SIDDAGANGA INSTITUTE OF TECHNOLOGY, TUMAKURU-572103

(An Autonomous Institute under Visvesvaraya Technological University, Belagavi)

Project Report on

Vehicle Plate Recognition System

submitted in partial fulfillment of the requirement for the award of the degree of

BACHELOR OF ENGINEERING

in

ELECTRONICS & COMMUNICATION ENGINEERING

Submitted by

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

CERTIFICATE

Certified that the project work entitled "Vehicle Plate Recognition System" is a bonafide work carried out by Dinu V (1SI15EC028), Harshith C H (1SI15EC037), Santosh Tuppad (1SI15EC089) and Shreyas S Bagi (1SI15EC097) in partial fulfillment for the award of degree of Bachelor of Engineering in Electronics & Communication Engineering from Siddaganga Institute of Technology, an autonomous institute under Visvesvaraya Technological University, Belagavi during the academic year 2018-19. It is certified that all corrections/suggestions indicated for internal assessment have been incorporated in the report deposited in the department library. The Project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the Bachelor of Engineering degree.

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Course Outcomes

CO 1 : Identify and formulate the problem through literature survey and knowledge of contemporary engineering technology.
CO 2 : Apply engineering knowledge to arrive at optimal design solutions for solving engineering problems in compliance with the prescribed safety norms/standards taking into consideration environmental concerns.
CO 3 : Select suitable engineering tools, platform, sub-system for solving identified engineering problem.
CO 4 : Implement the proposed solution on the selected platform, considering societal, health issues. Validate the design, analyse and interpret the results using modern tools.
CO 5 : Comprehend and prepare document as per the standard, present effectively the work following professional ethics, interact with target group.
CO 6 : Contribute to the team as a member, lead the diverse team.
CO 7 : Demonstrate engineering and management principles, perform the budget analysis through utilization of the resources (finance, power, area, bandwidth, weight, size, etc)

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO-1	3	3										2	3	
CO-2			3									2		3
CO-3			3											3
CO-4				3	3	2	2					2		3
CO-5								3		3		2		2
CO-6									3					3
CO-7											2		2	
Average	3	3	3	3	3	2	2	3	3	3	2	2	3	3

Attainment level: - 1: Slight (low) 2: Moderate (medium) 3: Substantial (high)
POs: PO1: Engineering Knowledge, PO2: Problem analysis, PO3: Design/Development of solutions, PO4: Conduct investigations of complex problems, PO5: Modern tool usage, PO6: Engineer and society, PO7: Environment and sustainability, PO8: Ethics, PO9: Individual and team work, PO10: Communication, PO11: Project management and finance, PO12: Lifelong learning

Abstract

License plate recognition is an image processing technology that uses character recognition approaches to identify authorized vehicle by reading their license plate automatically. The system can be used in different security applications such as traffic monitoring and law enforcement, vehicle tracking, access control, automation of vehicle parking, electronic toll collection, etc. The task is quite difficult because of different environmental conditions and the relative motion between the vehicle and the acquisition device makes the task more challenging.

The license plate recognition system consists of the following steps: Image or Video acquisition, Image pre-processing, Number plate extraction, Character segmentation and Character recognition.

From the selected frame of the video or a still image, the number plate of the vehicle is detected and segmented from the pre-processed image using fusion of spectral analysis, color features, geometrical features and connected component analysis (CCA). The task of segmenting alphanumeric symbols from the license plate is made using connected component analysis. For recognition of characters/numerals, histogram of gradients (HOG) features are used and finally a support vector machine (SVM) classifier is used for classifying the characters. The resulting data is then used to compare the records on a database in order to provide specific information such as the entry and exit time and to verify whether the vehicles is registered with the database or not. The system is implemented and simulated in Python OpenCV, and its performance is tested on real image.

Contents

List of Figures

Chapter 1

Introduction

License plate recognition system is an advanced machine vision technology that can read vehicle number plates without human intervention. There is a clear lack of standardization in number plates and character fonts in India, though “IND format” has been imposed by the Regional Transport Office. This poses challenges to the character recognition. Devoloping Automatic License plate recognition system is still a challenge under such situation, with varying formation of license plate. Further, different envirnomental conditions of lighting and illumination makes the problem more challenging. There are numerous variables that need to be taken into account to gain high accuracy in the recognition of the number plate, such as climate, time of day, and angles between the cameras and the license plates.

1.1 Motivation

As the number of vehicles are increasing every day, controlling and security of vehicles is becoming difficult. Hence Automatic license plate recognition system plays a vital role in intelligent transportation system.

1.2 Objective of the project

- To implement the license plate extraction using OpenCV-Python.
- To test the project at SIT main gate to maintain a log of vehicles entering and leaving the campus.
- Classify registered and non-registered vehicles.

1.3 Indian Vehicle License Plate

For vehicle identification purposes a plastic or metallic plate is connected to motor vehicle. n India, each district's Regional Transport Office issued vehicle license plates with a 9/10-digit alphanumeric ID. Within this issuing region, this alphanumeric ID recognizes the vehicle owner. An instance of an Indian license plate is shown in Figure 1.1. A standard Indian license plate is made up of five single purpose segments.

1. Segment1: The first two characters represent the territory of the union or the state of registration of the automobile. Example, KL-Kerala, TN-Tamil Nadu, AP-Andhra Pradesh, KA-Karnataka, etc.

2. Segment2: The next two numbers refer to the district sequential number to identify where the vehicle is registered.

3. Segment3: The series of the particular is defined by the next one / two characters.

4. Segment4: A distinct 3/4 numbers are used to identify the vehicle.

5. Segement5: The oval IND logo is an acronym for INDIA, and the chromium hologram at the top looks like the Chakra.

Figure 1.1: Indian License Plate with importance of every segment

1.4 Organisation of the report

Chapter 1 includes introduction, motivation, organization of the report. Chapter 2 explains about the literature survey. Chapter 3 explains about moving vehicle detection and extraction of vehicle. Chapter 4 describes license number plate detection and extraction. Chapter 5 includes the processes involved in character segmentation. Chapter 6 gives explanation of Character recognition and Chapter 7 provides results of the project and chapter 8 includes conclusion.

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Chapter 2

Literature Survey

In this chapter, a review of the previous work done in the area of the license plate recognition framework is reported in this chapter. The typical ALPR system consists of three major tasks such as extracting license plate from the acquired image, segmenting characters from the extracted license number plate and recognizing segmented alphanumeric characters.

2.1 Moving Vehicle detection and Segmentation

The subsequent image processing tasks such as extraction of license plate, character segmentation, and character recognition are applied on the best frame selected from video. To detect moving objects from video, many methods and algorithms have been developed.

The methods used for vehicle detection and tracking are median filtering and blob extraction[1]. Median filtering is used for extraction of the background, which is subtracted later for object detection from the motion frames. Morphological operators are used to extract blob. Using median filtering and morphological closing operation, object detection is achieved.

The frame differentiation, selective background update methods are used to generate initial background and update current background [2]. In addition, each processed image is filtered by a quick median filter to remove noise and moving objects in the video can be effectively detected by differencing background frames complemented by interframe differentiation.

Extracting moving foreground objects (image input) from stored background image (static image) or generated background image form image series (video) is referred to as background subtraction [3], resulting in the extracted information (moving objects) being the threshold of image differencing. After that, the Gaussian probability distribution model updated pixel values and these pixel values are updated in the new image series. Then each pixel (x, y) in the image is either categorized as part of the foreground (moving object or referred to as blobs) or background based on the adequate amount of knowledge from the above model using the equation.

$N(u, v) - M(u, v) < (K * Std(u, v))$, where $N(u, v)$ is intensity of each pixel, K is a constant. $M(u, v)$ is the mean and $Std(u, v)$ is the standard deviation.

2.2 License Plate Detection and Extraction

The license plate extraction directly impacts on accuracy of the system, hence it is the most important phase in ALPR system. The goal of this phase is to produce a number of candidate regions from the given input image and validating for true number plate. Several algorithms are used to extract the region of the license plate, each with different complexities and difficulties.

2.2.1 Edge analysis

For locating and extracting car license plate from the image, the sobel edge operator is used [4]. The system works for both moving and stationary vehicles in compressed low-resolution video streams from real working environments. For the detection of edges in the image, a moving window is scanned through the image.

2.2.2 Connected component analysis

Connected component analysis is the method used for detecting license plate from complex background images [5] [6]. First, it segments images with an adaptive binarization method to avoid the problem created by non-uniform illumination and remove some unwanted image areas by limiting the region properties of connected components. Secondly, connected components analyzes are used to build the nearest neighboring chain to detect candidate license plate regions. To handle images obtained from different views or distances, the average height and direction of each connected component is estimated and the most possible region is selected as the true license plate region.

2.2.3 Spectral analysis

Vehicle plate characters are an important feature for segmenting the license plate from the entire image input [7]. Characters are aligned horizontally and have the same colour. One way of extracting such information may be through the fourier transformation to perform spectral analysis. Spectral analysis was commonly used in text regions extraction. The intensity (gray scale) values of each row are calculated by a periodogram. The two - sided periodogram for a series of a finite length is an estimate of the Power Spectral Density (PSD). The periodogram provides an energy distribution per frequency band. After the estimation of the periodogram, a threshold of 30 percent or 40 percent of the maximum periodogram is set, the rows with the periodogram value greater than the threshold are considered and segmented as regions of the license plate.

2.3 Character Segmentation

The process of segmentation is used to segment all the characters, without losing character features from the given number plate image [8]. After separating the license plate from the image of the car. The foreground license plate characters are to be extracted from the license plate background. Segmentation of license plate characters from the license plate itself using horizontal and vertical projection or connected component analysis. Basic thresholding is applied to extract the license plate characters. But regions such as bolts fastening the license plate to the car, branding logos on the plate itself, or embellishments on the license plate frames are to be removed. Morphological operations such as dilation and erosion are used to eliminating the region of non-character or noise from the image of the license plate. CCA is used to find the connected components and lastly compared to standard license plate parameters such as width to height ratio, area in order to avoid non-character area.

2.4 Character Recognition

The final module in number plate recognition process is character recognition. The segmented elements are converted from printed alphanumeric characters to computer-readable text format. Since the extraction method significantly affects the quality of the whole process of recognition, it is very important to extract features that will be invariant to the different types of font used. The characters in the image segments must be resized to uniform dimensions and then the extraction algorithm extracts appropriate descriptors. The Histograms of Oriented Gradients (HOG) [9] is used to extract features from each character of each detected plate and the characters are recognized by the trained SVM classifier [10].

Chapter 3

Moving Vehicle Detection and Segmentation

The first stage of processing in a license plate recognition system is the video frame selection followed by detection and extraction of the license number plate area from a larger scene image to minimize computations and complexity of the algorithm.A dynamic object can be detected and tracked from a continuous video sequence based on the two primary information such as visual characteristics such as color, texture, shape, and motion characteristics. In video, as object moves from one frame to another, the object to be tracked changes its position. The variability in visual features is quite evident due to this movement. The various challenges facing a moving object detection and segmentation technique are illumination involving changes in brightness, dynamic background, background clutter presence, presence of shadow, camera movement, noise presence, etc. The car in the video is considered as positive images and all the background in the video is considered as negative images are classified using haar cascade classifier. Hence in the complete video only the positive part is extracted as shown in the figure 3.1 and 3.2.

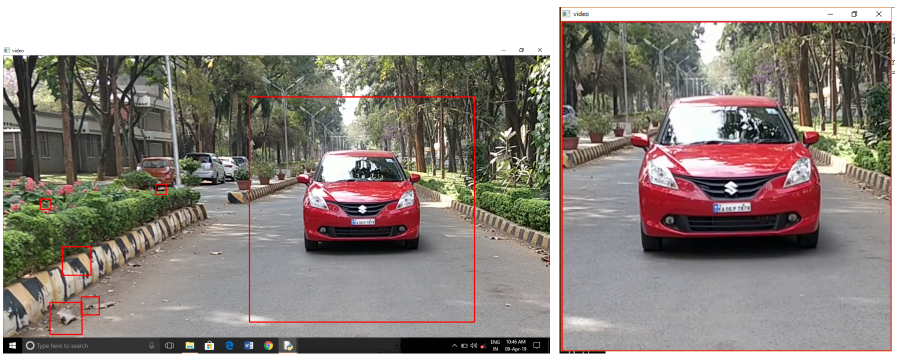


Figure 3.1: Vehicle detected and extracted in the video frame

Figure 3.2: Vehicle detected and extracted in the video frame

3.1 Extracting the Frames from the video

The car video is divided into multiple frames based on the length of the video, which is passed onto further process of license plate extraction to extract and recognise the license plate characters. The extraction of frames from the sample video is as shown in the Figure 3.3.

Figure 3.3: Frames extracted from the video

Chapter 4

License Plate Detection and Extraction

In an ALPR system, the first and most vital phase is the identification and extraction of number plate. This section intends about locating the vehicle number plate from the video frame or image of the captured vehicle. A well known Indian automobile number plate is a metallic rectangular plate bearing an alphanumeric ID of 9/10 digits connected to a motor vehicle. An ALPR system extracts number plate bearing the existence of increased vertical and horizontal edges and most eminent corner points due to contrast characters on the vehicle license plate. But in some cases, as mentioned in the literature review, this process can detect a non-license plate region, each of which has unique complexity and difficulty. The proposed approach is a fusion of edge analysis, morphological operations, Connected Component Analysis (CCA) and global image features such as area, aspect ratio, length of column-row, spectrum analysis, and detection of corner points. This part reviews explanation on the suggested number plate identification and extraction algorithm. The block diagram of vehicle plate detection and extraction is as shown in the Figure 4.1.

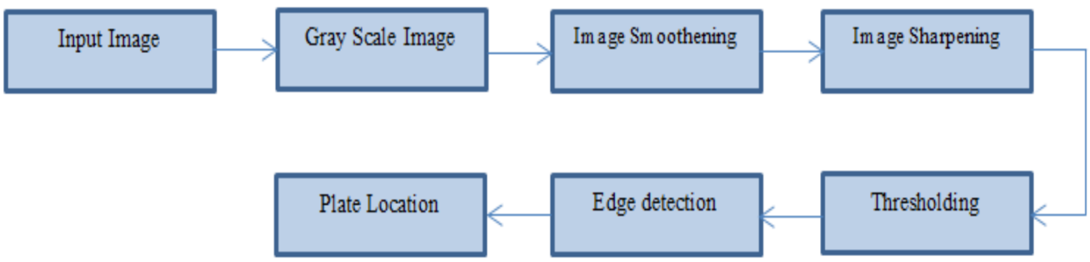


Figure 4.1: Block diagram of vehicle plate detection and extraction

4.1 Pre-processing

Using Haar cascade classifier, the moving vehicle is detected and fed into the license plate detection and extraction phase as input. The sample input images is as shown in the Figure 4.2. The input color image is converted into gray scale image as shown in the Figure 4.3. The extracted vehicle will be low contrast and blurred due to poor lighting conditions and distance of vehicle from the camera. This section intends to increase the quality of image acquired by de-noising and improving the contrast of image. Bilateral filter is a non-linear filter which is used to smoothen the image with reduced blurring effect and noise by more efficiently maintaining edges than median filter as shown in Figure 4.4.

To improve the contrast, filtered image undergoes Adaptive Histogram Equalization(AHE). AHE performs better than a simple histogram equalization, since AHE relies on gray level, local characteristics and spatial co-ordinates of picture elements with Peak Signal Noise Ratio(PSNR), where as HE relies merely on the gray levels of picture elements having low PSNR.

Together with required license plate region, the vehicle image could also consist of other regions. The other regions will be eliminated by casting off circular shaped regions through morphologically opening the AHE image using a circular shaped structuring element and subtracting the morphologically opened image with the AHE image, assuming that the square or rectangular shaped number plate region is present. This step enhances edges, corners and the necessary elements of license plate region. Figure 4.5 indicates the pre-processed result.

Figure 4.2: Input vehicle images

4.2 Edge Analysis and Morphology

To detect edges, binary image undergoes sobel operation along x and y axis. The purpose is locating boundaries of some objects having vertical and horizontal edges in an image. The discontinuity in brightness usually detects edges, so most of the edge detection tech-

Figure 4.3: Gray Scale Images

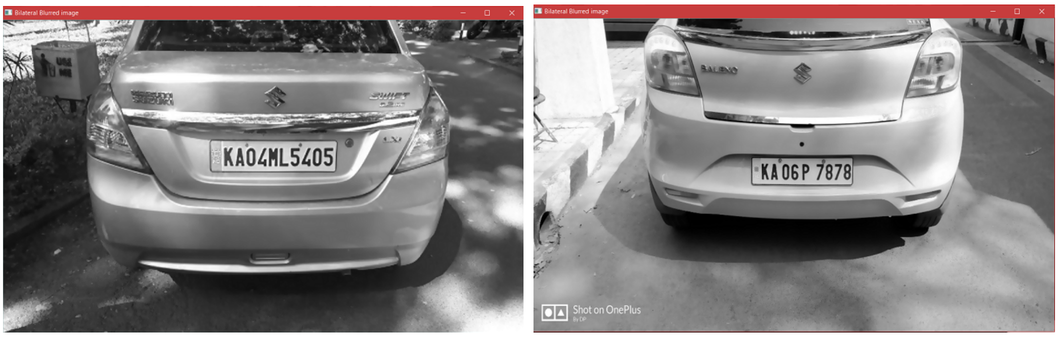


Figure 4.4: Bilaterally filtered images

nique aims in locating sudden changes in intensity levels to detect vertical and horizontal edges. By connecting these identified edges together, the boundaries of the object are framed. Sobel-operator is the most common and simplest edge detection operator with less time consumption used in real-time image processing applications. A sobel operator with 3 X 3 kernels is convolved with 2D-spatial gradient on image and highlight edges of regions with maximum frequency. The effect of edge analysed image is as shown in the figure 4.9. The pair of 3X3 kernel is given by,

$$dx = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix}$$

$$dy = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix}$$

To obtain the license plate regions, related morphological techniques are applied to image bearing edges as shown in the Figure 4.6. After the morphological operations, the differ-

Figure 4.5: AHE images

ence image is obtained by subtracting the opened image with original image as shown in the Figure 4.7. That difference image is thresholded as shown in the Figure 4.8. The image bearing edges undergoes dilation operation to reinforce the sobel operator extracted edges. In dilation as shown in the Figure 4.10, pixels are added across the boundaries of object in image containing edges. It is done by locating the local maximum and creating the resulted matrix using the following equation,

$$M \oplus N = \{X | (\overline{N})_x \cap M \neq \varphi\} \tag{4.1}$$

In the resulted image, holes are filled through hole filling as shown in the Figure 4.11 . Hole filling identifies the outline of the entities in a binary image through a set of dilation, complementation and intersection, as shown in the below equation,

$$\begin{gathered} Z_i = (Z_{i-1} \oplus N) \cap M^c; i = 1, 2, 3 \\ Termination : if Z_i = Z_{i-1} \end{gathered} \tag{4.2}$$

Morphologically opening is applied for hole - filled image to remove the unwanted portions. Opening usually smoothens an object's contours by separating the tapered isthmus and removing the projections. The sample morphologically opened images is as shown in Figure 4.12. Opening is erosion accompanied through dilation as shown with the aid of below equation,

$$M \circ N = (M \ominus N) \oplus N \tag{4.3}$$

Lastly, erosion is utilized to detect regions of applicant number plate. Erosion eliminates pixels of object borders in the opened image through locating local minima and generates the resultant matrix from minimum values as shown in the below equation.

$$M \ominus N = \{Y | (M)_y \subseteq N\} \tag{4.4}$$

Figure 4.13 indicates the impact of applying edge analysis and morphology with ten applicant number plate regions.

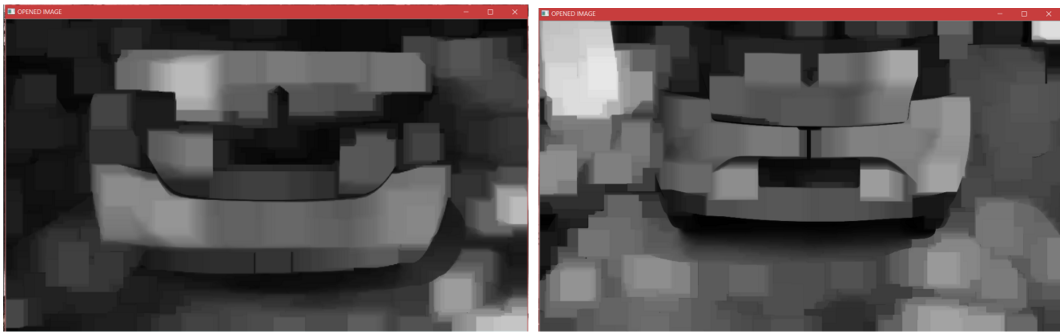


Figure 4.6: Morphologically opened images

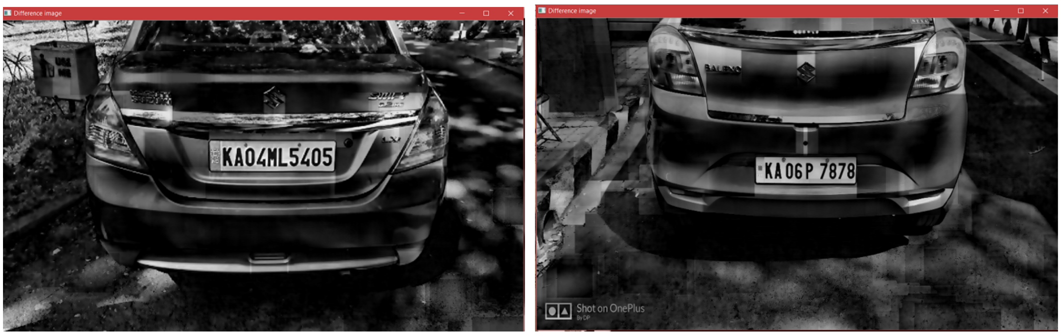


Figure 4.7: Difference images

Figure 4.8: Pre-processed binarized images

4.3 Spectral analysis

Characters are an essential feature in the vehicle number plate to segment the number plate from the entire image. Due to the presence of characters, spectrum analysis based fourier transform calculation is supposed to have peak value in the vehicle number plate region. Due to its complex nature, fourier transform consumes more time, so it

Figure 4.9: Edge analyzed images

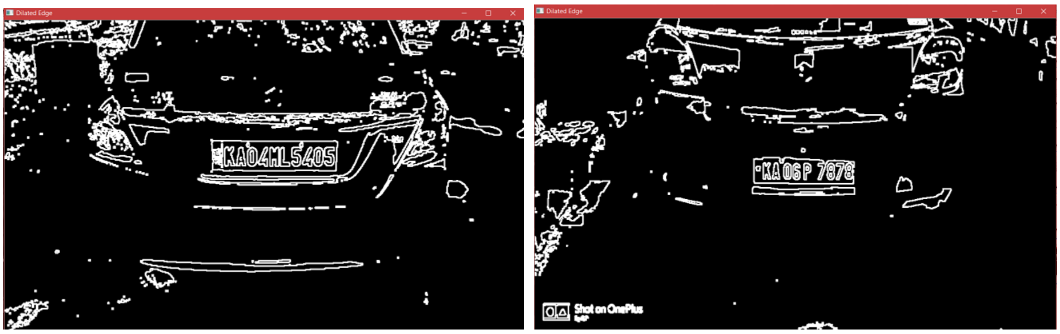


Figure 4.10: Dilated images

is appropriate to use fourier spectrum (fourier transform magnitude) or power spectrum (fourier spectrum square) for further analysis. The fourier spectrum and power spectrum equations are shown respectively in the below equations 4.5 and 4.6 respectively.

$$|F(x)| = [R^2(x) + I^2(x)]^{1/2} \tag{4.5}$$

$$P(x) = |F(x)|^2 = R^2(x) + I^2(x) \tag{4.6}$$

where R and I are real and imaginary parts of fourier transform respectively. An image of M X N, each row is inspected to examine if it crosses a character of a vehicle number plate. Periodogram is the estimation of power spectrum density. It is calculated on the pixel intensity levels along every row which gives an energy distribution per frequency

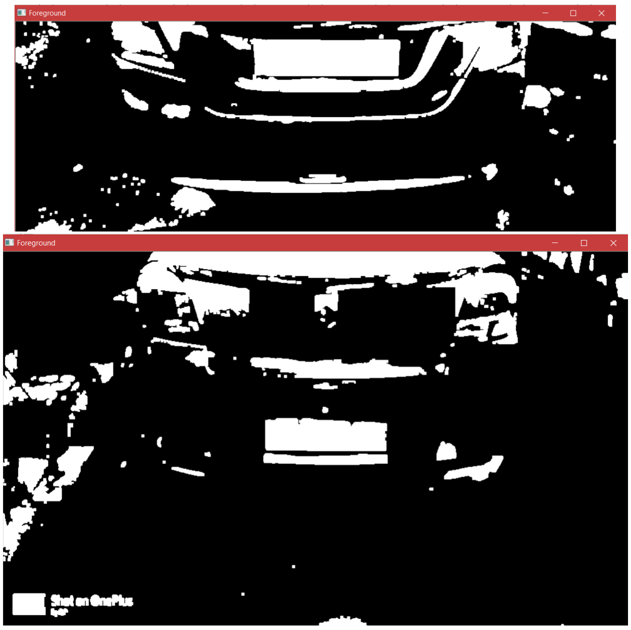


Figure 4.11: Hole filled images

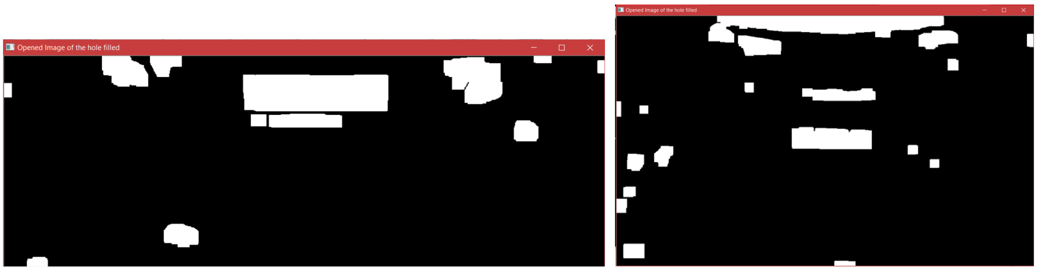


Figure 4.12: Morphologically opened images

band. The periodogram equation is given by,

$$\prod_{f}^{M}(x) = 1/M|\sum_{i=0}^{M-1} f(i)e^{-j2\Pi\eta i}|^2 \tag{4.7}$$

A threshold of 30 or 40 is set in the periodogram, in the rows with value higher than the threshold are regarded and segmented as a region of the vehicle number plate from the input image. In some conditions, the extracted pre-processed frame consisting of towing accessories such as vehicle logo or label, headlights and the required area of the number plate. In such conditions, corner point detection is used to take out the required region on the expectation that due to the presence of characters, there are maximum number of corners in the license plate region.

Figure 4.14 shows the effect of using spectral analysis. Figure 4.14(a) shows the instance of a momentary image in which two applicant number plate regions are appended, such as the number plate and the logo of vehicle. The periodogram plot of the temporary picture

Figure 4.13: Eroded images

with highest periodogram value at the real number plate region is shown in Figure 4.14(b) and Figure 4.14(c)indicates the authentic extracted region of the license plate using the proposed detection and extraction algorithm for the license plate.

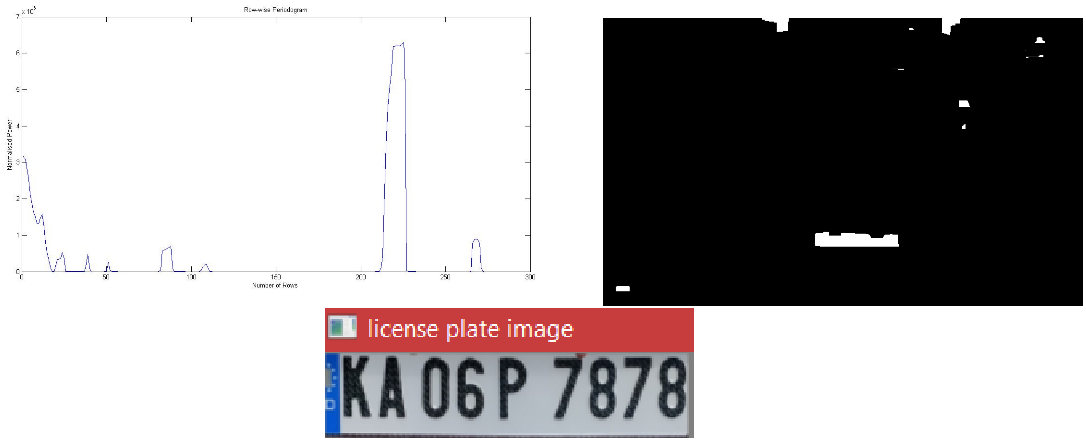


Figure 4.14: Result of applying spectral analysis on Connected component images and extracted number plate images

Chapter 5

Character Segmentation

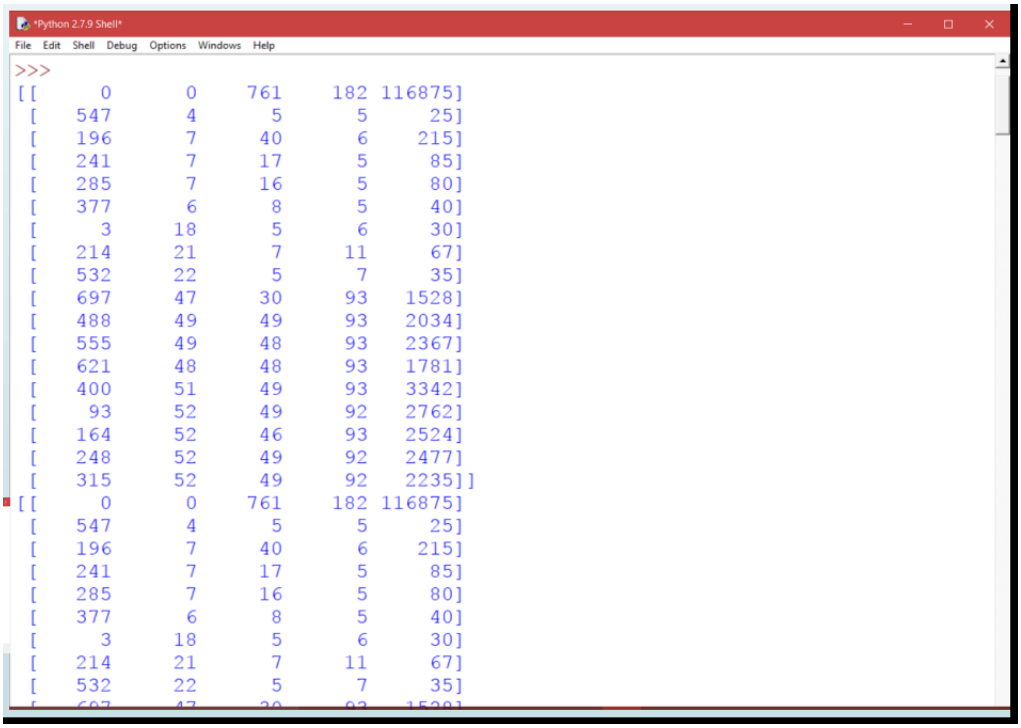
Standard license plates provide a significant advantage in LPR as they consist mainly of smooth backgrounds and highly contrasting characters. A smaller percentage of vehicles carry standard license plates. Though, license plates with unique stylish fonts are increasing in popularity and prominence should be given to strategies for appropriate segmentation and recognition as a significant majority of vehicles carry such license plates. The segmentation of alphanumeric symbols from the license plate will be discussed in this chapter. The character recognition module performance in LPR will depend heavily on the plate text segmentation efficiency.

5.1 Connected Component Analysis Approach

The CCA can be applied to an entire license plate. Each object extracted is thus a character extracted. Hence this method of character extraction requires the characters to be just separated in the license plate. The objects with very small or a very large width or height can be neglected as they don't correspond to characters. The sample binarized license plates is as shown in the Figure 5.1. These binarized plates are applied with CCA and its result is as shown in Figure 5.2. The CCA stats for sample image is as shown in the Figure 5.3. Based on the aspect ratio, area and height of characters, The aplha-numeric characters are extracted from the license plate as shown in Figure 5.4.

Figure 5.1: Binarized license plate images

Figure 5.2: Connected Component characters




```
>>>
[[     0      0    761    182 116875]
 [   547      4      5      5     25]
 [   196      7     40      6    215]
 [   241      7     17      5     85]
 [   285      7     16      5     80]
 [   377      6      8      5     40]
 [     3     18      5      6     30]
 [   214     21      7     11     67]
 [   532     22      5      7     35]
 [   697     47     30     93   1528]
 [   488     49     49     93   2034]
 [   555     49     48     93   2367]
 [   621     48     48     93   1781]
 [   400     51     49     93   3342]
 [    93     52     49     92   2762]
 [   164     52     46     93   2524]
 [   248     52     49     92   2477]
 [   315     52     49     92   2235]]
[[     0      0    761    182 116875]
 [   547      4      5      5     25]
 [   196      7     40      6    215]
 [   241      7     17      5     85]
 [   285      7     16      5     80]
 [   377      6      8      5     40]
 [     3     18      5      6     30]
 [   214     21      7     11     67]
 [   532     22      5      7     35]
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Figure 5.3: CCA Stats of sample image

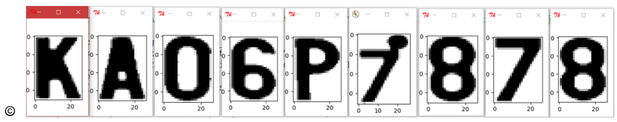


Figure 5.4: Extraction of characters from license plate

In cases where all the pixels of an individual character are not connected when the image is binarized, due to improper thresholding, character extraction becomes erroneous. The thin characters on the license plates also contribute for the errors. However, the connected component analysis was found to provide good results even in the presence of small extra regions also.

Chapter 6

Feature extraction and Character Recognition

A feature descriptor is a representation of a picture that improves the picture by separating useful data and expelling extraneous data. HOG is a feature descriptor.

The final module in number plate recognition process is character recognition after segmentation of elements (characters and numbers) i.e. converting printed alphanumeric characters into computer - readable text format. The recognition system is based on a Support Vector Machines classifier.

6.1 Histogram of Oriented Gradients (HOG)

In the HOG feature descriptor, the histograms of magnitude and oriented gradients are utilized as features[10]. Inclinations of a picture are helpful because the magnitude is large around edges and corners.In the System we first extract features of character set (0-9 and A-Z) using HOG descriptor and combine into a single feature vector which is classified using SVM classifier.

Implementation of the HOG descriptor algorithm is as follows:
Step 1: The character image from character set are resized to 27 X 36. Figure 6.1 shows the character A, M, 9 and 7 are resized.

Step 2: The horizontal and vertical gradients are calculated. This can be done using the filters as shown in matrix below. This step can also be done using Sobel operator. Figure 6.2 show application of Step 2 on character image M.

Figure 6.1: Alphanumeric charecters

$$dx = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix}$$

$$dy = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix}$$

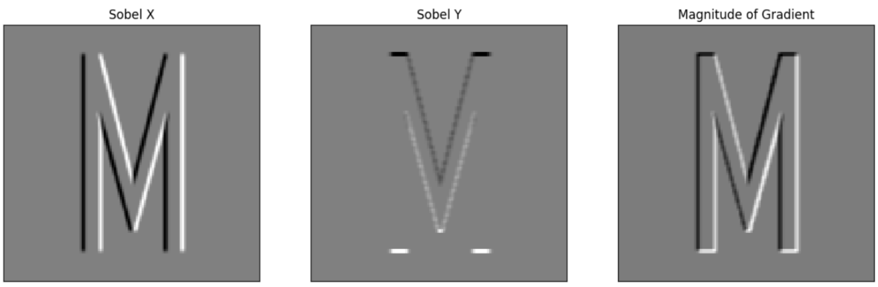
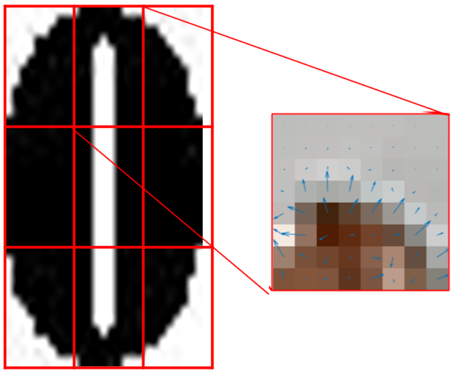


Figure 6.2: Application of the sobel operator

Step 3: Divide the character image into small cells and then compute a gradient direction and orientation for the pixels within the cell as shown in Figure 6.3 (a). The Figure 6.3 (b) and (c) gives the magnitude and angle of the cell.

Step 4: Next each cell is converted to angular bins according to the gradient orientation.
Step 5: Group of adjacent cells are considered as blocks. The blocks are normalized using Equation 6.1 and then represents the block histogram. Figure 6.4 shows how grouping of blocks is done.



(a) Cell division

2	3	4	4	3	4	2	2	4	2	2	2
5	11	17	13	15	25	39	9	3	4	7	10
11	21	23	27	22	17	4	6	10	5	8	3
23	99	165	135	85	32	26	2	5	8	9	10
91	155	133	136	144	152	57	28	98	45	55	59
98	196	76	38	26	60	170	51	54	78	88	90
165	60	60	70	70	85	90	95	100	120	120	115
71	75	86	95	74	74	51	0	5	40	65	100
120	150	225	200	204	203	220	195	196	175	162	53

(b) Gradient magnitude

80	36	5	10	0	64	90	73	45	58	65	90
37	9	9	179	78	27	169	166	155	145	120	165
87	136	173	39	102	163	152	176	87	36	156	130
76	13	1	0	45	87	23	10	56	89	100	180
156	45	23	123	145	120	125	170	80	30	150	136
70	130	100	50	80	90	50	62	48	73	81	41
45	89	25	56	65	48	71	73	79	90	95	96
93	95	45	145	165	125	135	167	142	102	105	108
156	123	145	178	158	169	147	158	123	126	159	175

(c) Gradient direction

Figure 6.3: Division of character image into small cells and calculation of gradients

$$L2norm: \quad f = \frac{x}{\sqrt{||x||_2^2 + e^2}} \tag{6.1}$$

Step 6: Flattening into a feature vector.

A Gray color vector [128, 64]. The length of this vector is $\sqrt{(128^2 + 64^2)} = 143.10$. This is also called the L2 norm of the vector. Dividing each element of this vector by 143.10 gives us a normalized vector [0.89 ,0.44]. The Figure 6.5 (a) is the character-4 image with the Dimensional Vector-972 (27 X 36 = 972) and Figure 6.5 (b) shows the HOG feature extracted from the character-4 image with the Dimensional Vetor-144.

6.2 Support Vector Machine Classification

SVM belongs to kernel methods or class of maximum margin hyperplane classifiers. The SVM map data from original space to the higher dimensional feature space. SVM classifier is utilized for recognition between two classes by finding a optimum hyperplane that

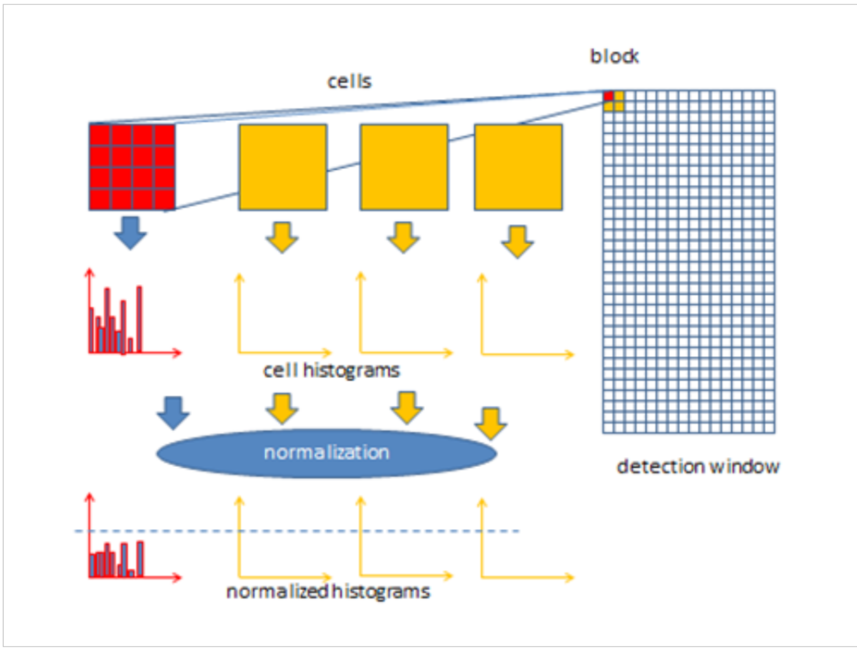


Figure 6.4: HOG feature extraction

(a) (b)

Figure 6.5: Reduction of dimension of feature

has most extreme separation to the closet points in the preparation set named as support vectors.

The training set of points $p_i \epsilon R^n$,i=1,2...N where each point p_i belongs to one of two classes distinguished by the name $q_i \epsilon -1, 1$. The objective of SVM classifier is to isolate two classes by a hyperplane with the end goal that separation to the support vectors are augmented. The hyperplane formed is called as Optimal Separating Hyperplane (OSH). The OSH is given as follows:

$$f(x) = w \cdot p + b, where w = \sum_{i=1}^{N} p_i q_i \alpha_i \tag{6.2}$$

The SVM classification of two classes using hyperplane and selection of optimal plane is as shown in the Figure 6.6.

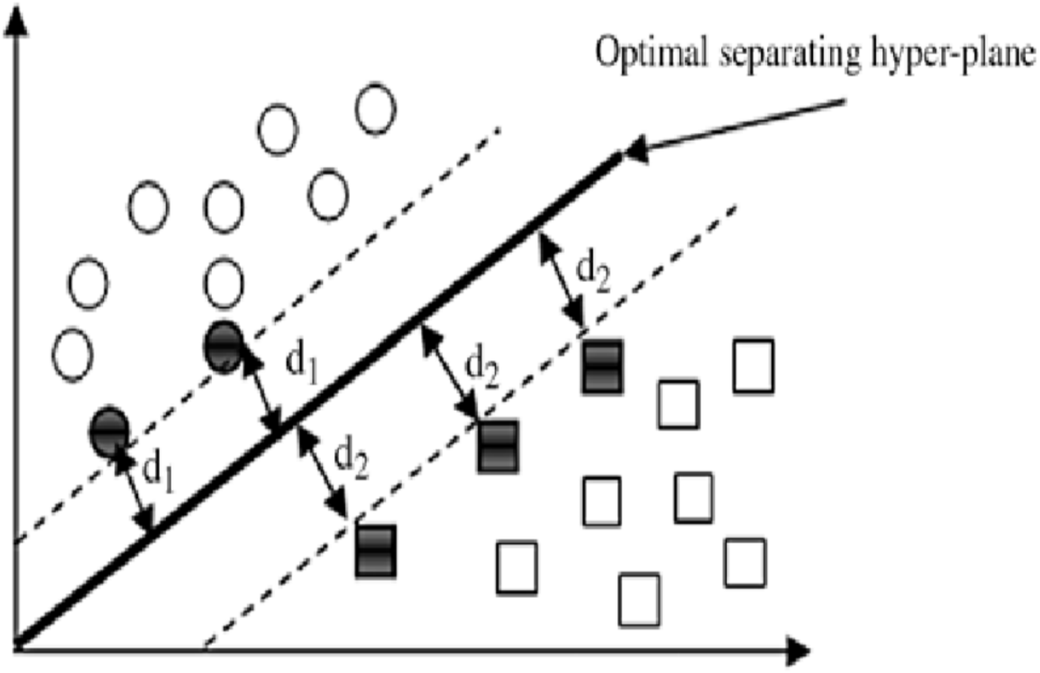


Figure 6.6: Selection of optimal plane in SVM

The coefficients α_i and b in 6.3 are solution of a quadratic programming problem. For the new data point p the classification is performed by computing the sign of the right side of the 6.3

$$d(p) = \frac{w \cdot p + b}{||w||} \tag{6.3}$$

In Equation 6.3 the sign of the d is used for classification for data point p, and $|d|$ is the distance from p to hyperplane. If larger $|d|$, then point is farther away from decision surface. Hence, more reliable the classification result. SVM is used as a multi - class classifier. One against one is the approach employed for the classification. The system is trained with the number of classes set at 36 including 10 numerals and 26 English alphabet letters. The size of segmented characters varies greatly. In this phase, all characters are standardized by image mapping technique to a size of 27 X 36.

Chapter 7

Results

A Graphical User Interface(GUI), consists of menus, buttons, text, graphics, etc. is developed. Using these menu buttons the user can interact with the LPR system. GUI help to analyze the results effectively.

7.1 Graphical User Interface using python Tkinter

A Graphical User Interface (GUI) is a program's pictorial interface. By providing a consistent presentation and user friendly controls, a good GUI can make programs easier to use. It is a graphical display that contains devices or components that allow interactive tasks to be performed by a user. This chapter includes few snapshots of Graphical User Interface(GUI) designed to demonstrate the various approaches discussed previously for License Plate Recognition(LPR).Figure 7.1 shows the welcome window displayed at the start of the GUI main file.

Figure 7.1: Welcome window at the start of GUI

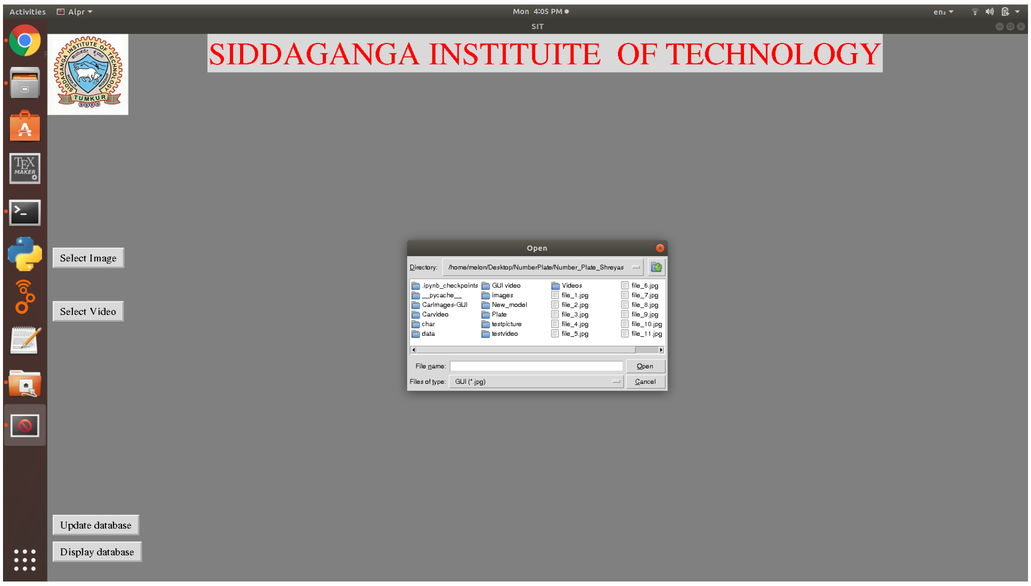


Figure 7.2: GUI window showing options for LPR of still images and video

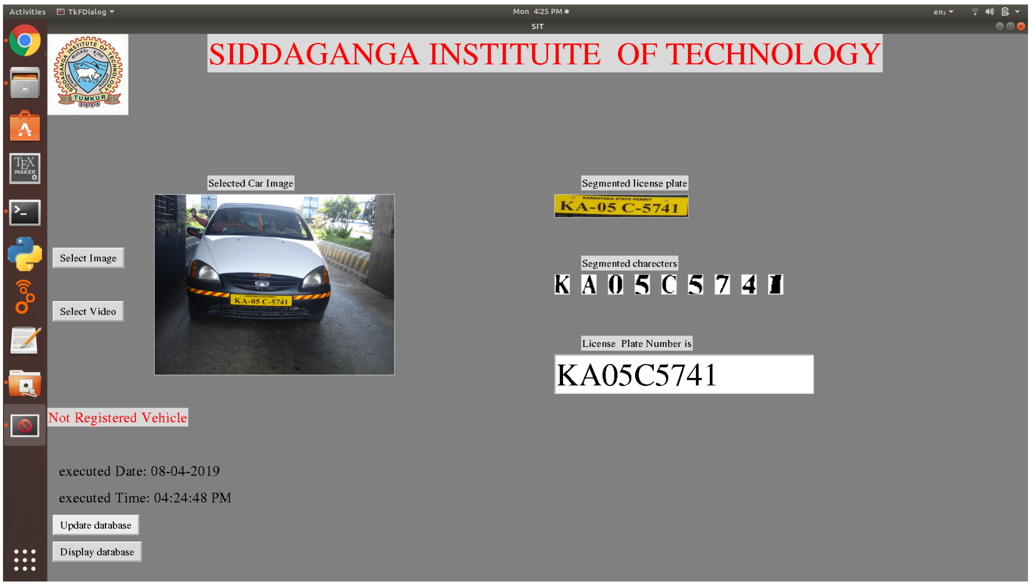


Figure 7.3: GUI window showing input image of a vehicle, segmented license plate, segmented characters and recognised license plate number of the vehicle

7.2 Results of Video Analysis

When the LPR system is applied to selected frames, the license plate candidate is obtained for each frame and so do the segmented character output and the recognition output. Figure 7.4 shows the output obtained for a length of video with number of frames=6.

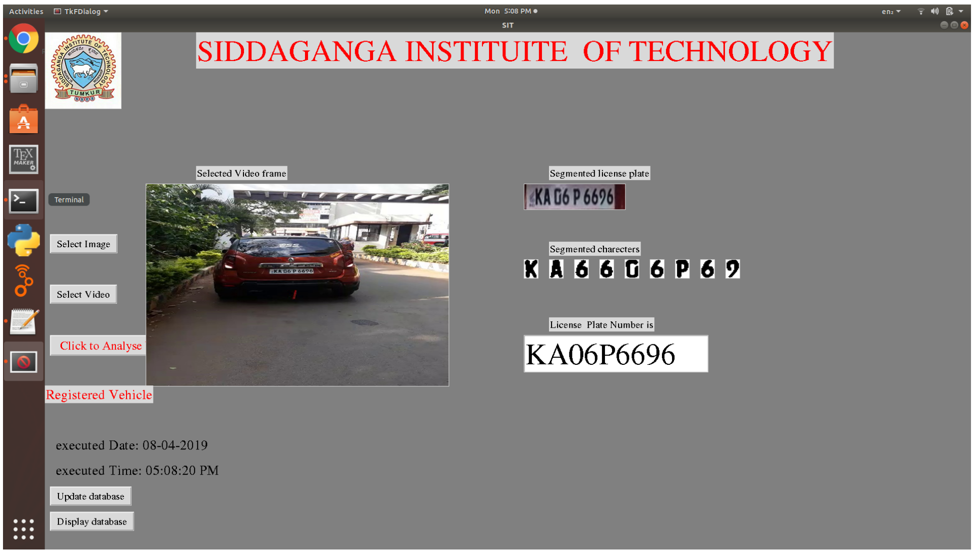
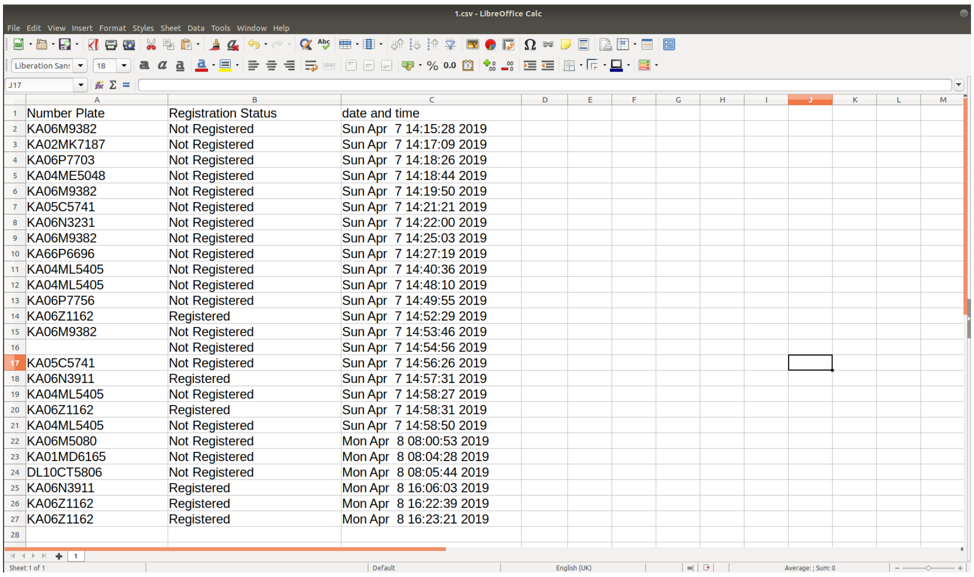


Figure 7.4: GUI window displaying result of video analysis

7.3 Results stored in Database

The results of static images and video analysis are stored in the database with their features such as license plate number, registration status and date and time of execution. Figure 7.5 shows the output stored in the database.

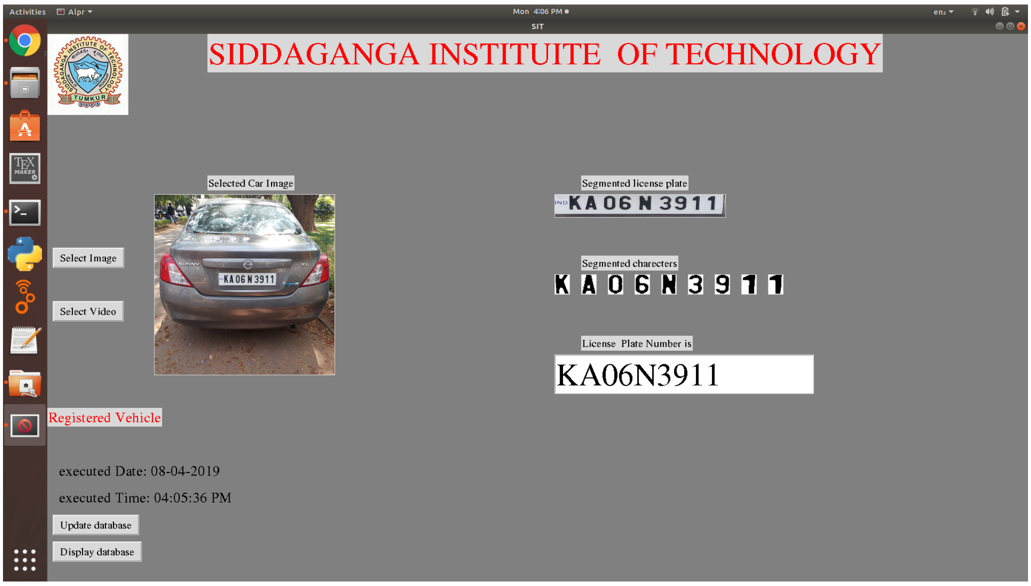


	A	B	C
1	Number Plate	Registration Status	date and time
2	KA06M9382	Not Registered	Sun Apr 7 14:15:28 2019
3	KA02MK7187	Not Registered	Sun Apr 7 14:17:09 2019
4	KA06P7703	Not Registered	Sun Apr 7 14:18:26 2019
5	KA04ME5048	Not Registered	Sun Apr 7 14:18:44 2019
6	KA06M9382	Not Registered	Sun Apr 7 14:19:50 2019
7	KA05C5741	Not Registered	Sun Apr 7 14:21:21 2019
8	KA06N3231	Not Registered	Sun Apr 7 14:22:00 2019
9	KA06M9382	Not Registered	Sun Apr 7 14:25:03 2019
10	KA66P6696	Not Registered	Sun Apr 7 14:27:19 2019
11	KA04ML5405	Not Registered	Sun Apr 7 14:40:36 2019
12	KA04ML5405	Not Registered	Sun Apr 7 14:48:10 2019
13	KA06P7756	Not Registered	Sun Apr 7 14:49:55 2019
14	KA06Z1162	Registered	Sun Apr 7 14:52:29 2019
15	KA06M9382	Not Registered	Sun Apr 7 14:53:46 2019
16		Not Registered	Sun Apr 7 14:54:56 2019
17	KA05C5741	Not Registered	Sun Apr 7 14:56:26 2019
18	KA06N3911	Registered	Sun Apr 7 14:57:31 2019
19	KA04ML5405	Not Registered	Sun Apr 7 14:58:27 2019
20	KA06Z1162	Registered	Sun Apr 7 14:58:31 2019
21	KA04ML5405	Not Registered	Sun Apr 7 14:58:50 2019
22	KA06M5080	Not Registered	Mon Apr 8 08:00:53 2019
23	KA01MD6165	Not Registered	Mon Apr 8 08:04:28 2019
24	DL10CT5806	Not Registered	Mon Apr 8 08:05:44 2019
25	KA06N3911	Registered	Mon Apr 8 16:06:03 2019
26	KA06Z1162	Registered	Mon Apr 8 16:22:39 2019
27	KA06Z1162	Registered	Mon Apr 8 16:23:21 2019

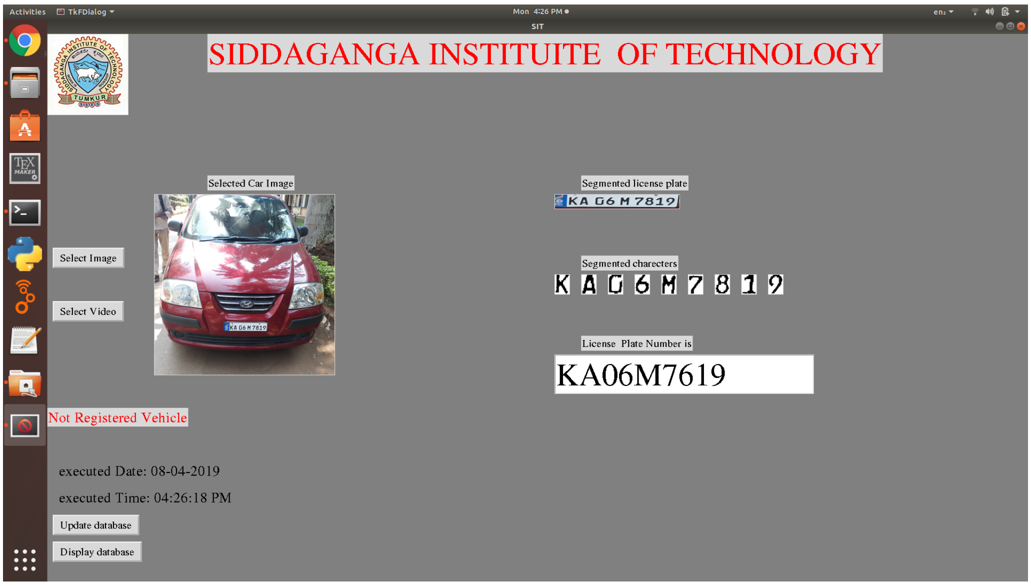
Figure 7.5: Database results stored after GUI execution

7.4 More Results of Still Images and Video Analysis

Figure 7.6 shows the results of the LPR system. The segmented license plate, character and recognized characters is shown in the GUI. Except in Figure 7.6(b) it can be obsereved

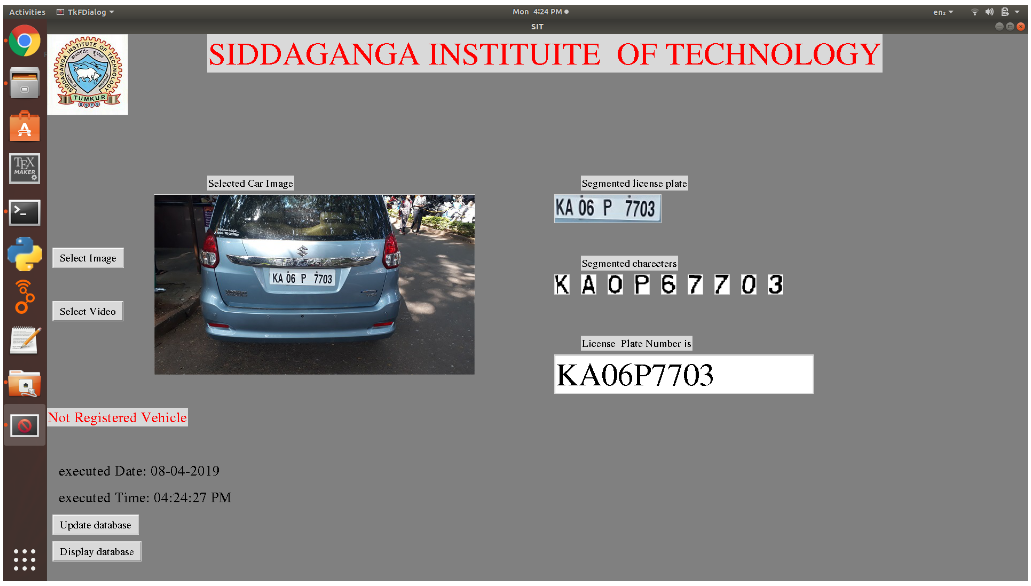


(a)

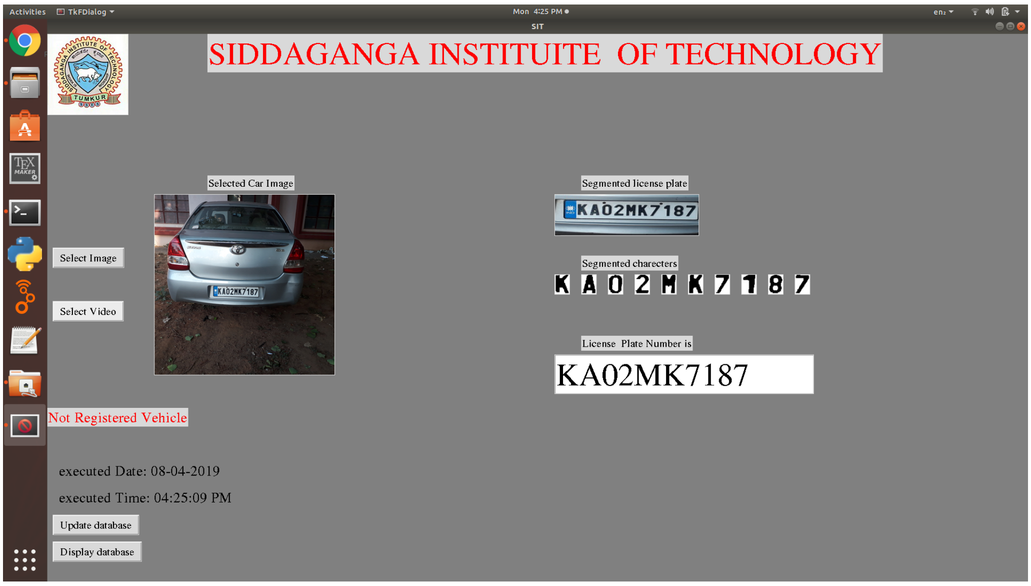


(b)

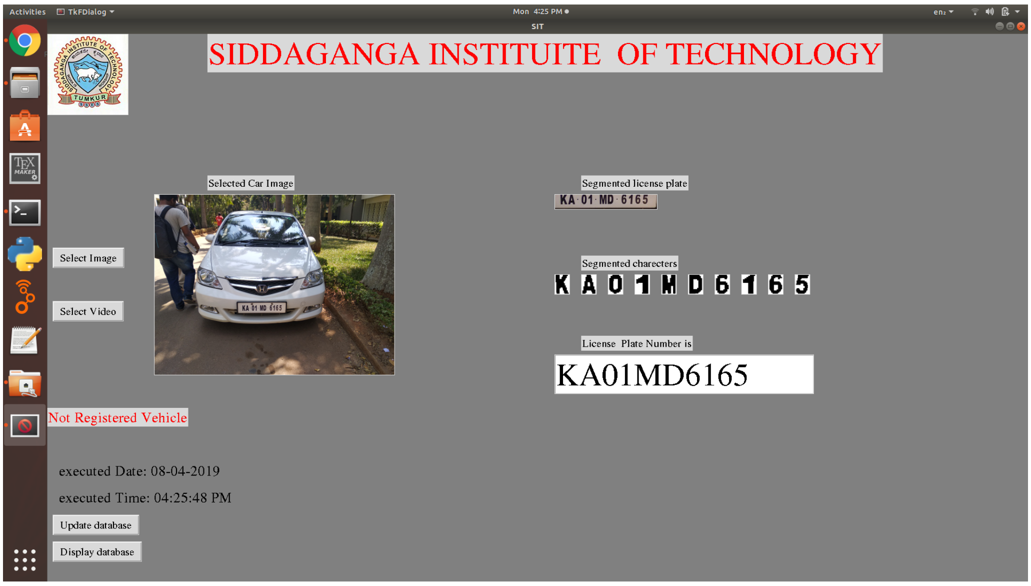
that the LPR system recognizes the characters in the license plate without any error. In Figure 7.6(b) the character '8' is falsely recognized as '6'.


SIDDAGANGA INSTITUITE OF TECHNOLOGY
Selected Car Image
Segmented license plate
KA 06 P 7703
Segmented charecters
K A 0 P 6 7 7 0 3
License Plate Number is
KA06P7703
Select Image
Select Video
Not Registered Vehicle
executed Date: 08-04-2019
executed Time: 04:24:27 PM
Update database
Display database

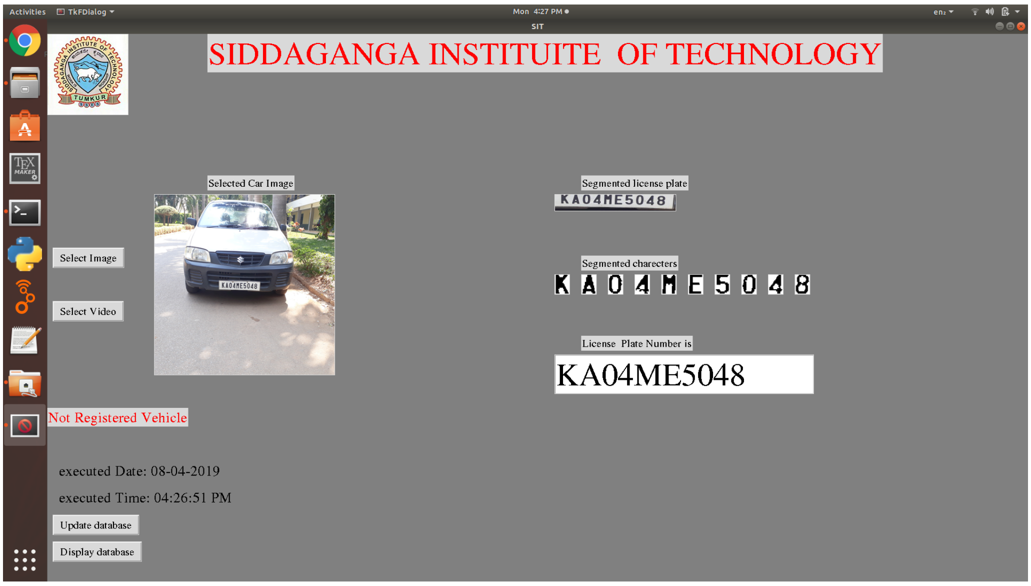
(c)


SIDDAGANGA INSTITUITE OF TECHNOLOGY
Selected Car Image
Segmented license plate
KA02MK7187
Segmented charecters
K A 0 2 M K 7 1 8 7
License Plate Number is
KA02MK7187
Select Image
Select Video
Not Registered Vehicle
executed Date: 08-04-2019
executed Time: 04:25:09 PM
Update database
Display database

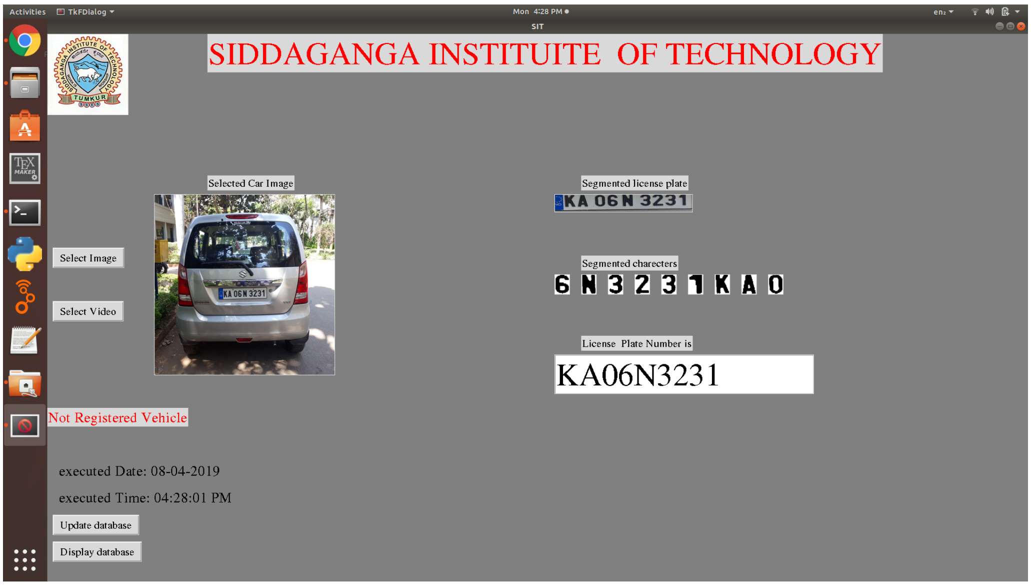
(d)


SIDDAGANGA INSTIITUTE OF TECHNOLOGY
Selected Car Image
Segmented license plate
Segmented charecters
License Plate Number is
KA01MD6165
Select Image
Select Video
Not Registered Vehicle
executed Date: 08-04-2019
executed Time: 04:25:48 PM
Update database
Display database

(e)


SIDDAGANGA INSTIITUTE OF TECHNOLOGY
Selected Car Image
Segmented license plate
Segmented charecters
License Plate Number is
KA04ME5048
Select Image
Select Video
Not Registered Vehicle
executed Date: 08-04-2019
executed Time: 04:26:51 PM
Update database
Display database

(f)

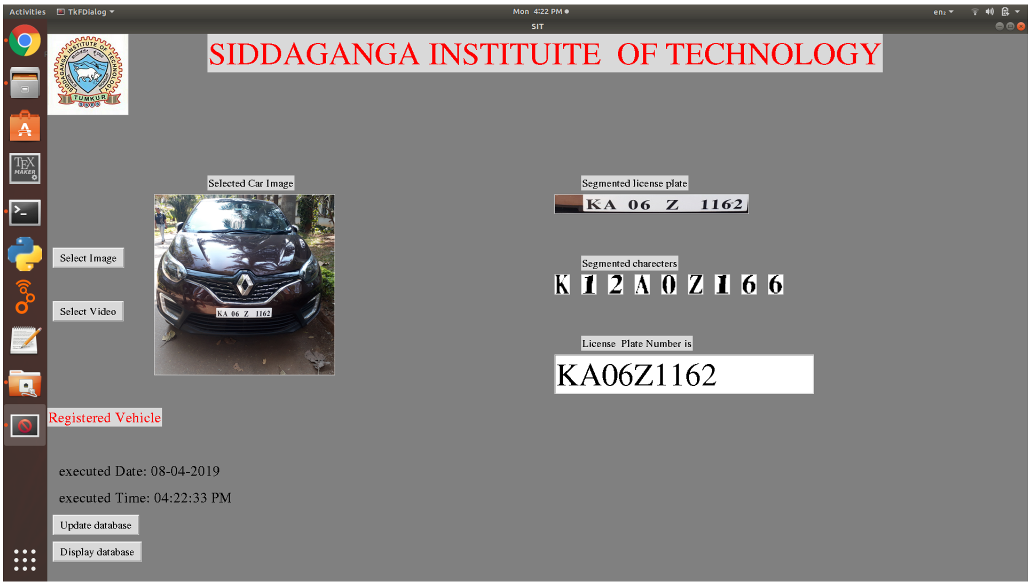


SIDDAGANGA INSTITUITE OF TECHNOLOGY
Selected Car Image
Segmented license plate
Select Image
Select Video
Segmented charecters
6 N 3 2 3 1 K A 0
License Plate Number is
KA06N3231
Not Registered Vehicle
executed Date: 08-04-2019
executed Time: 04:28:01 PM
Update database
Display database

(g)

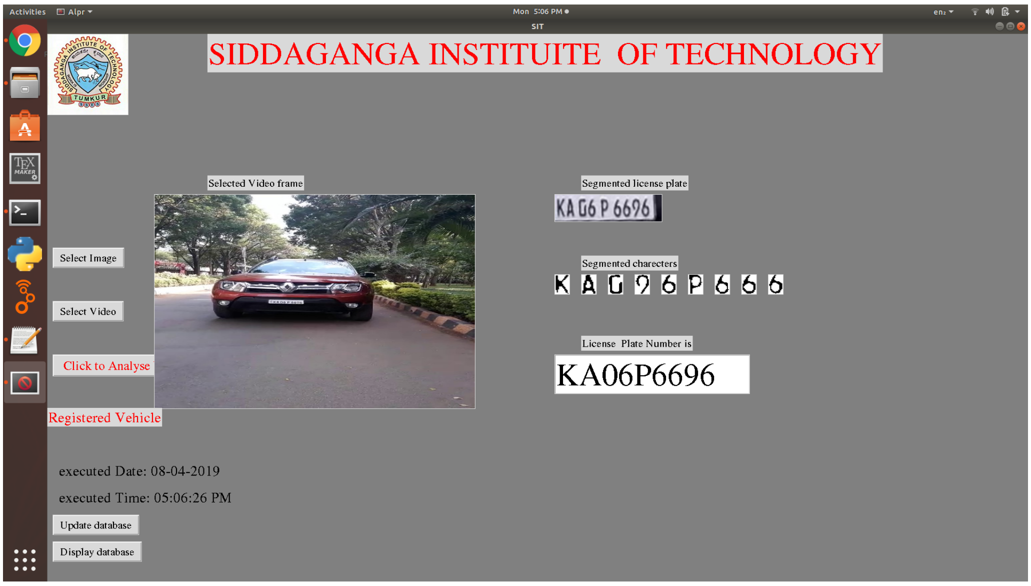
SIDDAGANGA INSTITUITE OF TECHNOLOGY
Selected Car Image
Segmented license plate
Select Image
Select Video
Segmented charecters
K A 0 Z 1 1 6 1 6
License Plate Number is
KA06Z1161
Not Registered Vehicle
executed Date: 08-04-2019
executed Time: 04:25:31 PM
Update database
Display database

(h)

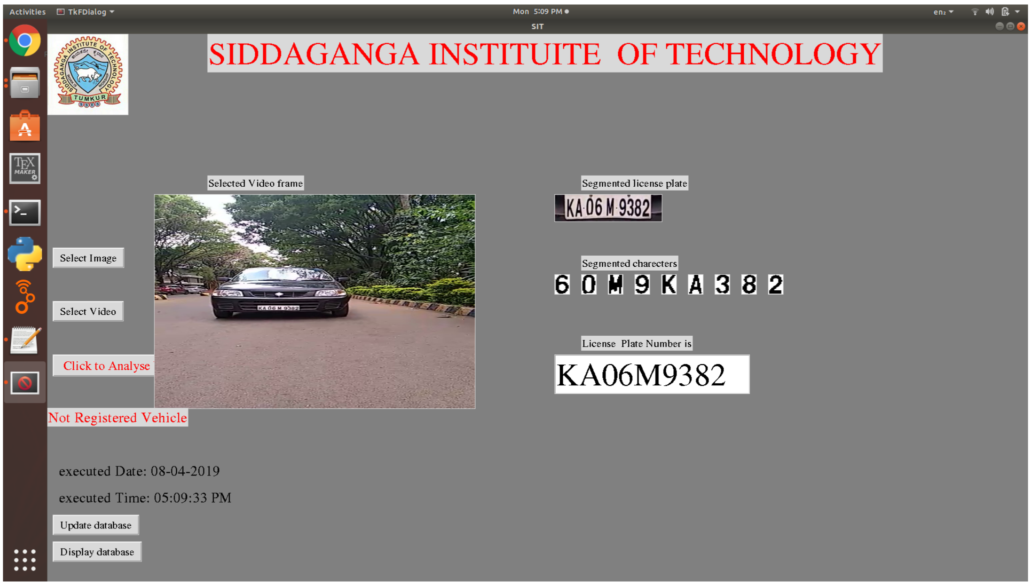


(i)

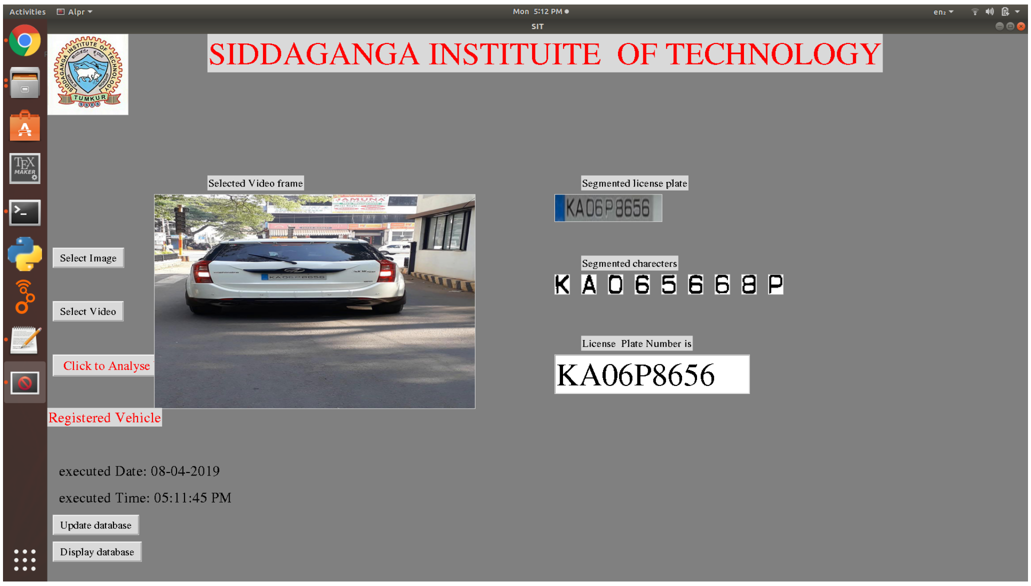
Figure 7.6: (a) to (i) GUI windows displaying segmented characters and the recognition results from the still images


SIDDAGANGA INSTITUITE OF TECHNOLOGY
Selected Video frame
Segmented license plate
Segmented charecters
License Plate Number is
KA06P6696
Select Image
Select Video
Click to Analyse
Registered Vehicle
executed Date: 08-04-2019
executed Time: 05:06:26 PM
Update database
Display database

(a)


SIDDAGANGA INSTITUITE OF TECHNOLOGY
Selected Video frame
Segmented license plate
Segmented charecters
License Plate Number is
KA06M9382
Select Image
Select Video
Click to Analyse
Not Registered Vehicle
executed Date: 08-04-2019
executed Time: 05:09:33 PM
Update database
Display database

(b)



(c)

Figure 7.7: (a) to (c) GUI windows displaying segmented characters and the recognition results from the selected video frame

Chapter 8

Conclusion

License Plate Recognition System for a video sequence has been developed and tested. To fast locate the position of a license plate, frames selection algorithm is adopted and license plate is recognized in each of the frame.

The hybrid approach of spectral analysis and connected component analysis is used for the extraction of license plate. It is found that they failed when using these techniques independently. However, fusion of both approaches gives better results in vehicle number plate extraction from the rest of the image.

For character segmentation, it is found that horizontal and vertical projections method is not efficient, since some license plates contain closely spaced and inclined characters. Connected Component Analysis provides better performance over the method of projections to segment license plate characters. Since the license plates have a definite order of alpha-numeric characters, heuristics is developed to improve character segmentation.

A Histogram of Gradients based feature extraction followed SVM classifier for character recoginization provides better accuracy of recognition. The database used in the training plays an important role in achieving better accuracy of recognition in any pattern recognition system. Better accuracy of recognition is obtained when the system was trained with different fonts and several samples per class. Syntactic analysis, i.e. prior knowledge of character sequence in license plate reduces recognition errors.

8.1 Scope for future work

IR cameras can be employed to capture images in the night time. Though high resolution images ensure better results, Super resolution can be implemented to get good resolution of the blurred images. The project is implemented in python. For better and faster results, DSP kits can be employed.

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Appendices

Figure .1: Character database used for training with 15 samples per class

Figure .2: Character database used for training with 15 samples per class