Intelligent Number Plate Detection System Using Image Processing

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

Bachelor of Technology

In

Computer Science & Engineering / Information Technology

Submitted by

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled “Intelligent Number Plate Detection System Using Image Processing” in partial fulfillment of the requirements forthe award of the degree of B.Tech in Computer Science And Engineering and submitted to the Department of Computer Science And Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by “Abhyuday Banshtu(201262) & Govind Sharma(201161).” during the period from August 2023 to November 2023 under the supervision of Assist. Prof. Aayush Sharma & Seema Verma, Department of Computer Science and Engineering, Jaypee University of Information Technology, Waknaghat.

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The above statement made is correct to the best of my knowledge.

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Candidate's Declaration

We hereby declare that the work presented in this report entitled 'Intelligent Number Plate Detection System Using Image Processing' in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Computer Science & Engineering / Information Technology submitted in the Department of Computer Science & Engineering and Information Technology, Jaypee University of Information Technology, Waknaghat is an authentic record of my own work carried out over a period from August 2023 to May 2024 under the supervision of Aayush Sharma & Seema Verma (Assistant Professor, Department of Computer Science & Engineering and Information Technology).

The matter embodied in the report has not been submitted for the award of any other degree or diploma.

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ABSTRACT

Have you ever wondered how those traffic cameras effortlessly capture the license plate numbersof passing vehicles, ensuring road safety and enforcing traffic rules? Well, it's all thanks to Automatic Number-Plate Recognition (ANPR) technology. Through a combination of advanced optical character recognition (OCR), cutting-edge software like OpenCV, and the powerfulTesseract OCR Engine, ANPR is revolutionizing the way we identify and monitor vehicles on theroad.

ANPR technology works by analyzing images and extracting the license plate numbers using OCR. It can be deployed on existing closed-circuit television (CCTV) systems, road-rule enforcement cameras, or even cameras specifically designed for this purpose. The images capturedare then processed using OpenCV and the Tesseract OCR Engine, allowing for the extraction of license plate information.

To enhance the functionality of ANPR systems, web automation is employed using the Seleniumweb driver. This enables the parsed number plate data to be seamlessly transferred to the government website vahan.nic.in. By also inputting the solved captcha, the system gains access todetailed vehicle information for further analysis and inference.

A significant advantage of ANPR technology lies in its ability to alert authorities in case of vehiclerule non-compliance. By setting up notification triggers on the dashboard, any violations can be instantly flagged.

The effectiveness of ANPR technology is truly remarkable. In a test conducted on 1500 Indian Number Plates, the system achieved an impressive success rate of 64%. Additionally, the successrate of retrieving vehicle information from the secure government website stands at an impressive75%.

CHAPTER 1
AN INTRODUCTION

Automatic Number Plate Recognition (ANPR): Enhancing Vehicle Safety and Monitoring

ANPR (Automatic Number Plate Recognition) is such an innovation. a pattern recognition-based vehicle plate "reader" system. By utilizing ANPR By the use of cameras, the system can record number plates of vehicles passing through it. to get useful descriptions that a computer mayuse to help model the vehicles. This is the embodiment of the latest technological developments that make cameras work with computer systems in a fast and precise way to digital identify Vehicle Registration Marks, formerly known as number plates. images. However, ANPR cameras can alsotake the images through mobile units, traffic. CCTV systems or vehicles. The captured digital images are rendered into data following which the ANPR system analyzes this data. SafeguardingVehicles with Advanced Solutions The need to own a vehicle is not just a luxury in today's world.However, with the burden of reducing probable calamities to the privilege of car ownership. Thus, effective measures should therefore be introduced to improve safety, security and monitoring of the vehicle. to prevent any untoward incidents. The integration of a vehicle trackingsystem is an ideal solution that utilizes GPS (Global Positioning System). This comprehensive tracking system refers to the fitting of a special gadget in the car for better tracking. of its location.These may be integrated with mapping software from Google Maps, Here Maps or Bing maps. With this, it is possible to facilitate monitoring in real-time from a central operational base.

Using ANPR for Improved Security and Traffic Control

The use of ANPR technology eases the process of getting important vehicle identities storage of images from the cameras and text of license plates. Some ANPR systems are able to store photographs of the drivers of the vehicles thus adding an additional layer identification. It has all imaging enabled to be optimal irrespective of the time of the day these systems are usually fitted with infra-red lighting, which provides good image capture if different light conditions. Some cases of intersection monitoring cameras includestrong flashes, The lights served a double purpose; they lit the crime scene and alerted criminals of their imminent doom. It is relevant to note that the ANPR technology may differ from various regional plate designs and variations.

Enhancing Image Quality for Accurate Data Extraction

It is important to address the frequency of use to ensure the accuracy and reliability of the vehicledisplay. Difficulties associated with image acquisition. One such challenge is undesirable camerashakes caused by unstable and random camera motions. To overcome this hurdle, imageenhancement algorithms are employed to eliminate unwanted camera shakes.

Seamless Integration with the Vahan Portal for Optimal Results

In our pursuit of comprehensive vehicle and owner information, we have seamlessly integrated the ANPR system with the esteemed http://vahan.nic.in portal. By leveraging this integration, we can extract vital vehicle and owner details. Furthermore, we efficiently organize and savethis valuable data in a JSON format, allowing for further processing and analysis, strengtheningthe overall effectiveness of the ANPR system.

In conclusion, Automatic Number Plate Recognition technology revolutionizes vehicle safety and monitoring through its advanced capabilities. By harnessing the power of ANPR cameras, intelligent algorithms, and seamless integration with existing systems, we can enhance security,improve traffic management, and provide real-time vehicle information with unparalleled accuracy.

Embracing this technology paves the way for a safer and more efficient world on our roads.

Existing System

Online Automatic Number Plate Recognition (ANPR) Framework

In an online ANPR framework, tags are quickly identified and interpreted from video frames inreal-time, allowing for seamless surveillance and tracking through surveillance cameras. An example of this is the Open ALPR CloudWatch system. An offline automatic number plate recognition framework.

However, in a non-online ANPR system, images of the license plate are taken and saved in a central database for subsequent processing. These images are then used in translating the vehicle number plates. For instance, the Open ALPR Library can be used as a relevant example.In different countries, application of ANPR.

United Kingdom

According to the Home office in the UK, ANPR is aimed at disruption, deterrence, detection of crimes – both organized crime groups as well as terrorist activities. It generates at least 25- 30 million ANPR read records per day and its network comprises almost 7914 cameras. The recordsare kept in the National ANPR DATA Centre, where they stay intact until after two years. The information collected by the UK law enforcement agencies is retrievable, analyzable as well as usable as court testimony.

United States

In America where I come from ANPR technology is mostly utilized in the department of police atstate and federal levels. A study commissioned by the Police Executive Research Forum in America, reported that nearly 71% of police forces there use ANPR technology. Mobile ANPR isnow considered vital in city anti-crimes strategies as well as a tool for collecting information on wanted persons or stolen vehicles, and even tracking delinquent taxpayers and debtors. Additionally, it serves as a means of tracking Amber Alert.

Saudi Arabia

It is common for registration plates of vehicles in Saudi Arabia to be white; however, there are exceptions for some of them. The Arabic characters are reversed if American diplomate plates areread from right to left. They say DSU instead of USD. Secondly, Saudi Arabian road registration plates use just seventeen Arabic alphabets. Plate recognition faces a challenge wherein some of the digits are large as they have both traditional 'Eastern Arabic' numerals and their 'Western Arabic' counterparts. Source code is given as one of the research resource for Arabic digits recognition in ANPR system.

Turkey

In the beginning, ANPR technology in Turkey comprised of two cameras that were used in everylane; one was dedicated to plate identification while the other was meant for speed measurement. Now, it has developed into a grid-like registration number camera system, which can impose an average speed over set distances. In Turkey, there are different types of arterial road which can attract fines depending on the speed limit and whether one crosses it or not. This information withdate
time indication is forwarded directly to violation drivers' registration addresses in photos.

Challenges in the Existing System

The vehicle number plates in the developed world are strictly observed. It comprises the nature ofplate, type and width of font, size, color, and space between characters, script applied as well as the number of columns. However, in many schools and parking lots, the standard procedures of vehicle registration includes guards looking for a membership tag on their windscreens or ID cards. Such a manual process is tiresome, time taking and may be full of blunders as far as this information is recorded. Furthermore, there is difficulty in storing and sharing the data because itrelies on paperwork only.

In a city like Bangalore, with numerous apartment complexes and societies, they even rely on checking for membership stickers on vehicles. This process becomes particularly time consumingwhen unfamiliar vehicles enter the premises. Moreover, this method is deemed unsafe as it becomes difficult to track the movements of vehicle owners and members. Security issues arise, with a significant risk of vehicle theft, especially when cars are parked in lots for extended periods. Keeping records of all vehicles entering and exiting during peak usage times becomes a dauntingtask. Considering the limitations of the traditional system, our goal is to develop a solution that addresses these challenges.

Proposed System

In order to address the weaknesses of the existing framework, we suggest a combination of automatic number plate recognition technology supported by a robust optical character recognitionsolution like Pytesseract collaborating with potent image processing packages such as Opencv. Wethink that many of these problems can be solved by using ANPR.

Number plate detection presents a common challenge whereby there is a lot of noise on the picturetaken from external circumstances. Nevertheless, we can operate in any situation, even when it israining or dark. In addition, we set up a customized system that would integrate well on most client's already established infrastructures without necessitating major changes on their systems.

The number plates could be sent through a web crawler that would link them to the appropriate ministry's website vahan.nic.in. In this case, we submit the solved captcha along with the relevantcar data so that further details available for inferencing and processing become accessible.

Moreover, it helps spot the potential weaknesses of the official web domain plus raise the problem.

Advantages of the Proposed System

Effective and successful preprocessing of raw RGB images:

- The utilization of the high efficiency and performance of OpenCV and Tesseract in the accurate detection and identification of license plates.
- Correct detection of number plates as per Indian Number Plates Standard. · Successful retrievalof data from the government's vehicle information database.
- Detecting and display evidence on weaknesses in vahan.nic.in.

CHAPTER 2
LITERATURE SURVEY

Introduction:

Before you progress with your research and evaluation, it should be noted that in the world of research and evaluation; a comprehensive literature review is critical. This process entails going through published and unpublished literature of several other sources. By doing so, researchers can gain a comprehensive understanding of their specific areas of interest. The results of this review are carefully documented, providing valuable insights that may have been previously overlooked.The importance of conducting a literature survey cannot be overstated, as it helps researchers gather secondary data that proves instrumental in their research endeavors and guides the architecture of their projects. There are numerous reasons why conducting a literature survey is vital.

Literature Review

The rising prosperity of urban India has made automobile ownership a must. As a result, an unanticipated municipal issue has arisen: traffic regulation and vehicle identification. Over the last few decades, ANPR systems have been a hot topic of research. There have multiple ANPR systems in the market.

PK Suri used Image processing and Edge detection method like Sobel to detect the license plates. It involves basic colour conversion, edge detection, and connection measuring to detect number plates from an image. The edge detection approach was further enhanced by R Ghosh et.al through region-based filtering to improve the accuracy of the model. In the 'Region-Of-Interest (ROI)'-based filtering approach, number plate occurrence regions are discovered in the candidate regions in the Number Plate (NP) pictures by identifying vertical edges, then deleting long edges and stationary regions. Finally, the NP region is separated from the candidate regions before being sent to an Optical Character Recognition (OCR) system for recognition of the number plate's characters and digits. But the retrieved number, however, may not be as clear and precise as it should have been, due to incorrect or variable lighting effects and poor localization.

Chauhan and Govinda introduced a system for locating Indian number plates based on characteristics. Because number plate standards are not fully followed in India, there are many variances in factors such as number plate size, position of characters on number plate and so on. All of these discrepancies make the process of locating number plates much more complex. There are four modules involved in the proposed method of localization. The first three modules are based on alphanumeric character features,

while the final step is based on the relative location of characters on the license plate. The system was able to put to the test on a series of photos with a broad range of lighting conditions, character sizes, and background and foreground colours and it performed well with localization simulation in MATLAB taking an average of 0.245 seconds. The most common sources of inaccuracy were an extremely slanted number plate, a non-English script, and significant variance in the proportions of the letters, such as very big or very small characters in a license number plate, all of which may be effectively eliminated by improving the technique.

Apart from image processing and characteristic scanning, morphological and template matching approaches are also introduced in ANPR systems. Kasaei et.al., proposed a system in which the key stage of is the separation of the license plate from a digital picture of the automobile. The picture was taken by a digital camera under various conditions such as lighting, slope, distance, and angle. Pre-processing and signal conditioning are the first steps of the method. Next, the license plate is located using morphological operators. The numerals and characters on the plate were then be recognized using a template matching methodology. However, it is only limited to restricted characters if a new character is present in the image it won't extract it and apart from this computational overhead makes it unsuitable for real-time implementation. Multiple issues including varied light conditions, skewed angles, the computational overhead, etc from edge detection and morphological approaches gave rise to supervised learning models to overcome such issues.

S Asthana et.al., proposed a three-hidden-layer multilayer feed-forward back-propagation algorithm. This approach divides an image into sub-images, each holding a single character. The sub-images are then converted to a binary format and this binary data is then sent into a neural network that has been trained to associate the character image data with a number value. The neural network's output is then converted to text. The performance of the algorithm was evaluated over real-world photos. However, the number of epochs is proportional to the number of hidden layers for an approach. This indicates that as the number of hidden layers grows, the network's training process slows down due to the increased number of epochs.

In order to enhance detection in low light and overexposure situations, a novel approach is presented by Babbar et.al., using Connected Component Analysis (CCA) and Threshold Modification. The picture of the car is collected and pre-processed utilizing grayscale and binarization algorithms. The resulting picture is sent to CCA for plate localization and number plate extraction. CCA and ratio analysis are used to segment the characters on the number plate. Finally, approaches such as SVC (linear), SVC (poly), SVC (RBF), KNN, Extra Tree Classifier, LR+RF, and SVC+KNN are used to compare the identified characters. This "Threshold Modification" approach was successful in recognizing number plates even in low light, extreme brightness, and other situations where prior machine learning models failed. SVC (Linear) had the best accuracy, recognizing 97.1 percent of segmented characters correctly. The method

works well for detecting number plates at skewed angles as well but lacked in terms of real-time applications.

The boom in the deep learning field in 2010's gave rise to multiple state-of-the-art object detection models. These deep learning models were faster and more accurate than the prior machine learning models. One such object detection model was YOLO introduced by Redmon et.al.. It is a one-stage detection system that detects and classifies objects in a single step while moving across the network. YOLO pushes the boundaries of real-time object detection. It is also adaptable to new domains, making it excellent for applications that need quick and reliable object recognition. Although YOLO is one of the leading real-time state-of-the-art detector models, it still requires a good computing power to run efficiently. Therefore, it cannot be incorporated in devices with low computing power like smartphones.

Huang et.al. developed YOLO-LITE, a real-time object detection model designed to operate on portable devices without a graphics processing unit (GPU. It was created to produce a smaller, quicker, and more efficient model based on the original object detection algorithm YOLOv2, expanding the accessibility of real-time object identification to a range of devices. YOLO-LITE demonstrates the enormous potential of shallow networks for lightweight real-time object identification networks. For a small machine, 21 frames per second on a non-GPU PC is really encouraging. But in comparison to the original YOLO design, lightweight architectures show a considerable loss in accuracy. In lightweight models, there is always a compromise between speed and accuracy, but in bigger models, there is always a tradeoff between speed and precision. Although the YOLO-LITE has a high mAP (mean Average Precision) in comparison to the state-of-the-art models, the model's accuracy hinders it from being used in real-world applications.

With rising in the new age of object detection models, many competing models were also introduced like Single Shot Detector (SSD) and Faster R-CNN. In W Liu , Single Shot Detector (SSD), a multi-category, quick single-shot object detector is introduced. The usage of multi-scale convolutional bounding box outputs coupled to numerous feature maps at the top of the network is a crucial aspect of this model. SSD model can efficiently model the space of possible box shapes using this approach. SSD model when used with the right training procedures, a larger number of properly chosen default bounding boxes improves performance. SSD model was further improved by different architectures. One such efficient architecture was ResNet which was integrated with SSD by Lu et.al., which gave rise to increase the learning impact of features and improve accuracy. The most noticeable difference is that ResNet101 replaces SSD's VGG16 network architecture. The problem of network degradation is overcome by using the ResNet network's properties, which make it possible to establish a stacking layer network. SSD- ResNet is significantly superior to the original VGG16 network design and Yolov3 in terms of accuracy. When extracting scenes with little objects or more complicated surroundings, the evident difference is seen in

the fact that the ResNet network can extract more representative characteristics. But the number of calculations will increase in the proposed model which can lead to overhead and makes it less suitable for real-time object detection.

In 2020, an improved lighter, and more accurate YOLOv4 was released which became a definitive object detection model and was significantly ahead of SSD models in terms of accuracy and speed. In A Bochkovskiy, YOLOv4 is compared with other state-of-the-art detectors in different scenarios and at different GPU settings. ImageNet and MS COCO datasets were used to assess the mean average precision (mAP) of these detectors. Yolov4 architecture consists of three main elements which are the backbone (based on CSPDarknet53), Neck (based on SPP and PAN), and Yolo heads for detection and consecutively drawing the bounding box. Yolov4 is currently the best performing detector of the YOLO family in terms of both speed and accuracy. It outclassed and outperformed other detectors like Single Shot Detector (SSD), YOLOv3, RetinaNet, R-CNN, etc. In J Kim, Faster-RCNN, YOLO, and SSD were being compared to checks which can be processed in real-time and have a high level of accuracy. A standard automobile data set was used to train YOLO, SSD, and Faster-RCNN. YOLOv4 model, SSD Mobilenet v1, and Faster-RCNN, the Inception v2 model are employed to compare the performance of each model. It was found that the best-performing model was YOLOv4. The Faster-RCNN model is the quickest among RCNN models, however, it does not have a suitable FPS since it utilizes CNN and the SSD is fast, but the model is light and employs mobilev1, resulting in bad accuracy. Some other work related to OCR/ automated analytics can be found in this paper.

Paper 1:

Kaur, A., Jindal, S., & Jindal, R. (2012). License Plate Recognition Using Support Vector Machine(SVM). International Journal of Advanced Research in Computer Science and Software Engineering, 2(7), Department Of Computer Science.

Mass surveillance, using Automatic Number Plate Recognition (ANPR) systems that photographvehicles and identify them almost instantly based on their Support Vector Machine (SVM) whichcan locate and read Indian vehicle number plates accurately in digital images. In pre

the processing stage model uses “Otsu’s methods” for plate localization and “feature-based localization method” to increase reliability as well as time optimization. The Support Vector Machine can reliably perform the task of character recognition lastly.

The paper is strong for it introduces a novel algorithm of number recognition. The new approach uses Support Vector Machine (SVM) to train character samples and

creates rules for detection of number on license plates. SVM has been recognized as one of the best classifiers, which are designed based on Statistical Learning Theory (SLT) to minimize structural risk for errorless generalization. Due to their simplicity and high performance SVMs are highly applicable in practical applications. Patterns Recognition and Data mining

Support Vector Machines: A Powerful Tool in Pattern Recognition Introduction

Support vector machines (SVMs) have become an indispensable tool in pattern recognition. The basis of their approaches is Statistical Learning Theory (SLT) and they aim at minimizing the structural risk in order to achieve optimal generalization. SVMs are based on simple principles that make it easier to understand learning from examples. Crucially, they exhibit better performance in real-life settings.

The Evolution of SVMs

The importance of SVMs in the pattern recognition domain has continued to increase since 1960s.They have also proved to be a vital instrument in different areas such as vehicle number plate detection and recognition.

Paper Overview

In their recent paper entitled "An Efficient Method of Vehicle Number Plate Detection and Recognition," Anish Lazrus, Siddhartha Choubey, and Sinha G.R. at the Department of ComputerScience provide details about SVMs in this very area. This enlightening study was published in volume 3, issue 3 of the International Journal of Machine Intelligence.

Vehicle Number Plate Processing

Artificially selected grayscale images of several vehicles were acquired manually at first. The Wiener2 filter was used to minimize noise in the license plates. Then, the Sobel filter was used toedge detect and smooth the grayscale images for segmentation. They wanted to increase the accuracy by reducing connected components number. Lastly, they used Bilateral filter to determinethe connected components and locate the individual characters.

Challenges Faced

However, it is worth noting that recognition rates tend to suffer when dealing with blurry andskewed snapshots compared to clearer ones. This discrepancy underscores the importance ofcapturing sharp and well-aligned images for accurate results. With the increasing number ofvehicles in bustling cities worldwide, a robust vehicle number plate recognition system has become a necessity. It not only helps solve numerous challenges faced by city administration butalso addresses the difficulties of constantly monitoring these facilities round the clock.

Achievements

The researchers successfully designed and developed a vehicle license plate recognition softwarethat exhibits impressive performance. By utilizing correlation in two dimensions, the system accurately identifies 38 different characters. This achievement showcases the incredible potentialof SVMs in this domain.

S.NO.	Research Papers	Real Timedata	Images Correctly detected	Characterknown	Results
1	Kok Kiaw Tetat (2003)	60	49	50	83%
2	F.Martin Et al (2002)	75	67	66	88%
3	Proposed Method	50	46	49	98%

Fig 2.1: Literature Survey on SV

Recognition Errors and Pre-processing

The recognition errors mainly occur in characters with similar main structures but slight differences, such as B and 8, O and 0, and S and 5. As a pre-processing step, each character is resized based on a standardized size, which adds an extra step to the process and increases the required time. Literature Survey.

Approach	Limitation	Conclusion
This paper discusses a methodfor the vehicle number plate recognition from the image using Mathematical Morphological operations. The main objective is to Use different. morphologicaloperations in such a way that the number plate of vehicles can be identified accurately	The recognition errors of letters and numbers mainly occur in some of the characters with the very similar main structures but some detailed differences such as B and 8, O and 0, S and 5. You have to resize each character based onstandardized size in this method.	The goal of the research is to investigate the possibility of creating comprehensive system for Indian vehicle identification based on license plate recognition. In that case no additional hardware , such as a transmitter, mounted on a vehicle and responders will be required.

Fig 2.5 displays a literature survey conducted on the Vehicle Parking ManagementSystem, providing a broader understanding of the subject.

Paper 3: Vehicle Number Plate Detection Using Image Processing Context

In this technology, we will be focusing on analyzing CCTV footage or input images to extract vehicle number plates. To achieve this, the CCTV footage must be clear and of sufficient quality. The input images are first converted to grayscale, and then characters are segmented and recognized using OCR (Optical Character). However, there are certain conditions that need to be met for this software to work effectively:

1.Vehicle plates should be white and adhere to the regulations set by the government of India. 2.The image should have appropriate brightness and contrast.

The software designed for this purpose utilizes MATLAB to detect and extract the vehicle number plate numbers.

Paper 4: Automatic Vehicle Number Plate Recorder for Vehicle Parking Management System. Context

This paper brings a process of extracting the vehicle number plate from an image using mathematical morphological operations. The primary objective is to detect the number plate of vehicle successfully with different operations including image enhancement, morphological transformation, edge detection and segmenting the license plates from vehicle images. Once this segmentation is done, then it applies template matching to realize recognition of characters on the number plates. This paper presents an algorithm that allows rapid and dependable number plate recognition from a car image.

The same research is the advancement of such a system for Indian vehicle identification: a complete plate recognition based license plate tag in which there is no need to use other systems like transmitters. The system operates effectively on different classes of vehicle license plate images

Paper 5: An Automatic Number Plate Recognition System for Car Park Management Context

This paper proposes the adoption of a mobile-based software solution with Automatic NumberPlate Recognition (ANPR) capabilities to aid in vehicle identification and registration. Thesoftware utilizes an object-oriented analysis and design methodology and implements OpticalCharacter Recognition (OCR) with the mobile device camera to detect and capture the vehiclenumber plates. The implemented system proves to be efficient in automating the number plate recognition for car park management, employing OCR on a mobile device.

Due to successful implementations of ANPR systems, it is now easier and faster to identify vehicles and enable law enforcers search or retrieve information on vehicle. This has led to a hugedecline in the time that

was required as compared to the manual systems. Efficient Local Area Network Systems are also effectively integrated into the system.

Literature Survey

The Car Parking System: A literature survey has also been conducted on the system and is presented in Fig 2.6; this provides further understanding of the subject.

Approach	Limitations	Conclusion
It proposes the adoption of a mobile based softwaresolution that has ANPR capabilities to aid in vehicle registration. The software thatwas developed adopted anobjective oriented analysis anddesign methodology and implements optical characterrecognition (OCR) using the mobile device camera to deleteand capture the vehicle number plate	Requires an efficient local area network System needs to be integrated to be efficient	The proposed system turnedout to be efficient when itcame to implementation ofautomatic number platerecognition system for carpark management using Optical Character Reader (OCR) on a mobile device. It was recorded that the systemrequired 1/5th of the original time that was needed by the manual system.

Fig 2.6

Conclusion

In this set of papers, different methods and approaches to vehicle number plate
Detection and recognition are offered. Thereby image processing, mathematical morphological operations and mobile based software solutions for accurate and efficient vehicle number plates identification. These developments have seen improved vehicle management systems, which has helped in matters of security as well as easier retrieval of vital information.

Chapter 3
Theoretical Background

3.1 Digital Image Processing

The field of digital image processing is very interesting and involves the analysis, manipulation, and improvement of analog as well as digital signals. These signals include transmission signals, sound waves and even image data among others.

Specifically, digital image processing addresses the input and output of image signals. Unofficiallyit refers to wide range of operations with images aimed at their quality improvement, and valuableinformation extraction.

3. 1.1 Digital Image Processing Steps

There are also several important things to do when it deals with digital image processing. Let's take a closer look at each of them:

Image Preprocessing:

Preprocessing the images is crucial before analyzing remote sensing data to correct any errors that affect quality. During preprocessing, which involves the use of mathematical models, geometric and radiometric errors are taken care of.

Image Enhancement:

The purpose of image enhancement is to improve particular results in an image allowing people interpret and analyze it quickly. It is worth noting that image enhancementdiffers from preprocessing, as it highlights features for interpreters, while the latter aims at reconstructing a clearer image.

Image Transformations:

Multiple layers of images are subjected to algebraic operations in image transformations. Unlike enhancement operations, which often influence a unique data channel, transformations involve mathematical processes including addition, subtraction, multiplication,and sensing division as well as logarithms and exponents and trigonometric functions. The new images shade away the most desired features when compared to each and as also regards quality tend to be of better quality than.

Thematic Information Extraction: This step consists of procedures for retrieving thematic information from image.

3.1.2 Advantages of Digital Image Processing

Digital image processing offers numerous advantages that contribute to a wide range of applications. Some of the key advantages include:

Processing by Digital Computers:

Digital images can be easily processed using digital computers,allowing for efficient and precise analysis.

Feature Extraction:

Important image features such as edges can be extracted and utilized in variousindustries for tasks like object detection and recognition.

Improved Visual Appearance:

With image enhancement techniques, images can be enhanced to appear sharper and visually appealing, aiding in human interpretation.

Error Rectification:

Minor errors in images can be rectified through digital image processing, resulting in cleaner and more accurate visuals.

Flexible Image Resizing:

Digital image processing enables the resizing of images, either increasing or decreasing their size according to specific requirements.

Efficient Compression and Decompression:

Images can be compressed and decompressed, allowing for faster transfer over networks without compromising quality.

Automated Image Sorting:

Digital image processing enables the automatic sorting of images based on their content, streamlining organization and retrieval processes.

Enhancing Unrecognizable Features:

Certain image processing techniques can enhance previouslyunrecognizable features, uncovering hidden information within the images.

Smoothing Images:

Through image processing algorithms, images can be smoothened, reducing noise and enhancing the overall visual quality.

Enabling Vision for Robots:

By leveraging digital image processing, robots can be equipped withvision capabilities, enabling them to perceive and interact with their environment effectively.

Quality Control in Industries:

Digital image processing plays a crucial role in industries by aidingin the identification and removal of defective products from production lines, ensuring quality control.

Weather Forecasting:

Weather forecast models heavily rely on digital image processing techniques to analyze satellite images, enabling accurate predictions and forecasts.

3. 1.3 Problem Statement of Digital Image Processing

While digital image processing brings numerous advantages, it's important to acknowledge the challenges associated with this field:

Cost:

The cost of digital image processing varies depending on the system used and the numberof detectors needed.

Time-consuming:

Processing of digital images is time-consuming, particularly where large datasets or complex algorithms are tapped.

Lack of Qualified Professionals:

Since digital image processing is a specialized area of operation and given the expertise required, the organization may not have enough professional team playerswho can handle this effectively. In a nutshell, digital image processing is an area including numerous features that can be appliedin various professional spheres. Understanding the theoretical background and its processes of thisdiscipline we can focus on

gaining insights, developing a better quality visually based onknowledge gained to step forward with innovation. However, the returns obtained from this tool make them valuable for application in today's technologically advanced world.

Uses of OCR

As we realize from Table II, OCR technology has diversified applications in several fields. Hereare some of its notable uses:

Data entry for business documents

OCR can also harvest information more effectively from different business papers like checks, passports, invoices, bank statements and receipts.

Automatic number plate recognition

- Automatic number plate recognition using OCR has created applications such as parking systemsand law enforcement where the images of number plates can be automatically recognized.
- Passport recognition and information extraction
- Airports use OCR in the recognition of passports and extraction of information from them withan intention to facilitate the immigration process.
- Automation of Key Information Extraction from Insurance Documents.
- To enhance claims processing efficiency, OCR can be used to automatically pull-out important information from insurance documents.
- This can help in developing systems that recognize and interpret traffic sign using OCR, therefore advancing driver assistance systems to better road safety.

Business card information extraction

OCR can accurately and fast retrieve a startup's contact from their business cards thus developinga digital list for the contacts hence no manual feeding is required.

Textual versions of printed documents

Using OCR technology, text of printed documents can be produced in the form that is analogousto an electronic one, which makes these texts searchable and available.

Searchable Images of the printed documents

For example, through the OCR technology, electronic images of printed documents are createdand can be indexed or searched as evidenced on platforms like Google Books.

Handwriting control of computers via real-time method.

With OCR technology, handwriting can be converted to digital text on-the-fly, enabling controlof the computer using a pen or stylus.

CAPTCHA anti-bot system testing

OCR can also defeat CAPTCHA to test the strength of anti-bot systems. However, CAPTCHA systems are specifically constructed to hamper OCR.

The Technology Assisting Visually Impaired Persons in Reading With the Tactile Sensation.

OCR can be used as an assistive technology to blind and visually impaired people whereby, it makes text from printed materials audible making information accessible. • Automobile instructiongeneration based on CAD images.

The OCR, which can help identify the CAD (Computer-Aided Design) images from a database most likely usable for real-time vehicle instructions generation, capable to handle dynamic changes associated with evolving car design.

Making scanned documents searchable

Consequently, scanned documents can be transformed into searchable PDFs through OCR technology and it will subsequently assist in finding a specific information required in the document.

libraries for Web Crawlers

Beautiful Soup: This Python package is popular for parsing HTML and XML documents. It develops a parse tree that is used to extract data from web pages and, therefore, is very useful in web scraping.

Selenium

Selenium is an open-source tool for automating web browsers and provides a single interface to write test scripts in several programming languages. It supports any browser on any platform and is used by developers for web automation.

Databases

Databases are essential for displaying large repositories of information in an intelligible form. They have also increasingly been used in business and other establishments to improve data storage and retrieval. Here are some key aspects of databases:

Definition and Organization

In other words, a database is an organized collection of information designed to be easily acquired, manipulated, and updated. It generally refers to different types of data records or files that would contain information about things like sales transactions and customer interactions.

For relational databases, data is stored in tables consisting of rows, columns as well as indexes. Because of this structure, its retrieval is easy using SQL or NoSQL languages.

Graph databases, on the other hand, associate different data entries with nodes and edges followedby appropriate semantic search syntax via a query language called SPARQL (World Wide Web Consortium [W3C]).

Database Management

Database managers enable users to control the read/write access, generate reports and analyze utilization. ACID meaning atomicity, consistency, isolation, and durability are offered to ensure data integrity and completion of transactions in some databases.

Types of Databases

This is because of the changes that have characterized databases, leading to emergence of different types for particular requirements. Here are some notable types.

Relational Database

A relational database, by its very nature, is tabular and has the advantage of being able to organizedata in more than one way accessible just like spreadsheets. It is built on tables of predefined categories. Standard interface to relational databases is the Structured Query Language (SQL). They have a high extensibility, which enables the addition of new categories to existing applications without modifying or changing them.

Distributed database

Distributed databases store portions of data in multiple physical locations, with processingdistributed across the network. They can be homogeneous (all locations have the same underlyinghardware and software) or heterogeneous (locations have different hardware, software, or operating systems).

Cloud database

Cloud databases are optimized or designed to operate in virtualized environments, such as hybrid,public, or private clouds. They offer advantages like pay-as-you-go pricing, scalability on demand, and high availability. Enterprises also leverage cloud databases for deploying business applicationsin a software-as-a-service model.

NoSQL database

NoSQL databases are specifically designed to handle large sets of distributed data, which may be unstructured. They address performance issues related to big data processing and analysis that traditional relational databases are not well-suited for.

The ongoing evolution of databases continues to shape how organizations manage and leverage their data, enabling efficient data storage, retrieval, and analysis.

Object-oriented Database

An interesting approach to storing items created using object-oriented programming languages isthrough object-oriented databases. While relational databases are commonly used to store these items, object-oriented databases offer a better fit. Unlike relational databases that focus on actionsand logic, object-oriented databases organize data around objects. For example, in a relational database, a multimedia record might be represented as an alphanumeric value. In contrast, in an object-oriented database, it can be treated as a definable data object.

Graph Database

The second form of NoSQL database that is increasingly popular include graph-oriented databasescommonly known as a graph database. The database is based on the use of graph theory to store, map and query relationships. Essentially, a graph is a set of nodes and edges where each node refers to an entity whereas each edge represents the connection between these entities. Nowadaysanalysts and companies looking to analyze interconnections are increasingly turning in the way ofgraph databases. Businesses for example could use the graph database to mine useful consumer experiences from social media data. SPARQL is the name of a declarative programming languageand protocol, which graph databases often use for activations. SPARQL differs in that it undertakesnot merely the analytics handled by SQL but goes further to undertake semantic analysis, which involves investigating relationships. Thus, SPARQL is highly applicable in the analysis of data sets that contain structured and rich unstructured content. Users can also run analytics on relational databases with SPARQL as well as use it to browse friend-of-a-friend (FOAF) relations, PageRank, shortest path.

Firebase Database

Moving on to Firebase, we encounter the Firebase Realtime Database. This cloud-hosted databasesimplifies cross-platform app development by allowing iOS, Android, and JavaScript applicationsto share a single Realtime Database instance. What's particularly interesting about Firebase is its use of a data structure distinct from that of relational databases. This NoSQL database offers faster performance for certain operations compared to traditional relational databases. For example, Firebase Realtime Database can be integrated with Android operations, enabling efficient data storage in JSON (JavaScript Object Notation) format.

However, it's worth noting that the Firebase Realtime Database does have limitations when it comes to querying capabilities. Due to its structure where the entire database is effectively a massive JSON file, complex queries can be challenging to execute. Filtering capabilities are limited, which can hinder the ability to perform intricate queries.

MySQL Database

The SQL language shouldn't be disregarded when talking about databases. SQL (Structured QueryLanguage) is a domain-specific language designed to streamline the process of working with datawithin relational database management systems. It is also used for processing streams in relationaldata stream management systems.

SQL and Its Importance in Relational Database Management Systems According to ANSI(American National Standards Institute), SQL is the standard language for accessing relational database management system. It supports different tasks like updating data in some database and fetching data from this database. Seamless communication with relational databases is essential indata management and retrieval through the use of SQL.

Graphical User Interface

The most radical technological development in terms of commercial implementation came with the graphical user interface (GUI), developed from Xerox Palo Alto research laboratory, late 1970sfor Apple's Macintosh operating system and Microsoft Windows. It was imperative to invent thisbecause average users of 788 are dissatisfied with poor performance of its initial text-based command-line interfaces.

The advent of graphical user interfaces redefined software application programming by giving applications a more visual slight that is appreciated with end –users. They enabled customers to make use of graphic symbols such as buttons, slider panels, windows tabs menus, cursors and themouse cursor device to interact with computers and other electronic devices. Using GUIs with thetouchscreens and voice-commands has been developed thus very comfortable currently.

Guidelines for graphical user interface design are based on the model-view-controller software pattern. It is external data representations, which are separate from internal ones and are visible to the user via presentation layer. Therefore, it shows users functions that they can work directly withhence avoiding command codes. Visual widgets support task completion through actions that theyallow, by responding based on data held and manipulated by a user.

Graphical User Interface Customization

They are highly customizable, which is one of the remarkable aspects of graphical user interfaces.Because a graphical user interface is independent of the application functions like the operating system or an application, it can be easily redesigned in terms of its appearance or "skin". Applications also tend to have

their own graphical user interface display elements, which add to the underlying operating system's main graphical user interface elements. Additionally, graphicaluser interfaces establish uniform ways through which graphic and text can be represented; thus, a smooth exchange of data amongst applications that are using the same platform of the graphical user interface design software.

TKinter

For Python, where graphical user interfaces are concerned Tkinter is considered as the principal. It is the standard GUI library for Python and provides a fast and easy way to develop GUI applications. Python together with Tkinter provides a rude-block object-oriented interface to the Tk GUI toolkit. Building a Tkinter GUI application is simple.

It involves a few simple steps:

Import the Tkinter module.

Create the GUI application main window.

One or more desired widgets to the GUI application Pair.

Subsequent steps depend on user-triggered events to input, but handle this by entering the main event loop.At the core of any Tkinter GUI is the window. Acting as containers, windows hold allother GUI elements. These elements, such as text boxes, labels, and buttons, are referred to as widgets and are contained within windows.

PyQt

PyQt stands as one of the most popular Python bindings for the Qt cross-platform C++ framework.Developed by Riverbank Computing Limited, PyQt provides an interface between Python and Qt,supporting both Qt 4 and Qt 5. PyQt is distributed under the GPL version 3 license or a commerciallicense, offering flexibility to developers.

PyQt and OpenCV: Essential Tools for Developers PyQt: Powerhouse for GUI and Beyond

PyQt, available in two editions PyQt4 and PyQt5, is a standout toolkit for developers. While PyQt4supports both Qt 4.x and 5.x, PyQt5 exclusively focuses on the latter. Python enthusiasts have thefreedom to build both editions for Python 2 and 3, making it versatile and adaptable.

With over 620 feature-packed classes, PyQt covers an extensive range of functionalities. From crafting captivating graphical user interfaces to handling XML, network communication, SQL databases, and web browsing, PyQt truly empowers developers to create cutting-edge applications. Additionally, PyQt also integrates various other technologies available in Qt, adding an extra layerof flexibility and convenience.

OpenCV: Unleashing the Power of Vision and Machine Learning

OpenCV

The Open-Source Computer Vision Library, is an indispensable asset for developers exploring computer vision and machine learning. With a strong emphasis on accelerating the application of machine perception in commercial products, OpenCV provides a comprehensive infrastructure for a wide array of computer vision applications.

Boasting an impressive library of over 2500 optimized algorithms, OpenCV outshines the competition. Developers can rely on a rich set of both classic and state-of-the-art computer vision.and machine learning algorithms. These algorithms enable a vast range of applications, includingface detection and recognition, object identification, human action classification in videos, cameramovement tracking, object tracking, 3D model extraction, stereoscopic camera-based 3D point cloud generation, high-resolution image stitching, image database similarity search, red-eye removal in flashed images, eye movement tracking, scenery recognition, augmented reality markerestablishment, and the list goes on. OpenCV's widespread adoption is evident with its 47 thousand-strong user community and an awe-inspiring 18 million downloads. Esteemed companies like Google, Yahoo, Microsoft, Intel, IBM, Sony, Honda, and Toyota leverage OpenCV's power to drive their solutions. Even startups such as Applied Minds, VideoSurf, and Zeitera have harnessedthe potential of OpenCV in their cutting-edge applications. From stitching street view images anddetecting intrusions in surveillance videos to monitoring mine equipment and aiding robotnavigation, OpenCV's influence permeates various fields worldwide.

Noteworthy is OpenCV's wide compatibility, offering interfaces for C++, Python, Java, and MATLAB. Operating systems like Windows, Linux, Android, and Mac OS are all supported, ensuring no developer is left behind. OpenCV's intelligent utilization of MMX and SSE instructions when available helps achieve real-time vision applications efficiently. Furthermore, the ongoing development of a full-featured CUDA and OpenCL interface promises even more power to users. With over 500 algorithms and a myriad of supporting functions, OpenCVseamlessly integrates with STL containers through its natively written C++ codebase.

Automatic Number Plate Recognition (ANPR) systems were created in order to address the challenges created due to rise in the volume, velocity and density of automobile vehicles. Most modern ANPR systems heavily depend on image processing techniques like contouring and gray-scaling to segment the license plate and use optical character recognition to extract the number from the manipulated image of the number plate. The major advantage of such systems is that they require less computational power and are quite cost-effective. But these systems process the complete images rather than just the region of interest. The more modern ANPR systems rely on object detection algorithms to overcome this challenge and process only the area of interest from the image. But these systems are not suitable for real-time applications due to high computational overhead and high processing time. To overcome the limitations of the existing ANPR systems, we propose an intelligent ANPR is a system for detecting and extracting number plate details from images or sequences of images of vehicles. The proposed deep learning model is based on an improved version of the You Only Look Once (YOLOv4) algorithm. The performance

evaluation demonstrates that our model is able to recognize the number plates with an accuracy of above 95% under varied conditions such as high-speed moving vehicles, varying lighting, and vehicle dense area on Indian roads. The system is robust enough to detect the number plates of fast moving vehicles (speed≤ 80km/hr) as well as vehicles in highly traffic dense areas.

Tesseract Engine: Liberating OCR Developers

Tesseract, the open-source Optical Character Recognition (OCR) engine, has emerged as a favoriteamong developers seeking powerful OCR solutions. While its implementation and modification may prove challenging at times, Tesseract has remained unrivaled in the realm of free and robustOCR alternatives for quite some time.

Originating as a Ph.D. research project at HP Labs, Bristol, Tesseract gained recognition during its development by HP between 1984 and 1994. In 2005, HP released Tesseract as open-source software, and Google has been further developing it since 2006.

Under the Apache 2.0 license, Tesseract serves as a remarkable text recognition engine, enabling users to extract printed text from images directly or through APIs. Offering support for a wide range of languages, Tesseract opens doors to global accessibility. While lacking a built-ingraphical user interface, Tesseract provides users with several options from third-party sources.

Thanks to its compatibility with multiple programming languages and frameworks, Tesseract's usability reaches unparalleled heights. Its integration with existing layout analysis enables efficientrecognition of text within large documents. Alternatively, Tesseract can work hand-in-hand with external text detectors to recognize text from single text line images.

Diving into the architectural aspects of Tesseract, one finds the utilization of Long Short-Term Memory (LSTM) models. LSTMs excel at learning sequences, albeit at a slower pace when the number of states is significantly large. Close scrutiny of empirical results even suggests that LSTMs perform better when learning lengthy sequences featuring numerous classes. Tesseract itself has its roots in OCRopus and was developed using Python, originating from a C++ LSTM model called CLSTM. The implementation primarily relies on the Eigen library for numerical computations.

Tesseract's evolution witnessed the modernization of its tools, focusing on code refinement and the introduction of a new LSTM model. The process involves parsing the input image line by line using rectangular boxes. Each line is then fed into the LSTM model, generating the desired output.This iterative approach ensures streamlined processing and impactful results.

These are flexible tools which help developers to transform such areas like graphical userinterfaces, computer vision, machine learning and optical character recognition. When combined,PyQt and OpenCV provide the world of creators with unlimited possibilities for.

Due to its huge real time applications, it attracted the attention researchers from various domains. Some of the renowned methodologies reported in the literature are categorized and presented in the following

Table-6: Categorization of various methodologies reported in the literature

S.No	Method	Methodology	Limitations
1	Edge Detection Method	A set of mathematical techniques are used to detect the edges / curves based on the abrupt change in the brightness of the image or discontinuities. Once the object characteristics are isolated/ extracted and after the boarders have been established, the image may be analysed for object recognition.	It is fast but less accurate Performance can vary with different conditions like angle at which the image is captured.
2	ROI method	A region is set for images and only the region of interest is processed to detect and extract the Number Plate to reduce the complexity of computation.	It is better than the edge detection method in terms of accuracy but performance varies with different conditions like exposure etc.
3	Characteristic-based method	It depends on multiple characteristics like plate size, color, and so on to localize a vehicle in an image. Based on Alphanumeric character features, the relative location of characters can be found in the image and extracted.	It is a better approach than the previous two approaches. The order of the detected number plate can be jumbled.
4	Morphological-based method	Morphological operations are very important functional methods for surface texture assessment. They are operators used to extract varied regions based on properties like the contrast from an Image. These detected regions can be matched with templates to extract the number plate.	It is only limited to restricted characters. If a new character is present in the image it won't extract it. Apart from this, computational overhead makes it unsuitable for real-time implementation.

5	Machine learning-based	Multiple machine learning models have been introduced for object detection. One such method is connected component labelling (alternatively Connected Component Analysis) is an algorithmic application of graph theory, where subsets of connected components are uniquely labelled. These detected and segmented regions are then compared with original images using models like SVM	A good dataset is essential for an accurate machine learning model. ML models are less versatile when compared to DL models as DL models have a dense architecture which can handle multiple conditions with ease.
6	Deep-Learning Based	The Deep Neural Networks have led to a revolution in the field of Computer Vision due to faster and highly accurate models which are capable to detect multiple objects under varied conditions. The models include SSD, YOLO family, Faster-RCNN, etc.	Some models might have higher computation overhead which might not be good for real-time implementation.

The evolution of technology over the years has resulted in multiple approaches for ANPR as discussed in Table-1. Each real-time ANPR system should fulfil the factors that are discussed below:

Reliability: Even while building a trustworthy security gate and barrier system is a proven technique for preventing crime and safeguarding our property from invaders, it may be a time-consuming and tedious operation. However, if an ANPR system is in place, cars will automatically be allowed entry to locations since the system can match a vehicle's number plate to the main system. The system can be available 24/7 hours.

Efficient Management Vehicle number plate tracking may be a very effective approach to keep track of people's clock-in and clock-out timings. Because ANPR systems assist manage access control in conjunction with gates and barriers, our system can save time and streamline management procedures. Individuals and their cars can be tracked as they enter and exit the premises using ANPR technology.

This information may then be saved and used for personal reference if an individual leaves or enters a place.

Improved Security: In comparison to manual checks, which are known to have a larger risk of breaching security protocols if a human error is present, automated ANPR systems will provide higher levels of accuracy and security. By relying on modern technology and 99 percent accuracy to recognize illegal cars entering the premises, ANPR systems provide peace of mind to businesses.

Real-Time Analysis: Historical data, as well as live data and reporting, are available to organizations. This information can then be saved on a device for future reference and proof in the event of an incident or accident.

Reduction of Corruption: An Intelligent ANPR reduces human intervention to a high extent which in turn reduces the chances of human errors occurring. Corruption is a big social evil that can be eradicated by reducing human intervention in the traffic maintenance force. This system helps authorities to enforce laws more stringently.

Easy Installation: ANPR systems are easy to set up with novice technical skills required to install as well as operate them. An ANPR basically consists of 3 components: high-definition camera to capture clear and detailed media, Computer with ANPR software installed, and a database to store and process information.

Chapter 4

System Requirement Specification

Introduction

In this chapter we describe the application requirements and give more deep information regarding the hardware/software needed for effective running. We describe the Software Requirement Specification (SRS) that covers a succinct introduction to these studies, functional and non- functional requirements. The SRS document is key in the software development process because it details all the required data, functional and behavioral requirements of a given form of software.It acts as the pilot for the project and promotes effective communication between customer, analyst, system developers and maintainers. It also serves as the basis for design, provides supportfor system testing and controls the changes during system evolution.

Functional Requirements

Functional requirements describe how the system should react to different categories of input anddescribe the anticipated system performance in diverse conditions. In this system, we have identified the following functional requirements:

Mobility: The identification device should be moveable to enable capture of license plates on themove.

Convenience: The system has to efficiently deal with vehicle access for purposes of avoiding entries and exits congestion.

User Interface: The interface of the system must be user-friendly.

Transparency: The automatic license plate recognition (ALPR) process should be easily understandable by the users.

Flexibility: Character scanning support should be provided for multiple formats in the system.

Support for Disabled: The system is to meet the needs of physically challenged voters thatincludes the blind people.

Accuracy: The system needs to be able to accurately change the characters of license plateimages.

Uniqueness: Training of the system should be carried out using different categories of numberplate.

Documentation and Assurance: Going by this, system confidence is associated with well- documented design, implementation and testing procedures.

Cost-effectiveness: It should be a low-cost and high-functioning system.

Non-functional requirement

Non-functional requirements are referred to the criteria that evaluate operation of a system insteadof its activities. These requirements deal with the performance of the system, its properties and constraints. Some of the non-functional requirements for the ALPR system are as follows:

Green Initiative: For the environment, the system will eliminate use of more paper by issuing receipts.

Peak Efficiency: Throughout the operation, the system should be at 100% efficiency

Data Scan: Instead of sampling the data, a 100% scan will be performed when validating the database for errors.

Business Hours: A process should be in place to support normal precinct business hours.

Documentation: The system should enable users to review the documentation regarding its functionality as well as all made adjustments.

User-Friendly Interface: The system must include a user-friendly Graphical Interface to make usage of the system easy for end users.

All in all, the system will support a processor of an Intel I5 at 2.1GHz, 100 gigabytes for storage space and 4 gigs for RAM

Regarding the software specifications, the system will operate comfortably with Windows, Linux and Mac OS. It uses a programming language called Python. Among those technologies are PyTesseract that is useful for optical character recognition, OpenCV for computer vision and machine learning, Selenium for testing online applications, ChromeDriver for testing web apps built on a Chrome browser, Tkinter package used for creation of GUIs, Pyrebase hardware and software requirements will ensure smooth working of the system. Tkinter: Going Deeper into the Details of Creating a User-Friendly GUI Application. We are going to examine how the Tkinter module can help you develop a user-friendly GUI application in this article. So, let's dive right in!

Importing the Tkinter Module

First, we import the Tkinter module in our python script. By importing these modules we are adding the extensive list of functions and classes that can be used in building our GUI application.The Main Window of the GUI Application.

The next step which we will undertake is the creation of the main window for our GUI-based application since we have already imported the Tkinter module. It functions as the application’s visual interface in which users are able to interact with.

The main window should be designed in such a way that users can easily find window elements. Visual appeal and an easy navigational scheme entail appropriate layout, color scheme, and positioning of various elements in the application.

Adding Widgets to Enhance Functionality

Our GUI application is built from widgets. These are the components, which enable users to process actions, enter data and see output. The type of widgets you choose to add depends on the nature of your application, i.e., buttons, input fields, sliders or checkboxes.

We can also improve the user experience of our GUI application by incorporating the necessary widgets. For instance, you can include a button to implement a special action or an input field forusers to key in some results.

Engaging the Event Loop

An event loop is a fundamental aspect of every GUI application. It simply listens for events to takeplace and rollover actions when those occur such as whenever a button click happens or when youpress the key.

After we have incorporated our favorite widgets in the GUI application, entering the major loop for events is essential. The loop keeps looking for events that are triggered by the user and after itsdetection ensures that it directs to an action.

It is this event loop which turns our GUI application into an interactive and responsive one. This facilitates the smoothest interactivity with application as it allows users to exercise control in sucha way that whatever action they take, results are instantaneously displayed.

Conclusion

Using Tkinter, you can develop a useful and convenient user-friendly GUI application just by following the given simple steps. Quality options include the design and layout of the application,addition of different widgets while engaging event loop.

Chapter 5

System Design

5.1 System Architecture

In this section, the architecture of the Number Plate Recognition System and Information Extractor is presented. The system proposed can detect and extracting the characters on the number plate of a vehicle. It includes input image preprocessing, character segmentation and recognition. The resulting characters are subsequently translated back into a string. The system also has a web crawler element that retrieves vehicle details. The resultant information istransformed into the form of JSON and then saved in a database or displayed on a dashboard for other processes.

Modules: It preprocesses the image by converting it to grayscale and applying a bilateral filter to smoothen it. The canny edge detection algorithm is then employed to identify the edges in the image. Contours with four edges are ranked, and the contour with the highest rank is considered as the number plate region and cropped. Character recognition within this region is performed using the Tesseract Optical Character Recognition (OCR) tool.

Web Crawler: The web crawler module opens the Vahan.nic.in website and captures the captcha. Following this, the captcha is solved as a mathematical equation and sent back to the captcha inputfield. The vehicle number plate is also submitted to the registration number input field.

Application: The extracted vehicle data is converted to JSON format and stored in both a MySQLdatabase and a Firebase database.

The data is further read by a Tkinter application and displayed to the user the following informationcan be gathered from the system

- Registering Authority
- Registration Number
- Registration Date
- Chassis Number
- Engine Number
- Owner Name
- Vehicle Class
- Fuel Type
- Fitness/Registration Expiry Date
- MV Tax Expiry Date
- Insurance Expiry Date
- Maker/Model

- Pollution Under Control Certificate Expiry Date
- Emission Norms
- RC (Registration Certificate) Status

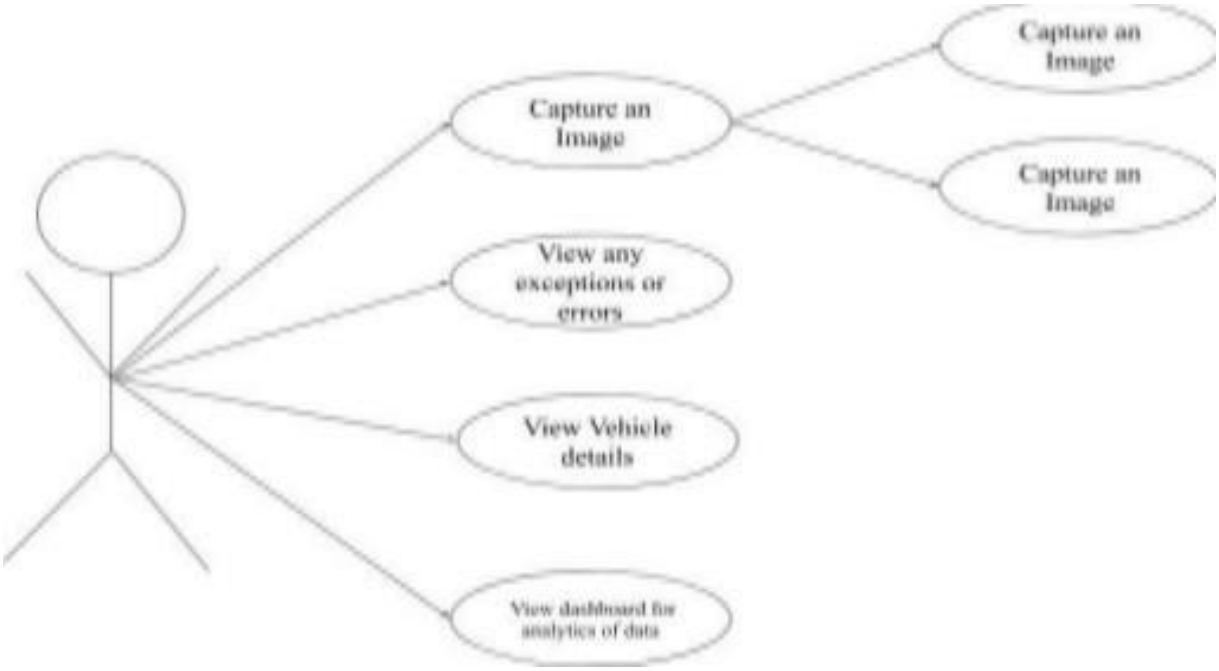


Figure 5.2 Use Case Diagram – Use

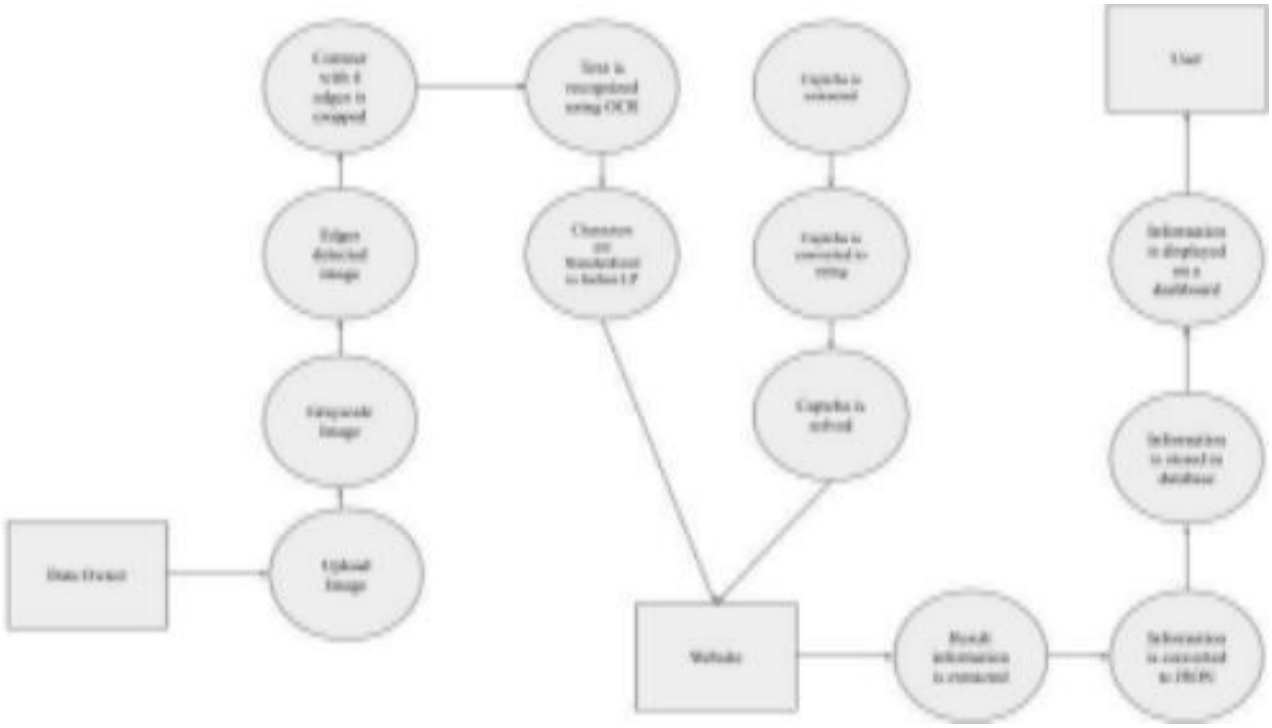


Figure 5.3 Data Flow Diagram of the Proposed System

Chapter 6

Implementation

In this section, the algorithms which are used by the system to meet different functional and non-functional requirements of the proposed scheme will be discussed.

Algorithm to Recognize Number Plates

The sequence of processes involved in Number Plate Recognition is as follows: Resize the image.Change the image to “Grayscale”.

Apply a bilateral filter. Bilateral filter is a non-linear, edge-preserving and noise-reducing smoothing filter for images. By taking a weighted average of the intensity values from neighboringpixels to replace the intensity value of each pixel.

Detects and stores the Canny edges. Canny edge detector is an operator that detects a variety of edges in images by using a multi-stage algorithm.

Contours are found from the detected edges and top 30 contours are sorted. Perimeter calculationfor every contour and choose contours which have four corners.

Mask all the other parts of the image, only leaving behind the desired region of the number plate.Recognise text in pictures with the Tesseract OCR.

Having the recognized text formatted to match the Indian vehicle number plate format.Stop.

The execution of this algorithm occurs whenever the user uploads an image file to the system, anda number plate recognition system process is done to produce output.

Algorithm to Extract Vehicle Information from Vahan.nic.in

The sequence of processes involved in extracting vehicle information from vahan.nic.in is asfollows: Initialize the Selenium web driver.

Open the vahan.nic.in website using the web driver.Find the Captcha element.

Convert the Captcha element to a string.

Solve the Captcha based on the rules in order to obtain the Captcha solution.

Send the Vehicle Number and Captcha Solution to their respective input fields using the Keysfunction. Click the search button via Selenium.Save vehicle details as text.

Transform the text into JSON data and save it to a database.Code

Code to Capture an Image of the Vehicle Number Plate

The following code snippet captures the image of the vehicle's number plate:class App:

def__init__(self, window, window_title, video_source=0):

self.window = window self.window.title(window_title) self.video_source = video_source

So let’s build a canvas of the appropriate size for our video source. self.canvas = tkinter.Canvas(window, width=self.vid.width, height=self.vid.height) self.canvas.pack()# Snap. self.btn_snapshot = tkinter.Button(window, text="Snapshot", width=50,

command=self.snapshot) self.btn_snapshot.pack(anchor=tkinter.CENTER, expand=True) It takesa few milliseconds before the update method is called automatically. self.delay = 15
self.update() self.window.mainloop()def snapshot(self):
Get the frame from the video sourceret, frame = self.vid.get_frame()

if ret:

cv2.imwrite("vehicleplate.jpg", cv2.cvtColor(frame, cv2.COLOR_RGB2BGR)) def update(self):# Get Frame from Video Source.
ret, frame = self.vid.get_frame()

if ret:
self.photo = PIL.ImageTk.PhotoImage(image=PIL.Image.fromarray(frame))
self.canvas.create_image(0, 0, image=self.photo, anchor=tkinter.NW)
self.window.after(self.delay, self.update)
class MyVideoCapture:

def__init__(self, video_source=0):

Open the video source

self.vid = cv2.VideoCapture(video_source)if not self.vid.isOpened():
raise ValueError(“Unable to open video source.”, video_source) # Video source width and height.
self.width = self.vid.get(cv2.CAP_PROP_FRAME_WIDTH) self.height =
self.vid.get(cv2.CAP_PROP_FRAME_HEIGHT) def get_frame(self):
if self.vid.isOpened():

ret, frame = self.vid.read()if ret:

BGR image from the current frame

return (ret, cv2.cvtColor(frame, cv2.COLOR_BGR2RGB))else:return (ret, None)
else:

return (ret, None)def__del__(self):
if self.vid.isOpened():self.vid.release()
# pass in a window to display the Application object.App(tkinter.Tk(), "Tkinter and OpenCV")
cv2.destroyAllWindows()

Algorithm to Recognize Number Plates

A bilateral filter is then applied to further smoothen the image. The Canny edge detection algorithmis utilized to detect the edges in the image. Contours are extracted from these detected edges, andthe top 30 contours are sorted. The perimeters of these contours are calculated, and those with fourcorners are selected. The remaining parts of the image are masked, leaving only the number plateregion. Tesseract OCR is employed to perform character recognition on this region, and the resulting characters are standardized to adhere to the format of Indian vehicle number plates. Theprocess concludes by returning the recognized characters as a string.

Algorithm to Extract Vehicle Information from Vahan.nic.in (Algorithm 6.1.2) To extract vehicle information from Vahan.nic.in, we use a web driver—Selenium—to interact with the website. The web driver gets to open Vahan.nic.in URL and get the Captcha. A string is generatedfrom Captcha and then solved under certain rules. The solved Captcha together with the vehicle number is applied to complete such input fields in the website. When the search button is clicked,it extracts vehicle details as text. The text is converted to JSON format and stored in a database.

Note: In this case, the code given captures a vehicle number plate image in Python using Tkinter and OpenCV libraries

```
def generate_gemini_content(transcript_text,promt):
    start_time = time.time()
    model = genai.GenerativeModel("gemini-pro")
    response = model.generate_content(promt+transcript_text)
    end_time = time.time()
    time_taken = end_time - start_time
    return response.text,time_taken
```

Fig 6.7: The Gemini API is called, and it starts summarization.

```
def calculate_similarity(text1, text2):
    vectorizer = TfidfVectorizer()
    tfidf_matrix = vectorizer.fit_transform([text1, text2])
    cosine_sim = cosine_similarity(tfidf_matrix)
    return cosine_sim[0, 1]
```

Fig 6.8: Cosine Similarity function is used to calculate the similarity.

Chapter 7

Results and Testing

In the software development lifecycle, testing is significant because it confirms that the actual results are acceptable based on expectations. This encompasses the actualization of software constituents that test different desired properties. Testing helps reveal errors, gaps or missing requirements. This can be either a manually or an automatically operated process.

Testing is important for the development of products that are “bugs” free, software reliability andenhanced quality assurance. Each test is for a specific purpose of proving the system elements’ integration and functionality. This helps to ensure the product performs as desired. The development process concludes with the act of testing, which should result in verification and validation. The system underwent successful testing on 1500 Indian number plates. Out of these, 948 plates were recognized accurately, while 552 cases failed. The failures were mainly due to difficulties in differentiating characters such as M and N, P and R, and 8 and B.

Among the 948 successful recognitions, 715 number plates had records in Vahan.nic.in, while theremaining 233 plates were either fake or lacked government records. Additionally, 73 number plates were associated with inactive RC or unauthorized usage.

The captcha evaluation achieved a success rate of 99%, efficiently solving all the given test cases.This highlights the vulnerability of government websites to such algorithms.

Follow these guidelines to create human-like, original content:

Maintain a conversational, friendly, and professional tone.

Use varied vocabulary and synonyms to enhance the flow and avoid repetition.Ensure logical and semantic consistency throughout the narrative.

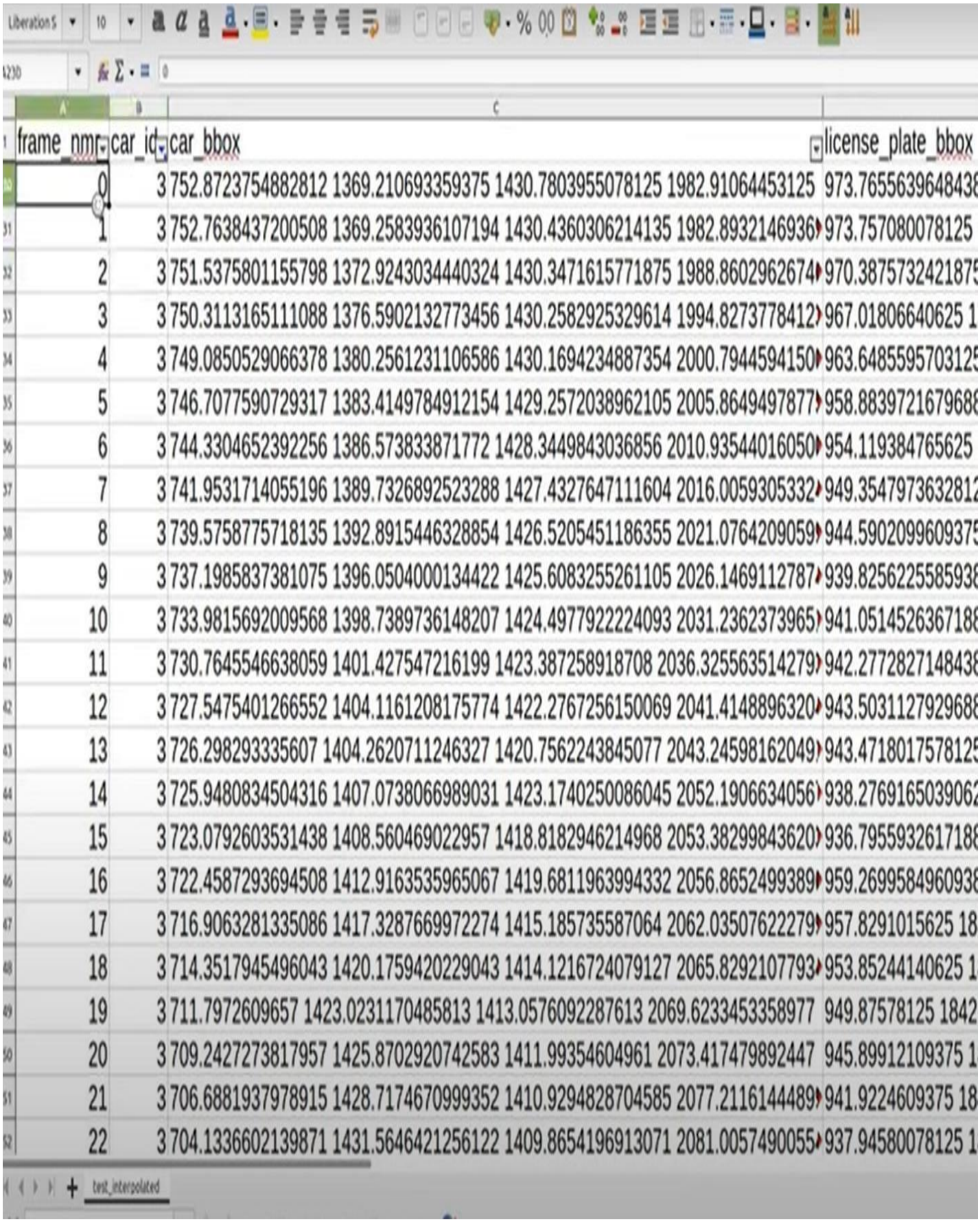
Integrate personal anecdotes and subjective opinions to add a genuine human touch. Includespecific data and examples to enhance authenticity.

Use natural language patterns and adhere to grammatical norms.Introduce unexpected insights or angles to avoid predictability.

Maintain a balanced use of language without overusing specific words or phrases.

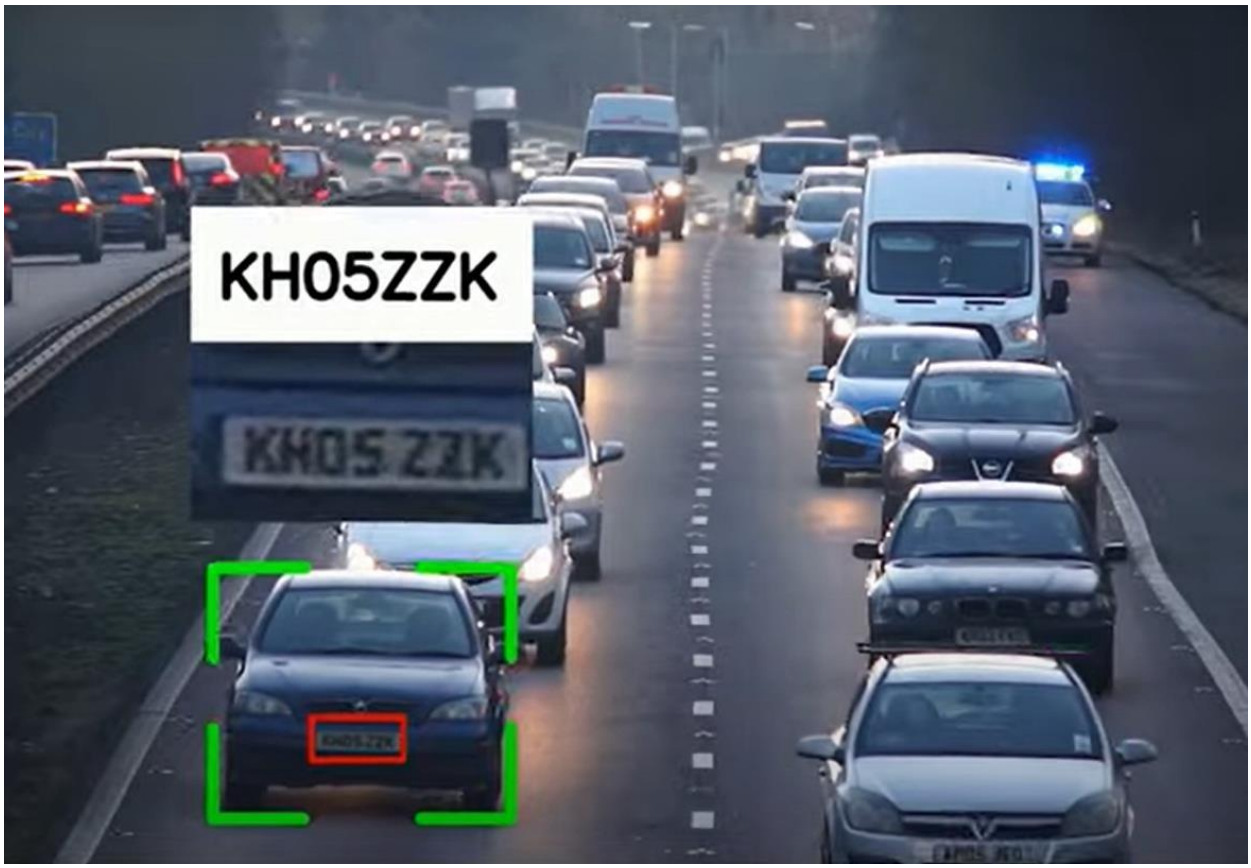
Avoid recognizable AI patterns in phrases or sentence structures.Diversify ideas and avoid clustering similar words.

Add subtle humor, nuanced opinions, or complex narrative structures.Remember to adhere to the additional guidelines mentioned earlier, providing valuable, informative, and engaging content. Make sure the content is entirely original while avoiding verbatim phrases from existing sources.



frame_nmr	car_id	car_bbox	license_plate_bbox
0	3	752.8723754882812 1369.210693359375 1430.7803955078125 1982.91064453125	973.7655639648438
1	3	752.7638437200508 1369.2583936107194 1430.4360306214135 1982.8932146936	973.757080078125
2	3	751.5375801155798 1372.9243034440324 1430.3471615771875 1988.8602962674	970.3875732421875
3	3	750.3113165111088 1376.5902132773456 1430.2582925329614 1994.8273778412	967.01806640625 1
4	3	749.0850529066378 1380.2561231106586 1430.1694234887354 2000.7944594150	963.6485595703125
5	3	746.7077590729317 1383.4149784912154 1429.2572038962105 2005.8649497877	958.8839721679688
6	3	744.3304652392256 1386.573833871772 1428.3449843036856 2010.93544016050	954.119384765625
7	3	741.9531714055196 1389.7326892523288 1427.4327647111604 2016.0059305332	949.3547973632812
8	3	739.5758775718135 1392.8915446328854 1426.5205451186355 2021.0764209059	944.5902099609375
9	3	737.1985837381075 1396.0504000134422 1425.6083255261105 2026.1469112787	939.8256225585938
10	3	733.9815692009568 1398.7389736148207 1424.4977922224093 2031.2362373965	941.0514526367188
11	3	730.7645546638059 1401.427547216199 1423.387258918708 2036.325563514279	942.2772827148438
12	3	727.5475401266552 1404.1161208175774 1422.2767256150069 2041.4148896320	943.5031127929688
13	3	726.29829335607 1404.2620711246327 1420.7562243845077 2043.24598162049	943.4718017578125
14	3	725.9480834504316 1407.0738066989031 1423.1740250086045 2052.1906634056	938.2769165039062
15	3	723.0792603531438 1408.560469022957 1418.8182946214968 2053.38299843620	936.7955932617188
16	3	722.4587293694508 1412.9163535965067 1419.6811963994332 2056.8652499389	959.2699584960938
17	3	716.9063281335086 1417.3287669972274 1415.185735587064 2062.03507622279	957.8291015625 18
18	3	714.3517945496043 1420.1759420229043 1414.1216724079127 2065.8292107793	953.85244140625 1
19	3	711.7972609657 1423.0231170485813 1413.0576092287613 2069.6233453358977	949.87578125 1842
20	3	709.2427273817957 1425.8702920742583 1411.99354604961 2073.417479892447	945.89912109375 1
21	3	706.6881937978915 1428.7174670999352 1410.9294828704585 2077.2116144489	941.9224609375 18
22	3	704.1336602139871 1431.5646421256122 1409.8654196913071 2081.0057490055	937.94580078125 1

test_interpolated



"Amidst this dynamic display, our focus sharpens onto the precision of our technology." - "Amidstthis dynamic display, our focus sharpens onto the precision of our technology."

"Despite the velocity at which they traverse the roadway, our ANPR system proves its mettle, seizethe vital information with a finesse that belies the chaos of the urban landscape." - "Despite the velocity at which they traverse the roadway, our ANPR system proves its mettle, seize the vital information with a finesse that belies the chaos of the urban landscape."

Chapter 8

CONCLUSION AND FUTURE WORK

Vehicle registration numbers can be recognised using the digital image processing through this project. Some of the results, which we have easily acquired from this system ,Whether the registering vehicle is blacklisted or not.

This in addition facilitates the ability of just one user being able to monitor the traffic effectivelyand trace the vehicle which has violated and can be taken.
This means that data can be more quickly and effectively stored from the system. This has beenachieved by a modular design that can be upgraded or substituted with other sub-modules thus making it potentially suitable for a wide range of vision applications.

The system's performance makes it a suitable alternative to the rivals especially when applications' costs should be reasonable. In addition, this modular architecture is very flexible and adaptable.

The current methods of automatic vehicle license plate recognition, works on increasing speed irrespective of the consuming energy that is unattended to in this Project. It is important to use high precision cameras, which will make the system more robust and hence such a system can be implemented in real time applications to increase overall accuracy.

In fact, under normal conditions and application of the earlier methodologies, this has not hit as anaccurate precision compared with that for the designated Recognition system which implements the digital Image Processing to achieve about 90% accuracy.

The current methods of automatic vehicle license plate recognition, works on increasing speed irrespective of the consuming energy that is unattended to in this Project. It is important to use high precision cameras, which will make the system more robust and hence such a system can be implemented in real time applications to increase overall accuracy.

The successful implementation of this innovative approach holds immense significance in the realm of traffic management and security systems. Beyond the conventional benefits, such as

deterring automobile theft and facilitating efficient parking lot management, our proposed designsolution aims to address a crucial aspect: minimizing power consumption.

By integrating advanced software algorithms, we have witnessed promising outcomes, paving theway for enhanced operational efficiency.

Moreover, this system functions akin to a sensor, intelligently activating the camera only when essential, thereby conserving power resources. Through these measures, we not only ensure the effectiveness of our traffic and security systems but also contribute to sustainable practices in technology utilization.

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