Retraction

Retraction: Number Plate Detection and Recognition using a Novel Computer Vision Approach for Indian Motor Vehicles
(J. Phys.: Conf. Ser. 1916 012009)

Published 23 February 2022

This article (and all articles in the proceedings volume relating to the same conference) has been retracted by IOP Publishing following an extensive investigation in line with the COPE guidelines. This investigation has uncovered evidence of systematic manipulation of the publication process and considerable citation manipulation.

IOP Publishing respectfully requests that readers consider all work within this volume potentially unreliable, as the volume has not been through a credible peer review process.

IOP Publishing regrets that our usual quality checks did not identify these issues before publication, and have since put additional measures in place to try to prevent these issues from reoccurring. IOP Publishing wishes to credit anonymous whistleblowers and the Problematic Paper Screener [1] for bringing some of the above issues to our attention, prompting us to investigate further.

[1] Cabanac G, Labbé C and Magazinov A 2021 arXiv:2107.06751v1

Retraction published: 23 February 2022
Number Plate Detection and Recognition using a Novel Computer Vision Approach for Indian Motor Vehicles

M Naveenkumar¹, V Vijayaganth¹, M Mohan¹
¹Department of Computer Science and Engineering, KPR Institute of Engineering and Technology, Coimbatore, India
naveenkumar2may94@gmail.com, kv.vijayaganth@gmail.com, m.mohansan@gmail.com

Abstract. Number plate detection research problem was carried out for some duration. Since each country has their own way of representing numbers for the vehicles, we couldn’t recognize all at once. In this paper, we focus on Indian vehicles’ number plate. Digital images are used in this model, so it provides additional features in security aspects like theft, parking in office, and in apartments to check only authorized persons are coming. The proposed method uses canny edge detection to find the edges of the vehicle, and the morphological transformation is used to highlight the characters in the number plate. Optical character recognition (OCR) is used to recognize the characters from the number plate, and we use bilateral filters to remove the noises.

1. Introduction
Each and every motor vehicle is registered with a unique identification number based on the respective states. The number plate number is an arrangement of alphanumeric characters. Every vehicle is separated by their own alphanumeric registration number. In the current era, the automobile industries are moving towards big changes in the motor vehicles. Due huge number of population growth, more number of motor vehicles are sold in smart cities and peoples are using their own vehicles instead of using common vehicles [1]. Due to heavy traffic, it creates many problems like accidents, traffic congestion, more travel time, pollution levels are increased, fuel consumption and so on. We need more parking slots to park the vehicles in order to reduce the traffic congestion [2]. At night there is no proper light facility for most of the roadside areas. Due to over speeding of vehicles, a huge amount of accidents occurs at night time. In this regard, we can introduce more automation and intelligent systems to avoid such kinds of accidents at the time of traffic congestion at night.

Artificial Intelligence and computer vision are growing technologies that are introduced in the modern era to adopt all the image and video related analytics and to provide an effective solution for the number plate detection and recognition. While detecting a number plate, we need to recognize the number plate characters using character recognition. It is categorized as two parts, namely offline and online character recognitions [3]. In this project we are concentrating on online character recognition.

2. Related Work
[4], used morphological dilation and erosion to recognize number plate of Indian motor vehicles. It was developed with digital images of number plates to extract the characters in the number plate. In
this work morphological methods are used to test the number plates and the recognition is achieved by edge detectors and labelling approach. It was accomplished by optical characters for template matching.

[5], introduced localization of number plates for motor vehicles in West Bengal, India and segment the alphanumeric characters to identify the vehicle. The approach based on morphological methods and sobel edge detection techniques are used. He segments all the characters and digits used in the number plate with the help of detection techniques. Once the noise is reduced from the input frame we try to enhance the contrast with the help of histogram equalization. By using sobel edge detection he get good accuracy of number plate character detection.

[6], explained the number plate recognition and inspection was done using image processing and OCR. In this work, the optical character recognition to create an application to train the interface using LABVIEW Software.

[7]introduced a novel approach for automatic number plate recognition using Optical Character Recognition (OCR). In this work they introduced an observation for vehicle number unique proof in view of OCR. The OCR is used effectively to find the character pattern recognition and mapped with its own template matching.

[8]initiates the new method of automatic vehicular number plate recognition using OCR and Tesseract. In the proposed work, the system is able to identify car and bikes number plate. In this, various machine learning techniques and image processing were utilities.

[9]used OCR and REST API for efficient vehicle detection. The number plate image are preprocessed using REST application program interface to get the information of that derived number plates. The result of the number plate is recognized by OCR and it was compared with the neural network based motor vehicle number plate recognition.

3. Proposed Work
CVNPR is a novel approach to apply the image enhancement, restoration, processing, segmentation and other processing techniques in the conduct of number plate registration, identification and realization. This method mainly classified into three layers namely, pre-processing, detection and recognition are illustrated in the figure 1.

A. Pre-processing
In this process we will pass the input as image or video frames to process into the CVNPR. The image or the video frame must contain a number plate of any kind (i.e) of Indian motor vehicle which is shown below in figure 2.

Grey scaling is a method of translating the image from colour spaces namely, RGB, CMYK, HSV and etc to shades of grey. It differs from complete black to complete white. It receives the colour space conversion code. After that it will convert our original image from BGR colour space to grey colour space using OpenCV functionCOLOR_BGR2GRAY.

The grayscale image intensity are represented as M*N array in a single layered image. The output of the COLOR_BGR2GRAY function is a grey scaled image that is entirely different from the actual image. The input image is converted using Numpy array. Since image is converted into grayscale, image is represented in two dimensional arrays with equal number of rows and columns. Image value in an array is represented by the pixel values 0 to 255, where 0 indicates dark shades and 255 indicates light shades [10-11].
Colour images are represented as three-dimensional Numpy arrays as red, green, blue channels. Figure 3 shows array of three dimensional images. As like grayscale arrays each pixel represents identical values. The RGB to GREY conversion can be done through equation (1),

\[ Y = 0.299R + 0.587G + 0.144B \]  

(1)
Figure 3. Numpy Array – RGB Channel

A morphological transformation is non-linear processes related to the shape of features in an image. Morphological methods deal with relative ordering of pixel values and basically process binary images. It can also deal with light transfer functions of grayscale which is unknown and their absolute pixel values are minor interest. This process uses two inputs, one for original image and another for structuring / kernel. Structuring elements focus on small portion of an image and tries to locate all possible of an image. It compares with neighbour pixels and make the element either fit or unfit pixels. The basic morphological operators are erosion dilation and gradient.

Morphological operations produces output images as the same size of the input images by applying kernel element to the input image. Morphological opening is $\gamma_{\mu B}(f)(x)$ and closing is $\Phi_{\mu B}(f)(x)$ as shown in Equations (2) and (3)

$$
\gamma_{\mu B}(f)(x) = \delta_{\mu B} \left( \varepsilon_{\mu B}(f) \right)(x)
$$

$$
\Phi_{\mu B}(f)(x) = \delta_{\mu B} \left( \varepsilon_{\mu B}(f) \right)(x)
$$

Where $\mu$ is a homothetic parameter, size is $\mu$ means a square of $(2\mu+1)^2(2\mu+1)$ pixels. B is the structuring element of size 3*3 here $\mu=1$.

B. Dilation

Dilation is opposite to the erosion operation. In this the pixel element is ‘1’ hence under the kernel it must keep at least one pixel as the value of 1. So that it increases the black region in the actual image. Dilation is used to maximize the region by enlarging the width of an image and increases the valleys to remove negative impulsive noises as shows in figure 4. The dilation of A by the structuring element B is defined by Equation (4)

$$
A \oplus B = \bigcup_{b \in B} A_b
$$

If the origin of the center is B, the dilation of A/B can easily understood the points enclosed by B. If suppose the point of B is moving towards inside the A, then the dilation of the image DI and the structuring element SE is specified by DI SE. SE is located with its origin of (X, Y) then the new value is resolute by the rule by Equations (5)

$$
g(X, Y) = \begin{cases} 
1 & 
\end{cases}
$$
C. Erosion

It covers the boundaries for the front of the objects in white. The kernel transparencies through 2D convolution. The image pixel are mainly with 1 or 0. The pixels lower than the kernel are 1 otherwise 0. Pixels adjacent to the boundary are rejected with respect to the kernel size. Because the dimension of foreground object become reduced. This approach is mainly used in the actual images to remove the black noises are shown in figure 5. Due to this the dark square is changed to light square. It denoted by Equation (6)

\[ A \setminus B = \{ z \in E | B_z \subseteq A \} \]  

(6)

If the image pixel is 0 then the output will be 0. Erosion of an image EI by Structuring Element SE is notated as \( EI \setminus SE \). SE is located at the origin of \((X, Y)\) then the value of pixel is resolute through by Equation (7)

\[ g(X,Y) = \begin{cases} 1 & \text{if } (X,Y) \in SE \\ 0 & \text{otherwise} \end{cases} \]  

(7)

D. Gradient

The variance of dilation and erosion of the corresponding image is said to be gradient. The output of the gradient image seems like, outline of the object as shown in Figure 6.
E. Bilateral Filtering

It is more effective in noise removal process while maintaining the edges sharp. This method applies a bilateral image to a filter. It is defined by Equations (8) and (9)

\[
I_{filtered}(x) = \frac{1}{W_p} \sum_{x_i \in \Omega} I(x_i) f_r(||I(x_i) - I(x)||) g_s(||I(x_i) - I(x)||)
\] (8)

and normalization term, \(W_p\), is defined as

\[
W_p = \sum_{x_i \in \Omega} f_r(||I(x_i) - I(x)||) g_s(||I(x_i) - I(x)||)
\] (9)

Where \(I_{filtered}\) is the filtered image;
I is the original input image to be filtered;
X are the coordinates of the current pixel to be filtered;
\(\Omega\) is the window centered in x, so \(x_i \in \Omega\) is another pixel;
\(f_r\) is the range kernel for smoothing differences in intensities;
\(g_s\) is the spatial kernel for smoothing differences in coordinates;
The weight \(W_p\) is assigned using the spatial closeness and them intensity difference using the range kernel \(f_r\).

It takes a Gaussian filter in space, but another one Gaussian filter is used as pixel difference. The space creates blur on nearby pixels, while the intensity difference creates only those pixels with similar intensities to central pixel are measured for blurring. It preserves the edges because the pixels at the edges have more intensity variation to remove the noise are shown in figure 7. In an image, A pixel located at \((I, j)\) needs to be noiseless through its nearby pixels and one of its nearby pixels is at \((k, l)\).
To noiseless the pixel \((I, j)\) is carried by Equations (10) and (11)

\[
w(i, j, k, l) = \exp\left(-\frac{(i-k)^2 + (j-l)^2}{2\sigma_d^2} - \frac{||I(i, k) + I(k, l)||^2}{2\sigma_r^2}\right)
\] (10)

Where \(\sigma_d\) and \(\sigma_r\) are flattening parameters, and \(I(i,j)\) and \((k,l)\) are the intensity of pixels \((i,j)\) and \((k,l)\) respectively. After measuring the weights, normalize it into

\[
I_p(i, j) = \frac{\sum_{k,l} I(k, l) w(i, j, k, l)}{\sum_{k,l} w(i, j, k, l)}.
\] (11)

Where \(I_p\) is the noiseless intensity of pixels \((I, j)\) as shown in Figure 7
F. Canny Edge Detection (CED)

Once the noise is reduced the respective edges are detected. Many edge detection techniques are available in the market. We can use the concept called canny edge detection method. The procedure is as follows,

**Step 1:** Get the input image from the actor.

**Step 2:** Implement the grey scale transformation to an image and then smooth it with the Gaussian filter since the background noise using the discrete kernel in the axis could be removed.

**Step 3:** Identify the region in image by exploiting Prewitt Operator, Roberts Cross and Sobel to strengthen the intensity of gradients by Equations (12) and (13).

\[
MG = \sqrt{MGx^2 + M Gy^2}
\]  
\[(12)\]

where MG is a magnitude gradient.

The direction of the gradient \( \Theta \) is:

\[
\Theta = ATAN(\frac{MGy}{MGx})
\]  
\[(13)\]

**Step 4:** Combine the non-maximum suppression to thin out the image edges. This would exclude the unwanted image pixels which is not into an area of the particular edge.

**Step 5:** Use a lower and higher boundary on the gradient when a threshold is applied.

**Step 6:** Identify the specific edges with hysteresis through conquering weak edges that is unrelated to robust edges as shown in Figures 8 and 9.

**Step 7:** Once the back noise is eliminated resize the image in the required dimension to train data. The image with a dimension of 256 x 256 should be resized to 224 x 224 using image resizing on the ratio basis of the current image mentioned Equation (10)

\[
P(h, w) = round\left(\frac{f cf(p(h, w) - f cf_{min})}{(Rows \times Columns) - f cf}\right) \ast (I - 1)
\]  
\[(14)\]

Where,

- fcf is the cumulative distributed frequency of the gray level,
- fcf_min is the minimum cumulative distribution frequency,
- fcf(P(h,w)) is the intensity of the current pixel and I is the intensities.
G. Contour

A contour is a locked arc joining all the points having identical color. They symbolize the objects identified in an actual image. This technique is beneficial for analyzing the object detection with recognition using OpenCV. Contour is an abstract collection of points that is equivalent to the objects in an image. We programmed the contours in this output such that, to organize the object shape, cut the object from the input image using findContours. Contour is a link of equal intensity points along the system boundary.

In OpenCV(open source computer vision) the findContours method used to finding the number plate from the black background therefore during the adaptive CED, the reversal operation is applied. Once the process is completed, we need to create the zeros function. It is used to create an array with zeros. If we want to highlight the number plate in the image by applying the mask, we need to use the drawContours. findContours() is used to find the dilated images. In cv.findContours() usually three parameters are there as shown in Figure 10.

```
Rectangle Points for two wheeler: [[139 100]]
[[132 171]]
[[441 277]]
[[451 212]]

Rectangle Points for four wheeler: [[100 195]]
[[225 208]]
[[231 179]]
[[215 170]]
```

**Figure 10.** Finding the edge points of the rectangle using contours

Contours are used with list python libraries to work with all the image. It is an array of (X, Y) points of Numpy boundary for the object. It is mainly used to find the number plate with black background. It focused on detecting the block texts boundary edge of the given input image. After processing we need to do the image masking and crop the dimensions from the restricted edge of the captured image.

H. Optical Character Recognition (OCR)

OCR is easy to understand by the human to look the contents of an actual image. We can identify the text from an image is easy and understand to read because the text is available in the human readable language. But, computers are not function similarly as like humans. They only understand the text that is structured and this is exactly where OCR comes in the system flow. Through loop each contour will take the coordinates of (X, Y) and (H, W) using cv2.boundingRect(). By using cv2.Rectangle() we can able to draw in an image with obtained attributes. Parameters for cv2.rectangle() are, input image, coordinates, boundary colour BGR value and size. Now we can crop the rectangular region and then pass it to the number plate sketching and print the alphanumeric characters as shown in Figure 11.
4. Result and Discussions

The proposed work CVNPR system can recognize both the two wheeler and four wheeler number plate which are written in English fonts. Number plate images are captured through camera and we tested the method with real time images. It was done through Jupiter notebook with OpenCV library functions for image processing applications shown in Figures 12-16.

Figure 11. Optical Character Recognition of the input image

Figure 12. Input image for the work

Figure 13. RGB to GRAY Conversion

Figure 14. Extracting the region of the interest
5. Conclusion
CVNPR was carried with help of Indian vehicle number plate. The goal of this work is to detect alphanumeric characters from number plates. Experiment was conducted with different number plates like car, bike and bus (both front and back number plates). It was observed that an image that contains character in bike was difficult to identify because bike number plate has bend on both sides. This work was done with help of morphological transformation, canny edge detection and bilateral filters to pre-process the input images. Optical character recognition is used for pattern recognition. In future new algorithm can be developed to attain 100 per cent accuracy.

References
[1] Naveenkumar M, Srithar S, Vijayaganth V, Ramesh kalyan G. (2020). Identifying the Credentials of Agricultural Seeds in Modern Era. International Journal of Advanced Science and Technology, 29(7s), 4458 - 4468.

[2] ArunVaishnav and ManjuMandot (2020) Template matching for automatic number plate recognition system with optical character recognition, Information and communication technology for sustainable development, Advances in Intelligent Systems and Computing, 683-694.

[3] J. Pradeep, A. Muthukumaran, G. Nareshraman, R. Krishnan and B. SakthyRosseouPrasanna (2020), Efficient Vehicle Detection System using OCR and REST API, International journal of engineering research & technology, Vol. 9, Issue 07.

[4] P.Anishiya, Prof. S. Mary Joans,” Number Plate Recognition for Indian Cars Using Morphological Dilation and Erosion with the Aid OfOcrs.” International Conference on Information and Network Technology, Vol.4, 2011.

[5] Sourav Roy, AmitavaChoudhury, Joydeep Mukherjee., An Approach towards Detection of Indian Number Plate from Vehicle International journal of Innovative Technology &Exploring Engineering(IJITEE)Volume-2, Issue-4, March 2013.

[6] AbdKadirMahamad, SharifahSaon, and Sarah NurulOyun Abdul Aziz, A Simplified Malaysian Vehicle Plate Number Recognition, Springer International Publishing Switzerland 2014.
[7] D. Devikanniga, A. Ramu, and A. Haldorai, Efficient Diagnosis of Liver Disease using Support Vector Machine Optimized with Crows Search Algorithm, EAI Endorsed Transactions on Energy Web, p. 164177, Jul. 2018. doi:10.4108/eai.13-7-2018.164177.

[8] H. Anandakumar and K. Umamaheswari, Supervised machine learning techniques in cognitive radio networks during cooperative spectrum handovers, Cluster Computing, vol. 20, no. 2, pp. 1505–1515, Mar. 2017.

[9] J. Pradeep, A. Muthukumaran, G. Nareshraman, R. Krishnan and B. SakthyRosseouPrasanna, Efficient vehicle detection system using OCR and REST API, International Journal of Engineering Research & Technology (IJERT), Volume No 9, Issue No – 07, jul 2020.

[10] M Naveenkumar and Vishnu Kumar Kaliappan 2019 J. Phys.: Conf. Ser.1362 012063.

[11] N. Nandhini and R. Bhavani, Feature Extraction for Diseased Leaf Image Classification using Machine Learning, 2020 International Conference on Computer Communication and Informatics (ICCCI), Coimbatore, India, 2020, pp. 1-4.