SMART CAR PARK MANAGEMENT WITH LICENCE PLATE DETECTION

A project report submitted in partial fulfillment of the requirements for the award of the degree of

Master of Computer Applications

in

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By

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BONAFIDE CERTIFICATE

This is to verify that the project **“Smart Car Park Management with License Plate Detection”** is a project work successfully done by **Ankush Sikarwar (205121024)** in partial fulfilment of the requirements for the award of the degree of Master of Computer Applications from National Institute of Technology, Tiruchirappalli, during the academic year 2023-2024 (5th Semester – CA749 Mini Project Work).

Dr. B. Balaji	**Dr. Michael Arock**
Project Guide	**Head of the Department**

Project viva-voce held on ………………………………………………………

Abstract

Efficient management of parking spaces within urban landscapes is a critical aspect of modern infrastructure. This study focuses on the implementation of a smart Car Park Management system employing the Haar Cascade algorithm for precise and real-time number plate detection. The integration of this algorithm aims to streamline parking operations, enhance security measures, and optimize resource allocation within parking facilities. The motivation behind this research stems from the pressing need to address challenges in traditional parking management systems, including congestion, manual handling of entry/exit processes, and limited security measures. Leveraging computer vision and machine learning techniques, specifically the Haar Cascade algorithm, presents a promising solution to automate license plate detection and significantly improve overall parking management efficiency.

The primary objective of this study is to develop and implement a robust system capable of accurately detecting and recognizing number plates in diverse environmental conditions. The Haar Cascade algorithm, known for its computational efficiency, is employed to process real-time video or image feeds captured by cameras strategically placed at entry and exit points of parking facilities. This algorithm's capability to detect patterns using integral image representations enables rapid and reliable identification of number plates, contributing to streamlined parking operations.

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CHAPTER 1

INTRODUCTION

Managing parking spaces efficiently has become a crucial aspect of urban infrastructure. Smart Car Park Management systems equipped with License Plate Detection technology offer innovative solutions to optimize parking operations. This integration of advanced technologies not only enhances convenience for drivers but also streamlines overall management. License Plate Detection technology involves the use of cameras and specialized software to capture and recognize license plate numbers of vehicles entering and exiting a parking facility. This system operates in real-time, providing accurate and swift identification of vehicles, thereby enabling automated and seamless parking processes. Parking management integrated with license plate detection is a sophisticated system designed to revolutionize the management of parking facilities. This innovative technology harnesses the power of computer vision and artificial intelligence to automate and streamline parking operations. Specialized cameras equipped with advanced image recognition capabilities are strategically placed at entry and exit points of parking lots.

These cameras capture images of vehicles and extract license plate information using complex algorithms. This data is then processed and stored, allowing for efficient management of vehicles entering and leaving the premises without the need for traditional ticketing or manual verification processes. One of the primary goals of this system is to optimize the efficiency of parking facilities. By automating entry and exit procedures, it significantly reduces congestion and traffic jams within parking areas. Vehicles can smoothly enter and exit, enhancing the overall flow and minimizing delays. Additionally, real-time data on parking space availability and occupancy durations enable better planning and allocation of parking spaces, ensuring optimal utilization of the available area. Moreover, license plate detection in parking management greatly enhances security measures. The system maintains a record of vehicles entering and exiting, enabling facility managers to monitor and track movements. In case of any security incidents or unauthorized access, this information becomes invaluable for investigations and maintaining a safe environment within the premises.

This technology also significantly improves user experience. Customers benefit from faster and more convenient entry and exit processes, eliminating the need for physical tickets or passes. The streamlined procedures contribute to a more pleasant parking experience and higher levels of customer satisfaction. However, the implementation of license plate detection in parking management also raises important considerations. Data privacy is a critical concern, and ensuring compliance with regulations to protect user information is paramount. Moreover, system reliability and maintenance are crucial aspects to guarantee seamless operation and minimize downtime. Overall, the integration of license plate detection technology into parking management systems represents a groundbreaking advancement in enhancing operational efficiency, security, and user experience within parking facilities. Its implementation requires careful consideration of various factors to ensure both the effectiveness and privacy of the system.

CHAPTER 2

MOTIVATION AND PROBLEM STATEMENT

Traditional parking management systems face inefficiencies in traffic flow, manual handling of payments, and inadequate monitoring, leading to congestion, revenue loss, and security concerns.

Integrating License Plate Detection technology into car park management aims to revolutionize these areas by providing automated entry/exit processes, precise identification, and seamless fair payment mechanisms.

However, existing systems often encounter issues such as inaccurate recognition, high implementation costs, and limited scalability.

These challenges hinder the full potential of smart parking solutions, impacting user experience, operational efficiency, and the ability to derive meaningful insights from parking data.

Developing a robust and cost-effective Smart Car Park Management system with reliable License Plate Detection capabilities is crucial to address these concerns and realize the transformative benefits of streamlined parking operations, enhanced security, and improved urban mobility.

CHAPTER 3
PLATFORM

3.1 HARDWARE:

- Processor: Intel i5 11300H
- Memory: 16GB
- Hard Disk: 512 GB SSD
- GPU: MX450 2 GB

3.2 Software:

- Operating System: Windows 10
- Languages: Python
- IDE: Visual Studio Code

3.3 Libraries:

- TensorFlow
- OpenCV

CHAPTER 4

RELATED WORK

For in-depth insights into number plate detection techniques and advancements in the field, several research papers have significantly contributed to the domain of license plate detection.

TABLE 4.1: RESEARCH PAPERS

S.NO	RESEARCH PAPER	METHOD USED	LIMITATIONS
I	Vehicle License Plate Recognition Using Deep Neural Networks	Convolutional Neural Networks	Complexity and Computational Intensity
II	Rapid Object Detection using a Boosted Cascade of Simple Features	Real-Time Object Detection	Less Accuracy In Extreme Conditions
III	Real-Time License Plate Recognition on High-Definition Images	Deep Learning	Hardware Challenges
IV	OpenCV: Open Source Computer Vision Library	Image and Video Processing	Require High Resolution Equipments

CHAPTER 5

EXISTING SOLUTION AND ITS DRAWBACKS

Manual Entry: Human operators entering vehicle details manually are susceptible to errors in transcription, especially during high-stress or busy periods. Manual data entry is time-consuming, especially during peak entry times, leading to potential congestion or delays at entry points. Variations in handwriting, interpretation, or spelling errors may lead to inaccuracies and inconsistencies in the data entered, affecting the database quality.

Manual entry systems are limited in scalability and efficiency, especially in high-traffic scenarios or when dealing with a large volume of vehicles. Human-operated systems are reliant on operator availability, which might not provide 24/7 monitoring, leaving entry points unmonitored during certain times.

Human Error: Manual entry relies on attendants or users to input information, which increases the likelihood of errors in recording license plate numbers or payment details. These mistakes can lead to incorrect charges, misunderstandings, or even access issues.

Slow Processing Time: Manual entry processes can be time-consuming, especially during peak hours. This delay contributes to longer wait times for drivers entering or exiting the parking area, causing congestion and frustration.

Limited Data Accuracy: Human-entered data is susceptible to inconsistencies, affecting the accuracy of records and parking occupancy data. This can lead to inefficiencies in managing available spaces and planning for future requirements.

Increased Operational Costs: Manual systems often require additional human resources for supervision, payment processing, and data entry. This increases operational costs and reduces the overall profitability of parking facilities.

Security Concerns: Manual systems might lack adequate security measures, making them susceptible to unauthorized access, fraudulent activities, or the inability to accurately track vehicles entering and exiting the premises.

Scalability Challenges: Manual systems might struggle to scale efficiently with increasing parking demands. As the number of users grows, managing entries, payments, and space allocation becomes more complex and challenging.

Lack of User Convenience: For drivers, manual systems can be inconvenient due to the need to interact with attendants, carry cash for payments, or face delays in processing, especially during busy periods.

CHAPTER 6

Methodology

Using Haar cascades for License plate detection can be a part of the process to enhance safety and surveillance. Haar cascades are a type of object detection algorithm used for identifying objects in images. In last few years, ANPR or license plate recognition (LPR) has been one of the useful approaches for vehicle surveillance. It is can be applied at number of public places for fulfilling the purposes of parking system advancement.

Understanding and Implementing Haar Cascade Algorithm:

- **Training Cascade Classifier:** My contribution involves using a Haar Cascade classifier specifically for license plate detection. This process involves collecting a large dataset of license plate images, annotating them with bounding boxes around the plates, and training the classifier to recognize these patterns.
- **Optimizing Detection Parameters:** Fine-tuning the Haar Cascade parameters to ensure accurate and efficient detection of license plates within parking environments. This involves adjusting factors such as scale, neighbors, and minimum size to optimize performance in varying lighting and environmental conditions.

Integration into Smart Car Park Management System:

- **Real-time Detection and Recognition:** Implementing the trained Haar Cascade algorithm within the car park management system to enable real-time detection of license plates from video or camera feeds at entry and exit points.
- **Database Integration:** Integrating the detected license plate information with the parking management database to facilitate automated entry/exit, payment processing, and access control.

Enhancing Accuracy and Efficiency:

- **Error Handling and Validation**: Developing mechanisms to handle false positives and false negatives in license plate detection to ensure high accuracy.
- **Optimizing Speed and Performance:** Ensuring the algorithm operates efficiently in real-time scenarios, optimizing its speed and performance to handle a high volume of vehicles entering and exiting the parking facility.

Scalability and Adaptability:

- **Adapting to Varied Environments:** Ensuring the Haar Cascade algorithm is adaptable to different lighting conditions, vehicle angles, and plate variations commonly encountered in parking environments.
- **Scalability Considerations:** Designing the system to scale efficiently with increasing demands, accommodating larger parking areas and higher volumes of vehicles without compromising accuracy or speed.

User Experience and Integration:

- **Seamless Integration:** Ensuring the license plate detection system seamlessly integrates with the overall car park management solution, offering a user-friendly experience for both drivers and administrators.
- **Enhanced Security Measures:** Implementing additional security measures using the detected license plate information to enhance the overall security of the parking facility.

By contributing to the implementation of the Haar Cascade algorithm for license plate detection within Smart Car Park Management systems, the aim is to enhance efficiency, accuracy, and automation, ultimately improving the overall parking experience for users while optimizing management operations.

6.1 Model Training:

Keras Deep Learning Model: Keras is a simple, fast minimalist, highly modular neural networks library, written in Python and it can run on top of TensorFlow. TensorFlow is a software library developed by Google Brain Team for deep learning and artificial intelligence research. It combines computational algebra of compilation optimization techniques, which makes the calculations of mathematical expressions easy. As shown in fig 6.1.1

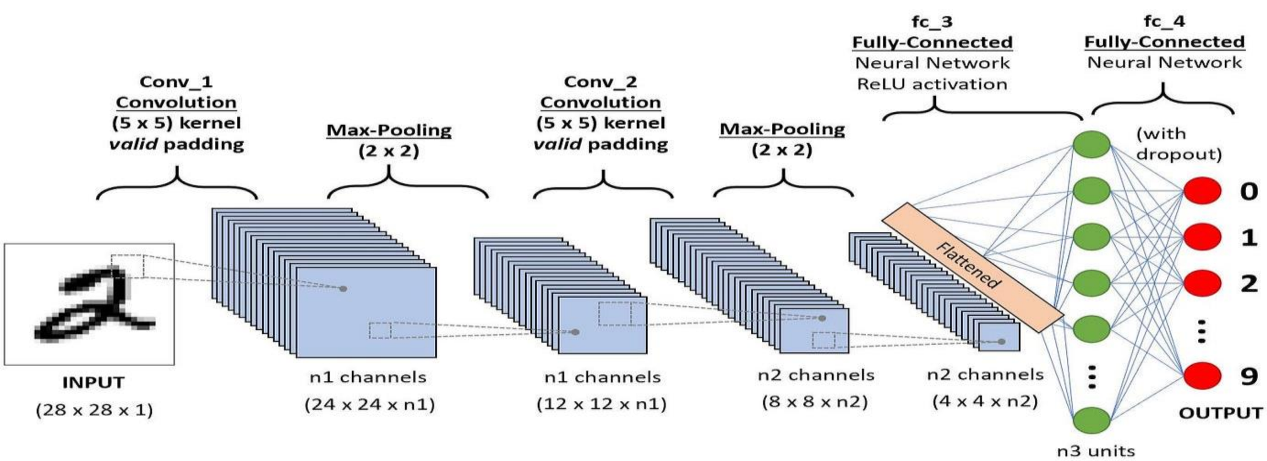

FIG 6.1.1: CONVOLUTIONAL NEURAL NETWORK

6.2 Algorithm Selection:

Haar cascades, also known as Haar classifiers, are a machine learning object detection method used to identify objects in images or video. They are particularly well-known for their effectiveness in detecting faces and other objects with simple geometric features. As shown in fig 6.2.2

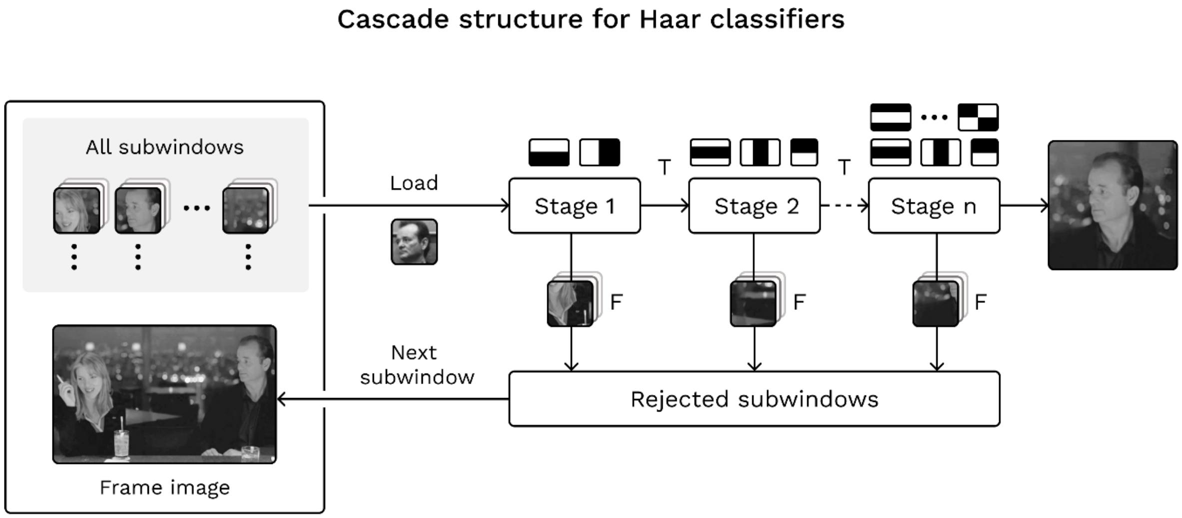

Fig 6.2.2: HAAR CASCADE CLASSIFIER

Haar Cascade has several features that can make it a strong choice for number plate detection in certain scenarios:

Real-time Processing:

- Haar Cascade is optimized for real-time object detection.
- It processes images or video frames quickly, ensuring low latency.
- Suitable for applications where low latency is crucial, such as parking management and Traffic management systems.
- Capable of easily detecting multiple objects in a single frame.

- Haar Cascades can handle variations in lighting, rotation, and scaling, making them suitable for different scenarios

Why Haar Cascade?

Computational Efficiency: Haar Cascade is computationally lightweight and can run relatively fast on resource-constrained devices, making it suitable for real-time applications.

Simple Architecture: The algorithm has a relatively simple structure, making it easy to understand and implement for basic object detection tasks.

Historical Use: Haar Cascades have been historically used for face detection and basic object detection tasks, providing a foundation for various applications.

Haar-cascade Features:

- **Haar-Like Features:** Haar-like features are rectangular areas within an image. These rectangles are placed at different positions and scales to capture various patterns. Compute the difference in the sum of pixel intensities in two adjacent rectangles. As shown in fig 6.2.1

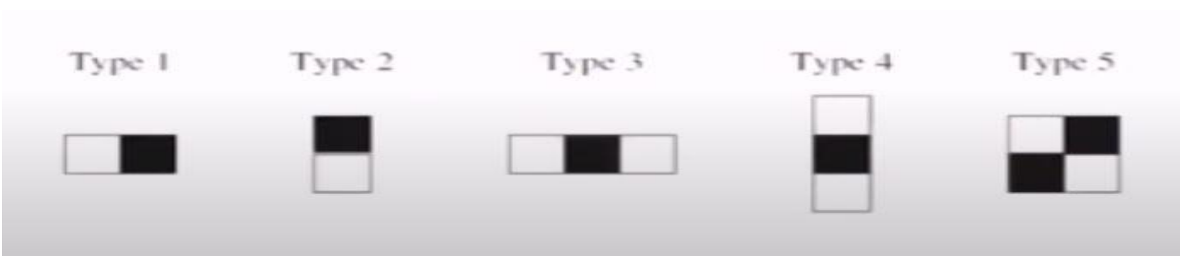

FIG 6.2.1: HAAR LIKE FEATURES

- **Adaboost:** AdaBoost (Adaptive Boosting) is an ensemble learning algorithm that combines multiple weak classifiers to create a strong classifier. It also helps to find best features among the all features. As shown in fig 6.2.2

FIG 6.2.2: ADABOOSTING

- **Integral Image:** An integral image, also known as a summed-area table, is a data structure used to efficiently compute the sum of pixel intensities within rectangular regions in an image. As shown in fig 6.2.3

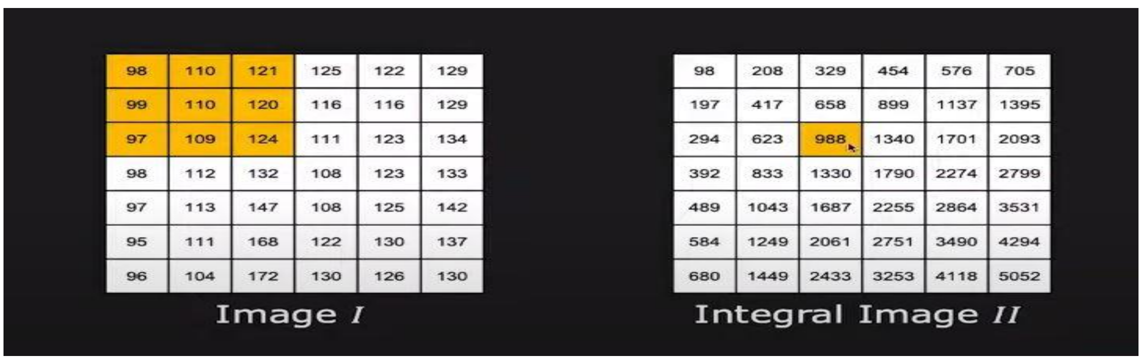

FIG 6.2.3: INTEGRAL IMAGES (1)

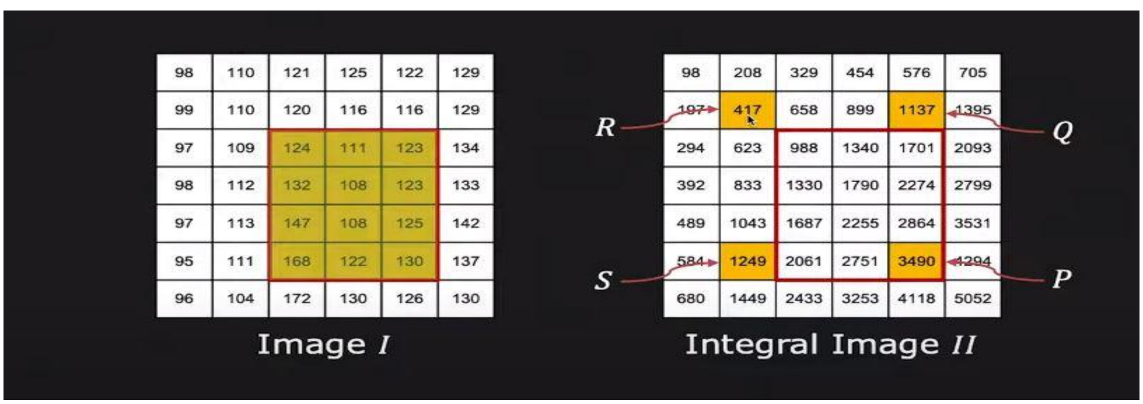

FIG 6.2.3: INTEGRAL IMAGES (2)

- **Cascading:** Cascading refers to the arrangement of multiple classifiers in a hierarchical structure, where each stage progressively refines the classification process. As shown in fig 6.2.4

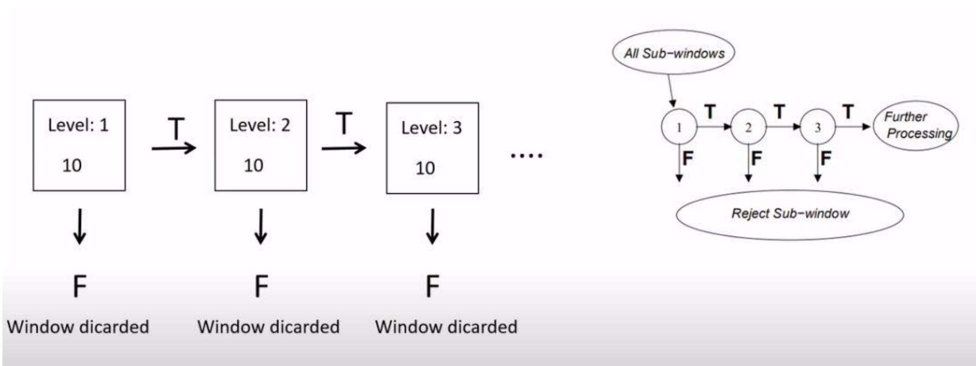

Fig 6.2.4: Cascading

6.3 Implementation:

- **Capturing the image of vehicle:**
  - It looks very easy but it is quite exigent task as it is very difficult to capture image of moving vehicle in real time in such a manner that none of the component of vehicle especially the vehicle number plate should be missed. So, we have to use a high-quality camera with faster shutter speed.
- **Input Image/Frame:**
  - Haar Cascade takes an input image or video frame with visible license plate.
- **Image Preprocessing:**
  - Common preprocessing steps include resizing to a fixed size (e.g., 416x416 pixels).
  - Convert images to grayscale to simplify feature extraction.
  - Pixel values are normalized, typically to a range such as [0, 1] or [-1, 1].
- **Neural Network Backbone:**
  - Initializing a sequential model using keras which allows us to build a convolutional neural network layer by layer.

- The network processes the preprocessed image through these layers to extract features at various levels of abstraction.

- **Finding Contours:**
  - Haar Cascade uses contours to help recognize the digits
  - After finding contours they are stored in a list as the coordinates.

- **Prediction based on probability:**
  - Now the model will predict the image which has been cropped from the original image.
  - After that it will recognize the number based on probability it will classify the different text.

- **Output:**
  - The final output is appended in a list, which is of length 10 or 9.

CHAPTER 7

RESULTS

- **Input:**

Fig 7.1: Input Image

- **Output:**

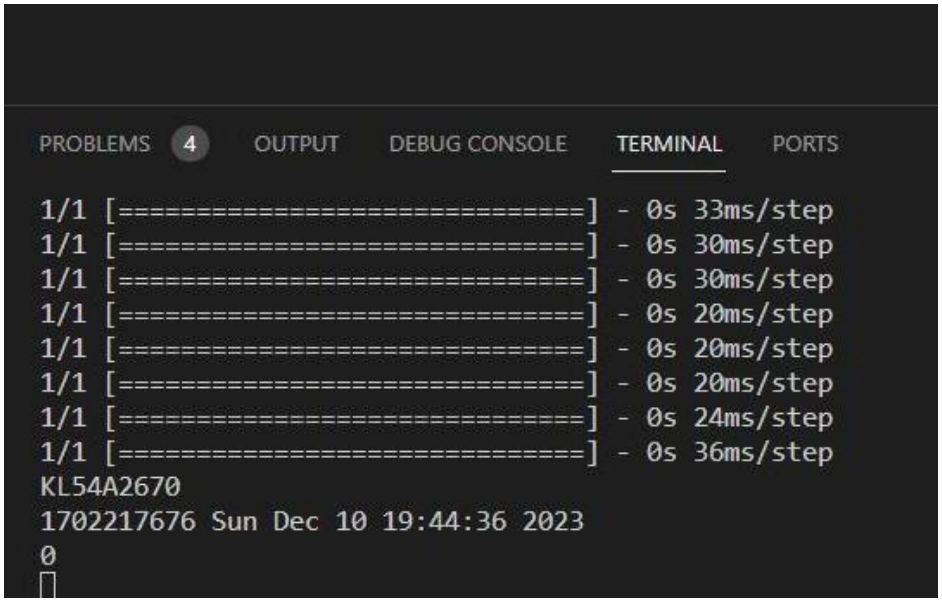

Fig 7.2: Output

- **Parking Price Calculation:**

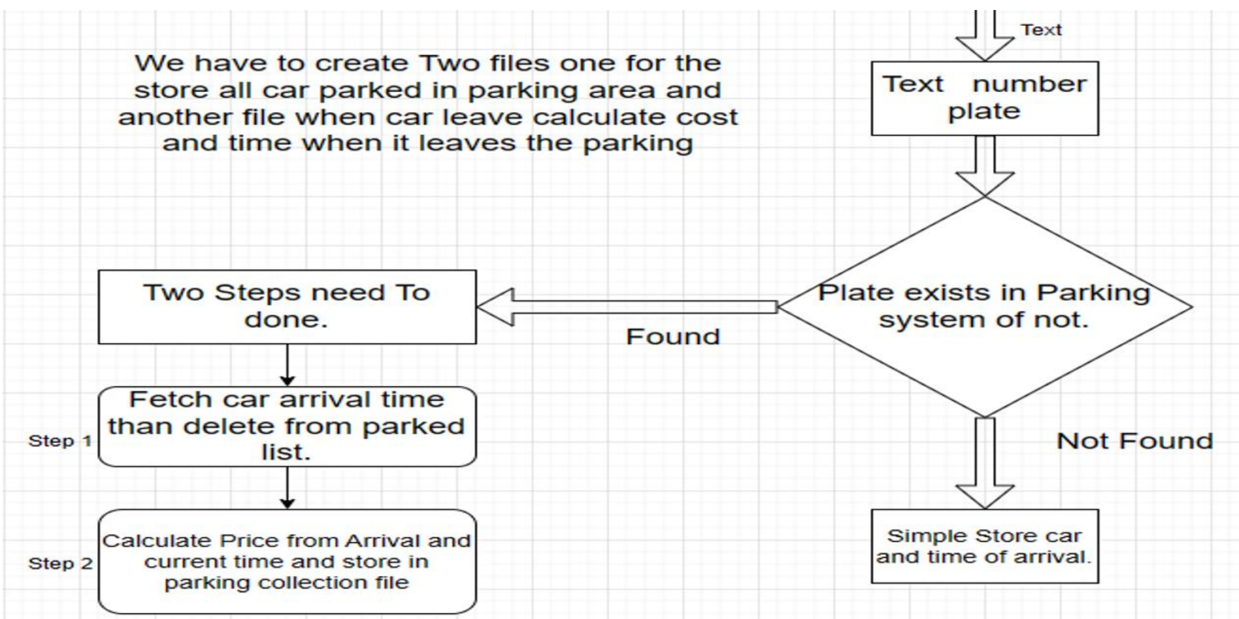

Fig 7.3: Parking Price Calculation

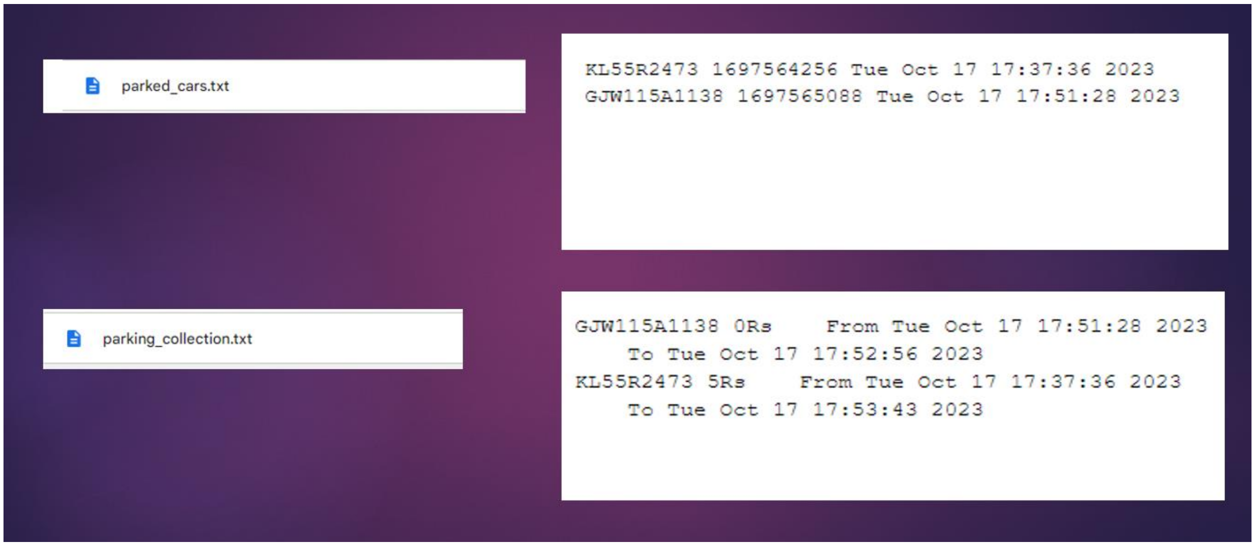

FIG 7.4: Parking Price Calculation Output

CHAPTER 8

CONCLUSION AND FUTURE WORK

- ## Conclusion:

In conclusion, while the Haar cascade algorithm has been historically used for object detection tasks, including face and object recognition, its application to number plate detection presents certain limitations and challenges. The Haar cascade algorithm's effectiveness for number plate detection can be summarized with the following points:

- Suitability for Simple Scenarios
- Challenges in Varied Conditions
- Training Demands and Data Requirements
- Computational Complexity and Real-time Performance

- ## Future Scope:

- **Enhanced Access Control**:
  Implementing automated gates or barriers that open based on number plate recognition, allowing authorized vehicles access to specific areas within the campus.
- **Security Monitoring and Alerts:**
  Using number plate detection to monitor vehicles entering and exiting the campus and providing real-time alerts for unauthorized vehicles or suspicious activities.
- **Theft and Crime Prevention:**
  Utilizing number plate detection to quickly identify stolen vehicles or vehicles associated with criminal activities on campus.

- ## Limitations:

- **Limited Robustness:**
  Haar cascades might struggle to detect objects if they deviate significantly from the features they were trained on. Changes in vehicle types, number plate designs, or occlusions can impact detection accuracy.

- **Accuracy:**
  Haar cascades might not provide high accuracy, especially in complex real-world scenarios. They might struggle with variations in number plate sizes, orientations, lighting conditions, and perspectives, leading to false positives or missed detections.

- **Dependency on Training Data Quality:**
  The performance of Haar cascades heavily relies on the quality, diversity, and quantity of the training data. Inadequate training data might result in poor performance.

- ## Enhancements:

  - **Quality Training Data:**
    Use a diverse dataset of high-quality images containing various types of number plates, considering different sizes, fonts, orientations, lighting conditions, and backgrounds.
  - **Use of Pre-Trained Models:**
    Start with a pre-trained model for a more general object detection task and fine-tune it specifically for number plate detection. This approach can save training time and provide a stronger starting point.

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