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Case study: software solution for vehicle license plate detection

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Abstract. This article illustrates the development of a software product aimed at automated recognition and classification of vehicle license plates using camera video images. The project goal is to facilitate and optimize the processes of access control and traffic management in restricted areas, including parking lots and private and corporate zones. The developed software product enables real-time analysis of the video stream, extraction of license plates, and their subsequent reading and identification. The article describes the technological development, including the selection of software tools. Furthermore, it discusses the advantages of the created software compared to other available market solutions, highlighting its efficiency, flexibility in settings, and potential for scaling and integration with other security and access management systems.

Keywords: automated license plate recognition, access control, video image analysis, software development, security systems integration, real-time analysis, vehicle identification

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Кейс: разработка программного решения для распознавания номеров транспортных средств

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Аннотация. В представленной статье освещается процесс разработки программного продукта, направленного на автоматизированное распознавание и классификацию номерных знаков автомобилей с использованием видеоизображений с камер. Целью проекта является облегчение и оптимизация процессов контроля доступа и управления транспортными потоками на территориях с ограниченным доступом, в том числе на парковках, в частных и корпоративных зонах. Разработанный программный продукт предоставляет возможность в реальном времени анализировать видеопоток, выделять из него номерные знаки и производить их считывание и идентификацию. В статье описывается технологический процесс разработки, включая выбор программных инструментов. Помимо этого, рассматриваются преимущества созданного программного обеспечения в сравнении с другими доступными на рынке решениями; отмечается его эффективность, гибкость настроек, потенциал для масштабирования и интеграции с другими системами безопасности и управления доступом.

Ключевые слова: автоматизированное распознавание номерных знаков, контроль доступа, анализ видеоизображений, разработка программного обеспечения, интеграция систем безопасности, анализ в реальном времени, идентификация транспортных средств

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Introduction

In an era where the demand for heightened security measures at enterprises, especially those with stringent security requirements, is ever-increasing, the relevance of developing software for recognising vehicle license plates from surveillance cameras is undeniable. Such an innovation automates access control in secured areas, significantly enhancing security levels and minimising the risk of unauthorised entry. The integration of advanced artificial intelligence and computer vision technologies in these systems enables the real-time recognition of vehicle license plates and their comparison with a database of vehicles authorised for entry [1]. It ensures high identification accuracy and dramatically speeds up vehicle passage through checkpoints, eliminating the need for security personnel to check documents manually. However, creating such systems involves tackling complex issues beyond the technical aspects, including the crucial need for personal data protection. Given that any information related to vehicle movements is confidential [2], it is imperative to implement robust encryption mechanisms and comply with data protection regulations to prevent data breaches or unauthorised access.

Moreover, an essential aspect of this development is the software integration with existing enterprise security and surveillance systems. It requires compatibility with various types of cameras and recording devices, access management systems, and databases of employees and vehicles. Such integration should allow for flexible access rule settings, considering different facilities specific operational needs and security regimes [3].

Developing software for identifying vehicle license numbers on surveillance cameras is a promising field that can potentially bolster enterprise security levels significantly. This process involves leveraging the latest advancements in artificial intelligence and data protection methodologies for seamless integration with existing security systems [4].

A review of the available software solutions in the market, such as HikVision, Tral-Parking, and AutoTRASSIR [5–7], reveals a diversity in approaches and functionalities each offers. For instance, HikVision is noted for its usability flexibility but requires individual management of each camera, which can be cumbersome with many cameras. On the other hand, Tral-Parking offers easy-to-install modules but faces limitations in integration and online management. AutoTRASSIR stands out for its capability to work with any camera and provides deeper customisation options, though its higher cost may pose a barrier for some organisations.

Considering these factors, developing a bespoke solution becomes a logical step for entities aiming to tailor a system that perfectly matches their enterprise

unique needs and conditions. This approach ensures better integration with current security and surveillance systems and allows for more flexible adjustments to recognition and responses to various scenarios. Additionally, owning proprietary software opens up possibilities for its further development and adaptation to evolving requirements and technological innovations, potentially offering a more cost-effective and efficient solution in the long term.

Methods

After an exhaustive comparative analysis of the existing market solutions, a detailed evaluation revealed their advantages and limitations, highlighting critical considerations for formulating our bespoke software project. This comprehensive market overview paved the way for the subsequent strategic decision-making phase, focusing on selecting the most apt programming tools and languages to ensure the project success. Among the various programming languages reviewed, including C++, C#, and Python, the latter emerged as the superior choice, particularly for tasks entailing real-time image processing and sophisticated data analytics [8, 9]. Python unparalleled strengths lie in its vast repository of specialized libraries and advanced tools dedicated to image manipulation and leveraging machine learning algorithms. This rich ecosystem positions Python as the quintessential programming language for crafting an innovative automatic vehicle license plate recognition system [10].

Its established reputation as the quintessential library within Python computer vision community dictated the decision to use the **cv2** library as the cornerstone for interfacing with cameras and managing video feeds [11]. **Cv2** offers an extensive array of functionalities essential for real-time image capture from cameras and encompasses a suite of tools designed for the initial processing and analytical examination of video content [12]. The **pytesseract** library tackled the intricate challenge of character and numeral recognition within images. This powerful tool facilitates the extraction of textual content from visual data, serving as a pivotal element in accurately identifying vehicle license plates. During the developmental phase, it became evident that enhancing recognition precision necessitated fine-tuning the image scanning parameters. This enhancement was adeptly achieved through meticulous adjustments in the program coding parameters, showcasing the adaptability of our approach [13, 14]. While **pytesseract** capability in discerning textual information proved highly effective, it encountered obstacles in precisely delineating vehicle numbers and regional codes. A strategic shift in focus on number recognition allowed circumventing the intricacies associated with regional code identification, thereby streamlining the process.

The deployment of the software product unveiled its capability to seamlessly connect to the camera system, subsequently presenting the video feed in real time alongside the accurately recognized vehicle number [15]. This initial success lays the groundwork for the future evolution of the software, envisaging functionalities like validating vehicle numbers for entry permissions and seamless integration with sophisticated access control mechanisms [16]. The journey to developing a cutting-edge automatic vehicle license plate recognition system entailed leveraging the synergistic potential of Python, complemented by the dynamic capabilities of the `cv2` and `pytesseract` libraries [17, 18]. This strategic amalgamation of programming prowess and technological innovation yielded a solution characterized by operational flexibility and task-oriented efficiency. The meticulously chosen development methodologies underscored the rationale behind the preferential selection of this particular technological pathway.

While inspired by examining diverse existing products such as HikVision, Tral-Parking, and AutoTRAS-SIR, the endeavour to engineer a proprietary solution was inspired by an ambition to surpass the limitations observed within these platforms. For instance, HikVision versatility is marred by the cumbersome requirement for individual camera management, which is impractical in scenarios involving extensive camera networks [19]. Conversely, Tral-Parking offers ease of installation but falls short regarding integration flexibility and online management capabilities. AutoTRAS-SIR distinguishes itself with compatibility across various camera types and intricate configuration options, albeit at a cost that may deter budget-conscious organizations [20].

This meticulous analysis and resultant strategic direction towards creating a tailor-made solution are predicated on the aspiration to fulfil each enterprise unique security and operational requirements. Such an initiative guarantees enhanced integration with extant security protocols and surveillance infrastructure, along with the latitude to finely tune recognition and responses to diverse situational exigencies. Moreover, owning the proprietary software engenders opportunities for ongoing refinement and adaptation in response to evolving security challenges and technological advancements, ultimately heralding a cost-efficient and effective long-term solution.

Results

Throughout the project development phase, a specialized software product was meticulously crafted, focusing on the real-time reading and recognition of vehicle license plates. This software showcases an impressive ability to seamlessly integrate with various camera types, encompassing standard surveillance

cameras and webcams. It offers users unparalleled flexibility in selecting their video stream source by specifying the camera ID in the program code.

Upon initiating the application, it automatically establishes a connection with the designated camera, enabling the user to witness a live broadcast. One of the system standout features is its capability to configure the detection area for license plates, enhancing the precision of recognition and making it adaptable to varying environmental conditions. The software employs a separate display window to display the identified license plate number, where the outcome of the frame processing is vividly presented.

The primary focus during the software development was on augmenting the accuracy of license plate identification. It was discovered that both the quality of the captured image and the adjustments made to the recognition zone profoundly impact the accuracy of the results. Through rigorous testing, it became evident that meticulous calibration of these parameters, coupled with optimal visibility of the license plates, significantly enhances the system recognition accuracy. The endeavour to refine the software functionality involved an iterative process of tuning and optimization aimed at achieving an optimal balance between image clarity and the precision of the detection zone configuration. This meticulous approach to development ensured that the software not only met but exceeded expectations regarding its ability to identify vehicle license plates under diverse conditions accurately.

This software solution represents a significant advancement in vehicle identification technology, providing users with a powerful tool that combines advanced image processing techniques with user-friendly customization options.

The success of this project is a testament to the potential of integrating cutting-edge technological innovations with practical applications, offering a glimpse into the future possibilities of surveillance and security measures. The outcome of this project has laid a solid foundation for further explorations and enhancements in the realm of automated vehicle identification systems, promising to usher in a new era of efficiency and reliability in surveillance operations.

Conclusion

Throughout the development of a new software product designed to identify license plates from video cameras, an extensive analysis of existing solutions was conducted, revealing their strengths and weaknesses. This crucial step enabled the formulation of specific requirements for the system under development, taking into account the unique aspects of the task at hand and the diverse needs of the users. The decision to utilize Python as the programming language proved exceptionally beneficial due to its versatility, the avail-

ability of powerful libraries for image processing, and its capabilities for machine learning.

The project demonstrated the feasibility of creating a functioning real-time license plate recognition system. The application of the **cv2** library for video stream analysis and **pytesseract** for text recognition confirmed that these tools could effectively address the challenge. However, they require fine-tuning to enhance the accuracy and stability of their performance.

The limitations encountered, particularly in accurately identifying regional codes on the license plates, underscore the necessity for continued refinement of the project. Developing a proprietary machine-learning algorithm or employing more advanced artificial intelligence models could significantly improve outcomes. Not only would this enhance the precision of identification, but it would also expand the product functionalities, such as adding the capability to determine the type of vehicle.

It is worth noting that the developed product holds significant potential for integration with other security and access control systems, opening up new possibilities for its application within enterprises and across urban infrastructure, parking lots, toll roads, and other sectors.

The project reaffirmed the relevance and importance of automatic license plate recognition and outlined directions for its further development. The insights gained and the experience accumulated during this endeavour can serve as a foundation for future projects in access management systems and security provision.

Discussion

In the realm of automatic license plate recognition (ALPR) systems, our project embarked on a journey not just to mimic the existing market solutions, but to innovate and refine license plate identification from video streams. This journey brought to light several insights and provoked discussions around integrating technology in security systems, the evolution of machine learning models, and the broader implications for privacy and data security [21].

One of the pivotal discussions sparked by our project centres around the technological backbone of ALPR systems – the programming language and libraries chosen for development. With its robust libraries like **cv2** for video processing and **pytesseract** for optical character recognition, Python stood out as a clear frontrunner. However, the choice of tools was not without its challenges [22]. For instance, the **cv2** library, while powerful for video stream analysis, required significant adjustments to optimize for real-time processing. The intricacies in configuring the detection zone underscore the need for a balance between flexibility and user-friendliness in design. An exciting ex-

ample of this was observed when adjustments to the lighting and angle of the camera dramatically improved the system accuracy, highlighting the importance of environmental considerations in system deployment.

The discussion around **pytesseract** brings forth the limitations of current text recognition technologies when applied to diverse and complex tasks such as license plate recognition. While **pytesseract** performs admirably in extracting text from images, the nuance of recognizing stylized characters and regional codes on license plates posed a considerable challenge. It led to the exploration of custom machine learning algorithms inspired by advancements in AI research, such as deep neural networks capable of contextual learning from vast datasets of license plate images. The exploration into these advanced models suggests a future where ALPR systems could not only recognize license plates but also categorize vehicle types and potentially detect stolen vehicles in real time, offering a glimpse into the expansive potential of AI in public safety applications.

Furthermore, our project implications extend beyond technical achievements, touching on vital privacy and data protection discussions. The capability to identify and track vehicles in real time raises significant privacy concerns, necessitating a dialogue on the ethical use of ALPR technologies [23]. The project underscored the importance of incorporating stringent data protection measures, such as encryption and secure data storage, to safeguard sensitive information. It is particularly crucial in integrating ALPR systems with broader security and surveillance networks, where the potential for data misuse is heightened.

As demonstrated in our project, the integration potential of ALPR systems opens up fascinating avenues for their application across various sectors. The use cases are vast, from enhancing security protocols in corporate environments to streamlining traffic management in urban settings. An illustrative example is the deployment of ALPR systems in parking management, where they can automate entry and exit controls, reduce congestion, and even assist in locating stolen vehicles. Similarly, integrating ALPR systems with toll collection mechanisms can automate billing processes, improving efficiency and reducing manual errors.

In conclusion, the discussions emerging from our project highlight the multifaceted impact of ALPR technologies. From the technical challenges and solutions to the ethical considerations around privacy, the project contributes to a broader understanding of the role of technology in modern security systems. As we look to the future, the continuous evolution of machine learning models and the integration of ALPR systems with existing infrastructures present exciting opportunities for innovation. However, they also emphasize the critical need for ongoing dialogue on balancing technological advancements with ethical and privacy

considerations, ensuring these systems serve the public good while respecting individual rights.

Furthermore, solutions like the one discussed in our article prove to be exceptionally effective under circumstances where financial constraints are prevalent or when the request to create a system is so unique that off-the-shelf solutions fail to meet the specific needs. This aspect introduces an additional layer to the discussion, emphasising the adaptability and cost-effectiveness of bespoke ALPR systems.

Financial constraints often force organisations to seek solutions that provide the best value for their investment. As our project outlines, developing a custom ALPR system allows for a more controlled expenditure, where resources can be allocated efficiently to meet the core requirements without the overhead costs associated with commercial products. This approach not only makes advanced technology accessible to entities with limited budgets but also ensures that their investment is directly contributing to solving their specific challenges.

The uniqueness of specific system requirements cannot be overstated. Every organisation operates within its rules, environments, and challenges. For instance, a company operating in a region with specific types of vehicle license plates, uncommon fonts, or formats might find that generic ALPR systems are inadequate for their needs. In such cases, the ability to tailor the

ALPR system to recognise these unique characteristics becomes invaluable. Our project illustrated this by customising recognition algorithms to improve accuracy for specific license plate types, showcasing the potential for tailored solutions to address niche requirements effectively.

Moreover, these bespoke solutions offer the flexibility to evolve alongside the organisation changing needs. As new types of vehicles are introduced or as the company expands its operations to new locations with different license plate standards, the system can be adapted accordingly. It contrasts sharply with off-the-shelf solutions, which might require significant additional investment or not be feasible to adapt.

In summary, the added discussion points reinforce the notion that custom-developed ALPR solutions, such as the one described in our article, hold significant value in scenarios marked by financial limitations or highly individualised requirements. They offer a pathway to adopting cutting-edge technology within a constrained budget and provide a fit-for-purpose solution that off-the-shelf products cannot match. This adaptability and cost-efficiency further underscore the broader implications of our project, highlighting its contribution to advancing the dialogue on the strategic deployment of technology in security and surveillance applications.

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