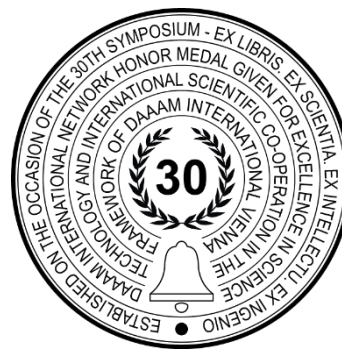


# ONE APPROACH TO THE DETECTION OF ILLEGAL OCCUPATION OF PARKING SPACES RESERVED FOR PERSONS WITH DISABILITIES

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## Abstract

The constant increase in the number of inhabitants in cities affecting all human activities in cities. Finding a free parking space is a growing problem. This problem is especially pronounced in people with disabilities. To make it easier for people with disabilities to perform various activities in cities, there are parking spaces that are intended and reserved for them. Most often, parking spaces reserved for people with disabilities are occupied by unscrupulous drivers. This paper presents one approach to the detection of illegal occupation of parking spaces reserved for persons with disabilities based on the use of license plate recognition cameras. By recognizing the license plate, it is possible to automatically check whether the vehicle has a parking permit for a parking space reserved for people with disabilities.

**Keywords:** people with disabilities; parking spaces; illegal occupation; license plate recognition;

## 1. Introduction

The constant increase in the number of inhabitants in cities is increasingly affecting all human activities in cities [1]–[3]. Moving cars and finding a free parking space is a growing problem [4]–[7]. This problem is especially pronounced for people with disabilities. In order to make it easier for people with disabilities to perform various activities in cities, there are parking spaces that are reserved for people with disabilities (parking spaces wide enough to allow wheelchair access to the vehicle, set up in locations that facilitate access for people with disabilities to various facilities, etc.). People with disabilities can park in places reserved for them, if they have permits, most often in the form of a sticker affixed to the vehicle or special license plates. The disadvantage of parking spaces reserved for vehicles of persons with disabilities is that their number is limited and distributed in a large number of locations that are dislocated.

An additional problem is unscrupulous drivers who often take these parking spaces even though they are not entitled to it [8]–[11]. Most often, parking spaces are occupied by regular drivers who park for a short time in a parking space intended for people with disabilities to perform some activity. Although such drivers park for a short time, they are a problem because in that case, people with disabilities have to wait for the parking space to be vacated, which can create a traffic jam and can affect safety. Another type of misuse of parking spaces for people with disabilities is drivers with fake licenses. Such drivers illegally occupy parking spaces for a long period, which makes it impossible for people with disabilities to use parking spaces that are reserved for them.

There are several ways to check if a parking space for people with disabilities is illegally occupied. One way to check is to tour the parking spaces reserved for people with disabilities by the person in charge of supervision. Upon arrival at the parking lot for people with disabilities, the supervisor checks whether the parked vehicle has a parking permit (sticker). If the vehicle does not have permission, a certain procedure is initiated to punish the driver (vehicle owner) and remove the illegally parked vehicle. This way of checking illegal parking in parking spaces reserved for people with disabilities is very inefficient because such parking spaces are located in a large number of locations in cities, which slows down the verification process. Various systems make it possible to automate the detection of illegal parking in places reserved for people with disabilities. One solution is based on the use of video surveillance cameras. The video surveillance camera is mounted to cover the area of parking lots reserved for people with disabilities and is enabled to do the checking whether the vehicles are illegally parked.

Using this solution there are two methods to determine if the owner of the parked vehicle is a handicapped person:

1. to check if there is a pointed out sticker on the vehicle that represents a parking permit for using parking space reserved for people with disabilities [12].
2. to check if the vehicle registration number is in the database of persons with a parking permit for parking on space reserved for people with disabilities [13], [14].

The advantage of these methods is that it can be quickly detected whether the vehicle is parked legally or illegally. In case of illegal parking, a penalty can be issued to the driver (vehicle owner) based on the vehicle registration number and the procedure for removing the illegally parked vehicle can be initiated. The disadvantage of such systems is that although they can check a larger number of parking spaces than manually by parking enforcement person, there is still a limit in the speed of checking the parking spaces (movement of vehicles from one location to another). To speed up the process of checking parking spaces, drones with mounted cameras can be used [15]–[18]. Although drones can visit a large number of locations in a short time, their biggest drawback is the autonomy of operation.

There are solutions for monitoring parking spaces reserved for people with disabilities based on RFID technology [14], [19]–[21]. Most often, an RFID reader is placed to cover parking lots, which reads the RFID tags that are placed on the vehicle (often places on the windshield of the vehicle). When a parked vehicle is detected, and the tag is successfully read, it is confirmed that the vehicle has a parking permit. If the tag is unsuccessfully read, the parked vehicle does not have a parking permit on parking space reserved for persons with disabilities, and the procedure for issuing a penalty to the driver of the vehicle (vehicle owner) and vehicle removal is initiated. The advantage of this method is the fast detection of illegally parked vehicles, which can speed up the initiation of procedures to penalize the driver or owner of the vehicle as well as the removal of an illegally parked vehicle. The disadvantage of this method is that in addition to an RFID reader, it is necessary to have additional sensors to detect the presence of a parked vehicle (optical sensors, inductive loops, ultrasonic sensors, etc.). One of the solutions for improvement of the monitoring parking spaces reserved for people with disabilities could be an introduction of the LEAN concept [22], [23] in organizing and positioning parking spaces for people with disabilities.

This paper presents a solution for the detection of illegal occupation of parking spaces reserved for persons with disabilities based on the use of license plate recognition cameras. The camera is placed so that covers several parking spaces reserved for people with disabilities. This is made possible by the use of Internet of Things cameras, which are becoming increasingly popular in parking lots control systems [24], [25]. The Internet of Things (IoT) refers to the large numbers of physical devices around the world that are now connected to the internet to collect and share data [26]–[32]. By processing the image from the camera, it is possible to detect which parking space intended for people with disabilities is occupied and by recognizing the license plate, it is possible to automatically check whether the vehicle has a parking permit for a parking space reserved for people with disabilities.

## 2. Conceptual solution

The idea is to mount an LPR camera to cover the area with one or more parking lots that are reserved for people with disabilities so that every license plate of vehicles that are parked in reserved parking spaces can be recognized. Figure 1. shows the concept of a solution for the detection of illegal occupation of parking spaces that are reserved for people with disabilities, which is based on license plate recognition (LPR). When the vehicle is parked on the reserved parking lot, the camera successfully detects the license plate and sends the information to the cloud server. Server checks if the license plate number is in the database that stores license plates of car owners with disabilities. If the license plate is in the database it means that the vehicle owner can use the reserved parking lot. Otherwise, if the license plate number is not in the database, parking enforcement service is alarmed and the procedure for issuing a penalty to the driver of the vehicle (vehicle owner) and vehicle removal is initiated.

For this solution, it is necessary that license plate numbers of all people with disabilities that are vehicle owners are stored in one database that is located on the cloud server.

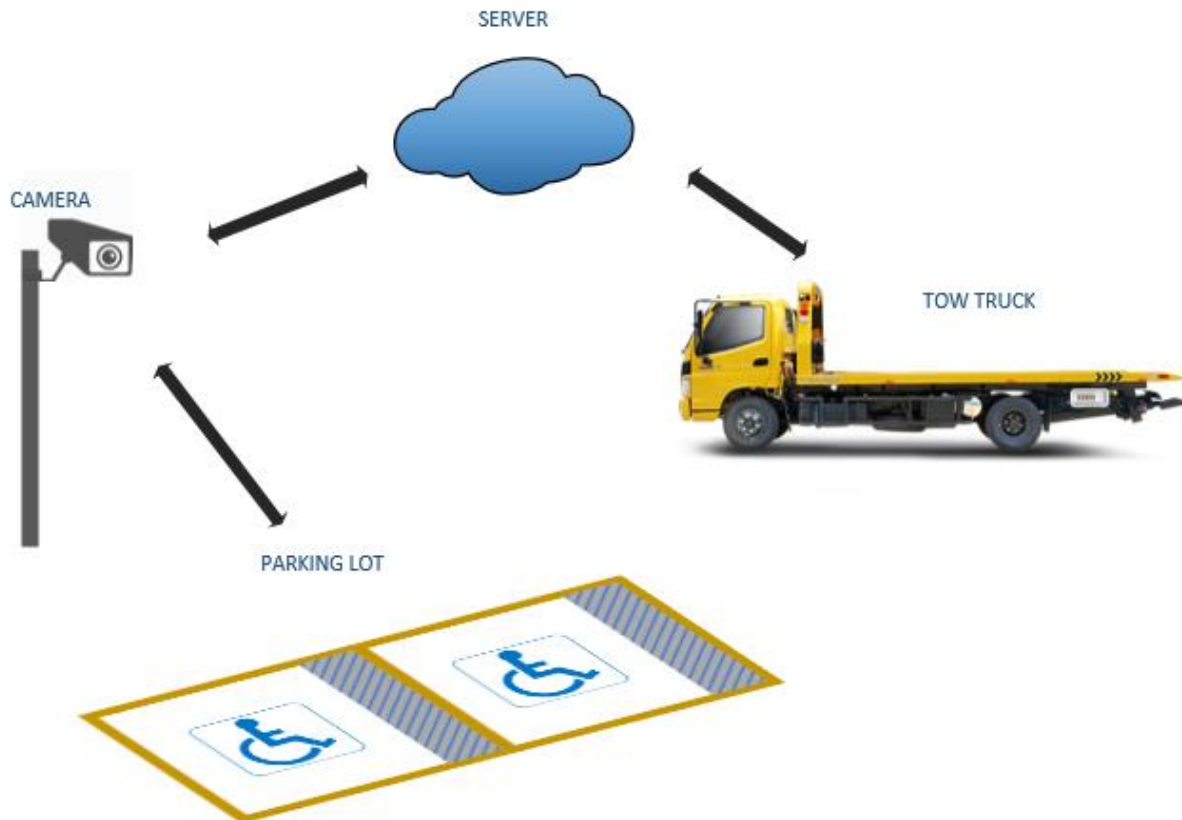


Fig. 1. The suggested solution that includes license plate recognition

### 3. Experimental setup

For testing purposes, an experimental setup was created to prove the feasibility of the system. The experimental system has consisted of a smart IPC camera, inductive loops for vehicle detection, an industrial computer as well as the other components necessary for the proper system functioning. The camera model is DS-2CD4A26FWD-IZS/P by Hikvision. The ANPR series ultra-low light smart cameras can capture vehicles and recognize their plate number, of various countries and regions, not only in regular but also in a dim light environment. This camera offers high resolution, 2MP, 120bB WDR, Auto-iris, PoE, Defog, EIS and 3D DNR. The camera can automatically recognize the vehicle license plate number in four different lanes. Since the system is designed to monitor two parking spots, for people with disabilities, the camera is set up like to monitors two traffic lanes with the possibility to detect license plates. The camera is placed according to the manufacturer's recommendations to get the best results. The camera is located on the pole, where the distance between the camera and the parking spots is 7 meters and it is at a height of 2.5 meters. The recognition rate of the camera is 96% or higher, which was also proven in the experiment. The proposed camera setup used in the experiment is shown in figure 2.

When the vehicle is parked in a parking space, the license plate is automatically recognized and sent via Ethernet communication to an industrial computer. The model of the industrial computer is WAFER-AL-N1-R10. This IPC has Intel Pentium Processor N4200, 128GB SSD, four USB 2.0 connectors, two RS-232 connectors, one HDMI and VGA connector, and one 8-bit digital I/O. Inductive loops are connected to digital inputs of IPC and thus obtaining information on the occupancy of parking spots. On IPC, a C# application is running which controls access to a parking space for people with disabilities. When the vehicles are parked in the parking spots and the license plates are recognized, the data obtained from the camera is sent to the IPC. If in addition to recognizing the license plates there is a signal from inductive loops, vehicles are present in the parking spots and it is necessary to check whether they have permission to park on the spots for people with disabilities. All plate numbers of vehicles owned by the people with disabilities are in the database located on the server. The plate number obtained from the camera is checked to see if it exists in the database. If license plate numbers exist in the database, then the vehicles have permission to park in the parking spot for people with disabilities. But if it does not exist in the database, then the vehicle does not have parking permission and in that case, the appropriate service is notified which is authorized to give a fine to the irresponsible driver. Figure 3 shows two parking spots that were used to test the entire system.



Fig. 2. Smart IPC camera



Fig. 3. Parking spots

Parking spots that are used in the experimental setup are located in the public place in the city of Novi Sad, Serbia with street lighting during nights.

#### 4. Discussion

The experimental setup was tested in all weather conditions (without and with precipitation (rain and snow)) and for 24 hours. The camera manufacturer guarantees that the recognition accuracy ranges from 90-95%. During the trial period, which lasted from November 1, 2019. to May 5, 2020., testing was performed on 4500 license plate recognition. In nominal conditions (daylight and without precipitation), the percentage of success in recognizing license plates with the letters of the English alphabet and numbers were 98%. At night, with street lighting, the percentage of successful license plate recognition was 94%, while without street lighting, the percentage was under 50%. In conditions of light precipitation and daylight, the successful recognition percentage was 92%. In conditions of heavy rainfall and daylight, the successful recognition percentage was 82%. In the conditions of lower precipitation and night with street lighting, the successful recognition percentage was 87%. In conditions of heavy rainfall and night with street lighting, the successful recognition percentage was 75%. The recognition of the following letters on the license plates proved to be an additional problem: Š, Ž, Č, and Ć. The percentage of success in recognizing license plates containing these letters in nominal conditions (daylight) was 93%. The achieved results of the license plate are shown in Table 1.

Period of the Day	Weather Conditions		
	Without Precipitation	Light Precipitation	Heavy Rain
Daylight	98%	92%	82%
Night	with street light	94%	87%
	without street light	<50%	<50%

Table 1. Results of license plates recognition accuracy in all weather conditions and periods of the day

Results of recognition show that it is necessary to make additional improvements in the process of license plate recognition. It is envisaged that the new version of the license plate recognition software will be tested for the same duration from November 1, 2020. to May 5, 2021.

#### 5. Conclusion

People with disabilities who drive vehicles need more spaces in parking lots and that is the reason why they have reserved parking spaces that meet their needs. With the population rising in cities there is a growing problem with finding free parking space, this dictates the rising of illegal parking on parking spaces reserved for people with disabilities. To maintain the normal functioning of people with a handicap in cities there is a need for better control of illegal use of reserved parking spaces.

In this paper is presented one concept of smart control of legal and illegal usage of parking lots that are reserved for people with disabilities. It is a simple solution that is based on using a cloud server. The main advantage of this system is the centralised architecture that uses one cloud server which contains a database with license plates of all vehicle owners with disabilities that have permission to use reserved parking lots. After determining illegal use of the parking lot there is an automatic alarming of parking enforcement to remove the vehicle from the parking lot and an automatic penalty procedure is initiated.

The disadvantage of this system is that there must be the centralised database with the license plate number of all vehicle owners with disabilities. Also, the use of an LPR camera for maximum cover up to 4 parking lots. Through the experimental part of the paper it is proven that this concept is usable and has high accuracy in determining if the vehicle belongs to a person with disabilities. One more advantage of this approach is the easy implementation of future developments. Directions for future improvements:

1. Possible detection of free spaces and sharing of location through cloud server to mobile apps that could be used by people with disabilities.
2. Using mobile apps by people with disabilities so that they can enter their plate number and some evidence of their disabilities through application that sends information to the server database.
3. One of the directions of future development of this system will be an attempt to introduce the LEAN concept in organizing and positioning parking spaces for people with disabilities.
4. Improving the process of recognizing vehicle license plates in conditions of precipitation and low light.

The proposed approach has proven to be acceptable for people with disabilities and with the proposed improvements can be a quality solution in controlling the occupancy of parking spaces for people with disabilities.

## 6. Acknowledgments

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