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Automatic Number Plate Recognition System for the Detection of Unauthorized Vehicles During Government Imposed Lockdowns

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Abstract: Automatic Number Plate Recognition is a precise, error-free technology-integrated system used for the detection and recognition of number plates without human intervention of any sort. Considering the government-imposed lockdown in most of the countries of the world due to the rampant spread of the novel COVID-19 virus, we have attempted to present a fail proof method for the identification of unauthorized vehicles violating the government mandated norms in India without the intervention of police personnel. Furthermore, after the removal of the lockdown this system can be easily extended to detect transgression of traffic laws, automated commercial parking systems etc. The proposed morphological algorithm uses the application of Canny Edge Detector and Connected Component Analysis for the extraction of the plate followed by the usage of Bounding Box morphological technique for the segmentation of the individual characters within the plate. Recognition of the characters is done by Template Matching and Optical Character Recognition System.

Keywords: Canny Edge Detector; Bounding Box; Optical character recognition; Pandemic

I. INTRODUCTION

Due to the WHO declared COVID-19 pandemic, a uniform lock down was imposed in India to curb the spread of the disease. While, special permits were handed out to public health workers, emergency service workers, custodial and sanitation workers, the same was not levied to citizens with non-essential backgrounds. Despite this a significant proportion of unauthorized vehicles were observed in various parts of the country making them susceptible to the disease and thereby increasing its transmission.

Furthermore, police personnel were deployed to man the streets and reprimand miscreants which further put them in the risk of contracting the virus.

A viable, cost effective solution for this problem is the implementation of an Automatic Number Plate Recognition System to easily detect such vehicles without the use of manpower. A typical ANPR system consists of the following steps:

1) Number Plate Extraction
2) Character Segmentation
3) Recognition of the characters.

Previously, unique methods for each of the steps stated above had been proposed. Hough transform combined with canny filter was used for the detection and extraction of the plate [1]. With a success rate of 89.70, this system proved to be quite accurate for the recognition of Islamabad plates but failed to provide satisfactory results in the recognition of Indian plates especially in regions with scanty illumination. M. M. Shidore, S. P. Narote [2] proposed a method for the extraction of Indian number plates by the application of Sobel edge detection filter integrated with certain morphological operation followed by Vertical Projection Analysis for the segmentation of characters. However, Canny Edge Detector was found to have an edge over Sobel in terms of non-maximal suppression and better noise reduction in [3]. Gisu Heo, Minwoo Kim, Insook Jung, Duk-Ryong Lee, Il-Seok Oh [4] suggested a method by implementing Line grouping algorithm by extracting line segments and line approximations followed by line pair recognition. This method was found to be more successful while using the double chance framework method by introducing Edge Density algorithm, which when applied separately had lower success rate. The proposed algorithm in [5] used median filtering and histogram equalization for the extraction of the number plates but additional methods for the local isolation of the license plate were not enclosed. Several papers also used artificial neural networks for the recognition of characters, [6] uses vertical and horizontal histograms for the segmentation of characters and the recognition of characters is done using Probabilistic Neural Networks. A remarkable success rate of 96.5 was observed in this

method however, the selection of the plate was done on the basis of certain plate characteristic features such as plate height of at least 12 pixels and a plate width of 16 pixels. This would lead to discrepancies in case of detection of noise of similar dimensions like car logos, bumper stickers etc. In [7], Haar wavelet and back propagation neural network is used for the recognition of characters. The recognition rate was found to be around 88. Lekhana G C [8] put forth a method to extract license plates using Spectral Analysis Approach (SAA) and Connected Component Analysis (CCA). This is followed by character segmentation and recognition, which uses Binary classification SVM as the primary method for character identification. It is found that SVM classifier gives better recognition accuracy when compared to PCA LDA feature extraction methods. [9] proposed a unique approach by implementing ANPR on ARM DSP and FPGA heterogeneous platforms. This method was combined with a number of morphological operations and artificial neural networks to obtain a satisfactory success rate of about 95.

II. PROPOSED METHOD

The proposed algorithm is primarily built on the basis of the following basic segments:

1) Detection, isolation and extraction of the number plate by the application of Canny edge detector and a number of other morphological operations
2) Segmentation of all the individual characters within the plate using Bounding Box analysis
3) Recognition of all the segmented characters by template matching using Optical Character Recognition (OCR).

Fig 1 represents the flowchart of a typical Automatic Number Plate Recognition System, which is the flowchart of the proposed Automatic Number Plate Recognition System.

A. Number plate Localization and Extraction

A key factor in ensuring optimum results is carrying out the number plate localization and extraction with highest possible accuracy. This is done in four steps as stated below.

a) Image Pre-processing

A camera with a high resolution is used to capture images. Fig 3 depicts an image of a car captured by the high-resolution camera. Noise in images can largely be attributed to poor illumination conditions, shadows of trees, background objects, screws in the number plates etc. Noise is also added during the transmission of images. The input RGB image is converted to a grayscale image. The grayscale image obtained is then converted to a binary image by mentioning a threshold (level), all the pixel values greater than the threshold are characterized as 1 (white) and the lower ones as 0 (black). Fig 2. depicts the image of a car captured by a high-resolution camera. Fig 3. represents the Grayscale converted image of the car.

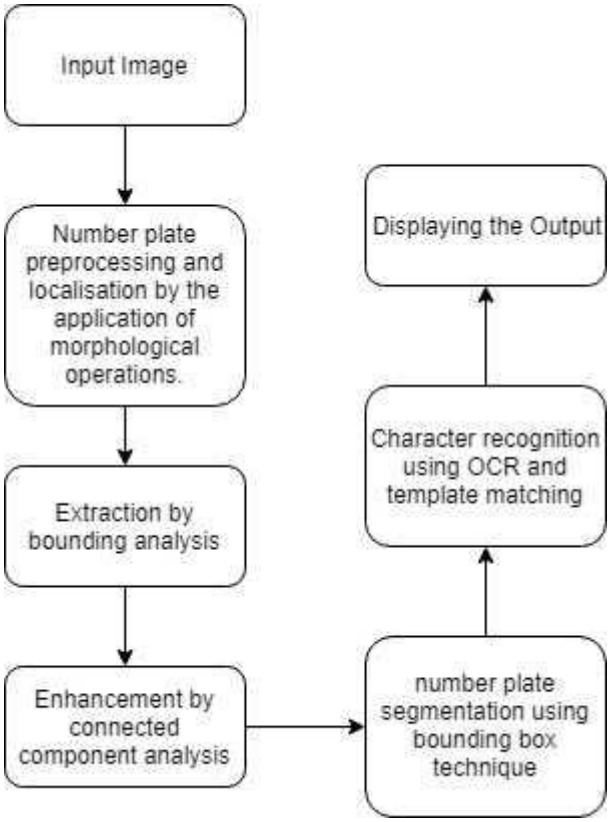

Fig 1. Flowchart of Typical ANPR System

Fig 2. Original image of the car.

Fig 3. Grayscale image of the car

b) Canny Edge Detector

Canny edge detection is an edge detection technique used to detect and enhance curves with rapid changes in intensity. Canny edge detector is a multi-step algorithmic operation that integrates calculus of variations to produce images with the edges indicated. Canny edge detector is applied to the binary image obtained for further

suppression of noise and for the detection of edges. The image of the car after the application of the Canny edge detector is depicted in the Fig 4. The edges of the car are clearly defined making it easier for the extraction of the area of interest.

Fig 4. Image of the car after the application of Canny Edge Detector

c) Morphological image processing

Morphological operations further enhance the desired region of interest by suppressing additional noise. Flood-fill operation is performed to fill holes in the input binary image. A hole is a set of pixels that fill into the edges of an image. The modified image is then subjected to a series of erode operations to highlight the area of interest.

d) Extraction and enhancement of the number plate

Bounding Box analysis operation is successfully used to isolate the number plate. The isolated image is overlapped with the binarized image to obtain the candidate of interest. The obtained area is further processed by subjecting it to connected component analysis. Maximal region of eight connected pixels is recognized and extracted. Fig 5 depicts the image of the car after suitably eroding and overlapping it with its binary image. The area of interest i.e. the Number Plate is clearly defined. The Number plate is highlighted further by the application of Bounding Box algorithm. Fig 6 depicts the localized Number Plate obtained after the application of Connected Component Analysis.

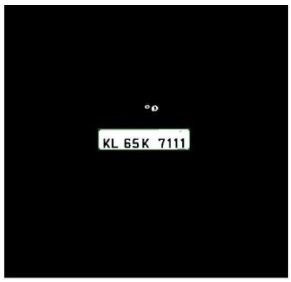

Fig 5. Image of the car with Bounding Box highlighting the Number plate.

Fig 6. Number Plate after the application of Connected Component Analysis

B. Number Plate Segmentation

Segmentation is a vital step in the ANPR system which dictates the degree of accuracy of recognition of characters. Here each character in the extracted number plate is separated out using bounding box technique and is cropped out. In this method, the pixels of the image are reversed to obtain white characters on uniform black background, the reversed image is then partitioned into different segments, each segment consisting of a single character thus eliminating unwanted regions of the number plate and thereby isolating only the characters. Each character is then resized to a block size of 32 x 21 for template matching. Fig 7 represents the Number Plate with all the characters enclosed withing Bounding Boxes. The Bounding Boxes are represented in the color red as shown in the figure.

Fig 7. Segmented Number Plate

C. Recognition of Characters

A database of individual templates of alphabets ranging from (A-Z) and numbers (0-9) each of size 32 x 21 is created. Here, Template matching, a widely used process that compares the extracted features of the segmented blocks to that of the pre-existing template database, is used. Template matching is integrated with OCR to provide optimal results. The process of feature extraction is applied on the segmented characters to yield maximal feature points which form the basis of the comparison procedure. For example, the letter E is found to have 3 equally spaced peaks at |90| degrees and one peak at 0 degrees. After resizing the image and the extraction of features, the now processed image is compared to the existing database and the index of the closest match is computed and stored as a recognized character. In a similar fashion, every segmented character is examined and compared to the database and an ideal match is suitably obtained. Fig 8 represents the cropped, segmented templates of the Number Plate that are matched with the database of pre-existing templates of letters and numbers.

III. RESULTS OBTAINED

This experiment was simulated using MATLAB R2019B on an intel core i5-8265U CPU. The sample of images used for this experiment were taken in both dim and illuminated conditions with additional background noise like trees, shadows etc. Cars of different colors and the different states of India were used in the sample. A success rate of 83% was observed in case of extraction of the images and a success rate of 85% was observed in the segmentation module.

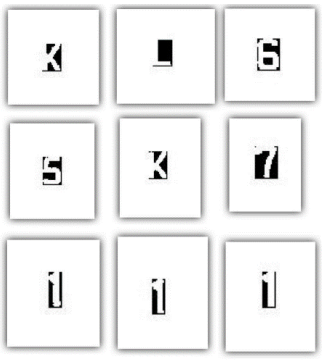

Fig 8. Individual Cropped Segments of the Number Plate

IV. CONCLUSION AND FUTURE WORK

The methodology proposed above can be applied to detect and recognize vehicles violating the lockdown without comprising on the accuracy of detection, thereby, considerably reducing the risk of exposure both to the police personnel handling the miscreants and the general public. Furthermore, the amount of manpower required for the surveillance of the streets is significantly reduced and can instead be redirected in other directions like the distribution of food, relocation of migrants etc. While the experiment yielded satisfactory results, certain shortcomings were observed in the case of cars with colors similar to that of the number plates and license plates with undefined borders and eroded characters. Blurry images and license plates with extravagant adornments like designs of flowers etc. were also not accurately detected and recognized.

In some of the number plates, the characters in the regional language were present too. We applied the proposed algorithm to a plate containing characters of the Kannada language and were successful in the extraction and segmentation of the characters. The cropped, segmented templates of the Kannada Number Plate is depicted in Fig 9. However, the recognition of the characters was not done due to database containing only characters of the English language. In the future our aim is to create a more universal database containing characters of multiple languages and also the creation of a neural network integrated OCR for faster and more accurate computation.

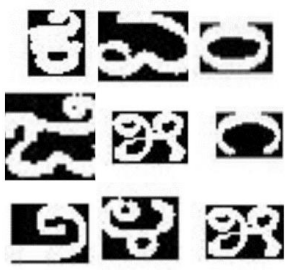

Fig 9. Segmentation of a plate in a regional language (Kannada).

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