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A REVIEW PAPER ON AUTOMATIC NUMBER PLATE RECOGNITION FOR DIGITAL GATEKEEPING

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Abstract: At most vehicle entry points, the entry process for guests, employees, or people visiting the society or gated communities involves a security guard writing the visitor data on a register and then confirming the registration details by checking an identification document. This process has a huge probability of involving human errors while the confirmation and registration process as it is a manual process. Registering and manually entering input and output data can be tedious and time-consuming work for security guards at the entry points. Since the information entered is in hard copy, it is difficult to share it and maintain. This paper proposes an automatic Gatekeeping system to reduce the manual entry process and minimize security guard efforts. When the vehicle gets close to the checkpoint, the camera will capture the vehicle's number plate, and Automatic Number plate recognition (ANPR) automatically recognizes its number plate with the help of image processing. If the vehicle belongs to a resident of the society a seamless entry is given otherwise it stores the information in the vehicle registration database which is associated with that particular vehicle number. Through this system, security and authorized personnel will be able to monitor the movement of the vehicle along with information about its owner. The proposed solution will reduce check-in and check-out time along with reducing the manual work
Keywords: Automatic Number Plate Recognition, Image Preprocessing, Machine Learning, Optical Character Recognition

Introduction: The growth of vehicles in India has grown rapidly from 2022 to 2023. In July 2023 the Indian automotive industry's growth stood up by 10 percent compared to July 2022. The increased growth of vehicles must be balanced with the services for vehicles such as parking spaces in public and private areas, toll booths, smart traffic management, and monitoring. Smart Management of Vehicles includes counting the vehicles on highways and keeping track of vehicle's entry-exit time. The services can be operated without any human intervention and save manpower. Vehicle management, authorization, and transportation are tiresome and time-consuming processes. If they are executed manually, there are high chances of mistakes and difficulties hence it is important to implement the Automatic Recognition and Detection of Vehicle Number Plate System.

In societies, vehicles enter and exit the society every day, and keeping track of the entry and exit time is time-consuming if done manually. The authorized vehicles of the society members will be stored in the system along with owner information. Every time the vehicles enter or exit society it will trigger real-time data and store the arrival and exit time in the database.

The main aim of our project is to develop a system to reduce the manual registration work of recording visitors' data. We develop an algorithm for license plate recognition for automobile vehicles. To detect a number plate for an image, the image of the vehicle should be passed through an algorithm to extract the character using Optical Character Recognition (OCR). Once the segmentation of characters is completed, these are passed to the OCR algorithm and the final format has to match the data from the database of the application. Different scales, resolutions, illumination, and light variations have to be considered.

1. Literature Review: This paper[1] presents a system that makes use of Raspberry Pi to capture car images and alerts a computer if an unauthorized vehicle is detected. The input for this system is the image of the vehicle and the output is the number plate number of the car. The system uses methods

likecolour conversion, vertical edge detection, and image enhancement, and uses the Linux operating system.

This paper [2]uses a Pi camera to capture images and store them in colour JPEG format. Grey processingand median filtering remove noise from images. A Bounding Box detects rectangular plate borders, while an Edge Detector detects vehicle edges. Segmentation separates characters in number plates, and OCR recognizes them. After recognition, the characters are displayed as output.

This paper [3]introduces an automated recognition system for number plates of vehicles which control campus entrances. The system captures, identifies, and verifies licenses using image processing technology. The system consists of three major steps: license plates, segmentation of character, and identification marks. The detected accuracy is 91.58%, the segmentation success rate is 91%, and the verification rate is 80%.

This paper [4]extracts the number plate andconverts into text. This text and entry time is then saved in the MySQL database. When this same vehicle leaves its exit time is also stored. The proposed work handles and works on imageprocessing, character segmentation, character recognition, and digital image processing.

The paper [5]proposes an automatic licenseand number plate recognition system which performs image-processing algorithms to extract license plate numbers from vehicles passing through a location. This system uses cameras to capture images, which are processed by ANPR software using localization, orientation, segmentation, and optical character recognition algorithms. The information is stored in adatabase for future retrieval.

This paper [6]uses traditional image processing methodologies to identify and extract the number plate area. The connected component analysis does the segmentation of characters and built-in OCR recognizes them. The image converted to HSV colour format, and strong blobs are found using binarization and morphological operations. The Ramer Dauglous Peacuker shape approximation algorithm detects rectangular shapes, with the most prominent being the number plate area.

This paper [7]proposes a technique of character and number recognition of number plates of vehicles in motion by using a Raspberry Pi digicam. The method extractsand preprocesses vehicle number plate frames, using a deep residual network structure with 34 layers for feature extraction and character identification.

This paper [8] uses CNN to identify vehicle number plates. The number plate area is isolated, and the photo is processed by converting RGB image into grayscale.Gaussian blur and edge detection reduce noise. Six layers of CNN are used to maximize accuracy. Using CNN in all images,even skewed and tilted ones are detected. Implementing CNN increased the system's accuracy by 9%, from 82% to 90.80%.

This paper [9]proposes a system that converts images to Gray RGB format to minimize colour visibility. Filters like median and Wiener filters remove noise, which can result from camera malfunction or weather changes.Morphological operations extract license plate regions from input images, and segmentation is used to segment the binary image of withdrawal permits. The algorithm examines horizontal lines to find conditions satisfying characters'positions, recognizing behaviour using an artificial neural network. The license number is then recognized and stored in anotepad file.

The study [10]proposes a sturdy recognition and identification system for transitional vehicle licenses. It improves character recognition effectiveness for number plates by using a 53-layer deep CNN architecture. Themethod was tested on a huge dataset containing eight license plate types from different Pakistani provinces, achieving aaccuracy of 97.82% and a character recognition effectiveness of 96%. The results were obtained after processing and determining the design's accuracy using the test model.

This paper [11]presents a deep automatic license plate recognition system for multinational license plates, based on YOLO networks. The system uses tiny YOLOv3 for character recognition and YOLOv3-SPP for layout detection. The system extracts the correct sequence of number plates of multinational plates.

This paper [12]proposes an idea for license-plate recognition for an auto service using

libraryOpenALPR for countries in Europe. To detect a numberplate the captured image undergoes character extraction OCR. The obtained text has to match with the data present in the database.
In this paper [13]TensorFlow, Keras, and YOLO are the Python libraries used for developing and training deep learning models.TensorFlow offers workflows for Python or JavaScript deployment, Keras is usedfor smartphones and distributed training, and YOLO is a popular algorithm for object detection with a speed of 45 frames per second and an understanding of generalised object representation. These methodologies enhance computer vision and speed up applications.
This paper [14] introduces YOLO, a fast object detection method that uses regression model to distinguish between different variants and class probabilities. Ituses a convolutional algorithm with 24 convolutional layers and2 full layers. YOLO takes photos at 155 frames per second, making it the fastest object detector. It produces more error in the region but less than the negative estimate. It also learns thegeneral representation of objects and outperforms other search methods such as DPM and R-CNN.
The study [15]compared the number plate identification and recognitionof Haar, LBP and YOLO v5 classifiers. While Haar achieved 99% accuracy, LBP and YOLO v5 fell short. Post-processing steps such as binarization, segmentation, and median filtering contribute to OCR in character recognition. PyTesseract helps improve the overall performance of the AVNPDR system by providing 91.6% performance on segmented characters.
This paper [16]proposes a real-time Vehicle Number Plate Recognition (ANPR) method to identify and verify the license plates. This method includes three stages: license check, category segmentation and recognition. It uses HAAR feature-based classifier for license plate detection, class extraction for class recognition, and CNN for class recognition. The time recognition rate of the system goes up to 90.90%.
This paper [17]proposes the use of an IP camera for automating plate recognition by analysing video feeds from vehicles. The k nearest neighbours' algorithm is used to identify segmented characters,with accuracy of 87.43%.This method outperforms existing techniques like artificial neural networks, with an average processing time of 0.034 s.
This paper [18]proposes an vehicle plate recognition system that has been established using digital image processing technology along with CNN theory. The system uses OpenCV and TensorFlow on Android to locate, segment, and identify license plate characters.
The paper [19]uses the YOLO algorithm forreal-time object identification and recognition in images. The YOLOv3 model, developed using Python libraries and YOLO datasets, consists of three major files: COCO, YOLO, and WEIGHTS. The model enhances computer vision and output through images, videos, or live streams. It uses a one-stage detection strategy, and combines the strengths with single-shotdetectors and YOLO, sacrificing some accuracy compared to two-stage detectors.
This paper [20] reviews Vehicle NumberPlate detection systems, focusing on their performance and advancements. It discusses the need for additional hardware and provides guidelines for future possibilities in ANPR, analysingextraction, segmentation, and recognition techniques.
This paper [21]uses image segmentation and OCR to extract vehicle number plates. The data is then compared against database records, including owner information of the associated vehicle. The system identifies the vehicle's RFID and extracts the license plate number. If the ID matches the database, the message"authorized person" is displayed, ensuring consistency with thedatabase. This system provides identification and automatic information on theft and criminal vehicles.
This paper [22] introduces a deep neural network architecture using TensorFlow and EasyOCR libraries to improve recognition accuracy in challenging environments like dim lighting, poor image quality, and occlusions. The architecture binds convolutional and recurrent layers, achieving 91% accuracy on an open dataset.
This paper [23] introduces a dim-light number plate recognition method, utilising a lightweight architecture similar to VGG, which outperforms generally used lightweight methods. It also visualises challenging data and identifies various data types forfuture research.

This paper[24] proposes a simple, configuration-independent method to improve outdoor license plate recognition and detection. The network uses lightweight, anchorless detection of the internet and attention- based recognition networks. Tests show that it is more effectivethan traditional methods and can be extended to other characters. This framework is resistant to spatial distortion andnoise.
This paper [25]explores deep learning's use in license plate recognition, addressing technical issues like license plateskew, and image noise. It categorises algorithms into direct andindirect detection, analyses their advantages and disadvantages, compares data sets, workstations, accuracy, and processing time, and surveys number plate recognition systems.
This paper[3] introduces a new system for vehicle number plate identification, which correctly segmented 1287 license plates (96.5%) using image segmentation and connected component analysis. The OCR system achieved an overall success rate of 86.0% and performsbetter with low background complexity.
The study [26] showcases a simple number plate recognition system using object detection and OCR to identify vehicle number plates and extract text and numbers. The YOLO model combined with the Py-tesseract engine has shown significant accuracy in license plate detection, with a 97.0% accuracy rate.
The paper [27]presents a method using ANPR to identify parking rule offenders by keeping extracted number plates in database and verifying these number plates against existing registered number plates that have given the parking amount. The proposed system can also detect stolen vehicles.
This paper [28] presents three modules to recognize vehicle number plates: image acquisition, license plate detection, and character recognition. OpenCV is used for data retrieval, YOLOv5 for plate detection, and OCR methods Tesseract OCR and EasyOCR for character recognition. EasyOCR outperforms Tesseract OCR with 95% accuracy.
In recent years, the application of License Plate Recognition (LPR) has evolved into an invaluable asset within the realm of vehicle surveillance, offering its utility across a spectrum of purposes. This encompasses the enforcement of traffic safety regulations, seamless automatic toll collection, efficient management of car park systems, and the facilitation of automatic vehicle parking systems. The underlying LPR algorithms are typically structured into four sequential steps: vehicle image capture, license plate detection, character segmentation, and character recognition. The ultimate success of the final step hinges on the accuracy and precision exhibitedby the second and third stages, as they work in tandem to precisely locate the vehicle's number plate and meticulously isolate each character. Across the domain of LPR, numerous systems rely on commonly adopted methodologies such as artificial neural networks, probabilistic neural networks, and OCR, among others.
In a parallel vein, one encounters an array of systems designed to meticulously track the entry and exit times of vehicles within locales like malls and gated communities. Among these, systems like "My Gate" excel in managing visitordata by seamlessly collecting and relaying this information to the corresponding flat or property owner for authorization and approval of the visitor. However, it is imperative to note that within these systems, the manual process of entering visitor details remains a significant challenge, presenting opportunitiesfor improvement and automation in visitor management. Manually entering the data of visitors at the entry and exit points is a very tedious and time-consuming job. Instead of doing this, we can reduce the time of this process with the helpof the proposed system. In existing systems, visitors must wait in a queue to register information about them which is maintained by security guards at the checkpoint. However, the proposed system can solve this issue. It will reduce the workload of security guards, reducing the waiting time ofvehicles at the entry point of the gate, and help to keep track ofthe visitor's information entering the society through the numberplate of the vehicle. At the entry point, the vehicle's number plate is recognized if it is a vehicle of the society resident then direct access is given or else the data associated with the number plate of the vehicle like owner name, address,phone number, car model etc are fetched and stored in the visitor's database. After that, the request goes to the owner andonce he approves it only then access is given to the visitor insidethe society or gated community. This system will help to keep track of all the vehicles visiting a

particular resident thus helping in having a secured entry exit and visitor record- keeping system.

2. Objective: This paper aims to design a technologically advanced gatekeeping system that saves time and reduces the manual entry process of entering the visitor's data into the registers. The aim is to automate visitor record management in gated communities and streamline the entry-exit process of vehicles.

3. Methodology:

3.1 ANPR: Automatic license plate recognition (ANPR) is a machine that recognizes and extracts vehicle numbers. Image capture is the first step in capturing the input image from the camera. Alphanumeric characters are first extracted from the plate in the image and then sorted individually. ANPR has two main components: a camera to capture license plate images and software for character recognition and segmentation. The whole process of license plate recognition is divided into four stages, such as capturing images, identifying the license plate, classifying symbols and the final step of recognition of character.

3.2 Image Acquisition: The first stage involves acquiring image data of vehicles with a number plate. Cameras capture RGB images, which can be affected by noise, light intensity, and vehicle motion. To avoid distortion, a pre-processing stage is introduced. RGB is used to determine if the number plate is private or commercial. Edge detection is a crucial step in Automatic Number Plate Recognition (ANPR) systems, isolating the characters or digits on a license plate from the background, making it easier to recognize and extract information. The final output is the license plate region. Mathematical definition of image: f (x, y) x and y are spatial coordinates of an image, and f is the intensity of light at that point. This function is always discrete on digital computers. x ∈ ℕ0 ᗅ y ∈ ℕ0, where ℕ0 denotes the set of natural numbers including zero.

We use a periodical convolution of the function f with specific types of matrices m to detect various types of edges in images:

$$:\tilde{f'}(x,y) = f(x,y) * m[x,y] = \sum_{i=0}^{w-1}.\sum_{j=0}^{h-1} f(x,y).m[mod_w(x-i), mod_h(y-j)$$

Here, w and h are dimensions of the image represented by the function f.The expression m[x y,] represents the element in xth column and yth row of matrix m

An image is represented by a function f (x , y) ,where $x_0 \leq x \leq x_1$ and $y_0 \leq y \leq y_1$.The [x_0 ,y_0] represents the upper left corner of the image, [x_1, y_1] represents the bottom right corner. If w and h are dimensions of the image then x_0 =0 , y_0=0, x_1=w-1, y_1=h-1.

The band b in the image f is an arbitrary rectangle b = (x_{b0}, y_{b0}, x_{b1}, y_{b1}), such as: ($x_{b0} = x_{min}$) ^ ($x_{b1} = x_{max}$)^($y_{min} \leq y_{bo} < y_{b1}$^ y_{max}) The plate p in band b is an arbitrary rectangle p =(x_{P0}, y_{P0}, x_{P1}, y_{P1}) such as ($x_{b0} \leq x_{P0} \leq x_{P1} \leq x_{b1}$)^($y_{p0} = y_{bo}$) ^ ($y_{p0} = y_{bo}$). The band is the vertical selection of the image, and the plate is the horizontal selection of the band. As shown in the Figure below. The number plate of the vehicle is given a red boundary box.

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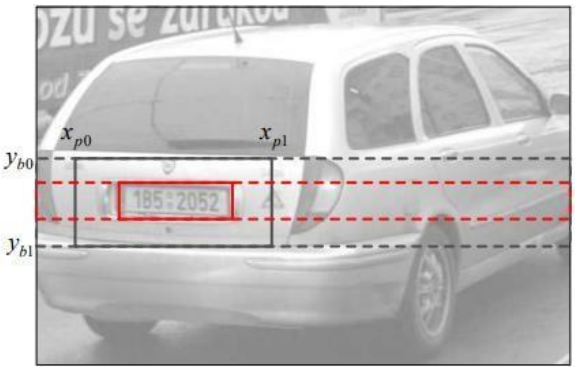

Figure 1. Detection of Number Plate Region

3.3 Character Segmentation: The rectangular-shaped numberplate is extracted and then split it into the binary image; the output image will contain the desired characters. Characters are divided into sections using the bounding box technique, where one box is drawn on top of another. Character Segmentation breaks down the characters of the license plate into each individual separate character which makes it easy to process them. This can be implemented using horizontal and vertical projection profiles and then the distribution of pixel values is analysed along with the rows and columns of the character. The gaps between characters should be recognized and separated.

3.4 Character Recognition: The primary Python tool for optical character recognition (OCR) is the Python-tesseract. It is capable of reading and identifying the data in the image. It will print the confirmation letter if it is used to create a letter. These characters read the characters on the license plate using optical character recognition (OCR) technology. The domain area is produced as a new image upon license approval. After character segmentation, OCR is performed to the newly created image to extract every character from the segmented characters. These symbols on the plate could be letters and digits. After that, the image is transformed into text and saved in an alternative string.

The text generated from the system, which is the license plate number will be further compared with the residential database, if the text i.e., the number plate is present in the database then permission to enter will be given to the vehicle but if it's not there in the database then it will fetch the data of the owner associated with the vehicle and a request will be sent for the approval and after approval, the vehicle will be given access in the society premise. The application will utilize a NoSQL database for real-time and batch-mode data storage, storing structured and unstructured data. It will have two databases: a dataset containing vehicle details for society or gated community residents, and a resident database updated as visitors arrive or enter the community, ensuring efficient data retrieval for historical records.

3.5 Mathematical Models:

3.5.1 Bounding Box:

Class: The class denotes the object inside the bounding box like cars, houses, buildings, etc.

(X1, Y1): Here, X and Y are the coordinates that belong to the top left corner of the rectangle.

(X2, Y2): Here, X and Y are the coordinates that belong to bottom right corner of the rectangle.

(Xc, Yc): Here, X and Y are the coordinates of the center of the bounding box.

Width: It denotes the width of the bounding box. Height: It denotes the height of the bounding box.

Confidence: It represents the possibility of an object being in the specified area.

$Xc = (X1 + X2)/2$

$Yc = (Y1 + Y2)/2$

$Width = (X2 - X1)$

$Height = (Y2 - Y1)$

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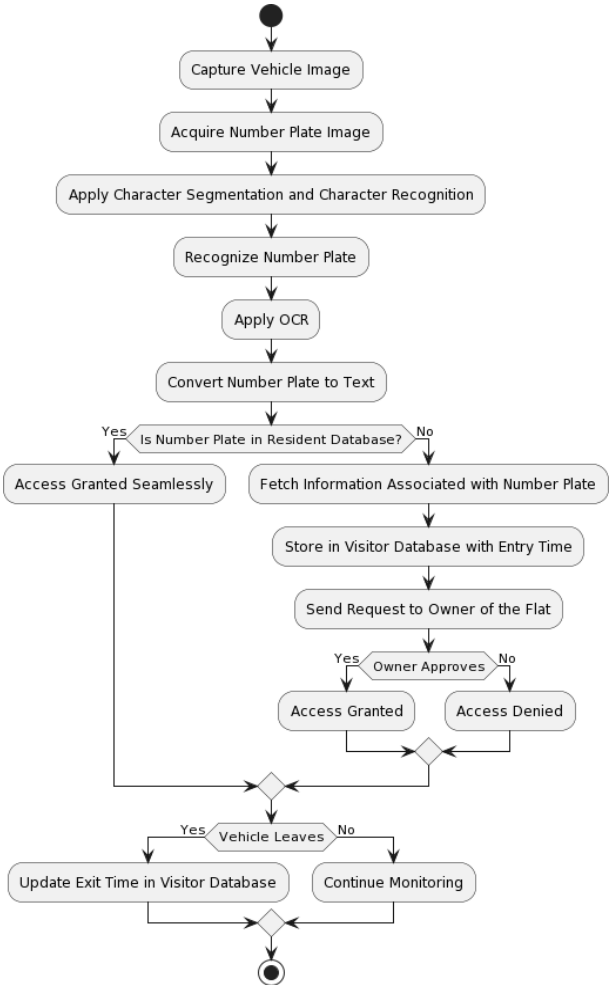

Figure 2. Flow Chart for Digital Gatekeeper

3.5.2 OCR:

F(x, y) = 1 if K(x, Y)>=T

= 0 if K(x, y) <T

F(x, y) = 1 for Image Object

F(x, y) = 0 for Background Object T= Threshold

There must be a way to separate images. In this way, the imageis converted into binary form to separate the object from the background. Grayscale thresholding is a simple method. Selectthe threshold (T) and compare it to the pixels of the input image.The input image is converted to the output binary image and then segmented. In global measurement, a threshold is used to divide the histogram of the image. Threshold refers to the grayscale value of the central border between the foreground and background in pixels.

Figure 2. Detection of Number Plate

The above image shows real-time number plate recognition, the number plate is recognized successfully and the value is displayed in the green boundary box.

4. Conclusion and Future Work: The evaluation of an Automatic Number Plate Recognition (ANPR) system involves assessing its performance using various parameters. These parameters include accuracy, speed, robustness, recognition rate, training time, adaptability, recognition range, integration and compatibility with cameras, user interface, and reporting and logging. Accuracy measures the system's ability to recognize license plates accurately, while speed and throughput measure its processing speed for real-time applications. Robustness tests the system's performance under various weather and lighting conditions, while recognition rate evaluates its ability to recognize different types of license plates. False Positive and False Negative Rates measure the system's ability to identify non-license plate objects as license plates and false negative rates measure its failure to identify true license plates. Integration and compatibility with cameras and other systems are also crucial. The user-friendly interface and reporting capabilities are also evaluated. Regular evaluations of an ANPR system are essential to ensure its effectiveness and reliability in practical applications, considering the specific requirements of the system and environmental conditions.

Numerous tests have been conducted to identify and recognize license plate numbers. Numerous approaches and strategies exist for this. The suggested work focuses on recognition technology, which takes a picture of the license plate using cameras and preprocesses it to extract information about the car owner from the plate. For the security guard at the checkpoint, registering, manually entering the data, and retrieving the result may be a laborious, stressful, and time-consuming task. Sharing and maintaining the data entered is difficult because it is in hard copy. So, in order to streamline the human entrance procedure and lessen the need for personal security, we suggested an automated gatekeeping system. When a vehicle's number plate is identified, it is compared to the resident database. If the vehicle is identified as a resident, access to the society is granted; if not, the owner's information is retrieved and entered into the visitor database along with the vehicle's arrival and departure times. The owner of the apartment receives a request for permission. The car can enter after the owner gives the permission.

In future, the efficiency of this system can be improved and the total entry time of a vehicle inside the housing societies can be reduced further.

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