Automatic solution for using public and private parking for vehicles

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Abstract— **Many paths lead to the rapid development of telecommunications. One aspect of this development is the use of artificial intelligence (AI). By using several technologies, such as license plate recognition (LPR), automatic license plate recognition (ANPR) technology, highly efficient optical character recognition (OCR) tesseract, and mask OCR algorithms, a modern parking lot can be created without congestion, and the space for the car is provided in advance to the user's satisfaction. In this article, we describe the application of artificial intelligence included in the mentioned technologies. Intelligent safety solutions enable a more advanced and safer world. AI algorithms enable the system to have a predictive capability to prevent undesirable situations. The basic idea of this work is to reduce the nervousness of the driver, to avoid uncertainties regarding the parking lot, and to find a good technical solution that includes the use of artificial intelligence.**

Keywords Artificial intelligence, LPR, ANPR, OCR tesseract, mask OCR algorithms

I. INTRODUCTION

Video content analysis is a possibility of automatic analysis to recognize and prevent certain events. The analysis can be used in many areas, e.g. healthcare, industry, smart cities, home industry, and automation [1].. In recent years, much attention has been paid to automation and artificial intelligence at the level of the camera itself. The analysis algorithms of artificial intelligence allow the system to make predictions to avoid undesirable situations, whether it is the protection of a parking lot or public safety. There is the possibility of correction by the user, and in most cases, corrections are made for integration into existing systems. The algorithms work based on a physical characteristic, such as a parameter of speed, direction of movement, or storage, as well as other parameters [2]. For example, cameras can now recognize faces and license plates and react to changes in the environment. The main focus is on integration with other security systems and data processing by the camera itself.

The demand for intelligent parking services is growing rapidly. This type of service enables automatic management of parking lots through accurate monitoring and the provision of this information to customers and facility management, and this information needs to be public-facing [3]. Some existing solutions focus on applications for parking lots, which are reflected in the execution of analytical processes by the camera itself. Today's cameras that use the Internet Protocol have powerful processors that are required for AI to work. In addition to the camera already having AI, it is also necessary for the recorder to support AI camera functions such as people counters, heat maps, kinetic maps, cross lines, intrusion detection, and similar analytical functions to utilize these capabilities [4]. The video management software (VMS) can be integrated at a later stage depending on the requirements of the project. Integrated VMS is used in a large system where the project provides for one or more types of cameras with various analytical functions, while the software is characteristic of the expansion of existing systems with cameras and other systems that have some kind of analytical function.

In this paper, we propose a hybrid approach for a smart parking system using a combination of inductive ring sensors, RFID cards, and LPR cameras. LPR cameras have advanced traffic sensors that operate in real-time and their function must be realized with very high precision [5]. Existing solutions with normal cameras cannot achieve this. Our goal is to implement a smart valet service that enables regular valet parking for the hotel's customers. The remaining parking lot would serve as a public garage. Entry to the hotel parking lot would be made possible with the help of RFID cards designed to control passage through the facility. RFID can provide a much greater amount of information than barcodes used on conventional tags. The RFID card records data about the customer's hotel room and length of stay and assigns them rights to access the parking lot. RFID can help to locate items efficiently and precisely at short distances. RFID speeds up the flow of information by effortlessly transmitting information to the hotel information system via radio waves without the need to manually enter the data between each step. We used inductive ring sensors as proximity sensors to detect when the car enters the circular hole in the center. The customer exits the hotel garage using an induction loop. We installed the induction loop module next to the payment device. Inductive ring sensors provide us with additional information, such as the number of vehicles per time unit, the type of vehicles... This solution is based on accuracy, reliability, and weather resistance.

The rest of the article is structured as follows. In the first chapter, we review related works that show us the characteristics and specificities of such a solution. The second

chapter describes the devices used in our solution and the function of the whole system. Then we explain the algorithms used to make decisions in the parking lot. Finally, we present the result of the project and conclude this article.

II. RELATED WORKS

In this chapter, we give an overview of the existing solutions for parking charges, their features, advantages, and disadvantages, and describe in particular the sensor system and the other parts of the equipment.

The Fleximodo IoT parking sensor ensures that only authorized vehicles can drive into the parking lot. This sensor enables precise identification of the vehicle using a secure authentication protocol. The IoT parking sensor works with an IoT parking card that is placed in the vehicle. Three independent measurement parameters eliminate the critical aspect of the Fleximodo system known as occupancy monitoring. They used a sophisticated decision mechanism [6]. This system only allows authorized vehicles to access the parking fees (this is not sufficient for our needs).

Makosmart smart parking system using IoT solution device must detect the presence of cars in a particular parking space and ensure that the parking space is recognized as occupied if there is only one car there [7]. The technology enables the smart parking system using the Internet of Things (IoT) to offer search, navigation, and reservation of parking spaces. Makosmart uses computer vision, proximity detection, and distance detection to develop the smart parking sensor. The Lora technology sensors detect the absence, arrival, presence and departure of vehicles. Makosmart uses the Person identification number (PIN) parking protocol cloud service and shares real-time parking data as well as the LoRaWAN protocol, which supports two-way communication and allows parking lot managers to query the sensors. This solution is more suitable for smart city services operated by city and county governments.

NEC's automatic vehicle location system is designed to collect real-time information about the vehicles traveling on the route. Based on this collected data, the information is passed on to passengers via displays at stops, in vehicles and via websites and mobile applications. NEC's AVLS solution provides a true multi-tasking and multi-user environment with the ability to monitor, control, and manage operations with real-time data [8]. The system is based on a combination of global position system (GPS), general packet radio service (GPRS), geographical information systems (GIS) and web technologies and utilizes its IoT-based core architecture. As the name suggests, the passenger information system focuses primarily on providing information to passengers on the busses. The information for passengers is shared via displays at bus stops showing journey times, routes, etc., as well as timetable information systems and estimated time of arrival via mobile applications and websites. NEC's system requires more resources, has higher consumption, and is more suitable for public services.

Coma has developed the CM-2101-L, a surface-mounted geomagnetic parking sensor with radar detection based on the standard LoRaWAN protocol. A geomagnetic detection element is a sensor that detects changes in the earth's magnetism and its peripheral magnetic environment based on magnetic flux density and uses this property to detect surrounding magnetic bodies [9]. LoRaWAN protocol for detecting the status of a parking lot, which can be occupied or empty. The status information of the parking space is sent to a LoRa gateway after the status of the vehicle is detected. The gateway transmits the information to the LoRa network server. [10]. Finally, the LoRa network server decodes the data and interfaces with the smart parking platform to enable real-time parking lot management. The CM-2101-L system was developed to measure traffic flow. The number of vehicles is counted by placing this sensor not only in parking lots but also on main roads.

A conceptual solution based on a mixture of several technologies. Artificial intelligence is used in the recognition of license plates in the payment system for parking spaces in a hotel. The parking spaces consist of two parts: a private part and a public part. The private part is equipped with an inductive ring sensor. The private part of the parking lot is monitored by an LPR camera. With the LPR camera, the users of the hotel apartment can use their part of the parking lot. Radio Frequency Identification (RFID) reader and printer for issuing cards for users of the public part of the parking lot. An RFID card reader was also added to allow hotel users to use the parking lot. The identification system and the parking fee issue the user with an entry ticket upon arrival of the vehicle at the garage entrance, allowing free entry. The exit of the private part of the parking garage is equipped with an LPR camera and an RFID card reader. These devices allow users to exit the private garage. The RFID card reader allows users to exit the public garage. RFID cards have additional functions and are intended for access control in the building, releasing rooms, and starting the building management system (BMS). Access control and the BMS itself use the same type of card. The main idea is that the RFID card (which is placed at the entrance to the parking garage) is used to enter data about the user's space and length of stay and grant them access to the parking garage.

III. PROPOSED APPROACH

In this chapter, we will describe the devices that will be used for our experiment. First, we will explain the RFID card reader. The card reader collects the data from the tags via radio waves. The data on the cards is forwarded to the information system. We use the RRU 4500 reader, which operates in the (865-868)MHz and (902-928)MHz frequency range. The maximum output power is 33dBm and complies with the standards EN302208-2 V2.2.1, EN301489-3, EN50364... The card reader has a low power consumption of about 25W and runs under Linux, Figure 1. [11]

Figure 1. RRU 4500 Reader Unit

Our solution consists of the RFG-HCO4 controller with 4 connections for antennas and the Impinj R2000 chipset, which supports reading multiple tags up to 500 times/second. The module operates in the range from 865MHz to 925MHz, the reading range is between 0 and 20m depending on the tag and environment. The controller uses a processor ARM9, 400MHz, memory FLASH 128, DRAM 32 MB. The operating system is Linux 2.6. We also chose this controller because it supports a faster data processing algorithm with an excellent communication protocol architecture, Figure 2. [12]

Figure 2. UHF RFID Contoller

The next device is RFID tags. RFID tags are smart, small electronic devices. Those devices have two operations. First, RFID tags store information (tags attached to objects), and second, they can communicate with other devices using radio waves (electromagnetic fields to automatically identify). Figure 3. [13]

Figure 3. RFG-T10 tag

These wireless RFID tags use state-of-the-art radio frequency identification technology to read information from a distance of several kilometers. We have used passive RFID tags, which are much more economical than active RFID tags. They are small, lightweight, and can potentially last a lifetime. Passive RFID tags do not require a direct line of sight to the RFID reader. These characteristics provide us with satisfactory conditions for the project, where we use RFID technology to bring the car into the garage and control access to the facility.

LPR cameras perform additional functions beyond the regular OCR of license plates and enable the digitization process in complex and extreme conditions (moving targets, very open angles, poor ambient light, fog, and dirt...). The LPR confidence of the cameras is a very important function. This is an AI-based probability calculation that measures the degree of certainty that the system has correctly read a particular license plate. We have also opted for waterproof, removable IP66 connectors for the hardware, which allow for a much faster and more reliable setup. The low-voltage power supply from 12V to 48V provides better protection for the cameras [14]. The zoom's variable aiming distances range from 2 meters to 12 meters Figure 4.

Figure 4. LPR IP camera

Inductive ring sensors are solid-state sensors and only need to be replaced if they are physically damaged. Dirt, sawdust, oil, and grease have no effect on the detection of targets by inductive sensors (Figure 5).

Figure 5. Inductive ring sensor

The induction loop is installed about 5 cm below the road surface. We use a 1.5-meter loop with wires connected to an oscillator that receives data in the form of pulses from the loop.

IV. DETECTION ALGORITHMS

We use ANPR technology, which uses optical character recognition in the image to read vehicle license plates. The license plates are identified by converting the captured image of the license plate into numerical values using OCR technology. The camera is mainly used to obtain information about the vehicle and then uses a recognition algorithm to identify the number, color, type, and other characteristics of the vehicle. In combination with a barrier system for the automatic entry and exit of vehicles, the license plate recognition system then provides access to Figure 6.

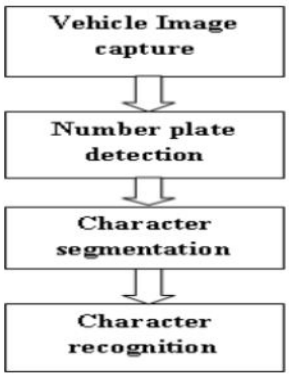

Figure 6. Algorithm for camera signal processing

Tables are identified by converting a captured image of the table into numerical values using OCR technology. In the recognition process, after capturing an image, the license plate recognition camera recognizes the system and automatically transmits the information to the server when the vehicle slowly drives through the line in the recognition area. The camera is integrated into the device itself together with the LPR software. The data is only transmitted from the license plates read via the IP network. This means that there is less load on the network and the server, as all the processing and analysis of the images is carried out on the device itself. License plate recognition systems are very accurate in most situations. In extreme and demanding situations, additional components may need to be integrated into the license plate recognition system. So our license plate recognition system is complex and the maintenance and management are more demanding, but the results are truly outstanding. OCR software that we have installed on the intelligent camera. The smart cameras meet the specified requirements that enable optimal operation. We used the Azure AI vision read REST API, which provides us with AI algorithms for extracting text from images and returning it as structured strings. These algorithms were written in C#. The way to read license plates from an image.

```
private void btnRecognizeImage_Click(object sender, EventArgs e)
{
    LPRParams parameters = new LPRParams();
    parameters.Countries = "SRB,NMK,MNE,BIH";
    parameters.MinPlateWidth = 70;
    parameters.MaxPlateWidth = 320;
    LPREngine engine = new LPREngine(parameters, false, null);
    List<LicensePlate> plates = engine.ReadFromFile("C:/Images/test.jpg");
    foreach (LicensePlate plate in plates)
    {
        Console.WriteLine(string.Format("Plate text: {0} Country: {1} Confidence: {2}",
            plate.Text, plate.CountryCode, plate.Confidence));
    }
}
```

The parking management system performs license plate recognition in the following steps. The algorithm positions the license plates and recognizes and positions them. Then the license plate characters and the individual characters on the license plate are separated. The license plate characters are recognized, analyzed, and classified, after which the complete license plate is formed. In this project, we use AI technology for many calculations: Localization of the license plates in the image, OCR – character reading, calculation of confidence level, determination of the type of license plate, and geographical area of origin. We can also use the AI option vector signature of the license plate if we need it in the current project.

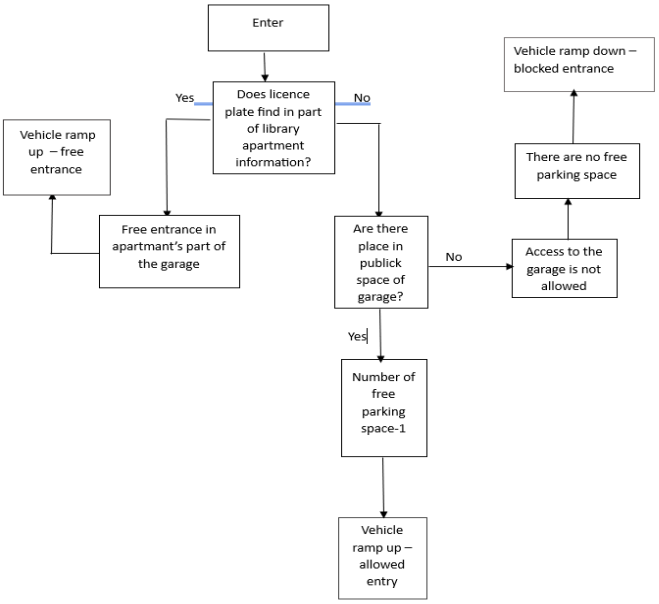

Figure 7. Algorithm for entrance vehicles in the garage

The most important requirement of this project was that the apartment owners were allowed to use the parking lot. The remaining part of the garage is used as a public garage if there is a free parking space.

V. TECHNICAL SOLUTION PARKING CHARGES IN THE HOTEL

The hotel "Zlatibor mountain resort&spa" has made an effort to find enough parking spaces for visitors and additionally a public parking lot. The hotel has 100 rooms – that means 100 parking spaces for visitors. The hotel also has 30 apartments, which require 30 parking spaces, and 70 public parking spaces. So there are 200 parking spaces in total.

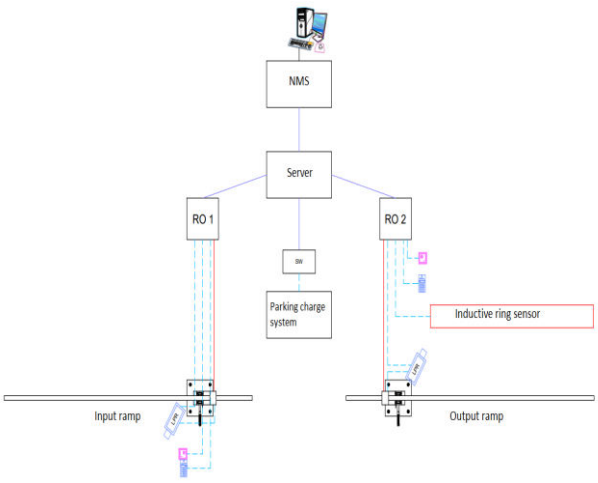

Figure 8. System for vehicle parking charge

The entire implementation of this system is shown in Figure 8. Lighting is an important element because the camera needs to capture plates both day and night. The smart cameras we have used have their own IC lighting. The solution for illumination is surface LEDs, which must have suitable lenses and diffusers to distribute the illumination in the shape of a rectangle rather than a large circle. Image resolution is another important point that we have planned. Image quality is a crucial factor for license plate recognition, so the resolution should be at least 1080p. OCR software for EU standard license plate recognition requires about 256 pixels per meter of strip width. The next parameter that is important for us (for the project) is the distance between the vehicle and the cameras. The most important factor for successful license plate recognition is the position of the cameras. Our cameras are located at a height of 5' and 15' above the ground. The best result is achieved with a license plate offset by 15° to 30° (Figure 9). [15]

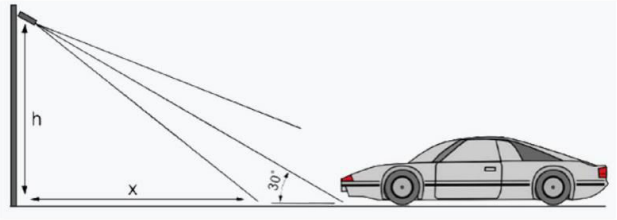

Figure 9. Recommended height of LPR cameras

For us, two angles are important – the vertical angle between the longitudinal axis of the camera and the plane in which the vehicle is moving, and the horizontal angle between the longitudinal axis of the camera and the longitudinal axis of the vehicle—figure 10.

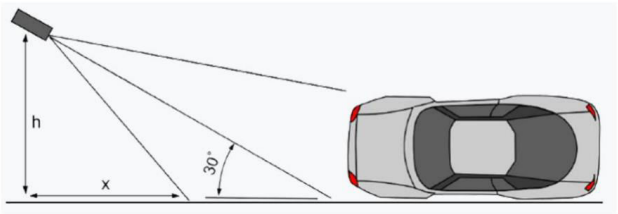

Figure 10. Recommended coverage angle of LPR camera's

The correct reading of the license plate to maintain a 30-degree roll and pitch angle.

VI. AI SOFTWARE FOR PARKING FEES

The parking fees software controls the entire valet parking system. Using the sensors and cameras, the software concludes and initiates certain operational measures based on the analysis. AI application receives the data from several sources: LPR camera, input/output controller, and inductive ring sensor. The software has a multi-layered architecture and consists of several units: Database, communication application, and client application. The client application is used by the operators to work on the parking system and communicate with the database. The communication application exchanges data between the controllers and has the function of writing and reading important information in the database. The client application consists of several modules: Operator module, service module, and management module. The management module is used to enter the initial parking parameters, the price list, and all subscription cards with basic information about the owner, the period of validity of the cards, and the type of renewal of the subscriptions. All subscription card numbers are entered and then the cards are categorized. The function of this module is to monitor the entire system and generate statistical reports. The function of the service module is to adjust and diagnose the system. The operation module supports the work of employees in the valet parking system, issuing and accounting of tickets. Our access to the parking control and accounting software starts with entering the IP address of the main server in the same web browser. The software offers many possibilities: Setting up user information, setting up parking lots, various reports to help the operator work better, and switching the operation mode of the parking ramps from automatic to manual. Figure 11 shows our solution for accessing the parking management software. Our technology is scalable and allows the implementation of new functions and hardware devices to create new rules and actions at any time.

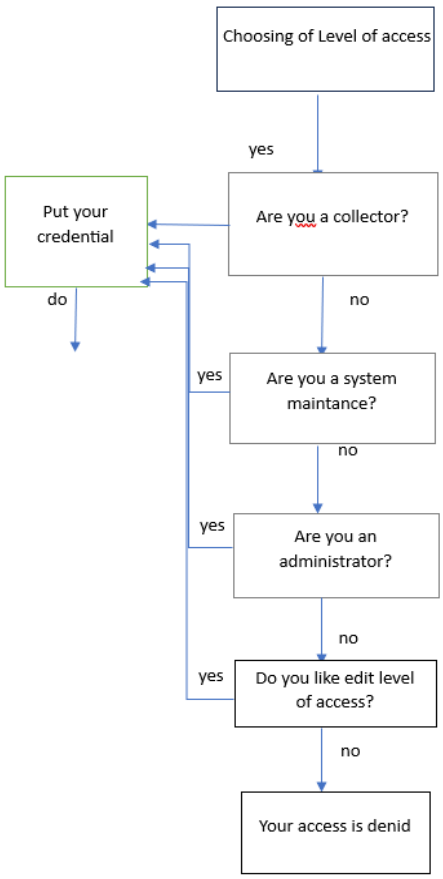

Figure 11. Level of access parking control system

The system is protected by authentication with different authorization levels. It is based on and accessible from PS and cell phones. We define precisely the rights for each access level and use Macchina's security system that meets our

requirements and functions. We used macchina,io EDGE software which consists of block-enabled parts of software. Those blocks of software enable applications to collect, process, filter, analyze, and visualize sensor and process data where the action happens[16] – this is a characteristic of good AI software. This software enabled us to our device application in a hardware-independent way. Through the software, we define parking spaces to rent, spaces reserved for tickets, time to leave the parking lot without paying, time to leave the parking lot, and prices of daily and weekly tickets. By reserving an apartment, there are automatic changes in the software in terms of parking space, and there are fewer users, it can be changed and adjusted to current requirements. The database contains information about apartment users who have a parking space, owners of apartments with a parking space, and users of the public part of the parking garage. macchina,io EDGE software is hardware-independent, open, and highly interoperable. As we have different types of equipment that adopted C++ programming language, it fulfills the objective of this project. This information is recorded by the camera with the AI software, Figure 12.

Zlatibor mountain resert

Figure 12. AL parking control system recognizes license plates

The license plate of the vehicle determines the access to the parking lot. The software searches the database and checks the status of the license plate. The parking ramp is opened if the license plates belong to the apartment owners or guests renting the apartment in the complex. If the plates are not recognized in the database, the system checks again if there are free public parking spaces. The parking ramp is open for public garage users if there is a free parking space. The user of the public part of the parking garage collects the card.

VII CONCLUSION

In this paper, we have argued the use of artificial intelligence in solving complex parking problems. We have also proposed detection algorithms for Hotel "Zlatibor mountain resort&spa". For this project, we use Automatic number plate recognition (ANPR) technology that uses the optical character recognition (OCR) method. These technologies would use the enumerated types of sensors and hardware for implementation. This system would process real-time data on parking availability places. Unlike the conventional parking system for vehicles, We used AI to improve the ability of data processing and analysis, automatically based on the existing database, solve the problem and data analysis more easily, and further enhance the accuracy of decision-making. This research proposes a new framework for solving the public/private problem of parking lot allocation, using self-learning video analytics. Analytics for license plate recognition is performed on the camera itself, so only reading data is transmitted over the network license plates. This kind of analytics reduces the data load on the network and server because complete processing and recordings are done on the device itself. The start of work is based on the defined rules in the system that we have created. We define the size of the parking lot for apartment owners and apartment users, as well as part of the space for the public garage. Self-learning video analytics provides the ability to classify and identify vehicles of interest, which are defined in advance. Those vehicles that are not in the database and that want a parking space are analyzed and released depending on the occupancy of the parking lot. Smart parking solutions can save drivers up to 20 minutes each day. To set up the proposed system parking fees require a significant investment. Considering the expected frequency of guests in the hotel complex and the use of public parking spaces, this system is already in the first two years of operation and will bring a profit.

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