostatic pressure. The load-bearing structure of the building is assembled and made of steel. The cladding is ventilated in the SATJAM system. The first above-ground floor is completed by the external cement-lime plaster with ceramic skirting board. The ironmongery structures are made of zinc-coated metal sheet. Above the first above-
ground floor there is a reinforced concrete ceiling. In the first above-ground floor, the outer wall around the perimeter is made using the Porotherm system. The roof is flat with a bituminous welded layer. The wiring is optical as well as powered, with an automatic circuit-breaker. The floor is lined with ceramic tiles including a plinth. The interior door is full and smooth. Most of the first floor is made of glass. The entry from the street is made of an aluminum frame, the gates are roller gates. Cold and hot water distributions use plastic pipes. Water is heated in a boiler. The interior staircase is spiral and made of a steel structure.

![Fig. 2. APS Ostrava - Svinov (Exterior 1).](image)

5. **MULTITOWER automated parking system (Ostrava - Poruba)**

Technical This parking house with an automated parking system entered into operation in 2012. Its floor plan dimensions are 19 m x 17.6 m and in addition to the operation of a VSB TU lab, it allows the storage of 37 passenger cars. The average time for parking is 193s and 168s for leaving. The technology type of the building belongs to the KOMA - TOWER series, which means that the system is diametrically different from the stacking system in Svinov. It in fact implements a new unique system of car stacking operated by a highly sophisticated control system. In addition to coordinating the partial handling systems, it also controls the concurrence of multiple parking sequences in order to speed up its operation.

![Fig. 3. APS Ostrava - Svinov (Interior).](image)
The automated conveyor center combines theory and practice in a single building - the research and development of the security software and actual verification of the automated computer operated multi-story high-capacity parking facility. On the ground level of the building, the area has been extended for the teaching purposes of the Faculty of Electrotechnology and Informatics of VŠB TU in the form of a new lab used to teach students in doctoral study programs and employees of VŠB TUO about the research and optimization of technologies. It is a glass cube, with a flat roof, above which the lift engine room is located. The construction system of the above-ground part of the building is based on the construction of an automated stacking system, which at the same time forms the load-bearing structure of the whole automated conveyor center. The stacking system is designed as a steel structure, on which the fully automated system for car storage is installed. Both parts - the steel load-bearing structure and the automated storage system of parked vehicles - are closely connected to each other in terms of construction.

The facility has four floors. The ground floor is used for parking / leaving (entry/exit area with a turntable); it contains 4 parking boxes and one transfer skip. The other three floors are identical and each contain 11 parking boxes and 1 transfer skip. The floors are connected by a lift that is equipped with two-pallet equipment.
6. Conclusion

At present, we are increasingly encountering the issue of parking in residential areas and central parts of cities. Creating an intelligent and efficient parking solution is what improves the quality of our lives. Whether in cities or in the countryside, building land is scarce and, especially in recent years, has become a sought-after and expensive resource. The high demand for mobility around the world means a constant increase in road traffic and a deterioration in parking spaces. Therefore, it is necessary to use valuable building land in a way that improves the quality of life of people through intelligent and efficient parking systems.

The article analyzes automatic parking systems. The history, description of the operation of the systems and other knowledge such as BIM and connection with mobile applications were specified. Furthermore, the article contains detailed descriptions of automatic parking systems located in the city of Ostrava. The systems are popular in all parts of the world and more and more companies are improving their patents so that the customer is satisfied in all areas, such as placement directly in housing estates, near central parts of cities, etc. This information is essential both for the professional public, which is interested in this issue, and for ordinary citizens, due to the range of advantages over conventional parking. There is a growing interest in this issue and the construction of these systems continues. In conclusion, it should also be noted that the problem of lack of parking spaces is being addressed in every single country, and therefore it is necessary to participate in deepening the issue and disseminating information on the most efficient systems further and further.

Acknowledgment

This work was supported from the funds of the Students Grant Competition of the VSB – Technical University of Ostrava. Project registration number is SP2021/102.

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