PATTERN PROPOSAL FOR DETECTING OBJECT OCCUPANCY IN AVS UTILIZING ML, EDGE CLOUD, AI, AND CV FOR PARKING LOTS

Pavle Dakić[1,2], Mohammad Daud Haiderzai[3], Anja Dragojević[4], Anastasija Dragonić-Uremović[5]

[1]*Faculty of Informatics and Information Technologies, Slovak University of Technology in Bratislava, Bratislava, Slovakia*
[2]*Faculty of Informatics and Computing, Singidunum University, Belgrade, Serbia, pavle.dakic@stuba.sk, pavle.dakic.11@singimail.rs, 0000-0003-3538-6284*
[3]*Faculty of Informatics and Information Technologies, Slovak University of Technology in Bratislava, Bratislava, Slovakia, mohammad.haiderzai@stuba.sk, 0000-0003-1060-2972*
[4]*Pan-European University "APEIRON" Banja Luka, Bosnia and Herzegovina, anja.d.dragojevic@apeiron-edu.eu, 0009-0007-7492-9970*
[5]*Pan-European University "APEIRON" Banja Luka, Bosnia and Herzegovina, anastasija.d.dragonicuremovic@apeiron-edu.eu, 0009-0008-5027-5412*

Original scientific paper

https://doi.org/10.7251/JIT2402093D UDC: 004.414.23:656.1.08

Abstract: The purpose of this article is to provide an overview of current parking system management issues as well as support for effective object identification in circumstances of autonomous parking. In particular, we will look at existing solutions and patterns that have the most immediate use in automobiles and other businesses that rely on these technical approaches. The question arises as to the effectiveness and expense of existing solutions during various times of day (rain, fog, snow) and weather conditions, which can significantly alter the visibility of any systems that use cameras for object detection. This is applicable to parking lots that use cameras and a computer system's integrated capabilities to detect and classify items using a machine model that makes certain decisions or suggests certain objects for object occupancy tracking. Our parking system concept proposal can be summed up in a dozen successful implementations for autonomous vehicle (AV) control and other Internet of things (IoT) systems. Image processing could be carried out using a mix of one or more algorithms and patterns that require specific hardware and software in the background, such as CI/CD, HPC, edge, cloud computing, and cluster microservices. Key contributions and findings can be given in the form of a novel pattern method known as combined detection of parking occupancy on chip (ComDPOCh), which can be applied in a real-world setting using appropriate hardware and software.

Keywords: Machine learning and computer vision, parking lot occupancy, watershed segmentation algorithm, object detection in autonomous vehicles, image processing, autonomous vehicles, artificial intelligence, Internet of things (IoT)

INTRODUCTION

A practical analytical approach to solving the current problem related to the best possible management of the parking system requires a more precise determination of the number of vehicles in the parking lot or during vehicle movement. Cameras that constantly monitor the required terrain, combined with advanced software inside the vehicle, can detect the availability and number of parking places. Each research requires certain funds for investment into new technology, as well as its maintenance [1, 2, 3, 4]. In company which deals with innovative research and creation of new technologies it is also important to have certain knowledge, with the help of which competitiveness on the market can be achieved using SEO, SEM, CI/CD, Cloud and Edge technologies [5, 6, 7, 8]. External influences can create reduced sight, making it difficult to operate these devices in case of problems with logistics organization and product availability on the market. All this together affects the economic profitability and delays in the delivery of the final product, such as a complete vehicle that can be partially or fully automated.

Improving software technologies and security is a prerequisite for improving hardware solutions to common challenges with different power sources [8, 9, 10]. In other words, we have reached a point where a software system can surpass a hardware solution in all aspects [10, 11]. That is why algorithms are utilized for the identification and classification of movements in the continuous monitoring of parking lots and points of interest, based on which the machine model makes certain conclusions or suggests specific items.

Detection model training processes in most situations need the application of HPC, cloud computing, cluster microservices [12], edge or a development process that uses CI/CD at its core [13, 14, 15, 16], to successfully obtain an efficient and applicable detection module inside the vehicle or camera itself.

There are many methods that deal with image processing, motion detection, and object classification using cameras and IoT devices, but the challenge of accuracy and speed remains. In this case, image processing can be performed using a combination of one or more algorithms to improve visual content under low visibility conditions. These algorithms can also be applied in the field of parking management [17]. The lack of object detection support under night conditions is evident in existing systems. In general, in difficult conditions, all solutions give significantly worse results.

Computer assistance is gradually improving, and there is still space to upgrade existing surveillance camera systems and solve difficulties with limited visibility utilizing patterns and algorithms. However, all possible solutions are better or worse than others in individual scenarios and produce different results.

Existing solutions use only one method with only one approach, but no implementation is robust enough to be used for several different scenarios (parking schedule, car position, camera angle, etc.) and temporal and spatial conditions [18, 19]. The work is intended for readers who have a certain knowledge and experience in the field of machine learning (ML), artificial intelligence (AI), computer vision (CV), autonomous vehicles (AV), along with other interconnected technologies and hardware approaches [20, 21, 22]. Considering the intended use, it is important to choose the algorithm best suited for the serving the purpose.

The main contributions within this paper relate to the presentation of the idea proposal of implementing a technical solution for parking occupancy. This proposal relies on the possible application of several different algorithms for detection in mixed lighting and weather conditions. While within the conceptual proposal, the contribution is providing a better understanding of the computationally efficient approach and the complexity of the future computer system with the required number of components for successful implementation by using video surveillance systems and cameras in the vehicle.

The research is divided into the following sections: introduction, materials and methods, cost of automotive sensors and optimization processes, related work which include the important literature in this topic. This section discusses the opportunities and challenges associated with existing solutions and how some difficulties can be solved by combining multiple algorithms based on the time of day and light intensity. The results section encompasses solution ideas and collected assumptions. In this section, we described alternative methodologies and algorithms, along with a proposal for a future solution presented in the form of a visual representation of a computer system that could be deployed. Additionally, the prospects for software development and integration with CI/CD are being investigated, and conclusion summarizes the current findings and directions of future research.

METHODS AND MATERIALS

Methods and materials were gathered through research questions. The research method is based on empirical observation and the possibility of proposing future solutions. The study focuses on non-numerical data and the collecting of various ideas and perspectives on the topic of direct application, summarizing the current state of affairs in this field. The volume of literary study connected to all solutions from 2004 to 2024. The literature is studied through the lens of possible direct applicability in many applications and sectors. We looked at the financial implications of sensors and their impact on the development of appropriate detecting software.

Research Questions

The research framework is focused on finding answers to the following questions:

1. What are the sensor prices and total costs for a partially or completely automated vehicle?
2. What solutions exist for object detection and support for nighttime applications?
3. What is the optimal solution for effective parking detection and application within AV and other industries?

Related Work

The question arises as to how well existing solutions perform depending on time of day (rain, fog, snow) and weather conditions, which can have a considerable impact on the visibility of any systems that employ cameras to detect objects. In general, this has an impact on the management of self-driving vehicles as well as assistance for successful object recognition in automatic parking applications. Based on all of this, the camera is unable to acquire a sufficient amount of high-quality data, which has a substantial impact on the algorithm's outcomes.

Where the details related to the existing approaches are summarized and selected based on the possibility of obtaining certain results during the analysis of the obtained graphic display. The focus within the related literature is on looking at the possibility of connecting future implementations of algorithms, technologies, software, hardware, and the subsequent implementation of real experiments. The planned experiments should be realized inside the vehicle and on video surveillance systems, where could be obtained the possibilities of application for different purposes. Key findings and arguments on the direct use and use of small embedded computers inside a car or a laboratory environment that might be used in a public free parking lot.

Within the mentioned section, we focused on algorithms and their application possibilities. On the basis of which we made the appropriate organization in the following way: image preprocessing, Fog and haze, Darkness, Precipitation, Motion tracking, Algorithm in scene illumination, Image segmentation and Categorization.

Cost of Automotive Sensors and Optimization processes

Automotive sensors play an important function in modern automobiles, ranging from improving reliability towards enabling automated driving. The integration of the sensors in automobiles has become vital for optimizing performance and costs [22, 23]. For example, the cost implications of sensors vary depending on the level of autonomy of a vehicle. According to the data we collected, 9 sensors in a Level 1 vehicle add $300 to the total cost, but 28 sensors in a Level 5 vehicle add $1,758. There is a significant difference in adding the additional total cost of the finished product without accounting for software production costs [23, 24].

This emphasizes the significance of cost minimization measures in sensor integration. In the pursuit of cost optimization, advances in the field of sensors have been developed to improve efficiency and cut wasteful costs. For example, the use of AI in vehicle upkeep has been shown to minimize sustaining costs and resources through the provision of scheduled repairs. The new self-driving capabilities include a wide range of sensors and autonomous characteristics, and their number is projected to grow in the future which is shown in Figure. 1.

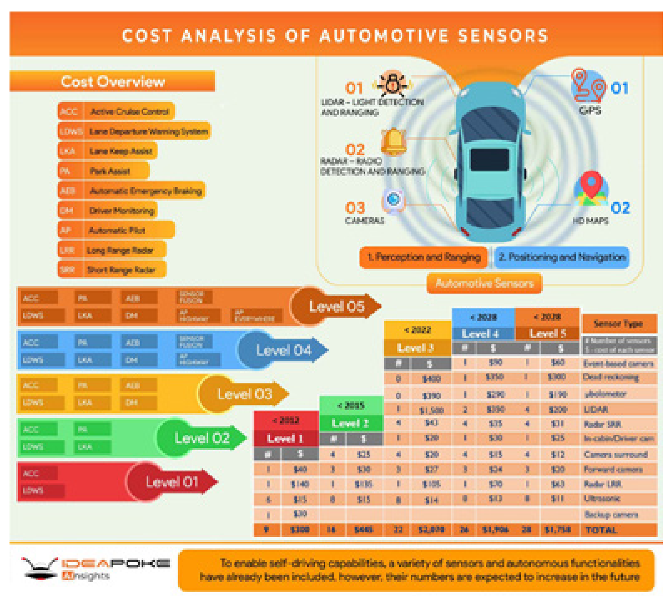


Figure 1. Matching Sensor Cost with Automotive Disruption. Source: [22]

Furthermore, optimizing sensor placement on vehicles is crucial to boosting performance. In the sphere of security, we must strike a balance between cost optimization for automotive cyber-physical systems and security-related hardware cost optimization. While CAN FD-based systems have highlighted the importance of balancing security measures with financial costs in the event of a breach of security [25].

Types of existing detection solutions

There are several ways to approach the solution to this problem in the literature and related works. In general, the solutions could be classified into 2 or 3 groups, surface-oriented and object-oriented, and the third group would be a hybrid combination of methods from the first two.

Disruptive factors, such as bad weather, affect more solutions in the surface group. However, problems regardless of time can be caused by shadows or differently lit surfaces. Some of the algorithms in these situations can scan and recognize an occupied part of the parking lot that is in the shade, and in the sun as free.

In the following, Dakić et. al [11] we discuss existing solutions that have the greatest degree of direct application within vehicles and other industries that rely on these technological approaches. This applies to parking lots that rely on cameras and the integrated capabilities of a computer system that detects and classifies objects. Most solutions require the application of appropriate standards Dakić et al. [26] and their harmonization depending on the country in which the solution is used. In most cases, Todorović et al. [26] standards compliance is monitored on appropriate control panels/dashboards using analytical software in real time.

Surface-oriented solutions

Surface-oriented implementations of the relevant software and hardware use the parking lot's surface to detect whether parking spaces are free and occupied. The solution of Liu et al. [27] is presented via the use of multi-support vector machines on portions of three neighboring parking lots to find linkages between adjacent patches. The essential parking space is classified according to its qualities. According to the authors of Liu et al. [28] and their understanding reveals that there are options based on a breakdown of blocks of grayscale parking cell photos. The approach is based on dividing each parking place into four equal-sized chunks. Each of these was then evaluated using particular homogeneity criteria. If the unit in question does not match these requirements, it is broken into four subunits, which can be represented as a computational grid or programming code. Most software deployments, Kročka et. al [29] necessitate the use or the creation of machine detection models with AI and CV application capabilities that employ table detection approaches where direct application can be done within the vehicle, using static cameras in the parking lot.

Each block is split interactively until the output passes the homogeneity condition and is consistent with the trained recognition model. The consistency of the parked cell (1x1) can be found by summing all of the reinforcing blocks of one parking cell, i.e. if it contains non-homogeneous constructions, such as vehicles. Their presentation can be realized in a number of different ways within 2D and 3D space using matrices. A similar approach is offered by Funck et al. [30]. They also apply to parking areas in their grouping of parking cells, where an image of an empty parking lot is used as a reference and compared to the present status in each consecutive frame. A better approach is Huang et al. [31], who improved this group's solutions by referring to the complete object in the parking compartment as a surface. This strategy may be the most productive of the entire collection of approaches.

Best possible detection and classification

The second group's solutions are based on the most accurate identification and classification of items from photographs. Parking system solutions can be summarized in a dozen effective automobile industry deployments and highway vehicle control. An outstanding solution using a CNN classifier offered by Amato et al. [32] can work on smart cameras with limited resources. This approach uses a 5-layer CNN to identify both a vehicle and an empty parking space for categorization.

The third group includes hybrid solutions that use the background for motion detection. A very robust solution in the field of urban traffic management comes from Feris et al. [33] which shows the possibilities of achieving vehicle tracking and detection from many different angles. A straightforward rule-based vehicle classifier is used, which examines the form and movement of foreground spots at predetermined time intervals. They determine if the aspect ratio, size, and direction of movement of specific foreground spots are within a predefined range of parameters that identify the vehicle.

The authors Bhaskar et al. [34] offer a unique algorithm for vehicle data recognition and tracking using the Gaussian mixture model and speckle detection methods, a similar solution was proposed by Foresti et al. [35]. Postigo et al. [36] propose an approach that allows background removal and vacancy map analysis, which is proposed by Postigo et al. [36]. From this map, vehicles are detected and tracked to determine their parked or abandoned status, as well as to account for frontal and neutral occlusions. Occlusions refer to changes in temperature and differences between certain objects that are detected by rendering them through a certain color. An estimate of free parking space is also given. Their algorithm is capable of estimating the dimensions of a parking lot. Mithun et al. [37] offered a similar solution to time-space images.

Application of various algorithms and detection conditions

Detecting procedures can be implemented in a variety of ways, and in this section, we have discovered relevant algorithms and circumstances that can be applied to our conceptual solution. Each phase step and the use of various algorithms are described in further detail and justified.

In the first phase, Chen et al. [38] It essential to perform initial image processing from various image sources. Most sources can be found inside the car or in an external system. The procedure is receiving the image from the recording device and processing it with as much detail, high quality, and as little noise as possible before saving it. After completing the first storage operation, advanced algorithms can be used to process the data for object recognition. The approaches applied in this step shall be prioritized in low-visibility and nighttime conditions, as well as rain and fog. The selection of proper algorithms for the image processing is critical, and the degree of precision of the subsequent processes is heavily reliant on the findings.

On the basis of the knowledge gathered in this work and the literature source [39, 38, 40, 41, 42], we had the opportunity to become familiar with the most common image problems that occur in conditions of reduced visibility. All of this is represented in the image's low contrast between visible items and backdrop, poor illumination, and heavy noise. In addition, the way the image is processed is heavily influenced by the conditions in which it was captured. Simply expressed, the choice of image processing technique is determined by the challenges to be handled, which include reduced visibility, low detail, and high noise. Nevertheless, a poor image might be created by the time of day, sunlight, fog, haze, or excessive precipitation. It is required to select the option that provides the greatest score for better image quality under the specified circumstances. This necessitates the selection of appropriate image processing techniques based on the present weather and optical conditions. In the following, we discuss some of the essential methods and publications that deal with applicability under diverse weather and illumination circumstances [40].

Fog and haze

There are many great works in the field of image enhancement. One of the methods for image processing under fog and haze conditions is Efficient Image Dehazing with Boundary Constraint and Contextual Regularization by Meng et al. [43]. The advantage of this solution is that it does not depend on knowing the scene in an ideal state, i.e. only one image input is sufficient which is shown in Figure 2.

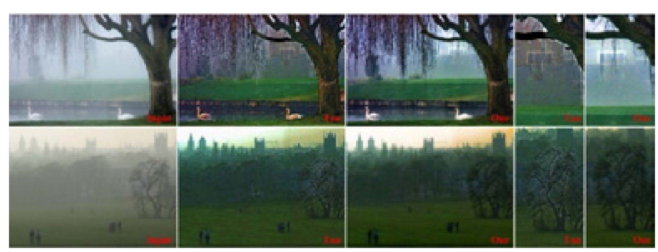


Figure 2. *Image Dehazing with Boundary Constraint and Contextual Regularization. Source: [43].*

When it comes to nighttime picture processing, the most popular methods are those that use histogram equalization to increase the brightness and contrast. These algorithms work on the principle that after finding the mean value of brightness, it begins with the lowest level and compares it to the mean value; if it is lower, the next level is added to it and compared to the mean again. The operation proceeds until the value that is closest to the mean is determined. All the levels of brightness are then grouped together, allowing for an approximate harmonization of the histogram [42].

We can distinguish between the following equalization methods: normal histogram, adaptive, adaptive contrast histogram, adaptive contrast limited histogram, and multipeak histogram. In the work of Bhandari et al. [44] where image enhancement and object recognition for night vision surveillance are discussed, Contrast Limited AHE (CLAHE) was shown to be an algorithm with extremely good results.

The GCANet solution by Chen et al. [45] Shows excellent results in eliminating precipitation from the scene. In this network, a smoothed dilation technique is utilized to remove network artifacts generated by extensive dilated convolution with minimal additional parameters, and a closed subnet is used to integrate data from different layers.

Algorithm in scene illumination

When the illumination in the scene changes, the algorithm's functioning may get more complicated. The algorithm should account for variations caused by the day and night cycle, as well as lighting changes caused by, say, a quick change in clothing. Background noise might also hamper the algorithm's operation. For these reasons, image preparation and pre-processing are required, as shown in the example on Figure. 3 and Figure. 4. The illustration shown shows the extraction of pedestrians within 2D and 3D space.

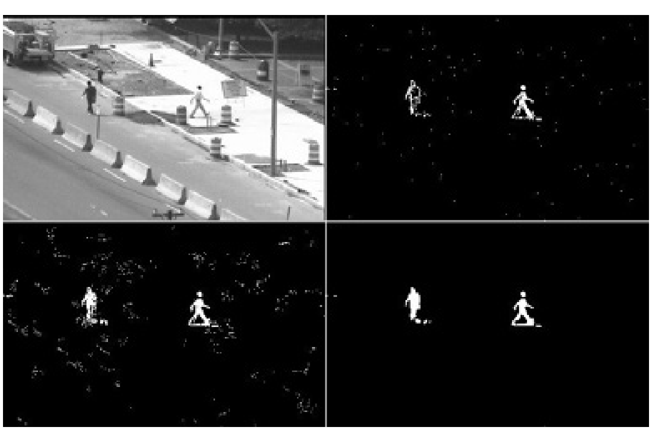


Figure 3. *Background subtraction. Source: http://vip.bu.edu/projects/vsns/background-subtraction/fa/.*

Image segmentation entails highlighting stationary elements. Due to the density of parking spaces and the usage of a limited number of cameras, vehicles are frequently obscured from the camera's view. However, this is a considerably more complicated issue because even the human eye cannot perceive what is behind the item blocking our view. This issue is particularly prevalent in computer vision. Consider the scenario in which vehicle A arrives at a full parking lot. Vehicle A passes past rows of parked cars, always concealed by the camera's eye. Watershed algorithm created by Google is later used for image segmentation [46]. For instance, the vehicle subsequently finds a free parking spot and halts for a moment and still is only partially visible to the camera lens (Figure. 4). The cameras covering vehicle begin to leave the parking lot, until the detected surface becomes fully visible. The camera lens then receives new information, but it happens that the algorithm for categorizing the received information does not take into account vehicle. The purpose of this method is to clearly and precisely distinguish the contours of objects from one another. The Watershed Algorithm views pixels as heights, with more visible pixels on higher terrain and darker pixels shown as gaps in the ground due to their low visibility. They can alternatively be represented in the table using the integers 0 and 1. Water will be injected into depressions (ground gaps) to improve pixel recognition. Also, these depressions, will be forming lakes with dams in between. The management of the dam represents the contours of the buildings and the shapes illustrated in Figure. 4.

Figure 5. *Image segmentation. Source: https://mi.eng.cam.ac.uk/projects/segnet/*

Categorization operations will be accomplished by classifying things of interest, auxiliary objects, and vehicles. We need good recognizability and segmentation of the incoming input results. Since classification of objects comes at the end, it is evident that the input to this method is a processed image with defined contours. Classification entails locating an object inside the group to which it belongs. As a result, object categorization requires the training and implementation of a neural network.

Results

Based on the defined questions, we managed to obtain the following results in the form of a conceptual proposal and certain initial assumptions regarding the future solution.

We developed a novel pattern method called combined detection of parking occupancy on chip (ComDPOCh). The technique described above was created as an outcome of the performed research, and based on it, we can propose a solution that would consist of four phases:

1. Image preprocessing
2. Motion tracking
3. Image segmentation
4. Categorization

The primary notion of this approach is to monitor movement in the parking lot. Motion can be defined as the difference between two (or more) pixels in the same scene. The simplest method for detecting motion is to subtract the modified frame from the original one. The outlines of the moving object can then be obtained simply by identifying the differences between the frames. To prevent detecting movements that we are not interested in, such as tree limb movement or light changes in the scene, we must first investigate and then set a suitable threshold that eliminates these events. The process would be carried out using a system that included a different scene for every OOI (object of interest). Regardless of the objects present, each new OOI would start with an empty scene (empty background). It would be required to undertake research on objects that piqued our interest. Vehicles come in a variety of shapes and sizes, and it is not uncommon for some to hide others' views to the point that just the roof, front, or back of the car is visible. Even then, it will not resemble a biker or pedestrian. This is precisely what may be used to improve the threshold for OOI.

A simpler visualization of the algorithm and patterns that are detected is shown in Figure. 5 which consists of 5 steps with two section parts A and B, that are explained below. At each step, there are two images of the scene: the color image (A - parking lot road) is the way we see it, and the black-and-white image (B - computer detection system) is the way the algorithm sees it. In the color image, the vehicle can have three colors: yellow - the vehicle is in motion, green - the vehicle is just parked, and green - the vehicle was already parked on the stage.

When the item reaches the OOI threshold, we start tracking it to the end destination Figure. 5 (steps 1-3). The scene in the computer's "eyes" appears to be a black background with a white item moving across it. When the OOI arrives at its final destination, it follows the tracks and we save its scene (steps 3 and 4). By integrating the scenes of all OOIs, we can obtain a global image and hence a clear picture of the number of vehicles parked in the parking lot (step 5). This allows us to determine the vehicle's position in relation to the parking lot as well as its proximity to other vehicles.

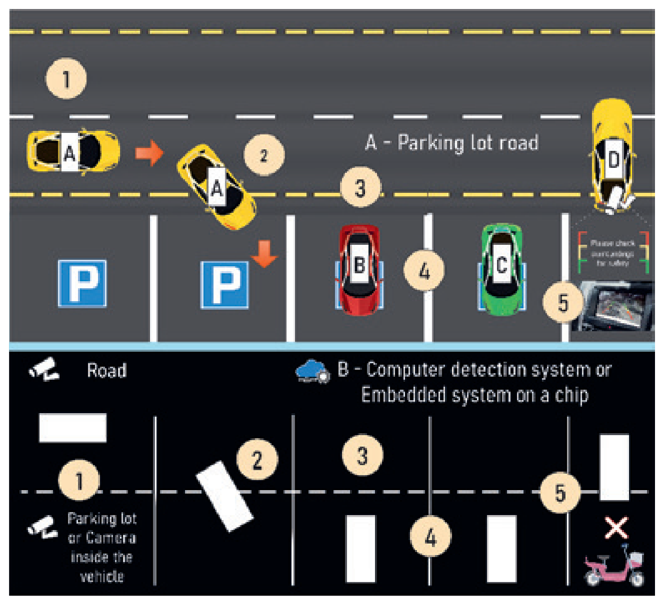


Figure 5. Working idea proposal for the Method in detection of parking occupancy on chip (ComDPOCh). Source: author's contribution.

It often happens that the vehicle entering the scene, vehicle A, is not visible from the camera angle because of the vehicle already on the scene, vehicle B, as vehicle B leaves, vehicle A becomes visible, and the newly discovered part of the vehicle is not always recorded at the scene when it is parked like for vehicle C. One of the ways to solve this problem is the application of the pattern for object presence detection and basin algorithm (Watershed Segmentation Algorithm) [46], which, based on the position of the vehicle, can display the newly discovered part that has been detected. The application can be inside the vehicle, as well as in the parking lot with static cameras or in Internet of Things (IoT) devices. After detection, the information will be saved in a special scene that represents the detected information in the matrix coordinate system that is used to save its information for further processing.

The detection computer system shown in Figure. 5 (B - computer detection system) could be created in the form of smaller microservices that are located inside the cluster and are started depending on the load and the demandingness of the operation itself [47, 12]. The software development itself could be realized by applying a modeled business process through which the detection model is trained and tested using the CI/CD pipeline [15, 14, 48].

Based on the proposed solution, the planned studies show how to investigate the possibility of vehicle detection in complete darkness, high levels of illumination, when it is snowing or raining, and combinations of these situations. As a result, the experiments themselves further processes would be mimicked in the laboratory or in a physical setting.

Another important factor that can aid in future detection is the usage of unique colors and road markings. With the help of the aforementioned information, improved efficiency may be achieved in the identification and recognition of patterns and objects studied by the sensor during the vehicle's movement. By using marking with green glow paint – photoluminescent show on Figure. 6 we can quickly perform the detection process itself and reduce the time required for detection and the complexity of processing the data obtained from the environment itself.

Figure 6. *marking with green glow paint - photoluminescent/ glow in the dark road & line marking. Source: author's contribution.*

After the successful application of the mentioned color shown on the Figure. 6, we can see the result during the night on Figure. 7, where they are clearly seen and noticed by the driver himself and the embedded computer system inside the vehicle.

Figure 7. *highlighting the effect of photoluminescent green glow paint, which glows in the dark for road and line marking. Source: author's contribution.*

The effective use of various strategies improves the success of detection alongside additional software development techniques. So that it is easier to digest real-world information that AI cannot understand without proper visualization and display in 2D or 3D space.

Discussion

All of this leads to a suitable conversation, which necessitates a more in-depth examination of the true potential and needs during software and physical vehicle testing. In accordance with the established research framework and research questions, we can summarize and report the findings, we came to the following answers:

RQ1: Referring to the studied data and available information, we found a significant difference for vehicles ranging from Level 1 to Level 5. As we can see, 9 sensors for the first level add $300 to the cost, whereas Level 5 and 28 sensors may run up to $1,758. I anticipate that in the future, the prices of the aforementioned sensors will be much lower.

RQ2: We have learned about different algorithms and the impact in detection conditions that must be met before starting the detection process itself. We have seen that there is a high level of complexity within this area and the necessity of knowing different solutions.

RQ3: Based on the research, we came to the knowledge that the best detection method is the collection of graphic information reflected in the reaction during the fulfillment of certain weather conditions, lighting, and object detection. Which can minimize the impact of false detection can be represented by combining the positive aspects of each of the solutions and applying them under certain favorable conditions.

Conclusion

In low-light settings, simpler visibility enhancement strategies can improve motion detection, complementing efficient classification methods and other object detection systems. These improvements allow for more reliable performance of the proposed solution under low-visibility conditions. Motion tracking can alert the system to activity in the parking lot and around vehicles, while accurate image segmentation will further enhance vehicle detection.

We developed a novel pattern recognition method called Combined Detection of Parking Occupancy on Chip (ComDPOCh), which offers a promising solution for efficient parking space monitoring. This method, the outcome of rigorous research, forms the basis of a comprehensive four-phase solution addressing critical challenges in real-time parking management.

The implications of this research extend to both practical applications and future studies. Practically, the proposed method can significantly enhance the reliability and efficiency of smart parking systems, particularly in urban areas where such solutions are in high demand. Integration into CI/CD pipelines will facilitate seamless implementation and thorough testing under diverse environmental conditions. However, legal and ethical issues, such as the suppression of personal data throughout picture processing, remain significant obstacles that must be solved to maintain compliance and create user confidence.

To increase system robustness, future research should focus on enhancing the reliability of occupancy detection in tough settings such as low visibility or weather-related issues. Furthermore, a more thorough examination of security and privacy of data standards would assure regulatory compliance while also enabling new applications. Addressing these issues will refine the proposed solution and contribute significantly to advancements in intelligent transportation systems.

Acknowledgements
The work reported here was supported by Erasmus+ ICM 2023 No. 2023-1-SK01-KA171-HED-000148295.

Informed consent
Not applicable

Conflict of interest
The author(s) declare(s) that they have no conflict(s) of interest.

Ethical approval
Not applicable.

Data Availability Statement
Not applicable.

References

[1] V. Todorović and K. Ristić, Regional economy and new international economic and financial challenges, International Thematic Proceedings; Proceedings - Marking the anniversary of three decades scientific forum "Danube river of cooperation", International scientific forum - Danube rover of cooperation - international scientific society, ISF DRC, Belgrade, e-format, Section - Selected papers number 10, ISBN 978-86-82825-20-0, 2019.

[2] P. Dakić, L. Filipović and M. Starčević, "Application of fundamental analysis in investment decision making: example of a domestic business entity," in *ITEMA 2019*, 2019.

[3] P. Dakić and V. Todorović, "Isplativost i energetska efikasnost autonomnih vozila u EU," *FBIM Transactions,* vol. Vol. 9 No 2, October 2021.

[4] P. Demeter and P. Dakic, "Visualization of Code Metrics for Code Quality and Assessment of Breach of Standards," in *2024 14th International Conference on Advanced Computer Information Technologies (ACIT)*, 2024.

[5] K. Ristic, R. Tesic, I. Zivotic, M. Djuran and V. Todorovic, Socioeconomic, Ecological and Financial Aspects of the Global Economy in the Western Balkan Countries, International thematic collection of works; Proceedings - Marking the anniversary of three decades scientific forum ``Danube river of cooperation'', International scientific forum - Danube rover of cooperation - international scientific society, ISF DRC, Belgrade, e-format, Section - Selecteted papers number 11, ISBN 978-86-82825-20-0, 2019.

[6] P. Dakić, "Software compliance in various industries using CI/CD, dynamic microservices, and containers," *Open Computer Science,* vol. 14, January 2024.

[7] P. Dakić, V. Todorović and V. Vranić, "Financial Sustainability of Automotive Software Compliance and Industry Quality Standards," in *Proceedings of Eighth International Congress on Information and Communication Technology*, Springer Nature Singapore, 2023, p. 477–487.

[8] J. Ágh, I. Makarova and P. Dakić,

[9] P. Dakić, V. Todorovic and B. Petrovic, "Investment reasons for using standards compliance in autonomous vehicles," *Economic and Social Development: Book of Proceedings,* p. 219–228, 2021.

[10] P. Dakic, M. Zivkovic, L. Jovanovic, N. Bacanin, M. Antonijevic, J. Kaljevic and V. Simic, "Intrusion detection using metaheuristic optimization within IoT/IIoT systems and software of autonomous vehicles," *Scientific Reports,* vol. 14, October 2024.

[11] V. Todorovic and P. Dakić, *The future of robotic vehicles with the contradictions of process in the green agenda and production of different power sources,* 2024.

[12] V. Radovanović, O. Krčadinac, J. Perišić, M. Milovanović and Ž. Stanković, "Comparison of Agile and Devops Methodologies: Analysis of Efficiency, Flexibility, and Application in Software Development," *JITA -Journal of Information Technology and Application,* vol. 14, pp. 78-83, June 2024.

[13] Ž. E. Nataša Đalić, "Digital Transformation as a Starter of the Creation of new Economic Business Models," *JITA -Journal of Information Technology and Application,* vol. 14, June 2024.

[14] T. Golis, P. Dakić and V. Vranić, "Creating Microservices and using infrastructure as code within the CI/CD for dynamic container creation," in *2022 IEEE 16th International Scientific Conference on Informatics (Informatics)*, 2022.

[15] P. Dakić, D. Lojaničić, H. Issa and M. Bogavac, "Choosing, creating and developing managers," *Oditor,* vol. 7, p. 105–134, 2021.

[16] N. Hroncova and P. Dakic, "Research Study on the Use of CI/CD Among Slovak Students," in *2022 12th International Conference on Advanced Computer Information Technologies (ACIT)*, 2022.

[17] P. Dakic, V. Todorovic and V. Vranic, "Financial Justification for using CI/CD and Code Analysis for Software Quality Improvement in the Automotive Industry," in *2022 IEEE Zooming Innovation in Consumer Technologies Conference (ZINC)*, 2022.

[18] F. Cák and P. Dakić, "Creating Feature Model for YAML Generator in CI/CD Pipelines with React Web Application," in *Proceedings of Ninth International Congress on Information and Communication Technology*, Springer Nature Singapore, 2024, p. 529–539.

[19] R. Szarka, P. Dakic and V. Vranic, "Cost-Effective Real-time Parking Space Occupancy Detection System," in *2022 12th International Conference on Advanced Computer Information Technologies (ACIT)*, 2022.

[20] P. Dakić, "Importance of knowledge management for CI/CD and Security in Autonomous Vehicles Systems," *JITA -Journal of Information Technology and Application,* vol. 1, pp. 7-16, June 2024.

[21] P. Dakić, I. Stupavský and V. Todorović, "The Effects of Global Market Changes on Automotive Manufacturing and Embedded Software," *Sustainability,* vol. 16, p. 4926, June 2024.

[22] A. Petričko, P. Dakić and V. Vranić, "Comparison of Visual Occupancy Detection Approaches for Parking Lots and Dedicated Containerized REST-API Server Application," in *CEUR Workshop ProceedingsVolume 32372022 9th Workshop on Software Quality Analysis, Monitoring, Improvement, and Applications, SQAMIA 2022*, 2022.

[23] I. Stupavský and V. Vranić, "Analysing the controversial social media community," in *2022 IEEE 16th International Scientific Conference on Informatics (Informatics)*, 2022.

[24] A. Shazmeen, P. Dakic and Z. A. Dhulfiqar, *B2A, A Straight-Through Approach from Basics to Advanced Level: Case Study for Python Course,* 2024.

[25] Ideapoke, *Balancing Sensor Cost and Automotive Disruption,* 2024.

[26] O. Shire, *How Car Sensor Technology is Transforming the Automotive Industry,* 2024.

[27] S. Jeyachandran, *Meet the 6th-generation Waymo Driver: Optimized for costs, designed to handle more weather, and coming to riders faster than before,* 2024.

[28] Y. Xie, Y. Guo, S. Yang, J. Zhou and X. Chen, "Security-Related Hardware Cost Optimization for CAN FD-Based Automotive Cyber-Physical Systems," *Sensors,* vol. 21, p. 6807, October 2021.

[29] P. Dakić, "Significance of Standards Compliance Organizations for the Sustainable Automotive Software and Car Production," *Acta Polytechnica Hungarica,* vol. 21, 2024.

[30] V. Todorovic, P. Dakic and M. Aleksic, "Company management using managerial dashboards and analytical software," *ESD Conference, Belgrade 75th International Scientific Conference on Economic and Social Development Development, ESD Conference Belgrade, 02-03 December, 2021 MB University, Teodora Drajzera 27, 11000 Belgrade, Serbia;,* 2021.

[31] Q. Wu, C. Huang, S. Wang, W. Chiu and T. Chen, "Robust Parking Space Detection Considering Inter-Space Correlation," in *2007 IEEE International Conference on Multimedia and Expo*, 2007.

[32] S. Liu, "Robust vehicle detection from parking lot images," *IEEE Transactions on Geoscience and Remote Sensing PP(99):1-12,* p. 27, 2018.

[33] M. Krocka, P. Dakic and V. Vranic, "Automatic License Plate Recognition Using OpenCV," in *2022 12th International Conference on Advanced Computer Information Technologies (ACIT)*, 2022.

[34] S. Funck, N. Mohler and W. Oertel, "Determining car-park occupancy from single images," in *IEEE Intelligent Vehicles Symposium, 2004*, 2004.

[35] C. Huang, Y.-S. Dai and S. Wang, "A surface-based vacant space detection for an intelligent parking lot," in *2012 12th International Conference on ITS Telecommunications*, 2012.

[36] G. Amato, F. Carrara, F. Falchi, C. Gennaro and C. Vairo, "Car parking occupancy detection using smart camera networks and Deep Learning," in *2016 IEEE Symposium on Computers and Communication (ISCC)*, 2016.

[37] R. S. Feris, B. Siddiquie, J. Petterson, Y. Zhai, A. Datta, L. M. Brown and S. Pankanti, "Large-Scale Vehicle Detection, Indexing, and Search in Urban Surveillance Videos," *IEEE Transactions on Multimedia,* vol. 14, p. 28–42, February 2012.

[38] P. K. Bhaskar and S. Yong, "Image processing based vehicle detection and tracking method," in *2014 International Conference on Computer and Information Sciences (ICCOINS)*, 2014.

[39] G. L. Foresti, C. Micheloni and L. Snidaro, "Event classification for automatic visual-based surveillance of parking lots," in *Proceedings of the 17th International Conference on Pattern Recognition, 2004. ICPR 2004.*, 2004.

[40] C. G. del Postigo, J. Torres and J. M. Menéndez, "Vacant

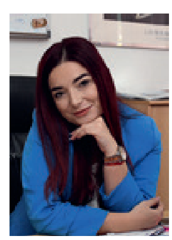
parking area estimation through background subtraction and transience map analysis," *IET Intelligent Transport Systems,* vol. 9, p. 835–841, 2015.
[41] N. C. Mithun, N. U. Rashid and S. M. M. Rahman, "Detection and Classification of Vehicles From Video Using Multiple Time-Spatial Images," *IEEE Transactions on Intelligent Transportation Systems,* vol. 13, p. 1215–1225, September 2012.
[42] J. Chen, F. Li, Y. Fu, Q. Liu, J. Huang and K. Li, "A study of image segmentation algorithms combined with different image preprocessing methods for thyroid ultrasound images," in *2017 IEEE International Conference on Imaging Systems and Techniques (IST)*, 2017.
[43] Y. Jin, J. Li, D. Ma, X. Guo and H. Yu, "A Semi-Automatic Annotation Technology for Traffic Scene Image Labeling Based on Deep Learning Preprocessing," in *22017 IEEE International Conference on Computational Science and Engineering (CSE) and IEEE International Conference on Embedded and Ubiquitous Computing (EUC)*, 2017.
[44] M. Krocka, P. Dakic and V. Vranic, "Extending Parking Occupancy Detection Model for Night Lighting and Snowy Weather Conditions," in *2022 IEEE Zooming Innovation in Consumer Technologies Conference (ZINC)*, 2022.
[45] W. S. J. Saputra, E. Y. Puspaningrum, W. F. Syahputra, A. P. Sari, Y. V. Via and M. Idhom, "Car Classification Based on Image Using Transfer Learning Convolutional Neural Network," in *2022 IEEE 8th Information Technology International Seminar (ITIS)*, 2022.
[46] Y. Schegolikhin, M. Mitrokhin and A. Eremin, "Image Preprocessing to Improve Object Recognition in Complex Weather Conditions," in *2023 International Russian Smart Industry Conference (SmartIndustryCon)*, 2023.
[47] G. Meng, Y. Wang, J. Duan, S. Xiang and C. Pan, "Efficient Image Dehazing with Boundary Constraint and Contextual Regularization," in *2013 IEEE International Conference on Computer Vision*, 2013.
[48] A. Bhandari, A. Kafle, P. Dhakal, P. R. Joshi and D. B. Kshatri, "Image Enhancement and Object Recognition for Night Vision Surveillance," *arXiv:2006.05787 [cs, eess],* June 2020.
[49] D. Chen, M. He, Q. Fan, J. Liao, L. Zhang, D. Hou, L. Yuan and G. Hua, "Gated Context Aggregation Network for Image Dehazing and Deraining," *arXiv:1811.08747 [cs],* December 2018.
[50] G. OpenCV, "OpenCV: Image Segmentation with Watershed Algorithm," May 2023.
[51] P. Dakić and M. Živković, "An overview of the challenges for developing software within the field of autonomous vehicles," in *7th Conference on the Engineering of Computer Based Systems*, 2021.
[52] F. Cák and P. Dakić, "Configuration Tool for CI/CD Pipelines and React Web Apps," in *2024 14th International Conference on Advanced Computer Information Technologies (ACIT)*, 2024.

Received: October 26, 2024
Accepted: November 19, 2024

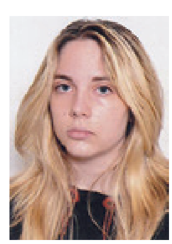
About the authors

Dr Pavle Dakić, PhD. holds a PhD in Electrical Engineering and Computing from Singidunum University, Belgrade and a second PhD. degree in Applied Informatics from the Faculty of Informatics and Information Technologies, Slovak University of Technology. His current research interests include computer networks, AI security, high-performance systems (HPC), Internet of Things (IoT), software development and testing, SEO/SEM, CI/CD, encryption, and data security, as well as business applications of telecommunications technologies.

Mohammad Daud Haiderzai is a PhD scholar at the Faculty of Informatics and Information Technologies, Slovak University of Technology. He currently works as a lecturer and software engineer. His research interests include organizational and design patterns, software development and testing, data security and encryption, high-performance computing (HPC), Internet of Things (IoT), continuous integration and delivery (CI/CD), and enterprise software product development.



Anja Dragojević for the last 3 years, she has been employed at the Pan-European University Apeiron as Erasmus+ coordinator and Administrator of the Career Guidance Center. She is also a fourth-year bachelor's student at the Faculty of Business Economics, majoring in Banking, Finance, and Trade Management.



Anastasija Dragonić - Uremović is currently a second-year student of Computer Multimedia and Graphics at the Faculty of Information Technologies of the Pan-European University Apeiron. In addition to her studies, she is currently employed in the IT support sector at the mentioned faculty.

For citation

Pavle Dakić, Mohammad Daud Haiderzai, Anja Dragojević, Anastasija Dragonić-Uremović, Pattern Proposal for detecting object occupancy in AVs utilizing ML, Edge Cloud, AI, and CV for parking LoTs, *JITA – Journal of Information Technology and Applications, Banja Luka*, Pan-Europien University APEIRON, Banja Luka, Republika Srpska, Bosna i Hercegovina, JITA 14(2024)2:93-103, (UDC: 004.414.23:656.1.08), (DOI: 10.7251/JIT2402093D, Volume 14, Number 2, Banja Luka, December (89-188), ISSN 2232-9625 (print), ISSN 2233-0194 (online), UDC 004