CO543 - IMAGE PROCESSING
MINI-PROJECT

SRI LANKAN VEHICLE PLATE RECOGNITION SYSTEM

MID-PROGRESS REPORT

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25/03/2022

Introduction

Vehicle number plates are used to uniquely identify vehicles for various purposes such as traffic statistics, identification of traffic law violations, etc. The recognition of number plates using automated systems is an important area of research since it allows the identification process to be more efficient and, in some cases, more accurate than manual identification. Such systems can be developed by utilizing image processing techniques.

License plate images used for number plate recognition (NPR) systems are typically obtained through CCTV traffic cameras. Hence, the software must initially be able to detect and localize the license plate from the full-frame. That is, the solution will crop the input image down to only the area containing the license plate.

Figure 1: Typical CCTV footage (left) vs. Localized Number Plate (right)

Another consequence of the images being from CCTV footage is that the images after localization and cropping are of low resolution and contain many visual artifacts, especially for images captured during nighttime where the low-light conditions of the environment severely impact the quality of the image. In addition, images captured from moving vehicles may also have some degree of motion blur which will impact the quality of the image.

Figure 2: Number plate images from high-quality ANPR camera (left) vs. CCTV camera (right)

As such, a lot of pre-processing needs to be performed on the images to remove such artifacts and obtain an image where the characters on the number plate are legible. In order for the software solution to function as intended, the character must be clear enough for the Optical Character Recognition (OCR) technology used by the software system to identify the number plate accurately.

Hence, the proposed software solution will perform such pre-processing techniques to enhance the features of the image, and utilize OCR technology to produce the license plate number in text form.

Problem Statement

This project attempts to develop a software solution that identifies features in a low-resolution image of a vehicle number plate in order to correctly identify the vehicle's license plate number. In order to develop such a solution, a large dataset of number plate images with various visual artifacts such as blurring, tilt, rotation, and brightness discrepancies so that the final solution can be robust enough to work properly on images taken in varying environmental conditions.

Due to the unavailability of such large datasets for Sri Lankan license plates, the publicly-available Chinese City Parking Dataset was chosen as a close alternative. The dataset contains over 300k test images with various distortions such as blur, tilt, and rotation. The dataset has been annotated with the actual license plate number as well as other metadata such as the tilt degree, blurriness, and brightness. This dataset was chosen in addition to the test dataset consisting of 24 license plate images provided as part of the project.

The final solution is expected to produce the correct license plate number to a reasonable degree of accuracy upon receiving an input image containing a vehicle license plate. Ideally, the solution should recognize the license plate number regardless of visual distortions and low-light conditions. Since the images are of low resolution it may not be possible to apply basic image processing techniques to recover the license plate number to a human-readable level from heavily distorted images. In such cases, it is possible to utilize a Convolutional Neural Network (CNN) to recognize the features of each character in order to improve the accuracy of the solution.

The dataset chosen contains annotations for each test image containing the actual license plate number. The algorithm can be evaluated against these annotations to verify the accuracy of the solution. Additionally, the provided dataset of test images will also be used to evaluate the accuracy of the final solution.

Technical Approach

Considering the above-mentioned requirements the steps to achieve an ideal solution is as follows.

1. Detect and localize a license plate in an input image
2. Extract Characters from the license plate
3. Identification of the characters

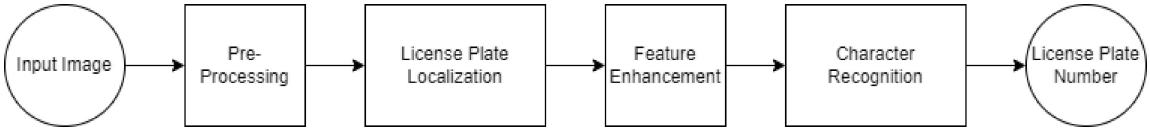

Figure 3: Block diagram of the proposed solution outlining the major steps

Since the images that are being considered contain various levels of noise and defects the preliminary approach would be to preprocess the images so that we can localize the number plates in images. Using techniques such as

Edge detection - Detect the borders of a license plate by identifying the pixel changes(Sobel filters).

Contrast stretching - To differentiate between the license plate and the surrounding background.

This would lead to an effective localization of license plates in the given images. Once the target area is identified we can move on with feature enhancement in order to gain details about the number. The second step of preprocessing is done so that we can get differentiable or extractable characters. Although addressed as characters these may or may not be exactly human-readable characters. Techniques used in feature enhancement,

Normalization - changing pixel intensity values to address poor contrast issues

Deblurring - recovering sharp features of images

Morphological operations - recover sharper edges of the given segment

After the above-mentioned step, we would be able to differentiate between the background of the number plate and the foreground which are the characters on it. The extracted images (license plates) will be analyzed using Tesseract-OCR which is an open-source optical character recognition engine that uses AI for text search and recognition of images.

However, if the final outputs of the approach prove to be not satisfactory or adequate, extracting the character/digits will be done with the use of a CNN model. (the optimal usage of tesseract for images is given as 300DPI(dots per inch).) The preprocessed images will be segmented to gain individual characters/digits to be recognized. Then the digits will be passed on to a model to be analyzed and provide the highest probable value for them. Models such as LeNet and VGG16 will be used to achieve this. The training data set here would be the above-mentioned CCPD dataset where we will be segmenting the digits and using them to train and

build the model. Since the dataset provides a variety of effects on the images(blur, nightlight, low-contrast, etc) we hope to generalize the model to recognize and give positive outputs for the images.

Figure 4: Types of number plates found in the dataset

Intermediate/Preliminary Results

To achieve the project objectives we have been experimenting with various image processing techniques to enhance the image quality. As per the requirements, the main goal of the process of implementation has been identified as the preprocessing of the images. Some of the few tests on the given image set are as follows.

1. **Edge-detection filters to localize the license plate**

   In order to isolate just the license plate from the input image, edge detection filters such as the Sobel operator were used since there is a stark contrast between the pixels of the license plate and the body of the vehicle. This allows us to use the edges around the license plate to isolate the license plate from the input frame.

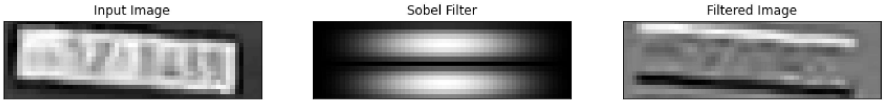

Figure 5: Applying the Sobel operator to the *'A1.PNG'* image provided in the test dataset

2. **Contrast stretching**

   To address images with very low contrast this technique is used. In return, this gives us a clearer image with a higher level of contrast. At times this method shows very little improvement so we had to resort to testing with thresholding to get a view of the characters on the license plates.

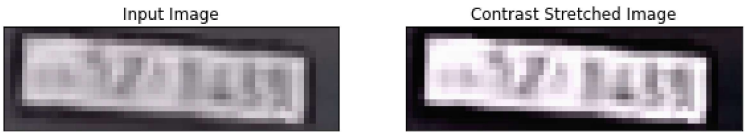

Figure 6: Contrast stretching applied to the *"A1.PNG"* image provided in the test dataset

3. **Histogram analysis**

With very little improvement with contrast stretching observations was done in image histograms in the form of histogram equalization. Compared to contrast stretching which is a linear approach this technique uses nonlinear transfer functions to map between pixel intensity values.

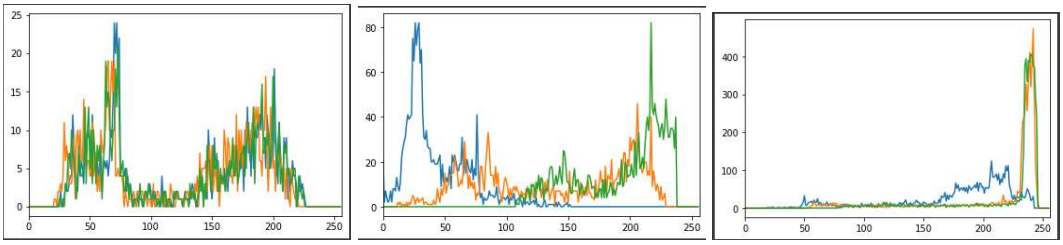

Figure 7: Results of histogram analysis on the provided test images

4. **Sharpening filters**

For the images that show very little difference between the characters and the background. These filters are used to emphasize and further enhance the digits so that they can be easily extracted.

5. **Fourier Domain processing**

Taking the images to the Fourier domain reveals the geometric characteristics of a spatial domain image. This allows us to visualize certain frequencies of the image. We have observed the variations in these image noises and methods of removing them by using filters to manipulate the frequency domain characteristics.

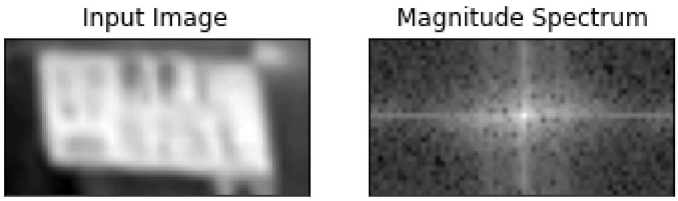

Figure 8: Fourier domain analysis of the image *'A1.PNG'* provided in the test dataset

Thus far we have been implementing image processing techniques to analyze the given test images as well as the other images on the dataset. Certain patterns have started to emerge in some of them and at the same time, some images have not shown a lot of improvement and require further processing.

References

1. Ajanthan, Thalaiyasingam & Kamalaruban, Parameswaran & Rodrigo, Ranga. (2013). **Automatic number plate recognition in low-quality videos**. 2013 IEEE 8th International Conference on Industrial and Information Systems, ICIIS 2013 - Conference Proceedings. 566-571. 10.1109/ICIInfS.2013.6732046.

2. Vasek, V., Franc, V., & Urban, M. (2018). **License Plate Recognition and Super-resolution from Low-Resolution Videos by Convolutional Neural Networks.** BMVC.