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Survey of Computer Vision Techniques for License Plate Detection

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ABSTRACT

To identify a vehicle, License Plate identification technology is the key technology of intelligent transport system, finding a stolen vehicle, monitoring traffic flow, in town management, highway tolls etc. The major issue in such applications is to detect the exact location of plate, because finding the location of number plate could vary and as well as its size and color; many of the vehicles have an uncertain difference in License plate position, location and unclean License Plate.In this paper we have conducted a very fresh surveyof most authentic techniques of license plate detection from a car, we studied different techniques and compared them; we figured out every technique has its own limitations, every method gives best results under some certain conditions so do bad results, we figured out all we need to do is to have locus of control, we shall control the environment we are working in, some techniques works good in dark light, some for bright light etc; every technique has its own parameters to identify license plate; this paper will lead you to choose the best technique for detection just according to your circumstance; you wouldn't have to waste much more time in order to figuring out the suitable algorithm, as well as will inform you its accuracy percentage.

Additional Key Words and Phrases: DWT (Discrete wavelet transform), PET (plate extraction time), SCW (sliding concentric window), ANN (artificial neural networks), GNN (genetic neural networks), RGB (Red Green Blue)

1 INTRODUCTION

Vehicles License plate is a technology of image processing. Vehicles License Plate detection is a type of automatic vehicle recognition. . The important role of license plate detection is to control traffic rules automatically and managing law enforcement on public roads. Since every vehicle carries a unique License Plate, no external cards, tags or transmitters need to be recognizable, only License Plate. It is also used for manage traffic, control border, access-control, calculation of parking time and payment; previously the popular technologies were used to identify vehicles are VIN technologies and e-tags which were expensive and had a big issue in common; if a new car comes than first you would have to install any of these technology in that car then you would be able to identify that car so to eliminate that factor the best way to identify a vehicle is to identify it's number plate with a simple camera. Different detection algorithm for detecting License Plate is presented. Shall give brief description, functionality how a method works in different environment. Numerous methods exist in License Plate Location but we shall discuss those methods which will give the most accurate results in critical situations like lighting distance effects etc. Some methods work for still images, some for videos and some for sequence images. We shall also discuss which method is best for lighting, distance, and other invariant.

In this paper we have total of 4 sections, in section each sub-section elaborates the technique for license plate detection and its limitations; in section 3 a comparison in form of table is given and in the last section number 4 we have provided conclusion.

Below in fig.1 there is a representation of different techniques:

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1.1 Classification diagram

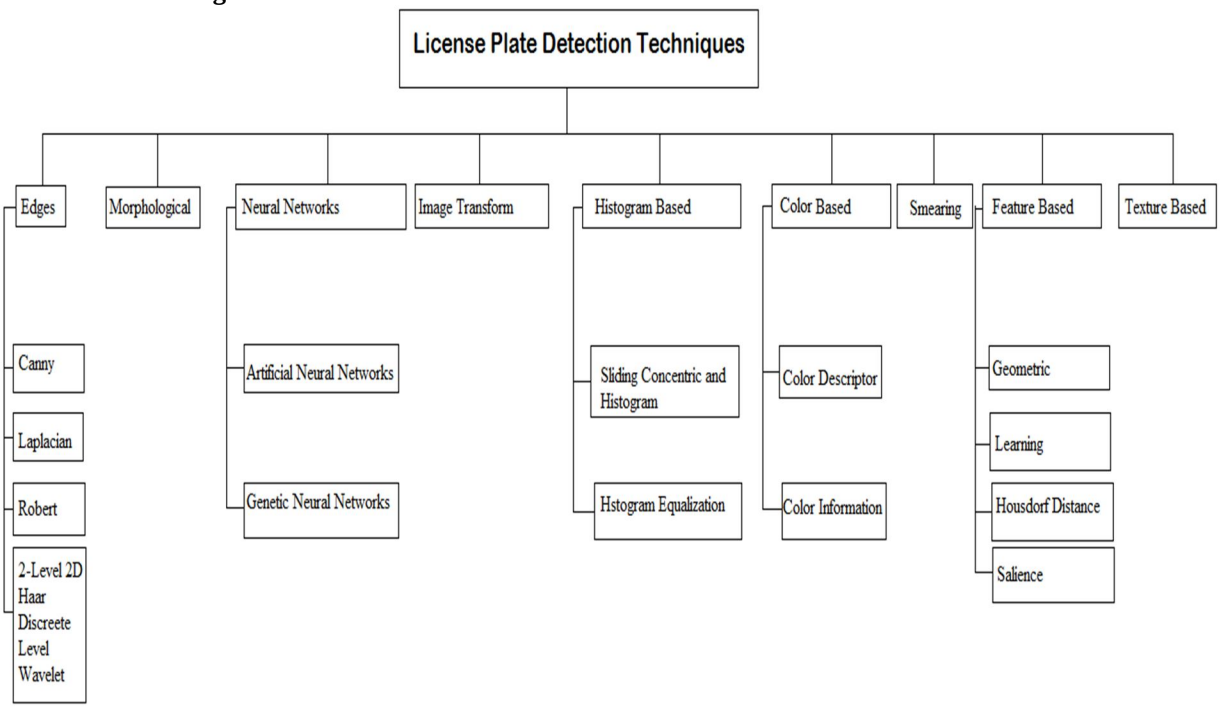

Figure 1 Classification Diagram

2 LICENSE PLATE DETECTION TECHNIQUES

2.1 EDGE DETECTION APPROACHES:

2.1.1 SOBEL OPERATOR:

It is one of the most useful techniques in image processing very popular in image processing as shown in the application of License Plate Detection [3-8]. Sobel Operator is a classical edge detector. With the License Plate of small integer valued filter into vertical and horizontal directions by using of (3x3) mask to convolve the image. The mask preferred is applied to the whole image and this mask process square pixel at a time on image. It represents a two dimensional spatial gradient measurement. Due to small integer values the Sobel operator is relatively expensive.

2.1.2 2-LEVEL 2D HAAR DISCREETE WAVELET:

2-level 2D Haar DWT method is an excellent method for detecting edges. It gives more detail about the vertical edge density and intensity of License Plate separately. It also removes that object which contains less information that causes the noise in the vertical edges background. In short, it differentiates between vertical edges and background noise. It works based on the gray scale image, first of all gray scale images converted and divided into four sub band images through 1-level 2D Haar DWT. After completing the whole process it detects the LICENSE PLATE [10].

2.1.3 CANNY OPERATOR:

First of all convert the RGB image to gray scale image and then remove noise from the image then apply the canny edge detector on the image. The canny edge detection provides an exact detection of the License Plate and provides better localization with very minute difference within the actual and provided edge [11]. The boundary of the object is represented by edges. Edges are also used to identify areas and shapes of the object.

2.1.4 ROBERT OPERATOR:

It computes the 2-D spatial gradient measurement and also highlights the high spatial gradient region corresponds to edges. It consists of a 2x2 convolution mask. In [12] it detects the LICENSE PLATE of the input image by down sampling. In [13] Robert operator first starts to detect the vertical edges of the input image and then it filters the image to get its horizontal edges.

2.1.5 LAPLACIAN EDGE DETECTION:

The Laplacian is a 2D isotropic measure of the 2nd spatial derivative of an image. It is similar to as Sobel operator. The only difference among them is that the Laplacian uses only one mask for both horizontal and vertical direction as in [13,14]. The mask approximates second derivate of the image and is very sensitive to noise. Noise reduction LOG is used which first smoothens the image with Gaussian filter and then applies Laplacian operator [13]

2.1.6 ROTHWELL OPERATOR:

The Rothwell operator is just like canny operator and it works on that stage where canny fails. It recovers reliable topological description [15]. Roth well smooth the image and account for image quantization, curved boundaries are fitted to provide reliable geometric description of edges chain and then finally the scene topology is recovered to detect object boundaries. The work flow of Rothwell operator is shown in fig.2 below

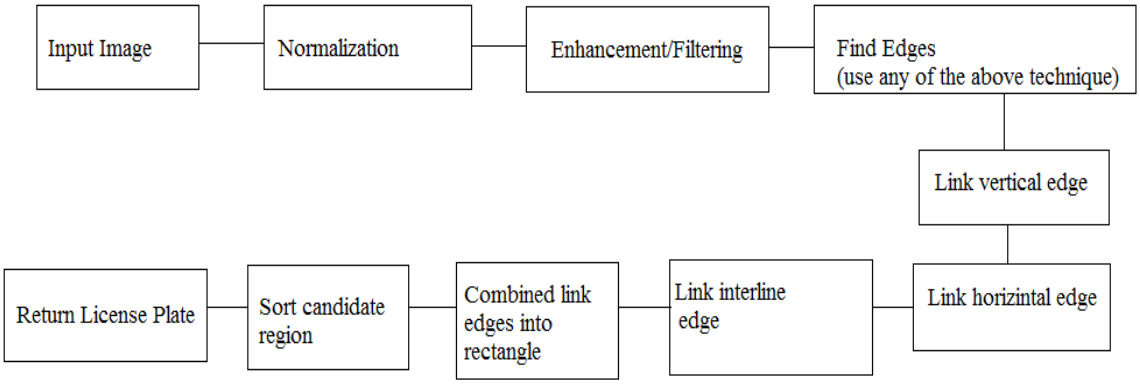

Figure.2License Plate Detection Flow Diagram

First of all algorithm normalizes the input image so that the difference between black and white pixels becomes very low the edges would be clear to find. After normalization Sobel, Canny, Laplace and Roth well filters are used to enhance edges. By applying an appropriate threshold it reduces the unwanted edges. After this it lists the rising and falling edges by using pixel variation. There are maximum edges of the License Plate region as compared to the other parts of the image. Finally the horizontal and vertical edges are connected, rectangles are calculated and compared.

2.1.7 LITERATURE REVIEW LICENSE PLATE DETECTION RESULTS

Ref	Edge detection algorithm	Success %
[1]	Sobel	Not reported
[2]	Sobel Vertical	97.0
[4]	Robert and Rank	96.3
[5]	Sobel Vertical	96.2
[8]	Sobel	Not reported
[16]	Robert and Rank	90
[17]	Sobel	95.2

2.1.8 EXPERIMENTAL RESULTS

Experimental Results present the overall results. Plate Extraction Time (PET) is defined as the time for plate detection. The results show that the time to process a single image containing plate is faster than the rather to process an image without plate.

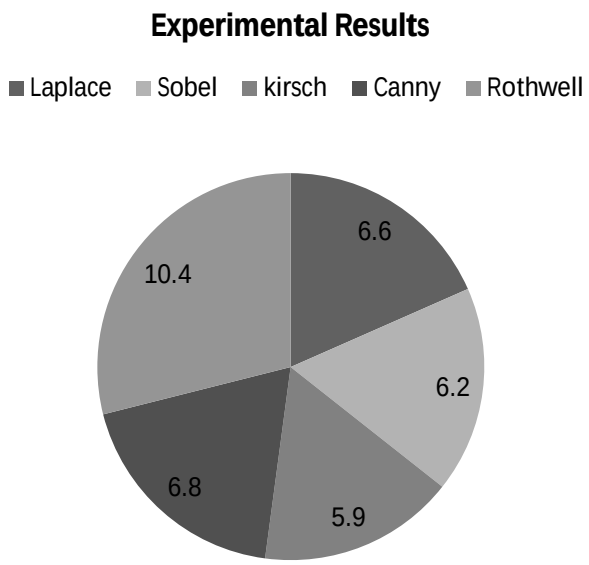

Figure 3.Experimental Results.

2.2 MORPHOLOGICAL:

In [18] primarily edges of the images are detected first, then the vertical projection of the edge image is detected, candidate regions are selected by means of these vertical edges in these structures. Compaction factor has been advised by the authors in order to avoid this problem. The vertical edges of the License Plate are less in numbers but become dominant in the case of structure. By applying method brightness of pixels in rows is found and maximum candidate area is given by the local maximum inside. Using that method plates can be easily extracted. The morphological binary map [19] is first generated by obtaining the difference between closing and opening image. Connected components for each candidate region are generated and then each connected component is reshaped to have smooth boundaries. The dominant local binary pattern is used to find the intensity variation around the transition pixel. The boundaries of the detected text regions are localized accurately using the projection of text pixels in the morphological binary map.

2.3 USING SMEARING ALGORITHM:

In[20] image is passed through vertical and horizontal scan lines for both vertical and horizontal smearing white pixels are turned black .Plate location can be specified by using morphological operation .97.6% success rate has been achieved by the authors by using this technique.

2.4 USING SMEARING TRANSFORM:

In [21] close boundaries of the objects can be detected by using contour algorithm and Hough transform. Contour lines converted to Hough, to detect two intersected parallel lines which form parallelogram and considered as candidate plate. There are two stages:

- Tabulating width/height ratio
- Tabulation based on cross cuts horizontally

In the first step selected candidates are verified according to W/H ratio .In the second step two horizontal cross cuts at 1/3 and 2/3 of candidate site are used. The number of objects cutting these cross cuts is counted. Constraints are defined primarily. 98.76% accuracy achieved by using this algorithm.

2.5 HISTOGRAM BASED APPROACHES:

2.5.1 SLIDING CONCENTRIC WINDOW:

In [22] SCW used for faster detection of region of interest (ROI), SCW operates in natural background and presents an algorithm to handle plates of various sizes. The algorithm steps are as follows

- Create two concentric windows for the pixel of the image
- Calculate the standard deviation of the pixels in the window
- First standard deviation of window if the ratio is greater than the threshold then the central pixel of windows is considered as vertical and horizontal region. Set the pixel value to 1 if it exceeds the threshold value otherwise set to 0.

Through this algorithm License Plate region is authenticated then the HSI color model is used to authenticate the candidate region. HSI color space identifies the color of Different objects. In the image processing HSI is used in histogram operations and by this License Plate region is extracted based on colors and histograms. Then finally it is verified by taking its vertical and horizontal histogram positioning whether this License Plate or not?

In short input image is a gray level image and the image after SCW is a binary image and after finding horizontal and vertical regions connected components are found to detect the candidate region and then by HIS color spacing candidate region is authenticated and the License Plate is extracted and through histogram positioning it is verified that candidate region is License Plate.

2.5.2 USING OTSU'S METHOD:

In [23] License Plate of the acquired image is detected using three main techniques

- Histogram Equalization
- Color Space Conversion
- Otsu's Method

The whole system is shown in the following diagram. Fig.4

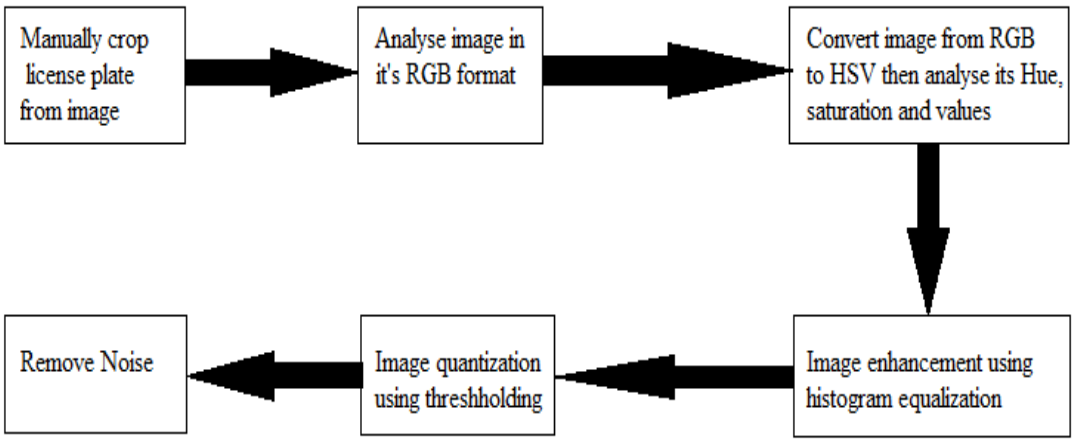

Figure 4.Process diagram of OTSU'S Method.

2.6 NEURAL NETWORK BASED:

Neural Networks are a different paradigm for computing:

- Von Neumann machines are based on the processing/memory abstraction of human information processing.
- Neural networks are based on the parallel architecture of animal brains.

Neural networks are a form of multiprocessor computer system, with

- Simple processing elements
- A high degree of interconnection
- Simple scalar messages
- Adaptive interaction between elements

A biological neuron may have as many as 10,000 different inputs, and may send its output to many other neurons. Neurons are wired up in a 3-dimensional pattern. Neural network is configured to Detect License Plate, [24, 25, 26] the mathematical morphologies, covariance descriptor and thresh holding techniques are used within the neural network respectively. In [27] to detect the License Plate region by using neural network, License Plate dimensions, Euler Number of binary image and combination of both are used as a criterion. If the study compared with a state-of-art detection method based on the weighted histograms of orientation the neural network outperforms in all cases.

2.6.1 ARTIFICIAL NEAURAL NETWORKS:

An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous system, such that brain, process information. An ANN is configured for the License Plate Detection Applications. The ability of neural networks is that to detect trends and extract patterns from complex objects by either humans or other computer technique. It thinks like an expert about data which is given for analyzing. It provides projections given new

situations of interest and answer what if questions. It works in different ways like adaptive learning, Real time operation etc. in [28] novel approach for automatic License Plate detection based on ANNs. First begins by pre-processing the image. Pre-processing involves noise reduction and an edge detection than apply the algorithm and detect the rectangles for each detected rectangle, a correspondent candidate plate with the same coordinates is extracted from the original image. For each plate candidate descriptor are calculated as

- Convert the candidate into gray scale.
- Apply 3x3 median filters.
- Divide the rectangle into 12 equal size sub blocks.
- Calculate grey scale histogram for each of the rectangle and 12 equal size sub blocks.
- For each histogram performs ascendant sort.
- As a classifier, used a MLICENSE PLATE with 13 neurons in the input layer, one hidden layer, and a single neuron in the Output layer. The best results came with a 20 hidden neurons configuration.

2.6.2 GENETIC NEAURAL NETWORKS:

In [29], a new Genetic Neural Networks (GNN) system has been used for License Plate Detection. The error rate very low during License plate Detection of Genetic Neural Network and result was very close to the actual License Plate. Effectiveness and precision depends on the parameters of the model, as well as pictures themselves respectively. It provides accurate results even in bad situations, such as, brightness as well as darkness images. The method also works with various positions and models of the License Plate.

2.7 TEXTURE BASED:

In texture based the input is received which can be a still image or sequence of images by text Extraction system [30, 31]. There is no bound on the image the can be of any format either gray scale, color , compressed. The problem is divided as follows:

- Detection.
- Localization.

A method was presented which working on the bases of color texture for detecting number plate in[32]. By using SVM and CAM shift it analyzes the color and textural properties of license plates in images and locates their locations respectively. While the proposed method does not assume the size and perspective of license plates, and is relatively insensitive to variations in illumination, it also can facilitate fast license plates detection and was found to produce a better performance than some other techniques. However, the

Proposed method encountered Problems when the image is extremely blurred or quite complex in color. [33] Use External region detection to localize the License Plate and text. External regions are connected component of an image.

2.8 FEATURE BASED TECHNIQUES:

2.8.1 GEOMETRIC FEATURE BASED TECHNIQUE:

For license plate detection Geometric method are used as a very efficient tool. The algorithm uses geometry based features to capture characteristics of License plate in the image regions[34]. Algorithm work as follows. Initially the algorithm selects vertical and horizontal lines by finding edges from the input image and also removes the noise by passing low pass filter. By using a certain threshold the vertical and horizontal lines are selected. The selected lines are stored in a list. By using these lines and their geometric properties rectangular shape is detected that shape contains the license Plate location. It works for all types of license Plates have white or black characters respectively. It captures large samples of vehicles and low labor intensity than other license Plate matching techniques.

2.8.2 LEARNING BASED TECHNIQUE:

Learning based technique is based on global statistical features and local Haar-like features[35]. Simple learning procedures are used to construct classifiers using global statistical features. These classifiers can exclude 70% of the background area from further training and detecting. Then the AdaBoost learning algorithm is used to make up the other classifiers based on selected local Haar-like features. Cascade classifier is obtained by combining classifiers using global and local features. The global featured classifier decreases the complexity of the system.. The whole algorithm is described in [34].

2.8.3 HAUSDORFF DISTANCE TECHNIQUE:

In [36] algorithm based on pattern matching with the Hausdorff Distance (HD) to pinpoint plate candidates. It validates or rejects the candidates on the symmetry detector. The pattern consists of a collection of points to be compared to another collection of points. HD detects license Plate in three stages.

- Vertical and horizontal lines are working as structuring elements; by using these lines eliminate the spurious edges, that stage also produces a mask of an image that contains white pixels in the area of vertical and horizontal edges.
- In a second stage searches the region where a license Plate could be located. A set of binary templates containing two vertical line segments is generated and used as an input pattern to the HD based search algorithm over the vertical component of the image got in the first stage.
- The third stage again used the HD algorithm to search for the actual plate shape using another collection of templates.

HD is capable of locating license Plates at low resolution with few misses and a manageable number of false alarms even with perspective distortion, as long as the boundary of the License Plate is reasonably well defined. Asymmetry criterion License Plates rejects bad plate candidates.

2.8.4 SALIENCE BASED FEATURE TECHNIQUE:

In [37] the salience feature based technique is used to locate the License Plate. Comparing with the other features of vehicle plate, shape feature, texture feature and color feature have more intuitionist human vision effect. The License Plate is a rectangle shape and its length-to-width ratio is fixed. The vertical and horizontal lines are detected by Hough transform. License Plate detection using salience feature follows the following steps.

- Classical Hough transform is employed and The sets of thresholds required by the
- Transform were established upon the information observed from the images.
- Peak values which are above some threshold are detected using polar coordinate image resultant from transform.
- Vertical and horizontal lines are selected and selection is based upon certain threshold, making near horizontal/vertical lines possible candidates. Storing them in the list.
- Rectangles are detected using the stored list by finding two horizontal and two vertical intersecting lines. Then a third list is created which contains the all rectangles. The equation to detect that the rectangle stored in the list is License Plate or not is described in detail in[37]

The obtained results are satisfactory enough and make the system able to work efficiently in practice. The error rate is low, and the human interaction is required to correct, in general, only one character of the proposed solution.

2.9 COLOR BASED TECHNIQUES:

2.9.1 USING COLOR DESCRIPTOR:

In [38] the proposed algorithm to detect License Plate firstly improves the quality of the image and improves the contrast area which consists of the License Plate. For image enhancement two techniques are described in [38].

- Image Enhancement Using Intensity Variance
- Image Enhancement Using Edge Density

These two techniques for image enhancement are discussed in detail in [38].
After enhancing the image four methods are used to locate the plate. Consider the fig.4

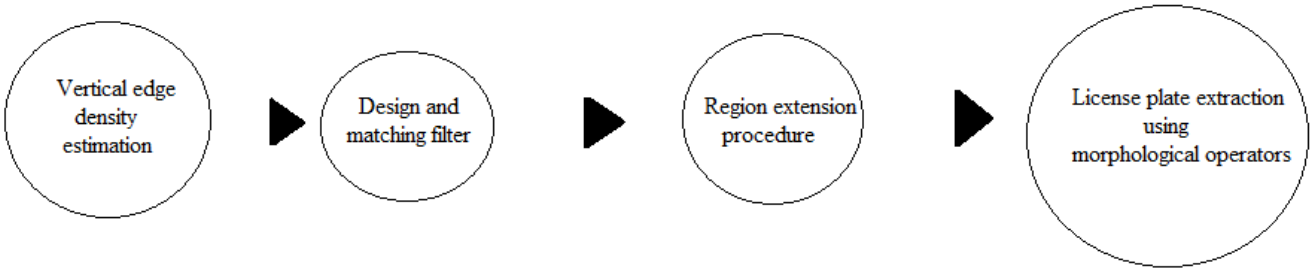

Figure.5 Four steps to locate the license plate

These four methods to locate the plate are discussed in detail in [38]

Color Analysis:

The above four methods are not good enough to detect License Plate to improve our detection rate color base detection can be used as a good tool. In color based technique it is considered that all License Plates worldwide almost contain the logo

of the country such as country flag. These colored logos can be considered as multimodal color neighborhoods with unique modes. The most important advantage of color object analysis in License Plate detection is the robustness to viewpoint changes, which increases the detection rate.

The input RGB image is first divided into first blocks. Then using mean shift algorithm, the color modes for each block is computed. A simple signature matching technique is applied to compute the dissimilarities between each feature [38].The algorithm attempts to find a match for all query features, assuming that the query signature contains only information about the object of interest.

2.9.2 USING COLOR INFORMATION:

In [39] algorithm is proposed to detect the License Plate. The proposed algorithm works as follows

1. License Plate Image Preprocessing

1.1. Gray Processing Method for Images

In it RGB image is converted into gray scale image.

1.2. Image Enhancement

Image enhancement technology often used to improve the image quality in image-processing, image enhancement refers to highlight certain information needed of the image, At the same time, weaken or remove some unwanted information. The main purpose of image enhancement is to improve the readability of the image.

1.3. Edge Detection

Gray edge is mainly vertical edge and few horizontal edges; this is determined by the Characteristics of the License Plate characters. The discontinuity of gray can be detected with directional operator, such as Sobel operator and line detection operator, with it, the corresponding horizontal or vertical edge can be effectively extracted from gray image.

2. License Plate Location

1. RGB image is converted into 256 color bitmap image then converted to grayscale.
2. Get the binary image with the binarization method based on orientation and dynamic threshold.
3. Get the edge image from binary image with vertical Sobel edge detection operator.
4. Get the License Plate rough location with experience threshold method (the first location) and License Plate region is extracted
5. Color information in the extracted License Plate region is used for the second plate accurate location.
6. License Plate region is extracted.

3 COMPARISON :

Table.2 Comparison of all discussed techniques

Techniques	Lightening	Background	Weather/ light	Image/video	Color model	Accuracy
Edge Based [43]	very sensitive to same light intensity and noise	Sharp edges are important for high quality result	NA	352*288 image 30f/sec	Greyscale	91%
Histogram [39]	Effective in poor illumination and different lightening conditions	Uniform background	Effective In varied weather	Grey scale 640*480 pixels digital images and binary	HSI	82.5%
Geometry Based [44]	High contrast	Uniform	Illumination should be uniform	For both	Grey scale	82%
Color feature based [40]	Work good in night and day images but bad for non-uniform light	Highly dependent on proper localization of license plate	Illumination shan't be skewed	Binary image	RGB->HSI	80%
Morphology [42][45]	Good for low illumination	Good for multiple backgrounds	Works for almost every weather.	Static image	Greyscale	88.54% [42] 96% [45]
Neural Networks [41] [46]	Day light with additional light in night frames and reflecting materials	Good for uniform background; and bit un-uniform background	Good for uniform illumination.	For optimum resolution image size shall be 1600*1200 aspect ratio 4/3 and digital image[41] 320*240 [46]	Input RGB to grey scale	94%

4 CONCLUSION

After this survey of all techniques one thing is for sure that there is no ideal technique which we can say that is suitable for all situations but there are certain techniques which works relatively good under different scenarios like in edge detection "canny" techniques uses pretty much frequently so all you need to identify your situation first and choose technique according to that. Likewise the comparison table has been presented in the above that reflect the comparison of different techniques under different circumstances. In this table one can see that Neural networks work fine. Its accuracy rate is 94% under the parameter given in table:2 which is higher than other comparative schemes.

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