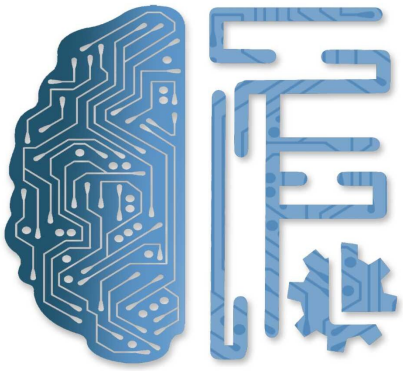
Automatic License and Number Plate Recognition

Product Model Development

submitted by

Manishankar Bag



Two Month Internship Program in FeyNN Labs : AI for Small Business

July 27, 2023

Contents

1 Abstract

Number plate detection is an essential task in many applications, such as traffic surveillance, vehicle identification, and law enforcement. This project aims to develop a machine learning-based system for automatic number plate detection and recognition. The proposed system utilizes state-of-the-art deep learning techniques, specifically convolutional neural networks (CNNs), to accurately detect and extract number plates from input images or video frames.

The project begins with the collection and preprocessing of a diverse dataset of vehicle images with annotated number plates. The dataset is carefully curated to include various lighting conditions, weather conditions, and vehicle types to ensure robustness and generalization of the trained model. The collected data is then used to train a deep CNN model, specifically designed for object detection tasks.

The trained model is capable of detecting and localizing number plates within input images or video frames. It achieves this by employing a region proposal network (RPN) that generates candidate regions likely to contain number plates. These candidate regions are then refined and filtered to obtain accurate bounding boxes around the number plates. Once the number plates are localized, a separate recognition module is employed to perform optical character recognition (OCR) on the extracted region, decoding the alphanumeric characters present on the plate.

To enhance the performance of the system, various techniques are incorporated, including data augmentation, transfer learning, and hyperparameter optimization. The model's performance is evaluated on a separate test set, measuring metrics such as precision, recall, and mean average precision (mAP).[2]

The results demonstrate that the proposed system achieves high accuracy and robustness in detecting and recognizing number plates across different scenarios. It showcases the potential of deep learning techniques in automating number plate detection, offering significant benefits in applications such as traffic management, law enforcement, and parking systems. The developed system provides a foundation for future research and improvements in the field of number plate detection, paving the way for more advanced and efficient solutions in real-world deployments.

2 Problem Statement

Automatic license plate and number plate recognition is a crucial task in various domains, including traffic management, law enforcement, parking systems, and vehicle tracking. However, the accurate and efficient recognition of license plates poses significant challenges due to factors such as varying lighting conditions, diverse plate designs, occlusions, and complex backgrounds. Therefore, there is a need for a robust and reliable system that can automatically detect and recognize license plates from images or video frames, enabling accurate and efficient retrieval of license plate information.

The existing solutions for license plate recognition often rely on traditional computer vision techniques that may struggle to handle the complexity and variability of real-world scenarios. These methods often require manual parameter tuning, making them less adaptable to different environments and license plate designs. Moreover, they may lack the ability to handle real-time processing requirements, limiting their applicability in dynamic settings.

To address these challenges, the goal of this project is to develop an advanced automatic license plate and number plate recognition system based on machine learning techniques. The system should be capable of accurately localizing and extracting license plates from complex images or video frames, followed by the precise recognition of alphanumeric characters on the plates. It should handle various challenging conditions, including low lighting, different license plate designs, occlusions, and

complex backgrounds. Additionally, the system should aim to achieve real-time performance to enable efficient deployment in time-sensitive applications.[1]

The developed solution should leverage state-of-the-art deep learning algorithms, such as convolutional neural networks (CNNs) and optical character recognition (OCR) models, to achieve high accuracy and robustness. It should utilize large and diverse datasets to train the models, encompassing different license plate designs, vehicle types, and environmental conditions to ensure generalization and adaptability.

Ultimately, the automatic license plate and number plate recognition system should provide accurate and reliable results, enabling efficient retrieval of license plate information for various applications. By addressing the limitations of existing methods and leveraging the power of machine learning, the developed system will contribute to improved traffic management, enhanced law enforcement, streamlined parking systems, and effective vehicle tracking, benefiting both individuals and organizations.

3 Business Need Assessment: Automatic License and Number Plate Recognition

Efficiency and Accuracy in Traffic Management: Automatic license and number plate recognition can significantly enhance traffic management systems by automating the process of identifying vehicles. This technology enables efficient monitoring and analysis of traffic flow, enabling authorities to optimize traffic control, detect traffic violations, and manage congestion effectively. Accurate recognition of license plates ensures reliable data collection for traffic analysis and facilitates the implementation of intelligent transportation systems.

3.1 Streamlined Law Enforcement:

Automatic license plate recognition streamlines law enforcement efforts by automating the identification of vehicles involved in criminal activities, traffic violations, or Amber Alert cases. The system enables rapid identification and tracking of vehicles, providing valuable information to law enforcement agencies for investigations. This technology improves the efficiency of law enforcement operations, enhances public safety, and aids in the detection and prevention of crimes.

3.2 Enhanced Parking Systems:

Implementing automatic license plate recognition in parking systems offers several benefits. It enables efficient entry and exit management, accurate billing, and improved security. With automatic recognition, drivers can seamlessly enter parking facilities without the need for physical tickets or manual interventions, reducing waiting times and enhancing customer satisfaction. Additionally, the system can monitor parking durations, identify violations, and provide real-time occupancy information to optimize parking utilization.

3.3 Vehicle Tracking and Fleet Management:

Automatic license and number plate recognition systems play a vital role in vehicle tracking and fleet management applications. By automatically capturing license plate information, organizations can monitor and track vehicles in real-time, ensuring efficient fleet management, route optimization, and

logistics planning. This technology enables businesses to streamline operations, improve delivery processes, and enhance overall productivity.

3.4 Compliance and Security:

Automatic license plate recognition contributes to compliance and security initiatives by enabling efficient enforcement of regulations related to vehicle registration, insurance, and roadworthiness. The system can automatically compare captured license plate data with databases, alerting authorities about non-compliant or suspicious vehicles. This enhances overall security measures, reduces fraudulent activities, and promotes a safer environment for both individuals and organizations.[3]

3.5 Customer Service and Convenience:

Implementing automatic license plate recognition can enhance customer service and convenience in various scenarios. For example, in toll collection systems, it eliminates the need for manual ticketing or cash payments, enabling seamless and efficient passage for drivers. In automated access control systems, it simplifies entry and exit procedures, improving user experience and reducing waiting times. By leveraging this technology, businesses can enhance customer satisfaction, streamline processes, and differentiate themselves in the market.

Overall, automatic license and number plate recognition systems address critical business needs across multiple industries. They offer efficiency, accuracy, compliance, security, and convenience, enabling organizations to optimize their operations, improve customer service, enhance safety measures, and make data-driven decisions. By adopting this technology, businesses can gain a competitive edge, increase operational efficiency, and provide enhanced services to their customers.

4 Target Specification and Characterization

By specifying these following targets for the automatic license and number plate recognition system, the business assessment can effectively evaluate.

1. **Accuracy and Recognition Rate:**

   The automatic license and number plate recognition system should achieve a high level of accuracy in detecting and recognizing license plates. The target specification should define the acceptable recognition rate, ensuring that the system reliably captures and extracts alphanumeric characters from license plates in various conditions, such as different lighting conditions, diverse plate designs, and complex backgrounds.

2. **Real-Time Performance:**

   The system should meet the target specification for real-time processing, ensuring that license plates are detected and recognized within a specified timeframe. The assessment should determine the maximum acceptable processing time per image or video frame to ensure the system can handle dynamic environments, such as traffic surveillance or real-time access control systems.

3. **Scalability and Adaptability:**

   The business assessment should address the scalability and adaptability of the automatic license and number plate recognition system. The target specification should define the maximum number of concurrent vehicles the system can handle without sacrificing accuracy or

performance. It should also consider the ability to adapt to different license plate designs, regional variations, and evolving regulatory requirements.

4. **Robustness to Challenging Conditions:**

   The assessment should evaluate the system's robustness to challenging conditions commonly encountered in real-world scenarios. This includes factors such as low lighting conditions, occlusions (partially obscured plates), complex backgrounds, and adverse weather conditions. The target specification should define the desired level of robustness, ensuring accurate recognition in challenging situations.

5. **Integration with Existing Infrastructure:**

   The automatic license and number plate recognition system should be compatible with existing infrastructure and systems, such as traffic management systems, law enforcement databases, parking management software, or fleet management platforms. The target specification should include requirements for seamless integration, ensuring data interoperability and efficient utilization of captured license plate information.

6. **Data Privacy and Security:**

   The assessment should address data privacy and security concerns associated with automatic license and number plate recognition. The target specification should define the necessary safeguards, such as encryption protocols, access controls, and compliance with relevant data protection regulations, to ensure the system's integrity and protect the privacy of individuals' personal information.

7. **Cost-Effectiveness:**

   The target specification should consider the cost-effectiveness of the automatic license and number plate recognition system. This includes factors such as hardware requirements, software licensing fees, maintenance and support costs, and any necessary infrastructure upgrades. The assessment should evaluate the return on investment (ROI) and assess the system's affordability and long-term sustainability for the business.

8. **Usability and User Interface:**

   The assessment should evaluate the usability and user interface of the automatic license and number plate recognition system. The target specification should define requirements for a user-friendly interface, providing intuitive controls, informative visualizations, and easy access to captured license plate data. The system should facilitate efficient management, querying, and reporting of license plate information.

5 Business Model:

Here is a possible Business model for Automatic license plate and number plate recognition system

1. **Key Activities:**

   - Research and Development: Continuously invest in research and development to improve the accuracy, speed, and robustness of the license plate recognition system.
   - Data Collection and Annotation: Acquire diverse and comprehensive datasets of license plates to train and fine-tune the machine learning models.

- Model Training and Optimization: Utilize machine learning techniques to train and optimize the license plate recognition models for accurate and efficient performance.
- System Integration: Integrate the license plate recognition system with existing infrastructure and software solutions, such as traffic management systems, parking management platforms, and law enforcement databases.
- Deployment and Maintenance: Deploy the system to customer sites, provide ongoing maintenance and support to ensure smooth operation and timely updates.

2. **Value Proposition:**

   - Efficiency and Accuracy: Provide a reliable and efficient solution for automatic license and number plate recognition, enhancing traffic management, law enforcement, parking systems, and vehicle tracking operations.
   - Real-Time Processing: Enable real-time processing of license plate data, facilitating quick decision-making and timely responses in time-sensitive applications.
   - Adaptability and Scalability: Offer a flexible and scalable system that can adapt to different license plate designs, regional variations, and evolving regulatory requirements.
   - Integration and Interoperability: Ensure seamless integration with existing infrastructure and software systems, maximizing the value of captured license plate data and facilitating data exchange with relevant stakeholders.
   - Compliance and Security: Address data privacy and security concerns by implementing appropriate measures to protect sensitive license plate information and comply with relevant data protection regulations.

3. **Customer Segments:**

   - Government and Law Enforcement Agencies: Provide license plate recognition solutions to aid in traffic management, law enforcement, and criminal investigations.
   - Parking Operators and Facility Managers: Offer solutions to automate parking systems, optimize occupancy, and enhance security.
   - Toll Road Operators: Enable efficient and automated toll collection through license plate recognition, eliminating the need for physical tickets or manual payments.
   - Fleet Management Companies: Assist in vehicle tracking and fleet management for logistics, delivery, and transportation operations.
   - Smart City Initiatives: Support smart city initiatives by providing accurate and reliable license plate recognition for various urban applications.

4. **Revenue Streams:**

   - Software Licensing: Generate revenue through the licensing of the license plate recognition software to customers.
   - Maintenance and Support: Provide ongoing maintenance and support services, including software updates and technical assistance.
   - Data Services: Offer value-added services such as license plate data analytics, reporting, and insights to customers.
   - Customization and Integration: Generate revenue by providing customization and integration services to tailor the system to specific customer requirements.

5. **Key Resources:**
    - Technology Infrastructure: Establish a robust infrastructure to support the processing and analysis of license plate data.
    - Machine Learning Expertise: Employ a team of machine learning experts to develop and optimize the license plate recognition models.
    - Diverse and Comprehensive Datasets: Acquire and maintain datasets of license plates for training and fine-tuning the models.
    - Partnerships and Collaborations: Collaborate with relevant stakeholders, such as government agencies, parking operators, and software vendors, to leverage their expertise and establish strategic partnerships.
6. **Key Partnerships:**
    - Government Agencies: Collaborate with government agencies to access data, comply with regulations, and contribute to smart city initiatives.
    - Parking Management Software Providers: Partner with parking management software vendors to integrate license plate recognition into their solutions.
    - Collaborate with system integrators to seamlessly integrate the license plate recognition system with existing infrastructure and software platforms.
    - Data Providers: Establish partnerships with data providers to access relevant datasets for training and improving the accuracy of the license plate recognition models.
7. **Cost Structure:**
    - Research and Development: Allocate resources for ongoing research, development, and optimization of the license plate recognition system.
    - Infrastructure Costs: Invest in hardware and software infrastructure to support the processing and storage of license plate data.
    - Data Acquisition and Annotation: Incur costs associated with acquiring diverse and comprehensive datasets of license plates and annotating them for training purposes.
    - Sales and Marketing: Allocate resources for sales and marketing activities to promote the license plate recognition solution and acquire new customers.
    - Operational Costs: Include expenses for ongoing maintenance, support services, and personnel required to ensure smooth system operation.

By implementing this business model, an automatic license and number plate recognition company can offer a reliable and efficient solution to various industries, generate revenue through software licensing, maintenance, support, and data services, and create value by improving traffic management, enhancing security, and contributing to smart city initiatives.

6 Product Details

1. **Product Description:**

    The automatic license and number plate recognition system is an advanced software solution that utilizes cutting-edge machine learning algorithms and computer vision techniques to detect, capture, and recognize license plates in real-time. It is designed to enhance traffic management, law enforcement, parking systems, and vehicle tracking operations.

2. **Key Features:**

   - License Plate Detection: The system employs computer vision algorithms to identify and locate license plates within images or video frames with high accuracy.
   - Optical Character Recognition (OCR): Advanced OCR algorithms accurately extract alphanumeric characters from license plates, ensuring reliable recognition.
   - Real-Time Processing: The system operates with low latency, enabling rapid detection and recognition of license plates in real-time applications.
   - Adaptability and Compatibility: The solution is designed to handle various license plate designs, regional variations, and evolving regulatory requirements, making it adaptable to different geographical contexts.
   - Robustness to Challenging Conditions: The system can handle challenging environmental conditions, such as low lighting, occlusions, complex backgrounds, and adverse weather, ensuring reliable performance in diverse scenarios.
   - Integration with Existing Infrastructure: Seamless integration with existing traffic management systems, parking management software, and law enforcement databases, enabling efficient data exchange and workflow optimization.
   - Reporting and Analytics: The system provides comprehensive reporting and analytics capabilities, enabling users to analyze license plate data, generate insights, and facilitate data-driven decision-making.
   - User-Friendly Interface: The system features an intuitive and user-friendly interface with clear visualizations and easy-to-use controls, simplifying system management and access to license plate data.

3. **Use Cases:**

   - Traffic Management: Real-time monitoring, traffic flow analysis, automatic violation detection, and congestion management.
   - Law Enforcement: Vehicle identification, wanted vehicle tracking, stolen vehicle detection, and suspect vehicle monitoring.
   - Parking Systems: Automated parking access, ticketless entry and exit, occupancy monitoring, and revenue optimization.
   - Toll Collection: Automatic toll collection, vehicle classification, toll violation detection, and toll plaza optimization.
   - Fleet Management: Vehicle tracking, route optimization, driver behavior monitoring, and fleet utilization analysis.

4. **Competitive Advantage:**

   - High Accuracy and Recognition Rates: Industry-leading accuracy and recognition rates ensure reliable license plate detection and character extraction.
   - Real-Time Performance: Low latency processing enables real-time response and decision-making in dynamic environments.
   - Robustness to Challenging Conditions: Reliable performance in challenging lighting, weather, and occlusion scenarios.

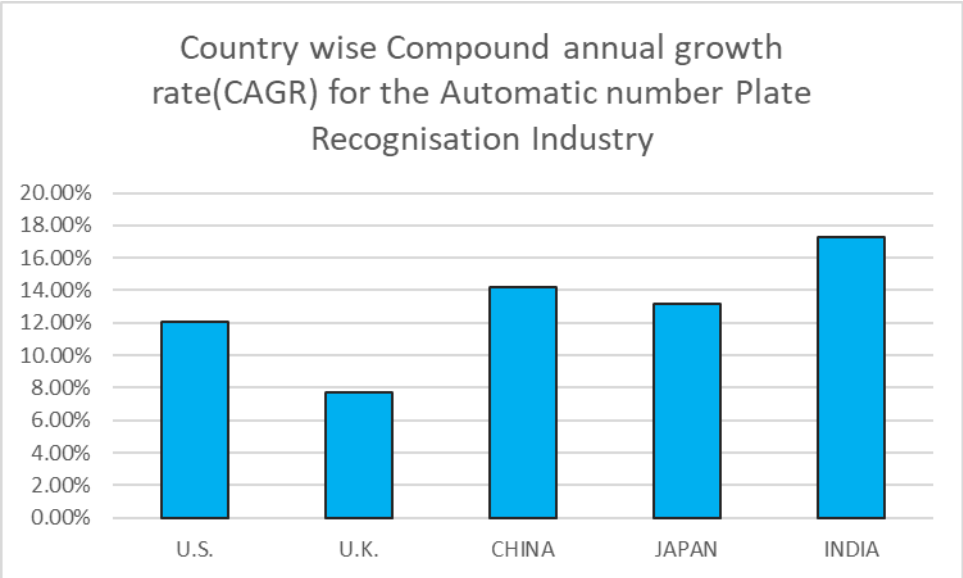


Figure 1: Country wise CAGRs for the automatic Number Plate Reorganization Industry

- Seamless Integration: Easy integration with existing infrastructure and software systems, minimizing disruption and maximizing value.
- Adaptability and Flexibility: Compatibility with various license plate designs and regional variations ensures broad applicability.
- Data Privacy and Security: Strong measures to protect sensitive license plate data and ensure compliance with data protection regulations.
- Comprehensive Support: Dedicated customer support, regular updates, and continuous research and development to address evolving needs.

5. **Target Market:**

   - Government and Law Enforcement Agencies
   - Parking Operators and Facility Managers
   - Toll Road Operators
   - Fleet Management Companies
   - Smart City Initiatives

6. **Pricing:**

   The pricing model is based on factors such as the number of cameras or installations, system capacity, and additional features. Customized pricing options and maintenance/support packages are available to cater to specific customer requirements.

By offering a feature-rich automatic license and number plate recognition system, the company aims to improve operational efficiency, enhance security, and facilitate data-driven decision-making for its customers.

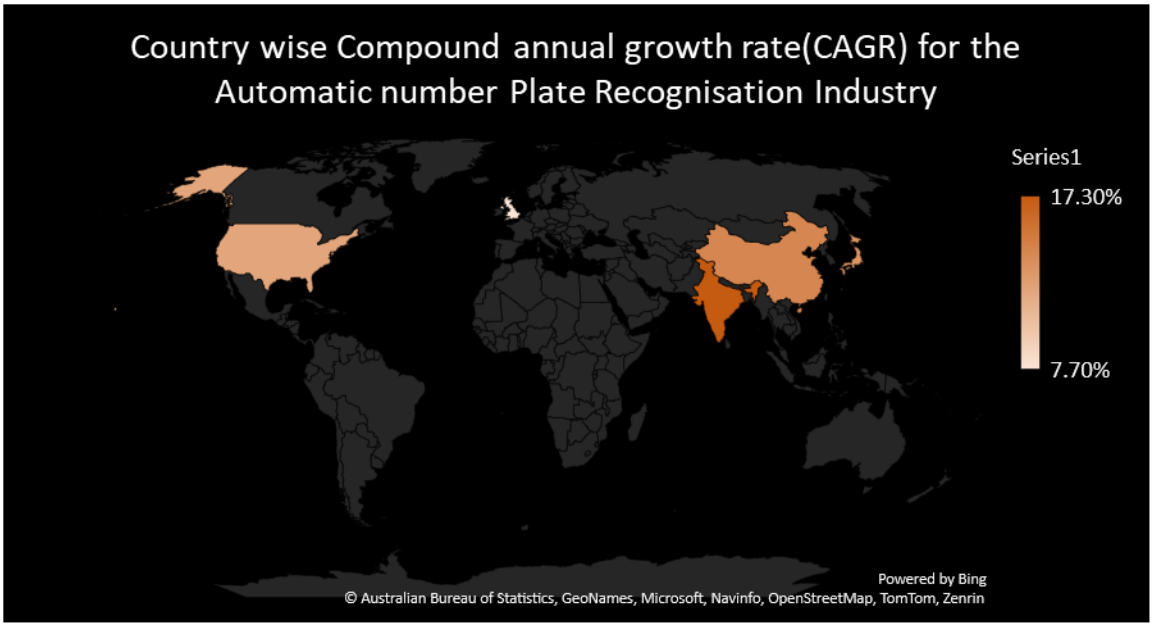


Figure 2: World wide view

7 Business Model

The Number Plate Detection on Automated Surveillance System business model presents a forward-thinking approach to enhance security, traffic management, and efficiency in various industries. By leveraging advanced technology and intelligent software, this system has the potential to revolutionize the way we monitor and manage vehicles on our roads, making our cities safer and more organized.

Here is the data of growth at the end of each financial years. From the Figure (8 it shows that the

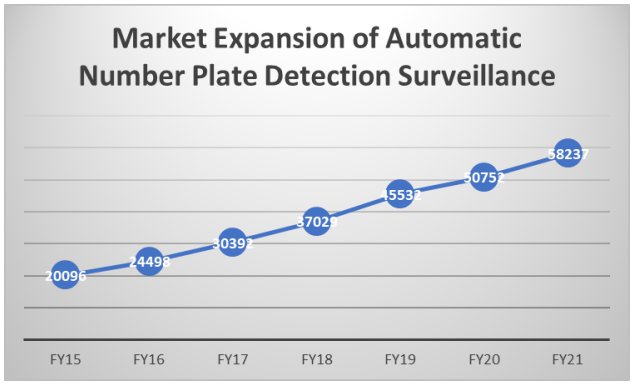


Figure 3:

growth of automatic number plate detection industry has been increasing steadily and linearly from the financial year 2015 to 2021. Now we see that the growth of the market cap of health insurance

is linear which is of the form,

$$y = mx + c \tag{1}$$

In the above x represents the financial year (FY15 – FY21, x =15 for FY15, x =16 for FY16,...) and y represent the revenue in the corresponding FY. An estimate has been made about the values of the co-efficient a and intercept b by fitting linear regression curve to the data shown in Figure (8) we get,

$$y = 6503x - 78969 \tag{2}$$

Now if C_F be the fixed cost and C_V be the variable cost then profit $P(x)$ will be,

$$P(x) = 2000y - C_V \cdot y - C_F = (2000 - C_V)(6503x - 78969) - C_F \tag{3}$$

.

8 Team Requirement

1. **Machine Learning Experts:** Require experienced machine learning engineers and data scientists who specialize in computer vision, image processing, and deep learning techniques. They will be responsible for developing and fine-tuning the license plate recognition models.
2. **Software Developers:** Need skilled software developers proficient in programming languages such as Python, C++, and Java to implement the license plate recognition algorithms, develop the software infrastructure, and ensure seamless integration with existing systems.
3. **Data Annotation Specialists:** Require a team of data annotation specialists who can accurately label and annotate license plate images and videos to create high-quality training datasets for the machine learning models.
4. **System Integration Specialists:** Need experts in system integration who can effectively integrate the license plate recognition system with various infrastructure components, such as traffic management systems, parking management platforms, and law enforcement databases.
5. **User Interface/User Experience (UI/UX) Designers:** Require UI/UX designers to create an intuitive and user-friendly interface for managing the license plate recognition system, enabling easy access to license plate data and generating actionable insights.
6. **Project Managers:** Require experienced project managers to oversee the development and implementation of the license plate recognition system, ensure timely delivery, manage resources, and coordinate with stakeholders.
7. **Sales and Marketing Professionals:** Need a dedicated sales and marketing team to promote the license plate recognition solution, generate leads, and engage with potential customers in various industries such as government agencies, law enforcement, parking operators, toll road operators, and fleet management companies.
8. **Customer Support Specialists:** Require a customer support team to provide timely assistance, troubleshoot issues, and address customer inquiries related to the license plate recognition system. They should have strong communication and problem-solving skills.
9. **Quality Assurance/Testers:** Need QA professionals who can perform rigorous testing to ensure the reliability, accuracy, and robustness of the license plate recognition system across different scenarios and conditions.

10. **Research and Development Team:** Require a dedicated team focused on continuous research and development to explore new techniques, algorithms, and technologies that can enhance the performance and capabilities of the license plate recognition system.

11. **Data Privacy and Security Experts:** Need experts in data privacy and security to ensure compliance with relevant regulations, implement robust security measures, and safeguard sensitive license plate information.

It is essential to have a multidisciplinary team with expertise in machine learning, software development, data annotation, system integration, project management, sales and marketing, customer support, quality assurance, research and development, and data privacy and security to successfully develop, deploy, and support the automatic license and number plate recognition system.

9 Implementation

9.1 Existing System

Currently in many sectors vehicle is identified using the number plate which is manually noted by a human which is a slow process.Thus, vehicle number plate recognition is an intensive manualprocess which can perhaps be automated using deep learning which forms the basis of this project.This is all about the existing system of the project"Automatic Vehicle Number Plate Recognition System Using Machine Learning".

9.2 Drawbacks Of Existing System

The following are the drawbacks of the existing system

- More Manpower.
- More Expenditure.
- High Error Probability.
- Less Performance.
- More Dependency.
- Time Taking

10 Algorithm

step 1: Start
step 2: Image Acquisition
step 3: Image Desaturation
step 4: Image Thresholding
step 5: Optical Character Recognition
step 6: Stop

11 Procedure

11.1 Loading and data pre-processing:

Loading and data pre-processing are crucial steps in building an Automatic Vehicle Number Plate Recognition (ANPR) system for number plate detection. Here's an outline of the process:

11.1.1 Data Collection:

The first step is to collect a diverse dataset of images containing vehicles with number plates. This dataset should cover various scenarios, lighting conditions, weather conditions, and vehicle types to ensure the model's robustness.

11.1.2 Data Annotation:

Each image in the dataset needs to be manually annotated to mark the bounding boxes around the number plates. Annotation tools allow you to create XML or JSON files that contain the coordinates of the bounding boxes.

11.1.3 Splitting Data:

Divide the dataset into three parts: training set, validation set, and test set. The training set will be used to train the deep learning model, the validation set to tune hyperparameters and monitor performance, and the test set to evaluate the model's final performance.

11.1.4 Image Pre-processing:

Pre-process the images before feeding them into the model. Common pre-processing steps include:
- Resizing: Resize the images to a consistent resolution suitable for the model input. This step is essential for faster training and inference. - Normalization: Normalize the pixel values of the images to bring them within a specific range (e.g., [0, 1]) to improve convergence during training. - Data Augmentation: Augment the training data by applying random transformations such as rotation, scaling, flipping, and brightness adjustments. Data augmentation helps in reducing overfitting and generalizing better to unseen data.

11.1.5 Creating Labels:

For training the model, convert the annotated bounding box coordinates into appropriate label format, such as YOLO format or bounding box regression targets.

11.1.6 Data Loading:

Implement a data loader that efficiently loads and prepares the pre-processed data during training and inference. The data loader should also batch the data for faster processing.

11.1.7 Handling Imbalanced Data (Optional):

In some cases, the number of positive samples (images with number plates) might be much smaller than negative samples (images without number plates). To address this imbalance, use techniques like data re-sampling or weighted loss functions.

11.1.8 Data Verification:

It's crucial to verify that the data is correctly pre-processed and loaded. Check a few random samples to ensure the images, bounding boxes, and labels match correctly.

11.2 Image acquisition

is the process of capturing images of vehicles and their number plates using cameras or other imaging devices. This is the first step in building an Automatic Vehicle Number Plate Recognition (ANPR) system. Accurate and high-quality image acquisition is crucial for the success of the entire ANPR pipeline.

Figure 4: Input Image

11.2.1 Camera Placement:

Cameras should be strategically positioned to capture clear views of vehicles' front or rear number plates. Common locations include entry/exit points of parking lots, toll booths, traffic intersections, and highways. The angle and height of the camera should be optimized to ensure a direct and unobstructed view of the number plate.

11.2.2 Camera Quality:

High-resolution cameras with good low-light performance are preferred for ANPR systems. The quality of the camera directly affects the clarity and readability of the captured number plates.

11.2.3 Illumination:

Adequate lighting is essential for clear image capture, especially during nighttime or low-light conditions. Consider using additional light sources or infrared illumination to improve image quality.

11.2.4 Image Format:

Choose an appropriate image format for storage and processing. Common formats include JPEG, PNG, or RAW. Consider the balance between image quality and file size.

11.3 Image desaturation

Image desaturation is a process of reducing the color saturation or vibrancy of an image, essentially converting it into a grayscale or black-and-white representation. This can be achieved through various techniques in image processing . Desaturating an image can be useful for different purposes, such as emphasizing specific features, reducing the file size, or preparing images for certain types

Figure 5: Making the original picture in gray format

of analysis. The simplest and most common way to desaturate an image is to convert it directly to grayscale. Grayscale images represent each pixel with a single intensity value ranging from 0 (black) to 255 (white). The color information is discarded, and only the luminance or brightness information is retained.

11.4 Image Thresholding

Image thresholding is a popular image processing technique used to create binary images from grayscale or color images. It involves converting an input image into a binary representation, where each pixel is either classified as "foreground" (belonging to the object of interest) or "background" (belonging to the rest of the image) based on a specific threshold value.The most critical step in image thresholding is selecting an appropriate threshold value. This value determines the dividing line between foreground and background. The choice of threshold value depends on the characteristics of the image and the specific task at hand. It can be a fixed value determined manually or computed automatically using various algorithms (e.g., Otsu's method).

11.5 Morphological Transformation:

Morphological change examines geometrical structure inside a picture by testing it with little examples called structuring components. Therefore, a nonlinear image operator that is appropriate for investigating geometrical and topological structure is produced. The operator is applied to a picture so as to make certain highlights evident and recognize significant data from insignificant twists by lessening it to a skeleton. This procedure as a rule has four sorts of activities, which are extension, erosion, opening and shutting activity.

Figure 6: Threshold Image

11.6 Segmentation:

The Image Segmentation is the way toward apportioning a picture into various parts which is then used to recognize objects or other pertinent data in advanced pictures. After morphological change, 2 fragments were distinguished as potential up-and-comers as delineated in underneath Figure. The fragments will at that point experience another significant procedure where the model will figure out which one has the best conceivable character. The fragment will at that point be segregated in a square formed picture, and it is tried with the goal that the longest rundown of potential character will be found and decided as the conceivable genuine number plate. The last picture with the most potential characters in it will at that point be picked to go for character acknowledgment in the following procedure

11.7 Dectacting and showing number plate

python model training to detect and recognize license number plate. The below output is achieved by running the python program which trains the model using the training dataset and saves the model by using python libraries. Then a predictor file is run with a test image which is not included in the training dataset and gets recognized and for better visibility of detection the license plate area is marked by a green border

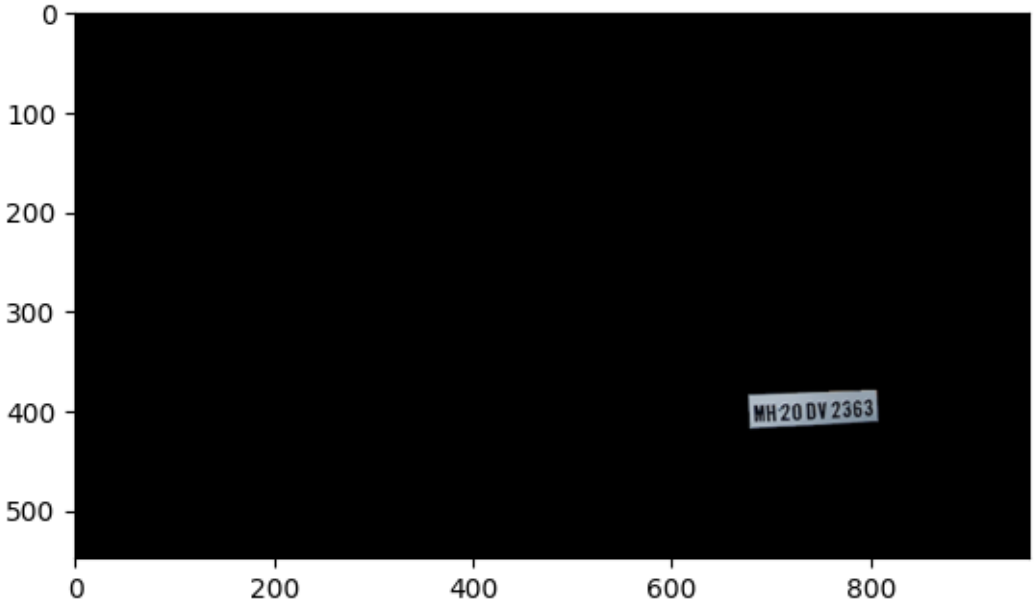


Figure 7: Segmentation

Figure 8: Decting and showing the number of number plate

12 Conclusion

The automatic license and number plate recognition project is a significant advancement in the field of computer vision and machine learning. It offers a powerful solution to enhance traffic management, law enforcement, parking systems, and vehicle tracking operations. Through the utilization of cutting-edge algorithms and techniques, the system can accurately detect, capture, and recognize license plates in real-time, providing valuable insights and improving operational efficiency.

The project's success relies on a skilled and diverse team comprising machine learning experts, software developers, data annotation specialists, system integration specialists, UI/UX designers, project managers, sales and marketing professionals, customer support specialists, QA testers, research and development experts, and data privacy and security professionals. Their collective expertise ensures the development, implementation, and support of a robust and reliable license plate recognition system.

By addressing the specific needs of various industries such as government agencies, law enforcement, parking operators, toll road operators, and fleet management companies, the project delivers value through enhanced traffic management, improved security, and data-driven decision-making. The system's adaptability, real-time processing capabilities, seamless integration with existing infrastructure, and strong data privacy and security measures provide a competitive edge in the market.

Continuous research and development efforts are necessary to stay at the forefront of technological advancements and meet evolving industry requirements. Ongoing updates, customer support, and customization services further contribute to the project's success and customer satisfaction.

In conclusion, the automatic license and number plate recognition project is poised to revolutionize the way license plate data is captured, processed, and utilized. By offering a comprehensive and efficient solution, it brings about significant benefits in terms of traffic management, law enforcement, parking systems, and vehicle tracking. The successful execution of this project relies on a dedicated team, strong partnerships, and a commitment to delivering reliable, accurate, and secure license plate recognition capabilities.

13 Code

```
!pip install easyocr
!pip install imutils
!pip install opencv-python-headless==4.1.2.30
!pip3 install torch torchvision torchaudio --index-url https://download.pytorch.org/whl/cu117

import cv2
from matplotlib import pyplot as plt
import numpy as np
import imutils
import easyocr

Convert colour Image into grayscale format

img = cv2.imread('/content/skoda-india-front-license-plate.jpg')
gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
plt.imshow(cv2.cvtColor(gray, cv2.COLOR_BGR2RGB))
```

```
Apply fiter and edge detection

bfilter = cv2.bilateralFilter(gray, 11, 17, 17) #noise reduction
edged = cv2.Canny(bfilter, 30, 200)  # edge detection
plt.imshow(cv2.cvtColor(edged, cv2.COLOR_BGR2RGB))

keypoints =cv2.findContours(edged.copy(),cv2.RETR_TREE, cv2.CHAIN_APPROX_SIMPLE)
contours = imutils.grab_contours(keypoints)
contours = sorted(contours, key=cv2.contourArea, reverse=True)[:10]

location= None
for contours in contours:
  approx= cv2.approxPolyDP(contours, 10, True)
  if len(approx)==4:
    location = approx
    break

location
array([[[807, 380]],

       [[678, 384]],

       [[679, 418]],

       [[808, 411]]], dtype=int32)

mask = np.zeros(gray.shape, np.uint8)
new_image = cv2.drawContours(mask,[location],0,255,-1)
new_image = cv2.bitwise_and(img, img, mask=mask)
```

```
plt.imshow(cv2.cvtColor(new_image, cv2.COLOR_BGR2RGB))
```

```
(x,y) = np.where(mask==255)
(x1,y1) = (np.min(x), np.min(y))
(x2,y2) = (np.max(x), np.max(y))
cropped_image = gray[x1:x2+1, y1:y2+1]

plt.imshow(cv2.cvtColor(cropped_image, cv2.COLOR_BGR2RGB))

```

```
from torch.nn.modules.module import register_module_buffer_registration_hook
reader = easyocr.Reader(['en'])
result = reader.readtext(cropped_image)
result

#Plot the Result
text=result[0][-2]
font=cv2.FONT_HERSHEY_SIMPLEX
res=cv2.putText(img, text=text, org=(approx[0][0][0], approx[1][0][1]+60), fontFace=
    font, fontScale=0.5, color=(0,255,0), thickness=2, lineType=cv2.LINE_AA)
res=cv2.rectangle(img, tuple(approx[0][0]), tuple(approx[2][0]), (0,255,0),3)
plt.imshow(cv2.cvtColor(res, cv2.COLOR_BGR2RGB))
```

References

[1] RA Lotufo, AD Morgan, and AS Johnson. Automatic number-plate recognition. In *IEE Colloquium on Image Analysis for Transport Applications*, pages 6–1. IET, 1990.

[2] Chirag Patel, Dipti Shah, and Atul Patel. Automatic number plate recognition system (anpr): A survey. *International Journal of Computer Applications*, 69(9), 2013.

[3] Muhammad Tahir Qadri and Muhammad Asif. Automatic number plate recognition system for vehicle identification using optical character recognition. In *2009 International Conference on Education Technology and Computer*, pages 335–338. IEEE, 2009.