Research paper on vehicle detection and recognition

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Vehicle Detection and Recognition

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***Abstract*— According to Wikipedia, a vehicle is any machine that transports people or cargo[4]. Vehicles include cars, bikes, buses, airplanes, space shuttles, cycles and many more. Vehicle detection and vehicle type recognition is a practical application of machine learning concepts and is directly applicable for various operations in a traffic surveillance system contributing to an intelligent traffic surveillance system. This paper will introduce the processing of automatic vehicle detection and recognition using static image datasets. Further using the same technique, we shall improvise vehicle detection by using live CCTV surveillance. The surveillance system includes detection of moving vehicles and recognizing them, counting number of vehicles and verification of their permit with the organization. Since algorithms play a very important role in any machine learning program, it is important that we choose the best model for our project. I am convinced with Tang. Y. Zhang's algorithm and we shall discuss the same throughout the research paper. Once the vehicle has been detected, LPR shall be implemented which is, License Plate Recognition. The recognized number plate shall then be processed to capture the license number. This license number will then be compared to an existing database and checked if it is valid, registered with the organization, permit's validity, if vehicle is parked at the allotted parking location and many other parameters. The many benefit of this project would be reduced manual efforts in manual checking of each vehicle and also in maintaining manual records of the same. This technique shall further be proposed to the author's home organization – LPU, as a result of this research.**

Keywords—Vehicle detection, recognition, feature extraction, License plate recognition, Database

I. INTRODUCTION

A CCTV camera is a very essential part of an intelligent traffic surveillance framework [1]. It is simply the automated process of monitoring the traffic in a particular area and detecting vehicles for further action, as shown in diagram. The captured images can provide valuable clues to the cops and other public essential tracking services, such as vehicle's license plate number, time and motion of vehicle, details associated with the driver, etc.. which all may lead to evidences to some crime or any unforeseen or unfortunate incidences . Earlier people used to process images manually. In fact, this system is still going on in India, whereas countries like KSA also have implemented automated machines-CCTVs that function 24x7 and take immediate action via signaling too. Manual work has always been proven slower and less efficient due to human errs and many other factors that affect living beings. Keeping these points in mind and moving with the advancement of technologies, many innovative thinkers have developed certain intelligent traffic control systems using various techniques[3]. This research is based upon the combination of two prior-made researches by scholars whose works have been published. The resultant research is expected to help Lovely Professional University. The author has chosen this organization as it contains a huge population – students, teaching and non-teaching staff, other workers and visitors. The university faces many vehicles each day with manual checking of registration of the vehicles, time slots and other parameters. And we know what manual work does. So this research shall help the organization build a system that can automate this process so the human labor that was previously used for manual traffic check within the premises can be exempted from that tedious task and allotted other important tasks that shall be fruitful to the organization as efficient works will maximize in lesser time and capital. A dummy image has been produced to explain this concept in a much clearer way. Consider the following figures.

Fig. 1. Simple vehicle detection

The above image is a output image of the part 1 of our research model which is simple vehicle detection and recognition. It just observes all objects but detects only those that are vehicles and classifies them on the same basis. Whereas fig.2 gives a gimplse of the ITSS and ITMS.

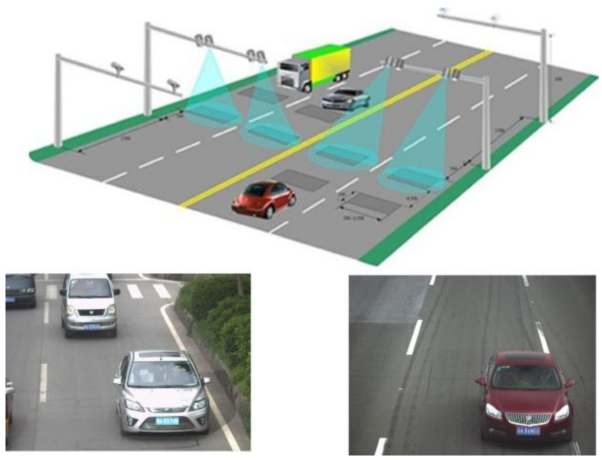


Fig. 2. ITSS

Figure 2 explains that when cameras are installed at traffic places, they scan and spot vehicles as shown. This data is further sent to cloud servers and processed. The detailed mechanism has been described in the form of animated image in the next figure, fig.3 below.

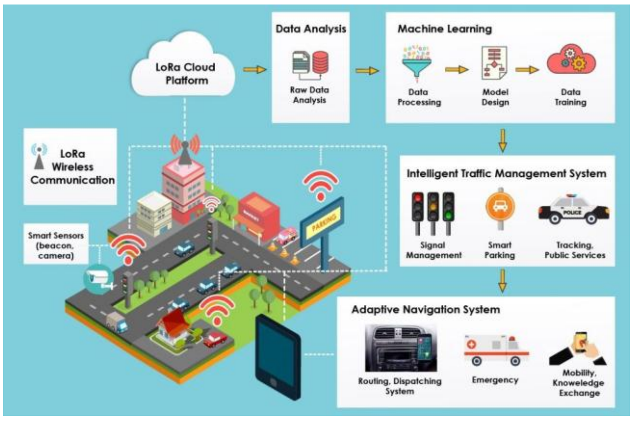


Fig. 3. ITMS with its working mechanism

The first image displays an intelligent traffic surveillance system whereas the second image speaks of the mechanism that makes the working in first one easier. The mechanism, to be precisely spoken of, mentioned in the second image is given by LoRa systems but we shall only consider the generic working principle. Smart sensors, such as cameras in our research, capture live data and transmit it to a cloud server where raw data is firstly processed, cleaned and then analyzed. In order to proceed further, we would require a model that would give best results for ITSS[1]. After selecting the efficient model, it is trained with analyzed data and tested. Once this is done, the vehicles are detected and recognized. Our part I of research ends here but the image describes further an ITMS[2]. In ITMS, the additional features are, once the vehicle is detected and recognized, it syncs the vehicle's data to cloud server and syncs data of traffic lights, parking services etc. to the cloud server simultaneously and also keeps sending reports of the data to public tracking services as traffic police. In that case, whenever an emergency occurs in traffic, the police shall immediately be informed of the incident and necessary actions shall be imposed accordingly. This way lesser labor would be required, and more commodities shall be linked with faster communication links and lesser delays. Anyhow we shall not proceed with ITMS so we shall not discuss of it any further. Proceeding to the layout of our research; the license plate recognition. LPR is not completely linked to vehicle detection as LPR focuses only on the license plate detection and extraction of the characters that appear on the license plate. A simple glimpse is shown below:

Fig. 4. Simple license plate detection and OCR on the plate

Fig.4 shows that the machine has detected a license plate and further processed the image and then using advanced OCR[3], the characters inscribed on the number plate are recognized and outputted to the user. According to Wikipedia, Optical character recognition or optical character reader is the electronic or mechanical conversion of images of typed, handwritten or printed text into machine-encoded text, whether from a scanned document, a photo of a document, a scene-photo or from subtitle text superimposed on an image[4]. It helps in capturing the characters from the recorded image. Combining these two concepts, we have built a mechanism whose results have been proven to be much more efficient and useful. Consider the following figure for exact working:

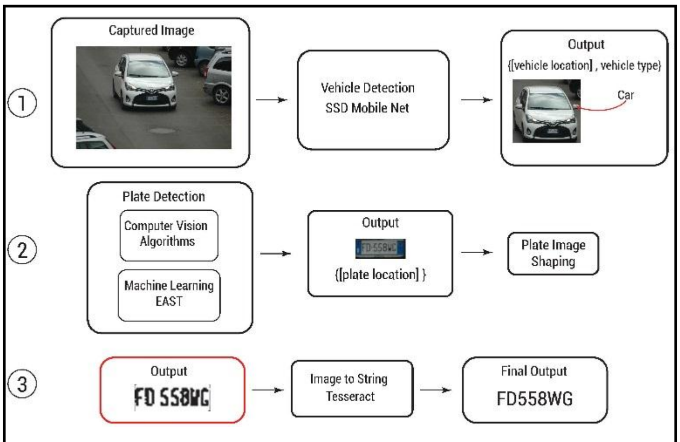


Fig. 5. Resultant mechanism of vehicle detection and license plate recognition respectively

The basic idea of fig.5 is to imply the vehicle detection first and then focussing on its license plate and capturing the license plate number to verify the vehicle's and/or owner's details and credentials and validity. This system is proven to be very efficient in terms of automated processes. We shall discuss the methodologies, working principles and related materials in detail in the upcoming sections.

II. Literature Review

As Archimedes once said, "*Man has always learned from the past. After all, you can't learn history in reverse!*" it is essential for man to learn from history. Thus, considering all past researches, the most relevant research glimpses have been picked to be explained in detail. The overview shall discuss relevant aspects contributing to our research.

A. *Research by Tang. Y. Zhang and Team[2]*

In the year 2015, a research on vehicle detection was made namely, "*Vehicle detection and recognition for intelligent traffic surveillance system*" by a team of researchers: Yong Tang, Congzhe Zhang, Renshu Gu, Peng Li & Bin Yang. In their research they have established a hybrid algorithm from already existent algorithms; For vehicle detection: Haar-like feature for describing the object appearance and features, Heat maps to detect objects, AdaBoost algorithm to build an enormous classifier from multiple weaker classifiers. For vehicle recognition: Gabor's wavelet transformation, Histogramic sequencing and Principal component analysis. All of these shall be further discussed in detail. Their research had given fruitful results with a superfast processing time,

[1] ITSS – Intelligent Traffic Surveillance System
[2] ITMS – Intelligent Traffic Management System
[3] OCR – Optical Character Recognition/ Optical Character Reader

92% recognition rate whose accuracy was penned to be 97.3%, which is considered highly accurate, and a 3% false rate, which may have been reduced but is still a decent false rate. Their technique is now the most efficient one to detect and recognize vehicles.

B. *Research by Priyanka Prabhakar and Team*

In the year 2014, a research was made on license plate recognition by an efficient team of researchers: Priyanka Prabhakar, Anupama P and Resmi S R. Their research was published by the IEEE in the 2014 International conference on control, instrumentation, communication and computational technologies (ICCICCT). Their research mainly focuses on an efficient technique for detecting, localizing, segmenting and recognizing the number on license plate. They have used various techniques as Hough transformation and segmentation which are major turning points. Further after being segmented, the image is smoothened and text from the segmented image is extracted into a group of single characters. They have claimed that their sequencing of techniques has proven to perform much better and provide way higher recognition rates than other methodologies and in much lesser computational costs. Their model has thus proved to be the best, yet, for license plate number recognition and verification.

C. *Research by Saran K.B and Team[6]*

In the year 2015, a research was made on Traffic video surveillance by a couple of researchers : Saran .K.B and Sreelekha G. Their research was published by IEEE in the 2015 International Conference on Cloud, Communication and Computing, in the city of Trivandrum, India (ICCC). According to their research, using Artificial Neural Networks would prove more efficiency than other models. Their model proposal involves background subtraction using Gaussians and vehicle detection be done through ANN re-modelling. Re-modelling here refers to tweaking the routine features of ANN for vehicle detection in order to achieve better outputs. They proposed a trio of new features which are: HOG (Histograms of oriented gradients) and Geometric factors of vehicles such as dimensions/size of vehicle, angle portrayed in the image and contrast feature. Their research has proved that using a routine HOG with the k-NN model would give a classification accuracy of 75.1% but utility of HOG with the modified ANN model has given a classification accuracy of 82.5%. Hence the modified ANN model provides better classification accuracy within lesser computational time, as recorded, is 0.015 with 65 frames/second, post-training. Whereas, computational time for the SVM model is 0.023 with 42 frames/second and computational time for k-NN model is 0.03 with 28 frames/second. This clearly shows that their research has borne fruitful results with ANN model to dominate others with a classification accuracy of 82.5%.
When compared to the research made by the first team, as in (A), this model lags behind. But what's a machine learning algorithm without comparing various classifiers and models that give each other tough competition. Hence, we shall also consider this model along with the rest in order to find out the best classification model for our project.

III. Proposed Methodology

Vehicle detection and recognition

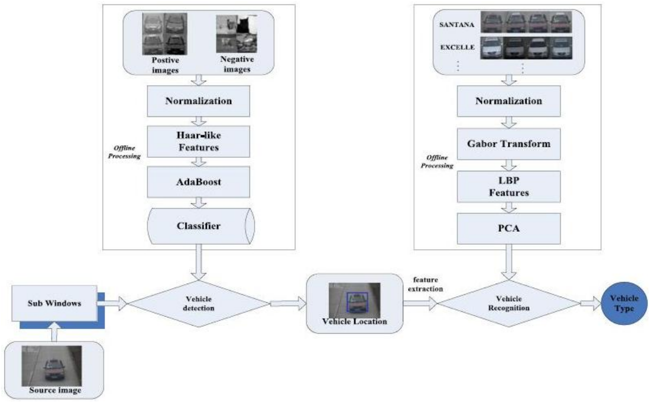


Fig. 6. Flowchart for vehicle detection and recognition

The given flowchart explains the mechanism and steps involved in detecting and recognizing a vehicle completely. The steps involved in building our resultant hybrid model have been discussed below.

A. *STEP-I (Method 1)*

1) *Haar-like features*

According to Wikipedia, Haar-like features are digital image features used in object recognition. They owe their name to their intuitive similarity with Haar wavelets and were used in the first real-time face detector.[4] Also, a Haar-like feature is just like a kernel used in CNN which is Convolutional neural network. A CNN consists of an input layer, an output layer and multiple hidden layers. It is a machine learning neural network model which is used majorly for image classification problems[7]. The main motive is to extract certain object feature information as in edges, contour and intensity gradient. This can be achieved by tweaking certain features of Haar-like temple: size, scale, position etc. This feature is very easy to implement and calculate with integral images.

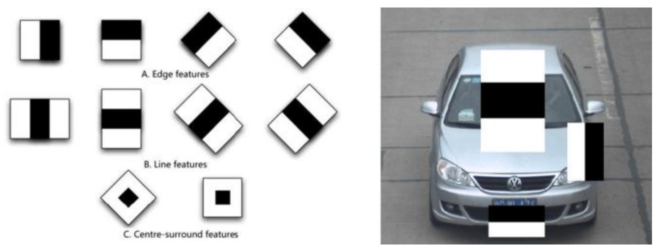


Fig. 7. Haar-like features

2) *AdaBoost algorithm*

As mentioned earlier, an adaboost algorithm is one which gathers features of multiple weak classifiers in such a way that the resultant combination of selected weak classifiers produces a super-strong classifier that performs in lesser computational time with higher efficiency and accuracy. The main motive of this algorithm is that multiple weak classifiers may also contain certain points that may be stronger than several random hits and thus this combination results in a much higher accuracy than the average of randomly chosen classifiers. The algorithm is given as follows:

A. Assume that samples are $(x_1, y_1), (x_2, y_2), \ldots (x_n, y_n)$, While, $y_i=1$ denotes a positive sample (vehicle), and $y_i=0$ denotes a negative sample (non vehicle). n is the number of samples.

B. Normalize the weights $w_{1,i}=D(i)$

C. For $t=1,2,3\ldots T$:

(1). Normalize the weights: $q_{t,i} = \frac{w_{t,i}}{\sum_{j=1}^{n} w_{t,j}}$

(2). For each feature f, firstly training a weak classifier $h(x, f, p, \theta)$, and then generate the weight sum of error rate $\varepsilon_f=\sum_i q_i |h(x_i, f, p, \theta)-y_i|$. At last the weak classifier $h(x, f, p, \theta)$ is defined as:

$$h(x,f,p,\theta) = \begin{cases} 1 & pf(x) < p\theta \\ 0 & otherwise \end{cases}$$

(3). Choose the best weak classifier $h_t(x)$, which have the lowest error , and the , is defined as: $\varepsilon_t=\min_{f,p,\theta}\sum_i q_i |h(x_i, f, p, \theta)-y_i|$

(4). For each training process, update the weights: $W_{t+1,i} = w_{t,i}\beta_t^{1-e_i}$.

D. The final strong classifier is: $H(x) = \begin{cases} 1 & \sum_{t=1}^{T} \alpha_t h_t(x) \geq \frac{1}{2}\sum_{t=1}^{T}\alpha_t \\ 0 & otherwise \end{cases}$, Where $\alpha_t = \log\frac{1}{\beta_t}$

This super-strong resultant classifier is now used in detection of vehicle. Detection is achieved by using sliding windows mechanism. In this process, a sub-window is slided all across the image and the sub-window that detects any object checks whether the object is a vehicle. But this process takes enormous time for detection and sliding. Hence scaling is done to ensure that sliding & detection is done in lesser time. After vehicle detection comes vehicle recognition. Vehicle recognition may be done in many ways. Yet, the Gabor's method seems most suitable to do so. The image of vehicle is capable of being translated into a model which is popularly known as a Local Gabor Binary Pattern Histogram Sequence[9]. The generic approach that makes this conversion possible includes a list of procedures:

- Gathering similar typed sample vehicle images
- Apply Gabor magnitude filters to achieve conversion of an average typed image to a Gabor magnitude image.
- Identify the local binary pattern for each Gabor Magnitude picture.
- Divide each output image from previous step to rectangular sections and calculate and form histograms throughout the space
- A compilation of histograms of each region is made in order to create a histogramic sequence.
- Perform dimension reduction analysis with principle component analysis method.
- The histogramic sequence is now compared to the vehicle image for checking similarities.

3) *Gabor's wavelets transformation*

Now what are Gabor wavelets filter? Mathematically the Gabor wavelets filters are defined as (refer equation 1):

$$\Psi_{u,v}(z) = \frac{\|k_{u,v}\|^2}{\sigma^2}\, exp\left[-\frac{\|k\|^2\|z\|^2}{2\sigma^2}\right].[e^{ik_{u,v}} - exp] \quad (1)$$

Theoretically, Wikipedia says that Gabor wavelets are wavelets invented by Dennis Gabor using complex functions constructed to serve as a basis for Fourier transforms in information theory applications[4]. And Gabor filter is a linear filter used for texture analysis, which means that it basically analyzes whether there are any specific frequency content in the image in specific directions in a localized region around the point or region of analysis[4]. Considering Gabor wavelet filter's remarkable performance in face recognition, the filters: multi-resolution and multi-orientation have been used to proceed further towards building a hybrid model. This process is also known as Gabor transformation. The figure shown below is an example visual of Gabor magnitude image of the vehicle on the left.

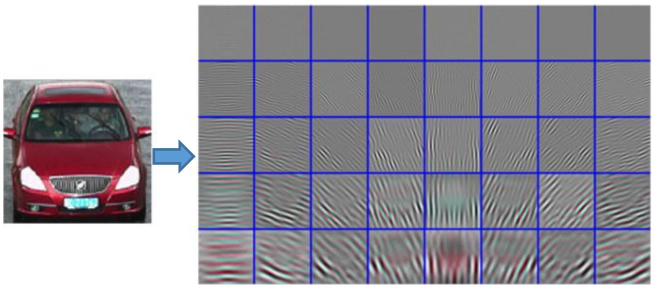


Fig. 8. Gabor magnitude

4) *Histogramic Sequencing*

As we discussed of the vehicle recognition steps, after Gabor transformation comes the encoding of magnitude values with the help of local binary pattern operator. We do so to enhance our data. The local binary pattern operator or the LBP creates an equation that represents the histogram of a particular labelled image. It is defined as:

$$H_i = \sum_{x,y} I\{f_l(x,y) = i\}, i = 0, \ldots n{-}1, \qquad (2)$$

The local binary patterned histogram for each region/sub-region is to be computed in order to form a sequence. Each histogram consists of local features, say a subset of features of the whole image, of that particular region/sub-region. A compilation of all these histograms would ultimately lead to a histogramic sequence which when combined shall contain 100% features of the image. In order to achieve the best representational efficiency, various random divisions of regions are made into sub-regions and the process is continued several times to achieve the same.

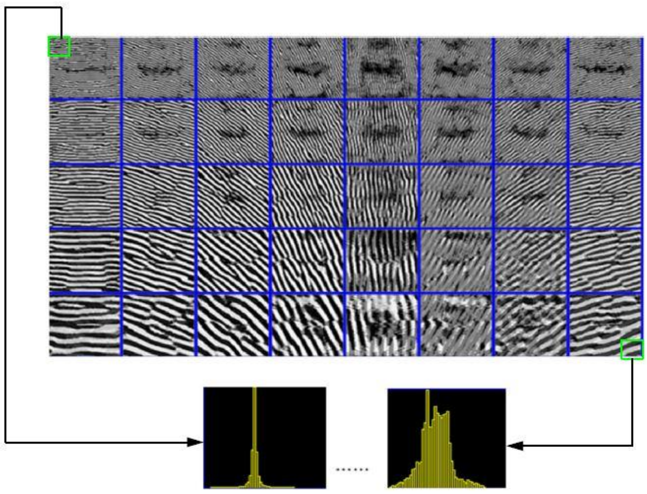


Fig. 9. Histogram sequence of local gabor binary pattern

The figure displayed above portrays a sample histogramic sequence of gabor magnitude image.

5) *Principal component Analysis*

As per Wikipedia, principal component analysis (PCA) is a technique used to reduce the dimensionality of datasets, increase interpretability and simultaneously to minimize information loss. It does so by creating new uncorrelated variables that progressively maximize net variance. We use this feature for dimensionality reduction of images. The following equations make this reduction possible:

$$m = \frac{1}{M}\sum_{i=1}^{M} x_i \qquad (3)$$

Where m represents the mean vector of x_i and then,

$$w_i = x_i - m \qquad (4)$$

Here w_i represents a mean-centered vector

$$C = WW^T \qquad (5)$$

And C is defined as the matrix of covariance and W is a matrix of column vectors containing w_i & W^T is the transpose of matrix W.

$$M_k = [w_1u_1, w_2u_2, \ldots, w_ku_k] \qquad (6)$$

Here M_k represents projection matrix

$$\varepsilon_k = \|\Omega - \Omega_k\| \qquad (7)$$

Here ε_k represents euclidean distance and our goal is to minimize it. If the euclidean distance is less than the pre-defined threshould amount, a vehicle is said to belong to class type '***k***'.

The following equations are used in order to get numerical values for the vehicle detection and recognition experiment.

$$DR = \frac{TP}{P} \times 100 \qquad (8)$$

$$TDR = \frac{TP + TN}{P + N} \times 100 \qquad (9)$$

$$FAR = \frac{FP}{N} \times 100 \qquad (10)$$

Here P is the no. of vehicle samples, N is the no. of non-vehicle samples, TP is no. of correctly detected vehicle samples, TN is no. of correctly detected non-vehicle samples, FP is no. of wrongly detected vehicle samples. Hence, we must target highest possible values of DR & TDR and least possible value of FAR.

(a) Positive images (b) Negative images

Fig. 10. Instances of positive and negative sample images

B. *STEP-I (Method 2)*

Artificial Neural Networks

Wikipedia claims, Artificial neural networks or connectionist systems are computing systems vaguely inspired by the biological neural networks that constitute animal brains. Such systems "learn" to perform tasks by considering examples, generally without being programmed with task-specific rules[4]. This neural network is trained using various datasets. It is capable of adapting to random adjustments of weights based on their respective inputs and outputs thereby to attempt to nullify the classification error. The following features are majorly used in this model, which shall be discussed in detail.

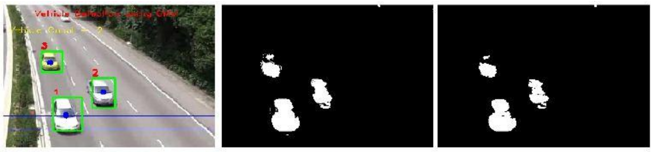
1) *Histograms of oriented gradients*

Histograms of oriented gradients may also be termed as HOG grabbing the initials of each word. This concept was found by Triggs and Dalal, mainly built for human detection. HOG is technically an image descriptor. It's calculated by dividing entire image into sub-blocks with a scaling of half-ratioed overlap (50%) which are further sub-divided and so on. The gradient of these blocks is measured in 2-D form, i.e., x-direction & y-direction. The following equation is implemented to achieve targets:

$$M = \sqrt{S_x^2 + S_y^2} \qquad (11)$$

$$\theta = arctan\left(\frac{S_y}{S_x}\right) \qquad (12)$$

Where M represents gradient magnitude, θ represents orientation, S_x represents horizontal gradients of an image and S_y represents vertical gradients of an image. Gradient magnitude can be defined as the vote that is cast during each gradient orientation[6]. HOG provides information of the orientation of edges and shape of vehicle. A sample image of vehicle detection post publishing the experimental results is shown in fig.11 below.



(a) (b) (c)

Fig. 11. (a) Video detection's original frame
(b) Binary masked detected frame
(c) Post-morphological analysis result

After detection of the vehicle, a sample visual of HOG of the vehicle has been provided in fig.12 s shown below.

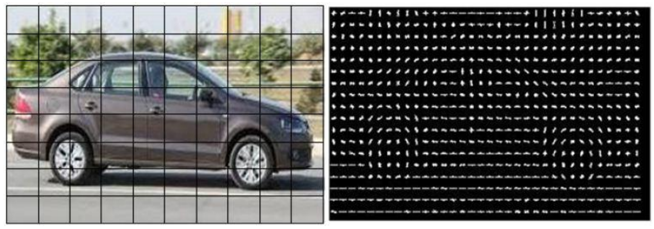


Fig. 12. HOG of the object

It can simply be built using the Python visualization library: matplotlib. One great observation to be made from fig.12 is that the maximum peaks of the histogram are located, when mapped, at the edges of the object, which is vehicle. This is an evidence that this visualization provides the edges of the object, wiz vehicle and thus gives information of the shape of the vehicle.

2) *Geometric features*

Vehicles can be of certain types. Trucks, cars and autos – they're all vehicles. Yet, they differ greatly in shape, size and various features as color, weight, angle of view, fuel used, number of tyres, type of vehicle as in mini-truck or truck, sedan or SUV etc. Vehicles vary in great ranges hence geometric features help to a great extent in classifying vehicles. Consider fig.13. Same vehicle when viewed from different angles give different sizes and shapes. Hence we've considered one geometric feature to be angles & perspectives. Size and shape is another important feature which is considered.

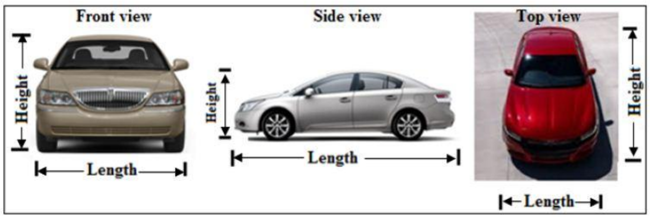


Fig. 13. Geometric feature recognition – size, angles, perspectives

There are two parameters that are used as and for input feature vecter for training the ANN model. These are ratios that used to compare geometric features of various vehicles. The first one is a ratio between length and height of vehicle (eqn 13) while the second one is a ratio between area of the vehicle and the perimeter of vehicle (eqn 14).

$$LTHR = \frac{l}{h}\,; \quad (\,l = length, h = height\,) \qquad (13)$$

$$PTAR = \frac{2\,(l+h)^2}{l \times h} \qquad (14)$$

Before implementing any geometric feature vectors, it is important to calibrate and keep in mind the camera angles of the CCTV/sensor device that is capturing live data.

License Plate Recognition

License plate recognition or automatic number plate recognition is a new generation model. It is a technology that uses optical character recognition on input images to read and identify vehicle registration plates. The information extracted through this technology can also be used in retrieving vehicle location data[4]. Some license plate arrangements use variations in font sizes and positioning—ANPR systems must be able to cope with such differences in order to be truly effective[9].

Our model requires the listed steps to be followed:

- Video/Image input
- Crop area of licence plate and save as image
- Preprocess the image
- Localise the image
- Segmentation of the image
- Extraction of text
- Text recognition
- Data validation

After following these steps, the ANPR is considered to be successfully executed. Consider the following flowchat for clearer explanation, go to fig.14 for detailed information.

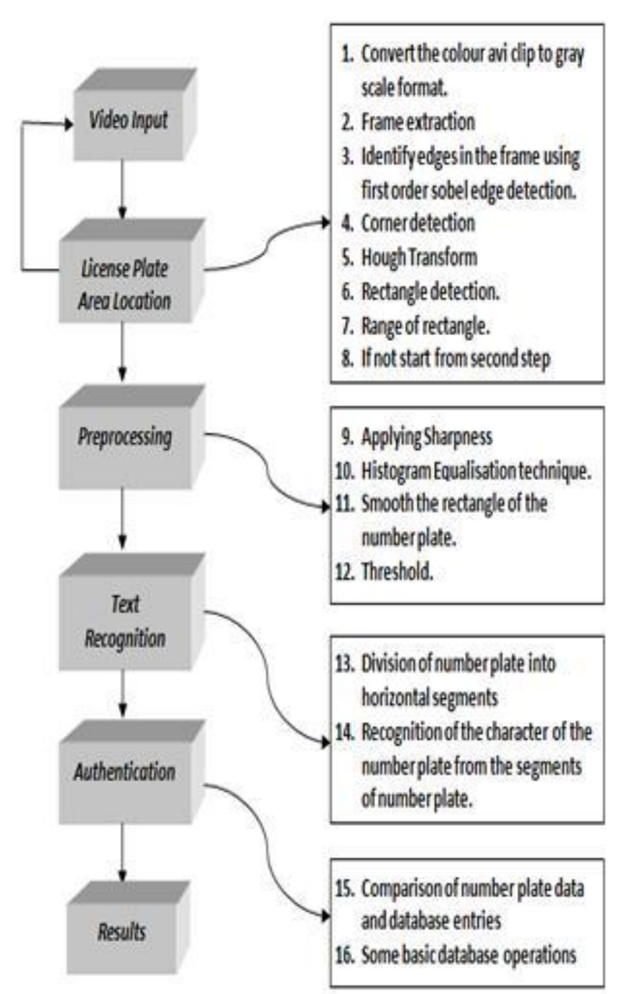


Fig. 14. Flowchart describing the steps involved in LPR

C. STEP-II

1) *Data preprocessing*

This step involves examining the input image to identify the presence of any vehicles present in the image. Once vehicle is identified, prime focus shifts to searching for a frame similar to that of a license plate and then detecting the edges of that frame in order to crop the image to that frame. Main job of data preprocessing is to sharpen the image and smoothen the rectangle of the number plate. Consider the following sample input image in fig.15. But first the image is converted from color print to grayscale and this is the only step in data preprocessing. This is possible with the following equation:

$$Grey = (0.299 \times Red) + (0.587 \times Green) + (0.114 \times Blue)$$

Fig. 15. Sample input image

2) Localisation

The main step involved in localization is identifying the vehicle plate region in the image so that the frame can be extracted and processed further. If in case the input is a video, then each and every frame in the video is clipped to an image and then the same process is applied for each image and the results are compiled in the end. We often notice that the number plates have a totally contrasting background. For instance, if the characters are written in black then its plate background remains white or yellow, which is a contrasting color. The advantage of this feature is that it improves he rate of recognition of the license plate region. These images are provided to the edge detector and the visual is similar to that of the image as shown in fig.16.

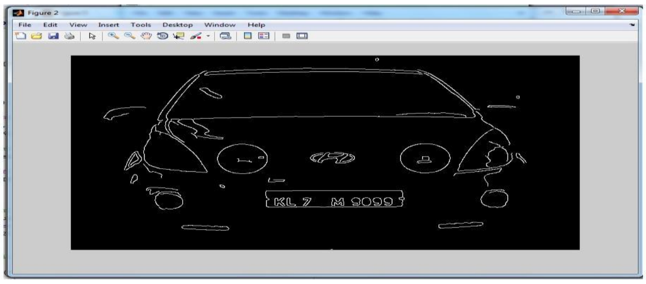
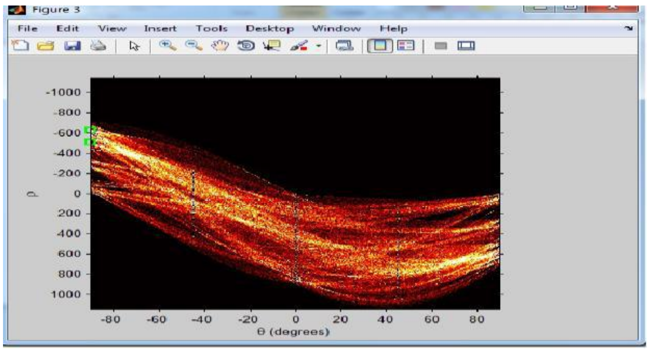


Fig. 16. Edge detection

Fig. 17. Hough transform and hough lines



Now the binary resized and edge detected images undergo Hough transformation.The Hough transformation is defined as a customary tool in image analysis that allows recognition of worldwide patterns in an image area by recognition of local pattern during a reworked parameter space[5]. Consider the following diagram in order to get the exact operational sequence post the detection of edges, refer fig.18.

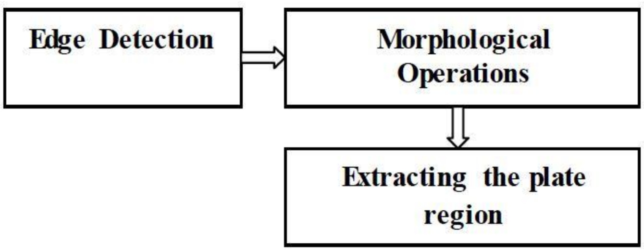


Fig. 18. Sequential steps of localization

3) Segmentation

After extracting the plate region, the threshold filter is applied frequently and then the image undergoes segmentation. In layman terms segmentation is a process that divides the image in certain parts wherever the character is identified. This is achieved with the help of skewing and de-skewing. Till date, only one-row plates have been in use. These mean that the horizontal plate holds high horizontal intensity of characters and background-to-character variation. In this case an assumption is made that the license plate is one-rowed. Hence, once the plate region is discovered, characters are extracted by deleting the spaces in between them and this process goes on until the end of plate region. This way the plate region is segmented. A demo visual of the segmented image is as shown in fig.19.

Fig. 19. Segmentation of characters

4) Recognition of characters

Now the segmented image is processed and then some operations shall be performed on the image that will lead to character recognition. These are binarisation and intensity inversal of the previously intensified image. Certain character sets are used in order to compare to the segmented images. The segmented images are pixelized and also the character images, and each pixel of both is compared simultaneously. Wherever a match is found between the two we increment one and upon finding a mismatch we subtract one. This way a match score is generated at the end of each segmented image comparison. This way the character which gets the best match score is mapped to the segmented sub-part of the image. A glimpse of the text recognition extract is demonstrated in fig.20 as shown below.

Fig. 20. Character recognition

IV. Results And Discussion

A. Results of established researches

Considering Tang Yang and his team's research, the calculated average accuracy of vehicle detection using their model is 97% which is a pretty decent score. Hence, their model has been proven to be the best for vehicle detection.

TABLE I. TANG & TEAM'S CONCLUSION

S.NO	P	N	TP	FP	TN	DR	TDR	FAR
1	517	203	503	7	197	97.3%	97.2%	3.4%

Considering Priyanka Prabhakar and team's research, the calculated average accuracy of number plate recognition using their model is 94.34% which, again, is a decent score. Hence, their model is considered the best for ANPR or LPR which is Automatic Number Plate Recognition or License Plate Recognition.

TABLE II. PRIYANKA & TEAM'S CONCLUSION

Various factors		No. of images	Accuracy (in %)
Distance (in m)	Short (<5m)	30	98
	Normal (range=[5m,25m])	50	95
Angle (in °)	Low (<15°)	20	98
	High (<30°)	20	90
Contrast (low)		30	90

Coming to the research made by K.B.Saran and team, their model has proven a classification accuracy of 75.1% and also consumes humongous time as compared to Tang's model. As we all know time is money and accuracy is godliness. Hence, in comparison to Tang and team's model, this model has lagged far behind. Future work on this model may seem fruitful but as of now this model is not to be used in vehicle detection system of our model.

B. *Proposal to build a hybrid model*

Let me define to all, a hybrid model is the one in which vehicle detection shall first take place and outputs from vehicle detection system serve as inputs to the ANPR and hence the vehicle plates of the vehicle shall be detected and validated for the organizational purposes or for security reasons or whatsoever. Considering the best models for vehicle detection and license plate recognition, out hybrid model is estimated to serve a classification and detection accuracy of 95.6% with a false positive rate of 0.0389. I believe that the hybrid model is just what our nation needs. It shall majorly benefit the national guarding forces as the police, which serve the public, and also to many other private security guards, as in Lovely Professional university, upon implementing this model can save a lot of manpower and capital.

C. *Challenges in hybrid model*

The common challenges that can be faced in implementing the hybrid model can be the issue that cameras are prone to be hacked or attacked in an illegal cyber manner or physically. Installation of cameras may also be termed as a challenge as the entire system depends upon the placement of the cameras or radars or whatever devices that are being used for the hybrid model.

D. *Proposed solutions to the challenges faced*

We can take measures for cyber-security of the camera. Before installing the hybrid systems and handing them over the manufacturer shall foul-proof it and secure it digitally so that no hacker can hack it Any cyber security expert can exhibit his professionalism in this reign. Next comes the physical issue; one security guard or multiple cameras in various angles may be installed and immediate contact can be made to the cyber cell upon the notice of any mischievous/unaccepted behavior. Coming to the installment of cameras, an expert who knows the importance of placement of camera and its position, shall install the cameras in desired locations. This way, the camera shall cover maximum and good coverage.

V. CONCLUSION

Fig. 21. Manual vehicle checking by guards in LPU

Fig. 22. Vehicle detection and recognition with the help of inductive loops in LPU, India

Our target organization - Lovely Professional University, India – uses manual vehicle checking at the main entry gates and vehicle induction loops, also known as inductive-loop traffic detectors, as shown in fig.21 & 22., at other gates which do only half the work. The images shown are an evidence to the current status of LPU's vehicle detection system which is still partially manual. But as a result of this research, we shall conclude that automated vehicle detection and tracking & license plate recognition shall together contribute to much more efficient and better outputs leading to brighter generations.

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VII. SOURCE CREDITS

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