SR'S: License plate recognition

SR'S: Reconhecimento de placas de veículos

SR'S: Reconocimiento de matrículas

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Abstract:
This article aims to address the growing problem arising from the exponential increase in the number of vehicles in circulation around the world, which is resulting in increasingly complex challenges about urban traffic. To solve this pressing issue, a project called the Security Recognition Service (SR's) was conceived. This project proposes automated solutions through the implementation of a device equipped with an advanced license plate recognition system. This device is complemented by a highly specialized data management system, specifically tailored to meet the needs of condominiums and similar urban spaces. To achieve this ambitious goal, concepts from the Internet of Things (IoT) will be applied in the development of the device. The heart of this system will be a Raspberry Pi minicomputer and a condominium's desktop platform, facilitating the seamless integration of cutting-edge technologies, including Python, Java, MySQL, OpenCV, and a host of other essential components and technologies, among others.

Resumo:
Este artigo aborda o crescente problema decorrente do aumento exponencial do número de veículos em circulação em todo o mundo, fato que resulta em desafios cada vez mais complexos sobre o trânsito urbano. Para resolver esse problema urgente, foi concebido um projeto chamado Serviço de Reconhecimento de Segurança (SR's). Este projeto propõe soluções automatizadas através da implementação de um dispositivo equipado com um avançado sistema de reconhecimento de placas, complementado por um sistema de gestão de dados altamente especializado, especificamente adaptado para atender às necessidades de condomínios e espaços urbanos similares. Para alcançar esse ambicioso objetivo, conceitos da Internet das Coisas (IoT) serão aplicados no desenvolvimento do dispositivo. O núcleo deste sistema será um minicomputador *Raspberry Pi* e uma plataforma de *desktop* do condomínio que facilitarão a integração de tecnologias de ponta, incluindo *Python*, *Java*, MySQL, OpenCV entre outros componentes e tecnologias essenciais.

Resumen:
Este artículo aborda la creciente problemática derivada del aumento exponencial del número de vehículos en circulación en todo el mundo, hecho que se traduce en retos cada vez más complejos en materia de tráfico urbano. Para resolver este problema urgente, se concibió un proyecto llamado Servicio de Reconocimiento de Seguridad (SR's). Este proyecto propone soluciones automatizadas a través de la implementación de un dispositivo equipado con un sistema avanzado de reconocimiento de matrículas, complementado con un sistema de gestión de datos altamente especializado, específicamente adaptado para satisfacer las necesidades de condominios y espacios urbanos similares. Para lograr este ambicioso objetivo, se aplicarán conceptos de Internet de las Cosas (IoT) en el desarrollo del dispositivo. El núcleo de este sistema será una minicomputadora *Raspberry Pi* y una plataforma de escritorio de condominios que facilitará la integración de tecnologías punteras, incluyendo *Python*, *Java*, MySQL, OpenCV entre otros componentes y tecnologías esenciales.

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1. INTRODUCTION

Due to the constant increase in the number of vehicles in circulation around the world, challenges arise in traffic, especially in its management and access control in parking lots, both in public and private places. This is especially seen in densely populated regions, such as the state of São Paulo.

According to data from the Secretaria Nacional do Trânsito (SENATRAN), in 2022, the fleet of vehicles registered in the country exceeded 115 million, with approximately 35 million of these vehicles being in the state of São Paulo.

This excessive number of vehicles in a single region justifies the problems of congestion and difficulties in access control. Given the data presented, the question arises: what can we develop to solve these problems related to traffic management?

This project aims to develop a simulation of a license plate recognition system, aiming to automate access control in condominium parking lots. Thus allowing the optimization of the entry process and an improvement in traffic management.

The system has an application for controlling data related to the condominium. In addition to a device that performs the identification of vehicle license plates and the possible release of the vehicle to access the place.

2. THEORETICAL RATIONALE

A chapter dedicated to theoretical rationale will present the main topics that permeate this project.

2.1. LICENSE PLATE RECOGNITION

Among the main technologies used for the automatic recognition of license plates, Computer Vision techniques stand out. One of the fundamental advantages of these techniques is their non-intrusive nature since they do not require any type of intervention in the vehicles being inspected. The only requirement for its operation is to obtain digital images of these vehicles, which can be carried out using cameras controlled by devices with predefined commands.

This process can be divided into three steps: locating the plate, segmenting the characters present on the plate, and recognizing the plate. However, finding a unique solution to this problem is a complex task, considering that the images captured can present significant variations in the license plate models, in addition to being subject to various weather conditions, and lighting variations.

Then, it is possible to use the technology to perform license plate recognition through a device with predefined commands, as well as a system that manages the data obtained from access control to a given location.

2.2. COMPUTATIONAL VISION

Computational Vision techniques have a key role in a wide range of applications, from pattern recognition and object identification in medical imaging to camera-based security systems and autonomous vehicles.

To achieve these goals, the steps involved in the computer vision process may include image pre-processing, feature detection, segmentation, recognition, and interpretation of the visual elements present in the image (BARELLI, 2018).

These technologies are rapidly evolving and have the potential to transform many industries, making machines able to "see" and understand the visual world in an increasingly sophisticated and accurate way.

The process for the development of these technologies requires a predefined set of steps, from the acquisition of the image to the extraction of the information it contains (GONZALEZ, WOODS, 2009).

2.3. IoT

The Internet of Things (IoT) is the interconnection of physical devices through the internet. According to Magrani (2018), it has a wide range of applications, from smart homes to industrial optimization and smart cities, connecting devices such as sensors, cameras, and home appliances to the internet.

According to Oliveira (2017), IoT collects valuable data on behaviors and usage patterns, enabling automation of tasks and offering data-driven insights, so IoT has the potential to revolutionize several industries.

3. MATERIALS AND METHODS

In this chapter, we will thoroughly explore the materials and methods employed in conducting this study. The quality and rigor of this work depend directly on the precision and clarity of the techniques employed, as well as the instruments and materials used.

3.1. MATERIALS

To develop this project, we have used technologies such as Java, Python, Open Source Computer Vision Library (OpenCV), and MySQL. In addition, IoT (Internet of Things) concepts were applied to build a device using the Raspberry Pi minicomputer.

Figure 1 – Technologies used
Source: From own author, 2023.

3.1.1. JAVA

Java is an object-oriented, cross-platform programming language designed to be robust, portable, and secure, as Junior (2021, p.10) states. According to Caelum (2003, p.4), Java was developed with the objective to be implemented in small devices, however, with the advancement of the internet, it was modified to meet the demands of the Web through small applications.

As declared by Schildt (2015, p.6), the secret for Java to be highly portable and secure is the use of a compiler that is not an executable code, but a bytecode. A bytecode is a highly optimized set designed to be executed by a Java Virtual Machine (JVM). The JVM allows a program to run in a variety of environments because it only requires its implementation for each specific platform. Once the JVM is present on a given system, any Java program can run on it.

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In addition to the JVM, according to Caelum (2003), there are two other major responsible for both the execution and development of a Java application, namely the JRE (Java Runtime Environment) and the JDK (Java Development Kit).

JRE is a Java runtime, consisting of the JVM and libraries, which the essential for running any Java application. The JDK has all the tools for developing a Java application. That is, it includes a compiler, a debugger (identifies and corrects errors), and the JRE to run the programs.

3.1.2. PYTHON

Python is a high-level, open-source programming language that was created by Guido Van Rossum in 1991. It stands out for its elegance and clear syntax, making it a popular choice for programmers of all experience levels.

It is known for its dynamic typing and interpretive nature, which means that the code is executed line by line, which helps in the testing and debugging of programs (PYTHON, 2023).

Python offers a wide variety of high-level data structures, such as lists, dictionaries, and sets, making it effective for manipulating complex data (BORGES, 2010). In addition, it is a versatile language, used in a variety of areas, from application development to automation and machine learning.

Their approach to object-oriented programming is simple and efficient, allowing developers to organize code in a reusable manner. The wide range of available libraries and frameworks makes it a solid choice for developing applications in a variety of areas, driving its popularity in its market (PYTHON, 2023).

3.1.3. OPENCV

The OpenCV (Open Source Computer Vision Library) is an open-source library that is widely used for image processing and computer vision.

According to Antonello (2017), it provides a comprehensive set of functions and algorithms that allow developers to work with object detection, and facial recognition, among others.

The OpenCV library has a wide range of features and modules. According to Marengoni (2014), some of the main ones are image processing, object detection and tracking, facial recognition, stereo vision and camera calibration, and machine learning.

3.1.4. MYSQL

According to Milani (2007, p.22), MySQL is the most widely used Open-Source Relational Database Management System (RDBMS) in the world. Initially designed to meet the needs of small-sized and medium-sized applications. Nowadays, MySQL can be used in large applications and with more advantages than its competitors.

According to Carvalho (2015), MySQL, like any database, consists of fields, columns, rows or tuples, and tables. The fields are used for the insertion of a specific piece of data; columns store the records for a given field; Tuples are the record rows of a set of fields; and tables are the sets of rows, fields, and columns. For a better visualization, below is an example of how these components compose a database.

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Figure 2 - Database Table's composing
Source: (MySQL, 2015, p.5)

3.1.5. RASPBERRY PI
The Raspberry Pi is a single-board computer developed by the Raspberry Pi Foundation, one of whose founders was the renowned Eben Upton.

According to Upton (2017), each version of the Raspberry has its specifications and features, ranging from the processor to the amount of RAM and the communication interfaces that can vary between models. However, according to Ebermam (2017), it still supports different operating systems, with Raspbian (a Linux distribution) being the most commonly used.

3.2. METHOD OF APPROACH
The method of approach used in this work is quantitative-qualitative. According to Creswell (2007), the distinction between quantitative and qualitative research has resided in the number-word dichotomy, which limits a broad understanding of the definition of assumptions, strategies, and methods.

It is an important agenda for contemporary research, as recognizing the nuances and complementarities between quantitative and qualitative approaches can enrich our investigations and broaden our understanding of complex phenomena.

3.3. PROCEDURAL METHODS
Procedural methods are used to answer how the phenomenon was analyzed. The monographic or case study method was chosen; through which it will be possible to verify and conclude the studies of this project.

According to Lakatos and Marconi (2003, p. 108), the monographic method consists of the study of certain individuals, professions, conditions, institutions, groups, or communities, to obtain generalizations.

3.4. RESEARCH TECHNIQUES
The research technique that will be used is indirect documentation, through bibliographic research and documentary research.

The bibliographic research consists of the analysis and review of already published literature related to the topic in question. It allows for a broad review of previous theories, concepts, and discoveries, providing a solid foundation for knowledge building. In this regard, a comprehensive review of relevant books, academic articles, dissertations, and theses that address the topic of interest will be conducted.

Documentary research, on the other hand, involves the collection and analysis of written documents, records, reports, and other types of materials that were not originally produced for research purposes but that contain valuable information about the topic under study. This can include historical archives, government policies, company reports, and more. Documentary research is valuable to contextualize and enrich the data collected and the information obtained in bibliographic research.

By combining these two techniques, this study aims to gain an in-depth and comprehensive understanding of the research topic, drawing on existing knowledge in the literature and exploring documentary sources to provide additional insights. Bibliographic and documentary research represents a solid approach to the construction of knowledge and the theoretical foundation of the study, allowing a complete analysis of the topic in question.

4. RESULTS AND DISCUSSION

In this chapter, we will explore the development of the project and the result we hope to obtain from this work.

4.1. SRS AS PROTOTYPE

For the development of this work, it was necessary to think about what would be the physical devices that would help us for the detection of the plate and the eventual recognition of the object. After discarding some components, the use of the Raspberry Pi 4 minicomputer and a webcam was defined, as well as other objects that help in the manipulation of these components, such as a monitor, keyboard, and mouse.

When using the Raspberry, it would be necessary to perform a brief configuration on the device using an SD card as storage, to eventually add the license plate recognition algorithm programmed in Python applied along with the OpenCV library. Below you can see how all the equipment was arranged.
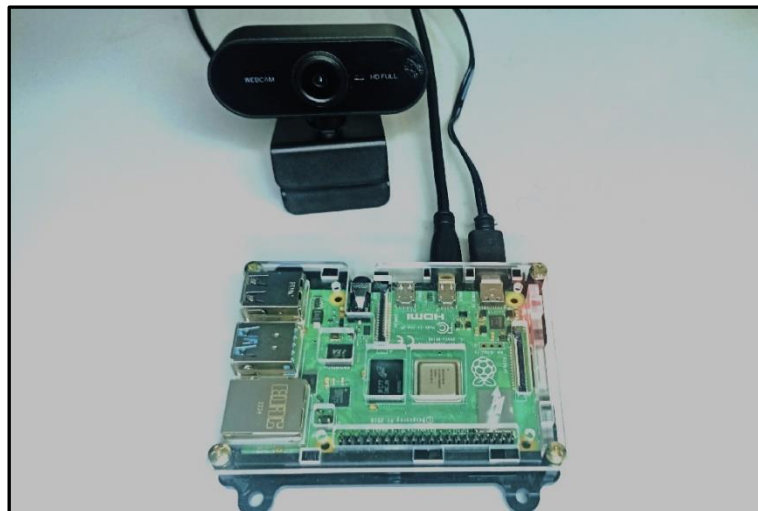

Figure 3 –SRs' components
Source: From own author, 2023.

4.2. SRS AS DESKTOP

The Java application we have developed plays a key role in the efficient data management of condominiums, their residents, and their respective vehicles. Having as its main objective of intermediating the data entry in this vehicle management system in condominiums, it offers a series of essential functionalities that make the process smooth and organized.

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One of the main functions of this application is to facilitate the registration of vehicles authorized to enter the condominium. Through the data collected by the condominium/gatekeeper of the residents and their vehicles, it would be possible to recognize the license plate and later release the vehicle's access to the condominium premises.

The application also offers a history of all vehicles that have entered the condominium, along with the date and time, providing a detailed view of all activities related to a particular vehicle.

Such information is extremely important because it is directly linked to the safety of the space.
In summary, Java application plays a crucial role in our system, simplifying access to information, improving security, and promoting more efficient administration.
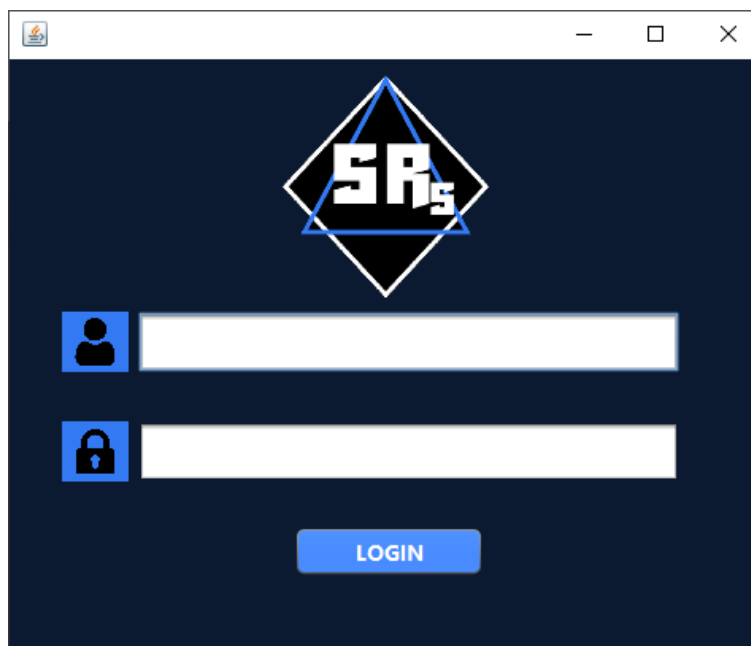

Figure 4 – Application Login Interface
Source: From own author, 2023.

4.3. EXPECTED RESULT
The expected results of this project are extremely promising, with the main goal being to significantly improve the effectiveness and agility of license plate recognition, due to the development of an algorithm dedicated to this purpose. The possible successful implementation of this algorithm represents a key milestone in the project's progress, with the potential to revolutionize several areas.
The algorithm we aim to develop will not only recognize license plates with high accuracy but will also be well done in real-time, providing agile and effective performance. This ability to recognize accurately and instantly has the potential to improve safety and efficiency in a variety of application areas. From traffic control, where it can improve road and road management, to public safety, allowing for quick identification of vehicles in critical situations, this algorithm has a significant impact.

In addition, its application goes beyond license plate recognition, with potential uses in a wide spectrum of object recognition, due to the methods and techniques involved in this project. This drives technological progress that can be applied in diverse industries, contributing to a safer and more efficient future. The benefits achieved through this project have the potential to transform the way we interact with the world around us, making our activities more agile, effective, and secure.

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5. CONCLUSION

This project was developed to automate the access control processes in condominiums, using important and modern concepts, as mentioned in other topics, for the construction of the application and the device. The result achieved was applicable, functional, and satisfactory in several contexts, although it was mainly directed to condominiums.

Even though it is recognized that the challenges related to traffic management are complex and difficult to solve, we believe that we have presented an interesting proposal to assist in this challenge. The validation of the proposed hypothesis, however, depends the presentations of arguments for or against the approach that has been adopted, and the acceptance rate of the proposal is something that is beyond our control.

SR's has a theoretically optimal functioning, but its effectiveness has not yet been proven. Therefore, to determine its utilization rate and level of utility, it would be necessary to deploy it in condominiums in a certain region, especially those with a high flow of people. Despite this limitation, we consider the overall result of the study as satisfactory.

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We would like to express our sincere gratitude to those who in any way participated directly or indirectly in this project that was presented to them.

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To our colleagues, who have supported us unwaveringly and shared the same enthusiasm for creating something truly innovative, we want to express our deep gratitude. This work is proof that we are capable of conquering and changing the world if we want this. We cannot forget to mention the importance of our teachers, whose instructions over the last three years have served as a basis for the construction of quality work, as well as taught. Due to you, we have built a valuable storehouse of knowledge that we will carry with great pride throughout our lives. Just as you make the world a better place by passing on all the knowledge you have gained throughout your lives, we are committed to doing the same, using all that we have inherited from you in a meaningful way.

We especially, want to express our special gratitude to the coordinators and advisors of the course, Jeferson Roberto de Lima and Rogério Bezerra Costa, who, despite the rigorous requirements, had a fundamental role, tirelessly motivating us to deliver a work of excellence. Your support and guidance have been indispensable to our success in this project.

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