License Number Plate Recognition Using Contours and KNN Algorithm

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***Abstract*—The project, License Number Plate Recognition basically aims at the detection of the Number Plate of a vehicle and further segmenting and recognizing the contents of that Number Plate. It is an important technique and majorly useful in ITS (Intelligent Transportation System). It is an advanced technology which is very helpful in identifying vehicles by their license number plates. Due to its various applications, it is an important area of research. The increasing development in the field of ITS using this plate detection and recognition technique provides the data of license number plates of the vehicles which can be useful in various analyses and monitoring of the vehicles. It is important in various fields like traffic problems, border and custom security, toll collection, places where high security is needed. Optical character recognition (OCR) is a fast growing research area that has the ability to extract and process data in the form of text from the images.**

***Index Terms*—Detection, Segmentation, recognition, Optical Character Recognition (OCR), KNN, Contours**

I. Introduction

In the present time, traffic congestion has become a major issue in most of the countries. Everyone wants to live a luxurious life. So the number of vehicles have been increasing dramatically. According to a report by researcher house Bernstein, the global numbers of the cars will be doubled till 2040. The growing GDP will increase the demand for luxurious life and vehicles. As the number of vehicles will increase, the traffic management will become more difficult to handle which will increase the violations of traffic rules. Also it will generate a shortage of parking places for so many vehicles. So this process will demand some technological solutions for this problem. In order to develop such a system, we have to create many algorithms for this so that the system can recognise the licence numbers of any vehicle from the images of vehicles. In this paper we are going to discuss such algorithms. We will also propose a method for resolving this problem. There are many issues in the licence number plate recognition such as climate conditions, environmental interference and accuracy of the license plate localisation. One method is to use the color characteristics and the probability distribution of the license number plate in between the two lights. There is another approach for licence plate detection which is based on the template matching. An another method is vertical edge based plate detection which is also very popular. The character extraction is also required. There are two algorithms designed for character segmentation. In the first method the x-axis projection of the image is considered while in other approach the contours which looks like some characters are being found. This method is better than the first method in terms of accuracy and testing. After extracting the characters , we need to recognise them so that we can tell the complete license number. For the recognition process, we used an approach which is a modified version of the 1NN algorithm. In this approach we divide the character into fourty nine subparts. Then for each of the subparts, we count the number of white pixels. Here we use a fourty nine element feature vector which is used in the identification of the characters. We calculate the average element of feature vectors for all classes. After this, the distance of the new character from all the average elements of all classes is computed. Now the new character will be considered of that neighboring class which will be the closest of all in terms of distance. In this paper, we will be discussing the three major parts of License Number Plate Recognition, i.e., number plate detection, character segmentation and character recognition. We will go through various research papers in the Literature Review section in order to have a better understanding of the previous works done in this field. Then, we will propose our solution to this problem and finally we will conclude this paper with our proposed algorithms and their accuracies.

A. MOTIVATION

The motivation for this project lies in the applications of this project. Analysis of city traffic during peak periods needs to be taken care of and this can be easily done using this project. It can be helpful for controlling enhanced vehicle theft, the law and traffic rules can be enforced effectively. In a car park we can have an automatic system for entry and exits of

vehicles. By this system we can easily manage all the details about the parked cars and improve the security protocols. In this way, the system will increase the user experience of the customers which will increase the numbers of customers. The licence number plate detection is a very important system at the state border. The government can easily maintain the information about the vehicles going outside from the state and coming inside the state. This information can play a vital role in decreasing crimes. It can be used by police forces and toll managements. It is also important in the high profile areas such as Parliament, Legislative Assembly, Various Department Offices etc. where high security is demanded.

B. ARCHITECTURE

The project is made up of four blocks as shown in the figure given below. There are four blocks in the figure which

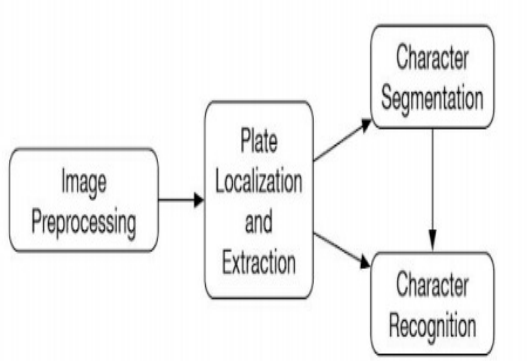

Fig. 1. Architecture of License Number Plate Recognition.

represents the four different stages of the model. The first stage is the image preprocessing stage. In this stage, the captured image is being prepared for the recognisation process. First the image is converted to grayscale image using OpenCV. Many image processing techniques are used in this stage.

The next stage is the plate localisation and extraction stage. In this stage the license plate is searched in the whole image and after finding it, it makes a boundary outside the licence plate and extracts this image into a new image which is used for further processing.

The third stage is the character segmentation stage. In our model, we have performed the character segmentation process before the character recognition process. It reduces the effects of noise and character arrangement. In this stage each character is segmented into different images and these segmented images are going for further analysis.

The final and most important stage is the character recognition stage. In this stage, the tesseract engine is applied on the cropped plate which recognises all the characters on this plate. The tesseract engine was trained before applying it on the plate so that the accuracy of our model can be improved. The engine finds all letters on the plate which are regional code, suffixes and registration number. It creates a text from these letters which represent the licence number of the vehicle.

C. SCOPE

a. License Number Plate Detection:
   - Both front side and back side plates are considered in this model.
   - A mixture of indian car images and tunisian car images is used in the training process.
   - It also covers the cases when vehicles were at some angles.
   - There is no restriction on the dimensions of the images.
   - Only one object is considered for the recognition process in the case of many vehicles in an image.

b. Extracting text from Detected License Number Plate:
   - In this, the output of the previous stage (Number plate detection) is considered as input.
   - The cropped licence plates are given for the OCR process instead of passing the whole image of the vehicle.

II. PROBLEM FORMULATION

After analysing the problem, we have divided to divide our project into three sub-problems:

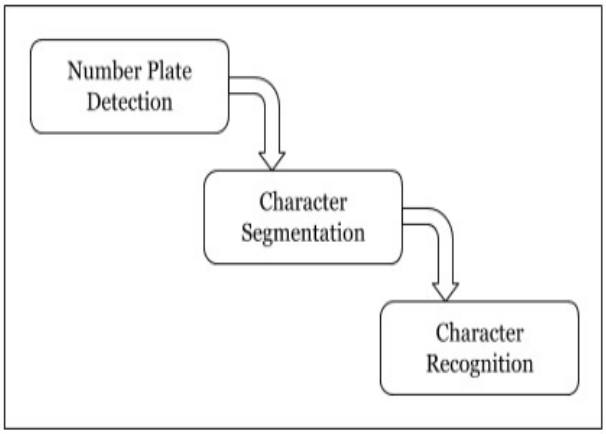

Fig. 2. Problem Division

- **Number Plate Detection:** The first task is to detect the license number plate from the image. This task can be handled using a very efficient approach which is Object Detection where we will train our model with car images with license number plates.
- **Character Segmentation:** After we succeeded in detecting the license number plate, we need to divide the characters using segmentation. For this part of the problem, we came to the conclusion that we will find contours to do the segmentation that looks like a character.
- **Character Recognition:** Finally, we will convert the license number plate content to text. We will train our model with various images of characters and then finally generate the desired output.

III. RELATED WORK

1. **Proposal for Automatic License and Number Plate Recognition System for Vehicle Identification**
   In this paper, an automatic License number plate recognition (LNPR) system is proposed. This system takes images of vehicles passing from a fixed location and can extract the license numbers of these vehicles using the image processing techniques. It doesn't require any additional instruments such as GPS, RFID etc. The system uses special types of cameras and captures the images of the passing vehicles. It sends these images to the computer for the LNPR processing. The system uses various image processing algorithms such as localisation, orientation, normalization, segmentation and optical character recognition. The system returns the license number of the vehicle which can be used in records in the database. The experimental results of this system shows that the system performs quite well on the real pictures of vehicles. LNPR system is proposed for monitoring and managing traffic in the parking lots of private and public organizations via identifying vehicle license plate numbers at the parking gate. This system can also be used to identify stolen vehicles on roads. No additional equipment needs to be installed on vehicles for operating this system. Fig. shows that the only requirement of this system is installing special cameras for identifying license numbers at the entrance and exit gates of the parking lots. The images taken by these cameras are subsequently processed in a computer. All vehicle traffic information (including the driver's image) is stored in the system database for a long time. Thus, detailed traffic information can be retrieved from different parking gates at different times. Moreover, this system can apply intelligent control in the parking lots through automatic opening of the gate only to authorized vehicles upon recognizing their license numbers according to Fig. Other advantages of the proposed system include online access to information such as the total number of vehicles currently present in the parking lot, the number of authorized vehicles, etc. Moreover, too much information on vehicle traffic statistics can be extracted from the system.

2. **Automatic Number Plate Recognition System (ANPR)**
   A Survey Vehicle owner identification is required, when a person violates the rules of traffic and drives too fast or when a person is any criminal is very difficult in India where traffic and population is more. Therefore, it is required to catch and punish these kinds of people because the traffic is high and due to high vehicle speed traffic police might not be able to see their vehicle number plates. Therefore, there is a requirement to develop systems like Automatic Number Plates Recognition (ANPR). There are various ANPR systems available today in the market. We use some different methodologies to these systems but it is still a challenging task for us because of the high speed of the vehicle. By considering image size different approaches of ANPR are discussed, here we use success rate and processing time as parameters and at the end of this paper we suggest an extension to ANPR.

3. **Automated Car Number Plate Detection System to detect far number plates**
   In this paper, the ANPR(Automatic Number Plate Recognition) is described with the help of the licence plate of the vehicle. In this method the user has a database stored in his PC. This system uses the image processing methods for number plate detection of the images stored in that database. This method returns very satisfying results on different types of number plates. The method was implemented and executed using the MATLAB. A new system is introduced for plate detection which uses classifiers based on the deep learning neural network algorithms. The ANPR(Automatic Number Plate detection) is an image processing technique which is used for vehicle plate detection. This technique is used in the field of traffic detection and violation of traffic rules. In order to extract data from the digital image , we use the computer vision technique.
   There are 5 steps in this ANPR system:
   - Vehicle image capture
   - Preprocessing of data
   - Plate extraction from the image
   - Segmentation of characters
   - Recognition of characters

4. **Traffic Detection using Opencv**
   This paper suggests implementing a smart traffic detector using OpenCV. The Traffic Detection plays out the fundamental usefulness of deciding the measure of traffic. OpenCV firstly converts the input image from BGR to grayscale, after which the picture goes through masking, for example pointless and excess information is eliminated utilizing suitable coordinates. At that point canny edge detection helps in laying out and characterizing each unmistakable item found in the picture. The following stage is to figure the HOG (Histogram of Gradient) change by deciding x-sobel (x subordinate) and y-sobel (y subsidiary) of the picture. The dataset then goes through a grid search where most effective gamma esteems are recovered as the yield. This is the premise on which the dataset is prepared utilizing a SVM model. This model is utilized to distinguish vehicles as well as classify them using an RBF kernel. Image preparation includes issues identified with Imagerepresentation, techniques which are used for compression and different difficult activities, it can be completed on the image information.
   - Sharpening
   - Blurring, and Brightening and

- Edge enhancement

These are image enhancement operations through which an image undergoes. Traffic on the paths is determined utilizing processing on image which is done on images of paths that are caught utilizing advanced cameras. Initially, the input image file is given for preprocess using file explorer. This file is processed by OpenCV which is used to preprocess the image and detect details (process mentioned above). The statistical data is fed to the trained model which computes and delivers the result The output is displayed to the user using GUI.

5. **Automatic Number Plate Recognition System For Vehicle Identification Using Optical Character Recognition**

In this paper, the automatic vehicle number plate detection system is presented which finds the licence number of the vehicle from images of vehicles using various image processing techniques. The system is implemented in MATLAB and is tested on many pictures of vehicles. The performance of the system was quite good. It was also performed well on the pictures of different angles and different lighting conditions. The main target of this system is to make an economically cheaper system which can be used for vehicle detection. This system can be installed at the many governments offices such as parliament, supreme court etc where security is highly needed. It can also be installed at the vehicle parking areas, Entry gates of institutes, State borders and various toll booths. Using this system we can easily find the owners of the vehicle and send a fine notice to them in case of traffic rules violation. In this paper OCR technology is used for character recognition.

This system works in three steps:

- Vehicle image capturing
- Plate extraction from the image
- Image segmentation and character recognition

In this paper section I and II are about the implementation of method and hardware required for the systems. Section III gives us the results obtained on the testing data by this ANPR system. Section IV explains the results and Section V concludes the paper and tells about the future work.

6. **An Overview of Contour Detection Approaches**

In fields like, Semantic segmentation and image classification Object contour performs an important role. In any case, the ex-foothold of shape is an inconvenient task, especially when the structure is lacking or unclosed. Previously stabilized contour detection approaches are taken in count and broadly divided into three arrangements:

- Pixel,
- Edge and
- Region Based

Likewise, since regular contour detection methods have accomplished a veritable level of headway, significant convolutional neural associations (DCNNs) have phenomenal execution in picture affirmation, accordingly, the DCNNs based structure affirmation methods are additionally requested in this research. It also showcases the classification of the algorithms of contour detection which are already in work. Also tried to differentiate the classes: Pixel, Edge and Region based.

7. **Segmentation Methods for Hand-Written Character Recognition**

In this paper we segment a text based image at various levels of segmentation for this we use different methodologies. This paper motivates people that are working for text based image segmentation which is an area of Computer Vision. First, the need for segmentation is justified in the context of text based information retrieval. Then we discussed various factors that affect the segmentation process. Followed by the levels of text segmentation are explored. And we discuss the advantages and disadvantages of the available techniques, along with directions for quick referral are suggested. And at the end we gave our approach to text segmentation in brief.

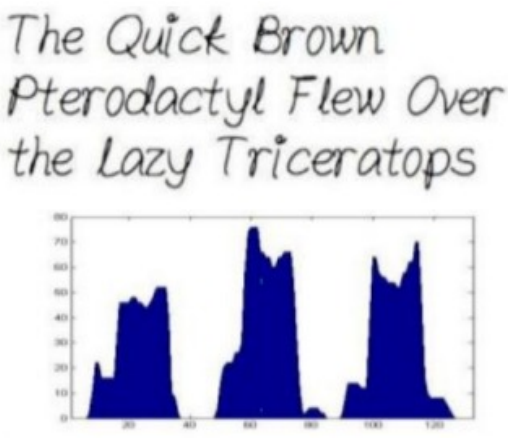

Fig. 3. a. Original Image, and b. Histogram of the input image

8. **Handwritten Digit Recognition by Combining SVM Classifiers**

4 SVM classifiers for handwritten digit recognition are discussed in this paper and each different feature set is examined. Using statistical reasoning We investigate the benefits and weaknesses of several cooperation schemes based on classifier fusion. There is difficulty for obtained results to exceed the recognition rate of a single, well-tuned SVM classifier applied straightforwardly on all feature sets. Only one of the corporation schemes in our experiments exceeds the recognition rate of a single SVM classifier. The classifier complexity and need for training samples is reduced by classifier cooperation, decreases classifier training time and sometimes improves the classifier performance. The System Architecture: The

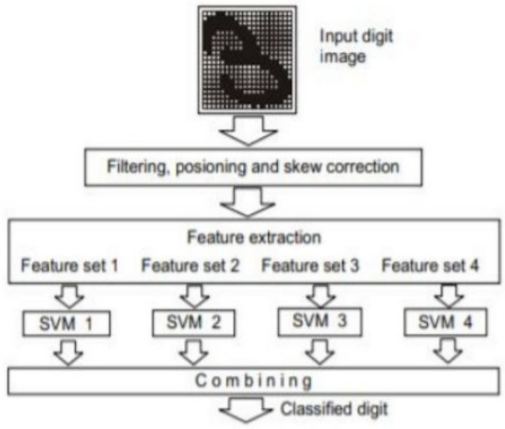

Fig. 4. Handwritten digit recognition using SVM

recognition system is constructed around a modular architecture of feature extraction and digit classification units. We use a preprocessed isolated digit image as input for the feature extraction module that transfers the extracted features toward SVM classifiers. Each image is first centered in a square bounding box after slant correction is performed on that image. The slant angle is estimated as the inclination of the line connecting the gravity of the top 25% and the bottom 25% part of the image. In order to remove the estimated inclination a sub-pixel precision shear transformation is performed.

9. **A Complete Optical Character Recognition Methodology for Historical Documents**
The work in this paper is on the framework which is an Off-line recognition which is for both historically hand-written documents and modern printed in machine documents. In this first the pre-processing is done on the documents in which they are converted in binary pictures, then the segmentation is done (precisely a top down segmentation) and all the characters are divided and extracted. And the final stage where characters which are segmented are recognised using database and converted into text document. Above mentioned approaches are in this flowchart in Figure 5. The principle preferred position of this approach is the way that neither any information on the textual styles in beforehand nor the presence of a general information base is required. This can also deal with the characters that don't show up regularly. Thus, it can be used for various sorts of reports. Dependent upon such verifiable records that we have to manage an information base that enables the acknowledgment strategy to be made. As more and more historic books go under this process , our information base keeps on increasing more and more and we come close to our social history. The major works on Pre-Processing, then segmentation and database creation and recognition.

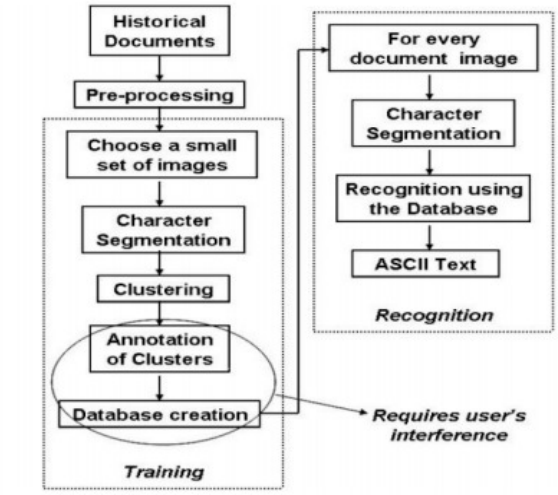

Fig. 5. Flow Chart for OCR Methodology

10. **An Automatic Number Plate Recognition System using OpenCV and Tesseract OCR Engine**
In this paper, Automatic Number Plate Recognition System is implemented using OpenCV and Tesseract OCR Engine. ANPR is a well investigated problem with several approaches. But these approaches are usually tuned towards a selected setting because of the variations within the options of range plates throughout the globe. Algo produced for the range plate recognition relies on these options and so a global answer would be tough to understand because the techniques from which these algorithms are built, called image analysis techniques are not itself hundred percent accurate. Objective of the research paper could be a projected algorithmic program that is enhanced to figure with ghanaian vehicle range plates. For locating the plate the code is in C++ with the OpenCV library that uses edge detection to extract the number plate from the given input image. The Tesseract OCR engine is used for character recognition.

11. **A Detailed Analysis of Optical Character Recognition Technology**
In this paper, Optical Character Recognition Technology is discussed briefly. Along with the challenges while implementing the OCR and phases involved in OCR. OCR is a technology through which a computer system is designed with the ability to extract and process text from images. The goal of OCR is to attain alteration or conversion of any format of text or documents containing text into associate degree editable digital format for additional process. Therefore, OCR allows a machine to automatically acknowledge text in such documents. There are some major challenges while using this technology and because of these challenges characters generally

might not be recognised properly by automatic data processing systems.

Challenges:

- Scene Complexity: In a regular environment, there exist many objects which have large structures and appearances as compared to the text and this situation makes text recognition very tough.
- Uneven Lighting: Capturing images in the space where there is improper lighting results in less accurate detection, segmentation and recognition results.
- Blurring and Degradation
- Aspect Ratios

OCR Phases:

- Pre-processing Phase: This is done to remove the noise in a picture while not missing any important data.
- Segmentation Phase: Segmentation is that method of uninflected text parts at intervals a picture from the image's background.
- Normal Phase: During this section eliminated characters are reduced to a selected size according to algorithms used.
- Feature Extraction Phase: It is the process of extracting the pertinent options from objects or characters to make feature vectors. Classifiers use these feature vectors to find out the input unit and associate objective output unit.
- Classification: It's the methods of distributing inputs with reference to detected data to their scrutiny category so as to make teams with solid qualities, whereas segregating totally different.

12. **Optical character recognition in real environments using neural networks and k-nearest neighbor**

In this research paper methods to implement optical character recognition are discussed that have high accuracy while recognising the character. Two methods discussed in the research paper are kNN and Neural Network. First we will go through the kNN approach as discussed in the paper and then Neural Network.

kNN (k Nearest Neighbour) is a non-parametric algorithm which is used for classification in Machine learning. In kNN algorithm, when we have to classify a character we first find its euclidean distance from the all training points and then sort the points on the basis of respective distance. Then we select the first k points having the minimum distance from our new character and take the classes of these k points. Then we classify this new character based on the majority of the k neighbours. For computing the euclidean distance we compute the square root of the sum of the squares of the distance between this character's image and each image in that respective category.

When the kNN classifier is used on the dataset, there are three possibilities of result.

- The character is localized and recognised. It means that the character is matched.
- The character is localized but not recognised which means that the character is not matched.
- The character is not localized which means that the character is not found in the process.

Neural Networks, Character request issue is alluded to with heuristic rule as individuals will get characters and records by their learning and data. Therefore the heuristic 15 base neural networks are highly recommended and accepted for this type of issue. A neural network is an accomplice deciding arrangement that features gigantically equivalent interconnection of adaptable center processors. Reinforcing of output from one node is to ensure sophisticated collaboration of all nodes within the network. Because of its comparable character, the rate of calculation is higher in such a way as to emphasize differences with the standard ways

13. **The Role of Image Understanding in Contour Detection**

Numerous prompts have been proposed for form identification or picture division. These incorporate low-level picture inclinations to elevated level data, for example, the personality of the articles in the scene or 3D profundity understanding. While state of the craftsmanship approaches have been joining more prompts, the overall significance of the prompts is muddled. In this paper, they look at the overall significance of low-, mid-and significant level signals to increase a superior comprehension of their job in distinguishing object shapes in a picture. To achieve this assignment, we direct various human investigations and think about their presentation to a few mainstream divisions furthermore, form location machine draws near. Their discoveries propose that the present status of-the-craftsmanship form identification calculations proceed just as people utilizing low-level signs. They likewise discover proof that the acknowledgment of articles, yet not impediment data, prompts improved human execution. Besides, when articles are perceived by people, their shape location execution increments over current machine calculations. At last, mid-level signs seem to offer a bigger presentation support than significant level prompts, for example, acknowledgment.

The evaluation was performed utilizing diverse human assessments and machine tests. In particular, they address the issue of article limit affirmation while changing the total and sort of data open. They can control the extent of near to data by moving the size of the conspicuous fix including the potential article limit. They may correspondingly control such data appeared by demonstrating powers or by pivoting the hiding channels.

Their assessments maintain three theories. In any case, further assessment on low-level signs may not yield improved division results. Their assessments show that individuals don't beat top tier division and shape area

procedures using simply little picture patches. This support the earlier disclosures of Fowlkes . Second, the affirmation of articles prompts a famous improvement in structure area precision, while obstacle information is less crucial. Tolerating there are no muddling factors, tests show that the updates in structure acknowledgment precision in light of greater fix sizes is caused somewhat by improved affirmation of the articles in the patches. Finally, while affirmation of articles prompts a basic improvement in structure disclosure, a greater display help is obtained from the development in mid-level information as the separated picture patches increment in size.

14. **An Efficient Character Recognition Technique Using K-Nearest Neighbor Classifier**
Optical Character Recognition (OCR) Systems offers human machine association and are conventionally used in a couple of critical operations. A huge load of assessment has recently been refined on the character affirmation in different vernaculars. This paper presents a strategy for affirmation of Printed text with fuss using Optical Character Recognition (OCR). The rule steps of this system are pre-getting ready of the substance including changing over the substance picture to dim/white and dispense with the disturbance from the substance picture, division of the substance picture to each character, Feature extraction using drafting based technique and gathering. The System is executed using MATLAB 2016a programming application program is up 'til now being chipped away at. Disturbance is wiped out from all the substance pictures. The idea of the data record is basic to achieve high precision. The structure can map characters from a block of 50 pictures.
The cycle of OCR incorporates a couple of stages including division, feature extraction, and portrayal. Seeing content in scene pictures is altogether all the more testing on account of the various possible assortments in establishments, surfaces, literary styles, and lighting conditions that are accessible in such pictures. Two significant kinds of character acknowledgment in software engineering are Optical Character Recognition (OCR) and methods based solely on picture getting ready methodology which consolidate isolating features in the image, com-paring those features with predefined ones in conclusion character affirmation, and Intelligent Character Recognition (ICR): fuses AI counts inside the affirmation cycle. Also targets physically composed print substance or cursive substance every glyph or character thusly.

15. **A New Approach for License Plate Detection and Localization: Between Reality and Applicability**
In recent years Licence plate detection and localization(LPDL) became one of the most progressive area in the field of Intelligent Traffic Management system(ITMS). Licence plate detection and localization is the major task in the field of ITMS. It provides the licence number of the vehicle using various image processing techniques and machine learning techniques. From the licence number all the details about the owner of the vehicle can be extracted. These informations can be very important in some cases such as traffic rules violation, state border crossing, vehicle thieveries and many more criminal cases. Various organisations can deploy this system in the tracking and monitoring of its vehicles and can find the accurate location of its vehicle. So this system makes the management process too easy. In this paper an algorithm for licence number plate detection and localisation is proposed which is based on character segmentation and morphological operators. Thus this algorithm also focuses on enhancing the quality of the images for this, it applies various morphological operators in order to extract the licence plate from the captured pictures. In this algorithm, there is no assumptions about the features of the licence plates such as color, font style, text size, text color , material used in making etc. After testing this algorithm in the real world, It has been seen that the algorithm has worked well as having 93.43% efficiency rate. This study is useful for many organisations which are using large numbers of vehicles and requires monitoring of its vehicle. Using this system they can easily manage all the vehicles in an efficient manner. This algorithm contains 10 steps in order to find the regions of interest. The algorithm was tested on 350 images of different types of vehicle. Out of 350 it detected the licence number successfully on 327 vehicles. So the algorithm has 93.43% efficiency.

16. **License Plate Recognition Using Artificial Neural Network**
In this research paper, the introduce an artificial neural network which is based on computer vision system which preprocess tha image of car in real-time taken by the camera, then it locates the license plate in the image, after this it segment the character present on the license plate, and finally recognizes the number written on number plate of the vehicle. Our model has four stages. First we locate the number plate. Second stage is segmentation of character. An ANN runs in the third stage of the process and recognition of character is dono after this. This paper presents a detailed explanation of the ANPR system. They used morphological operations for extracting the LP from the image.The feed forward back-propagation in the Artificial neural network gives an excellent result of accuracy rate 94.12% and it is done in an acceptable time of 400ms which is very suitable for real time application of ANPR.
The feed forward back-propagation artificial neural network is created with the set of input, outputs and sizes of hidden layers. Alsp transfer and training function

of ANN is defined, weights and biases are initialized with the default value. After assigning the default value to weights and biases, the network is trained with the training data set which includes feature value as input and output. And when the system is trained, the system is tested for the data set and accuracy is also calculated. The feed forward backpropagation is used to tranined our ANPR system. The system tested 200 images which are present in our dataset. The feature vector value is given to an artificial neural network for testing. With the help of a feature vector the artificial neural network recognizes the character from the vehicle number plate.

17. **Matlab Based Vehicle Number Plate Recognition**
The objective of this research paper is to design an automatic vehicle license plate identification system using the MATLAB. The system first captures the image of the vehicle as the vehicle reaches the security checking area. The capture image is preprocessed by some of the image processing techniques and then plate detection is done in the whole image after detection, segmentation of character is done . Optical character recognition(OCR) techniques are used for character recognition. The obtained data is compared with the database stored in the system. They implement and simulate that system using MATLAB and performance is tested on real images

18. **Text Recognition from an Image**
In this research paper, Optical character recognition and its objective, OCR system generations, Phases involved during text recognition and its applications are discussed. Optical character recognition is used to recognise the documents containing text and then convert it to editable digital format. Various OCR system generations are discussed mentioned below:
    - First Generation OCR system : This is the first OCR system, it only reads a special IBM font407. It uses template matching for recognising the characters.
    - Second Generation OCR system : This generation OCR system was only able to read the handwritten character and that too was limited to numeric and few other characters.
    - Third Generation OCR system : Third generation OCR system was able to recognise the printed and handwritten character but the limitation was that the document should be in good condition and of moderate size.
    - Fourth Generation OCR system : Fourth generation OCR system is OCR that we are using nowadays. It is able to recognise complex documents containing mixed text, hand written documents, colored text, documents having low quality, documents having noise etc.

19. **Text Pre-processing and Text Segmentation for OCR**
In this research paper, Text pre-processing and text segmentation for OCR is discussed keeping in the mind that the accuracy of OCR is completely dependent on the algorithms used for text pre-processing and text segmentation in the input image. The algorithms used in this research paper are applicable over the good quality of printed documents only. Future work can be extended to the character segmentation from words that have broken or overlapping characters in the printed or handwritten document.
The Method used in this research paper for text pre-processing is based on Fourier transform. The method aims to transform the input image from spatial domain to frequency domain and observe the direction of frequency distribution. This includes multiple steps such as first input image is skewed and skewed angle is found. Skewed image is taken to find the input image spectrum.and at last with the help of input image spectrum, the spectrum is divided into four quadrants. Now in each quadrant de-skewing is performed individually. 15-20 bright points coordinates are found in each quadrant and line is drawn through these coordinates in each quadrant. Now the angle between these lines and the x axis is found so 4 angles are found one for each quadrant. Now the average of these angles are calculated and the image is rotated by this calculated average angle and hence a de-skewed image is found.
For the text segmentation of lines, words and characters horizontal and vertical projection is used in this research paper. For the line segmentation horizontal projection is used and for the word and character segmentation vertical projection is used in this research paper. The histogram of pixel projection method is used to perform the horizontal projection and the vertical projection in order to find out the top, bottom, left and right limits of every given character. To find out the top and bottom limits of a character horizontal projection comes into play whereas the vertical projection is used to obtain the leftmost and rightmost limits of a character. Sum of the white pixels on a specific line along with the horizontal direction is the value of a group of histograms. The horizontal projection histogram is obtained after all the values of all the lines along the horizontal direction get calculated. To check the upper and lower limit threshold values are used and threshold values are considered as the mean value of the histogram. Similarly vertical projection histogram is obtained by interchanging rows with the columns of the image to find out the remaining two limits that are left and right limits of a given character.

20. **Efficient Licence Plate Detection By Unique Edge Detection Algorithm and Smarter Interpretation Through IoT**
In the present time the number of vehicles in the world is increasing exponentially. Vehicles are playing a vital role in our everyday life. In order to identify any ve-

hicle, it requires a unique identification system. So the number plate provides a standard identification system for the vehicles. In this paper an automatic licence plate recognition system is proposed. This system is based on 4 major steps:

- Preprocessing of the captured image
- Extraction of Licence plate region
- Segmentation
- Character recognition

In previous researches done on this topic, sobel edge detection algorithm or applying threshold methods was major part of them. In these methods when the intensity of the light is high, then the efficiency was quite low. When morphological operations were used in the character segmentation process, they produced the deformity. In this paper a novel approach to tackle these issues is proposed which is based on the unique edge detection algorithm. It was also difficult to frequently create and update the databases of the vehicles. In this approach this problem was solved by the Internet of Things (IoT) in which an online database can be created and updated in real time. We can connect more cameras in a specific area to a common server which can be used as a "universal eye". This method has drastically increased the probability of tracing a vehicle in comparison to the previous approaches which were using the manual database connected to each camera for identification purpose.

IV. DATASET

Dataset selection is among the most important tasks for the better implementation of every project and to train that particular project. For our project, we collected a large amount of images of vehicles. The dataset that we have collected contains two folders, one containing 478 images and other containing 433 xml files. These images have bounding box annotations of the car license plates within the image. The annotations are separately provided in the PASCAL VOC format and are stored as .xml files. For the testing phase, we used another dataset having 256 car images. For character recognition, we used knn to train our model and we have 36 classes (26 alphabets and 10 digits). The dataset to train our model contains two text files, "classification.txt" and "flattened_images.txt".

V. METHODOLOGIES REVIEWED

Different Phases along with the methods used to implement them are mentioned below.

A. License plate detection

An image of a vehicle with a licence plate as input is given to the program. Number plate first identified by the program and the crop the image. After cropping the output cropped image is used for the next stage that is character segmentation.

Plate Detection using YOLO(You Only Look One)

For detecting licence plates we use YOLO(You Only Look One) technique which is based on deep learning object detection architecture on CNN(Convolution Neural Networks). YOLO is prepared to start to finish a regression task predicting both object boundary box and object class; it is a solitary organization. Handling pictures with YOLO is basic and clear. Our framework. (1) resizes the input picture to 448 × 448, (2) By the model's confidence runs a solitary convolutional network on the picture, and edges the subsequent identifications. First create potential bounding boxes in a picture and then run a classifier on these proposed boxes. Post-processing is used to refine the bounding boxes, after arrangement, take out copy discoveries and based on other objects in the scene rescore the boxes. it measures pictures progressively at 45 frames per second. A more modest adaptation of the organization, Fast YOLO, measures every second, 155 frames.

B. License plate segmentation

Segmentation is the process of obtaining unicharacter from the given input image. Before performing the segmentation the Input image is converted from BGR format to Grayscale format as BGR format is more computationally expensive. This conversion of image format is performed in order to reduce the cost of computation of the process. The original colourful image is grayscaled using OpenCV.

- **The histogram of pixel projection method** is used to perform the horizontal projection and the vertical projection in order to find out the top, bottom, left and right limits of every given character. To find out the top and bottom limits of a character horizontal projection comes into play whereas the vertical projection is used to obtain the leftmost and rightmost limits of a character. Sum of the white pixels on a specific line along with the horizontal direction is the value of a group of histograms. The horizontal projection histogram is obtained after all the values of all the lines along the horizontal direction get calculated.

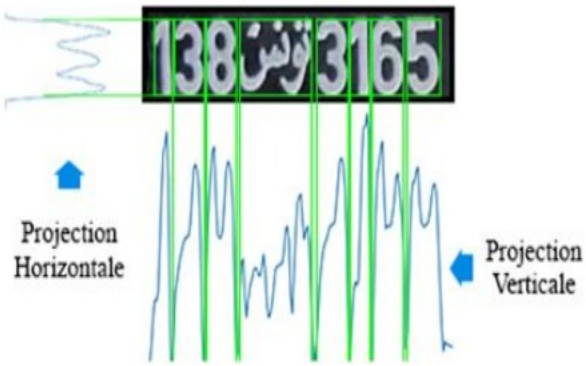

Fig. 6. Histogram of pixel projection

To check the upper and lower limit threshold values are used and threshold values are considered as the mean

value of the histogram. Similarly vertical projection histogram is obtained by interchanging rows with the columns of the image to find out the remaining two limits that are left and right limits of a given character.

- **Connected Component Analysis (CCA)** is the method that is used for character segmentation. This method relies on the pixel connectivity under this method pixels of a binarized image are scanned and labeled into components. And each pixel is labeled with the values according to the component assigned to it. Now the connected components are analyzed to strain long and broad components and solely left the elements supporting the outlined values. However the downside is that during this methodology the segmental result might not contain the precise vehicle plate regions.

- **Image scissoring algorithm:** For the character segmentation of a license plate, image scissoring algorithm is used. Image scissoring algorithms identify the characters given in the license plate. In this method the license plate is splitted into multiple images that contain only one single character. The segmentation of characters from the license plate involves a number of steps in which image contrast is done first. Since there is no fixed limit of characters in the number plates therefore vertical projection and connected component methods does not hold good in this case. Therefore Image scissoring algorithm is used. And this method contributes to the higher performance of character segmentation.

Fig. 7. Identified Character Components

C. Character Recognition

The character images obtained at the end of the segmentation phase, Character Recognition will be made on these images. The learning models must be able to read an image and to recognize each character.

- **Template matching** is the simplest technique for character recognition, taking into view coordinating the hang on models against the word or character to be seen. After gathering of shapes, pixels, curvature then forth, the amount of similitude between 2 vectors is decided by the operation of matching. A gray-level or binary image of character is input, which is compared in such a way as to emphasize differences with stored models. The recognition rate of Template matching is extraordinarily delicate to noise and input disfigurement.

- **Neural Networks**, Character request issue is alluded to with heuristic rule as individuals will get characters and records by their learning and data. Therefore the heuristic base neural networks are highly recommended and accepted for this type of issue. A neural network is an accomplice deciding arrangement that features gigantically equivalent interconnection of adaptable center processors. Reinforcing of output from one node is to ensure sophisticated collaboration of all nodes within the network. Because of its comparable character, the rate of calculation is higher in such a way as to emphasize differences with the standard ways.

- **Support Vector Machine:** Recognition of patterns and classification of data is done by Support Vector Machine (SVM) in such a way that no assumption is made about the underlying process through that observations were granted. Hyper planes are used by SVMs to separate different classes. Only one optimal separating hyperplane fittes it optimally, though there are many hyper planes which are fitted to separate the classes. The margin or the boundary between classes are maximized by the hyperplane.
  The steps included in SVM are as follows:
  - All types of preprocessing is done on the image and is converted on the grey-level or binary image.
  - Then the image is divided(segmented) into parts in which each part of the image contains one character.
  - Each divided part of the image is then normalized.
  - After normalization the feature vector is made out of it.
  - Then from the advanced trained SVM the character recognition is done.
  - These steps are continued until all the unclassified samples are over.
  - These tested samples are then added to the data-base for further training of models.
  - At the end, all characters which are recognised are brought together.

After looking into various research papers and the methods discussed, we finally reached the conclusion to use contours for the license plate detection in the image and finally knn for training the character recognition dataset and for testing as well.

VI. PROPOSED METHODOLOGIES

A. License Number Plate Detection Using Contours

Contour is an outline, representing or bounding the shape. Contour detection attempts to extract curves which represent object shapes from images.
Contour detection approaches are:

- In pixel-based approaches, features are constructed and then employed to determine whether each pixel of the image belongs to a contour.
- Edge-based approaches are based on contour related edges or curves provided by edge detectors or human prior experience, aiming to determine whether they are contained in a certain contour.
- Regarding contours as boundaries of interesting regions, region-based approaches take advantage of internal information of the regions to enhance their effectiveness and robustness.

As Licence plates normally occupy a small portion therefore, detecting licence plates from the image of a vehicle is a tough task. For detecting the licence plate of the candidate image, we use contour algorithm for objects having closed boundaries. There are various candidate-algorithm are applied on contour images which are obtained by applying contour algorithm on image of vehicles to separate plate objects.

However, this algorithm sometimes fails to process bad quality images due to scratches or blurring of the licence plate. In these cases, the contour algorithm produces incomplete boundary closed boundary lines images that don't have licence plate-images.

B. Character Recognition Using KNN

kNN (k Nearest Neighbour) is a non-parametric algorithm which is used for classification in Machine learning. The basic idea behind this algorithm is quite simple. In kNN algorithm, when we have to classify a character we first find its euclidean distance from the all training points and then sort the points on the basis of respective distance. Then we select the first k points having the minimum distance from our new character and take the classes of these k points. Then we classify this new character based on the majority of the k neighbours.
For computing the euclidean distance we compute the square root of the sum of the squares of the distance between this character's image and each image in that respective category.

$$EuclideanDistance(X,Y) = \sqrt{\sum_{n\ =\ 1}^{No.\ of\ Images} (X_n - Y_n)^2}$$

During this process the value of k should be odd because in the case of even points the draw can happen. When the kNN classifier is used on the dataset, there are three possibilities of result.

- The character is localized and recognised. It means that the character is matched.
- The character is localized but not recognised which means that the character is not matched.
- The character is not localized which means that the character is not found in the process.

Thus for the process of classifying, knn is used. And for recognizing, the rate of similarities is calculated using Euclidean Distance.

Algorithm: KNN

1. Load the data
2. Initialize K to chosen number of neighbors
3. For each example in the dataset
   - Calculate the distance between the query example and the current example from the data.
   - Add the distance and the index of the example to an ordered collection
4. Sort the ordered collection of distances and indices from smallest to largest (in ascending order) by the distances
5. Pick the first K entries from the sorted collection
6. Get the labels of the selected K entries
7. Return the mode of the K labels as it is a classification problem.

VII. EXPERIMENTAL ANALYSIS AND RESULTS

A. License Number Plate Detection

The table given below shows the accuracy while training and testing the dataset.

	Training Set(478 images)	Testing Set(256 images)
Successful	359	224
Failed	119	32
Accuracy	75.1046%	87.5%

Table: Training and Testing Accuracy.

B. Comparison of KNN and CNN for Character Recognition

There are many parameters that we need to consider in classification problems as only calculating accuracy is not sufficient to evaluate the overall performance of the model. Accuracy can sometimes lead to wrong results. For example, if we take a dataset with 950 positive examples and 50 wrong examples. A model will give an accuracy of 0.95 which classifies every example as positive. It is clearly very high and it can be clearly concluded that the classifier is fully biased. So, we considered more parameters to evaluate our overall performance like confusion matrix, positive predictive value or precision, true positive rate or recall and F-1 score.

- Confusion Matrix: It is a way to represent the performance of a classifier on a dataset for which we know the true values. The two figures shown below show the confusion matrix for KNN and CNN representing 26 characters and 10 digits.
  The number relation and the colour is shown using the scale given on the right side of the images. The correct categorisation of images is shown by dark colour. The similarity between the actual and predicted characters is represented by the dark diagonal line. The conclusion can be drawn that the confusion between '0'and 'O' and '1' and 'I' is much more than any other pairs.

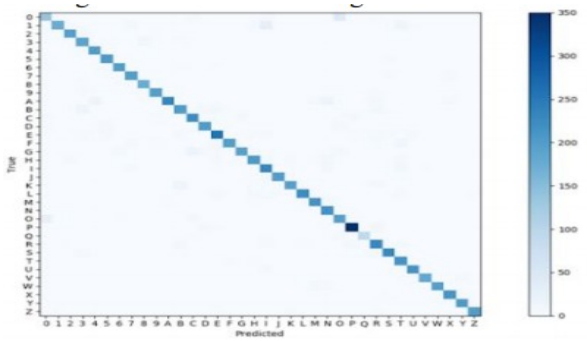

Fig. 8. Confusion Matrix for KNN

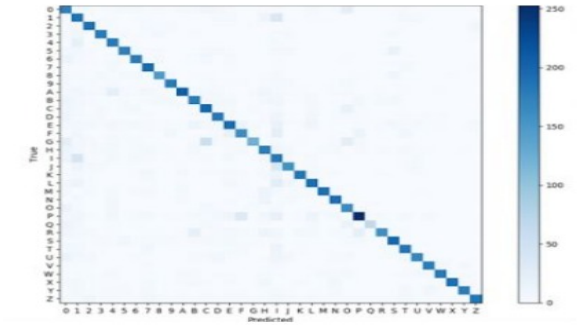

Fig. 9. Confusion Matrix for CNN

- Precision: Positive Predictive Value (PPV) or Precision is the fraction of relevant predictions (true positives) among all the predictions (sum of true and false positives) done. Mathematically, we have

$$Precision = \frac{TruePositives}{TruePositives + FalsePositives}$$

The figure given below shows the precision of different classes for KNN and CNN separately.

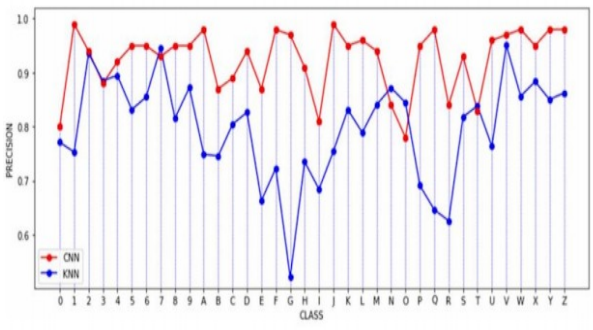

Fig. 10. Precision of different classes for KNN and CNN

From the graph, we can see that the precision for '0' shows less variation and ranges from 78%-80% for KNN and CNN respectively but shows a huge variation for 'A', 'J' ranging from 75%-95%.

- Recall: True Positive Rate (TPR) or Recall, can be termed as sensitivity of classification, is the fraction of relevant predictions that have been predicted (true positives) over the total amount of relevant predictions (sum of true positives and false negatives). Mathematically, we have

$$Recall = \frac{TruePositives}{TruePositives + FalseNegatives}$$

The figure given below shows the recall of different classes for KNN and CNN.

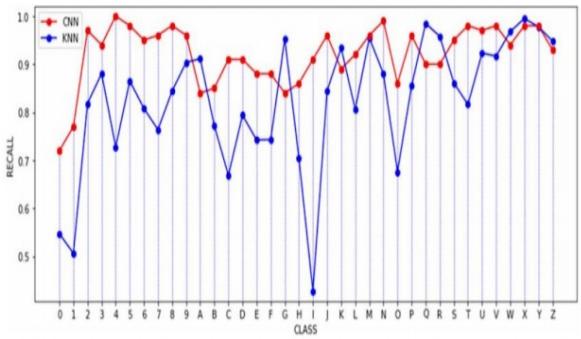

Fig. 11. Recall of different classes for KNN and CNN

Having better recall results is very important in order to estimate the actual performance of the classification. The true positive rate has perfectly labelled 'G', 'Q', and 'X' in KNN and perfectly labelled '4', '2' and 'N' in CNN. Because of the confusion of '0' with 'O', it has a low recall.

- F1-Score: The classifier should work well on both precision and recall metrics as only high precision and only high recall is not a good predictor for the quality of the model. Keeping this in mind, F1-Score is used for the combined effect of precision and recall. Mathematically, we have

$$F1 - Score = \frac{2 * Precision * Recall}{Precision + Recall}$$

The figure given below shows the F1-Score of all classes for KNN and CNN classifiers.

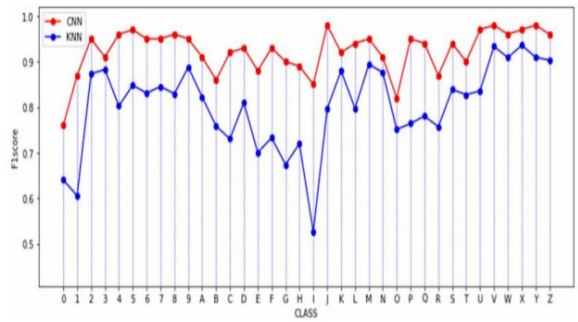

Fig. 12. F1-Score of all classes for KNN and CNN.

For KNN, the value of F1-Score is maximum at 0.91 and minimum at 0.55 and for CNN, the value of F1-Score is maximum at 0.98 and minimum at 0.75. From this, we can also see the importance of F1-Score as '0' has low F1-Score but has high precision.

- Accuracy: The figure shown below shows the curve between accuracy and number of epochs for training and validation (testing) data. An epoch is basically a

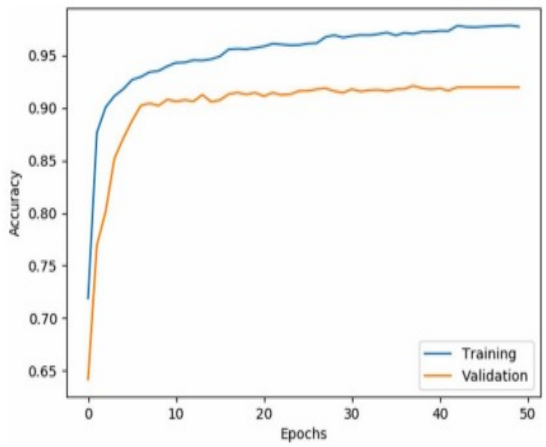

Fig. 13. Accuracy vs Number of Epochs

full training cycle consisting of one forward and one backward pass on the training dataset. We can see from the curve that after 20 epochs, the model converges. The training and validation accuracy is about 95% and 93% respectively at 20 epochs. The maximum accuracy obtained for training and validation set is 0.98 and 0.92 respectively.

C. OUTPUTS

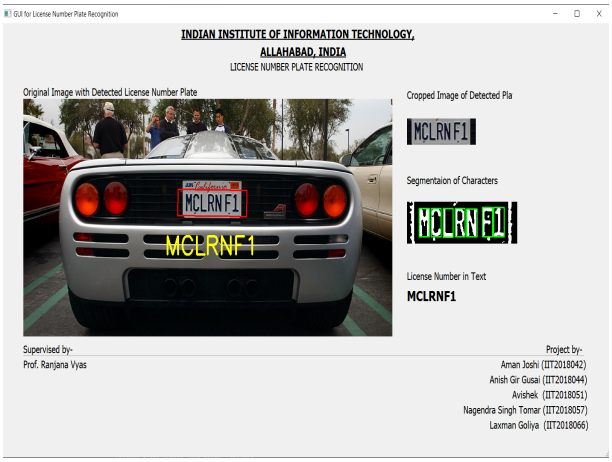

Fig. 14. Rear View Result from implementation

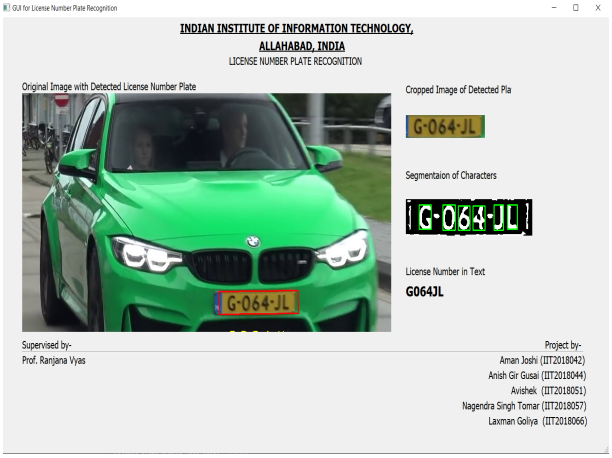

Fig. 15. Front View Result from implementation

VIII. CONCLUSION AND FUTURE WORK

In this report, the license number plate recognition project has been discussed. We have discussed various techniques in this report on which some work has been done in previous years. We have also discussed the prerequisites to start our project. The licence number plate detection process was divided in major three subtasks which were discussed in this report. There are a lot of challenges in the field of licence number plate detection for example, different number formats, different weather conditions etc. The implementation works quite well however, there is still room for improvement. For the future work, we need to improve the character recognition part and gather more data for training. We plan to develop a license number plate recognition system, which will have its own dataset, user interface and authorize people cars by identification of number plates. We can also extend it as a multilingual recognition system to identify the language of characters automatically based on the training data. For low resolution images, some improvement algorithms like super resolution of images can also be considered. Our project project works on processing one vehicle number plate but in real-time there can be more than one vehicle number plates while the images are being captured. We can improve it to work on multiple plates at a time.

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