Team Project Proposal

Title: An Approach to License Plate Recognition System on FPGA

Team Member 1: 雷伦昊 3019207152

Team Member 2: 武嘉闻 3019208197

Team Member 3: 钟金辉 3018202090

Team Member 4: 李崇灏 3019232090

March 24, 2022

1 Background

Automatic Number Plate Recognition (ANPR) systems have become one of the most important components in the current Intelligent Transportation Systems. A FPGA implementation of a complete ANPR system which consists of Number Plate Localization (NPL), Character Segmentation (CS), and Optical Character Recognition (OCR) is presented [1].

1.1 Background of Research

ANPR systems have been successfully operated in the UK for several decades. First generation ANPR systems were invented in 1976 at the Home Office Scientific Development Branch in England (now known as the Home Office Centre for Applied Science and Technology, CAST) and they have successfully detected simple crimes: Tracking and finding stolen vehicles and prosecuting uninsured or un-taxed road users. There are 35 million number plate reads per day in UK and this number is increasing every year [2] ANPR becomes an important technology for intelligent infrastructure systems like electronic payment systems, access control, tracing of stolen cars, or identification of dangerous drivers [3].

Typically, an ANPR system consists of three stages: Number Plate Localization (NPL), Character Segmentation (CS), and Optical Character Recognition (OCR). The NPL stage is where the Number Plate (NP) being detected. The CS stage is an important pre-processing step before applying OCR, where each character from the detected NP is segmented before recognition. In the last stage, characters are segmented from the NP where the image format will be converted into characters by a character classifier [4].

Most methods in current ANPR systems utilize general purpose CPUs to perform complex and computationally intensive image processing algorithms. The CPU must read each instruction from memory, decode it and then execute it. Additionally, any operation needs to be implemented from basic arithmetic and logical operations in CPU, which slow down the execution speed for each individual operation. Therefore, to achieve real-time performance, specialist hardware platforms can be one of valuable solution for accelerating computationally intensive image processing algorithms. Some of researchers have

chosen Digital Signal Processors (DSP) and/or Field Programmable Gate Arrays (FPGAs) as their platform for implementing ANPR systems [5]. However, most of the hardware-based systems focus only on one or two stages of ANPR system due to limited hardware resources or complexity of the chosen algorithms.

A. NPL Module

The proposed NPL module consists of two major stages:

1) Morphological operations for extracting plate features, and

2) Selection of candidate regions. The proposed NP feature extraction algorithm is mainly based on two open and one close morphological operation, the first open morphological operation is used to extract the features of the NP, the second open operation is used to remove noise, and the close operation is then used to fuse the pixels in the NP region together.

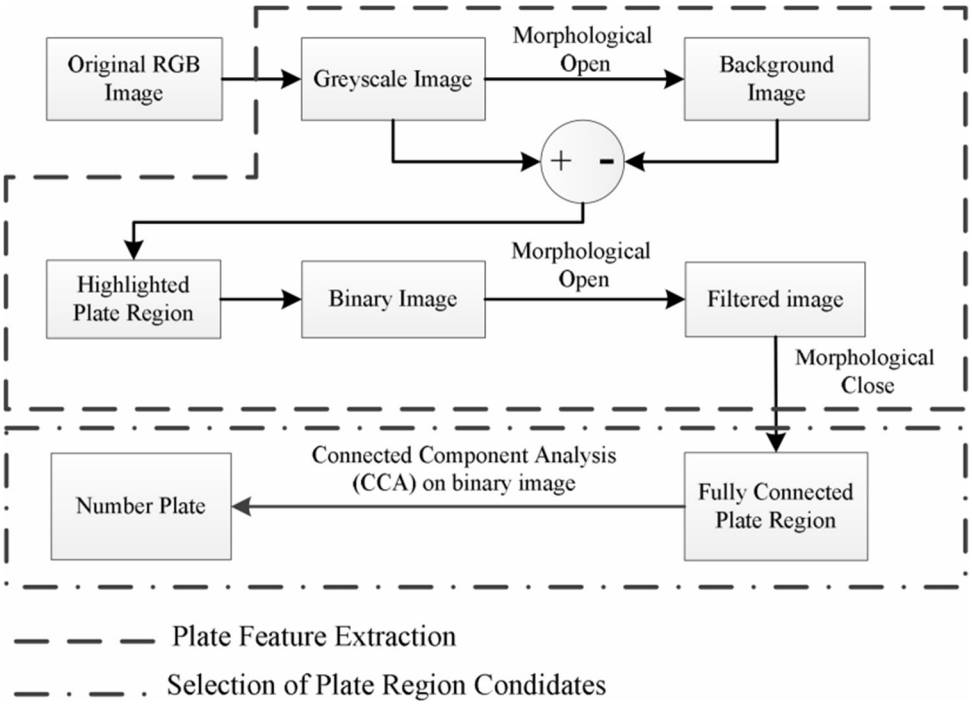

Figure 1. Block diagram of NPL system

B. CS Module

The proposed CS algorithm is mainly based on pixel projection and morphological operations. Compare to existing works based on pixel projection method [6], two optional morphological operations have been introduced in the proposed

improved algorithm to minimize the impact of noise and the entire horizontal pixel projection step has been replaced by an NP height optimization step. These modifications improve the robustness of the vertical projection and also accelerate processing speed.

The proposed method has three stages: 1) Pre-projection stage, 2) Vertical projection, and 3) Horizontal projection. Figure 2 shows the block diagram of the proposed CS module.

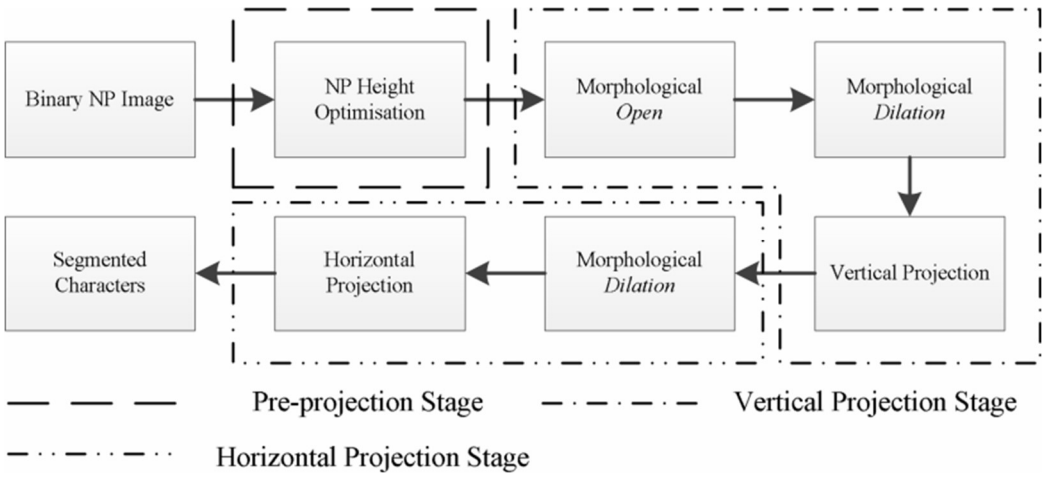

Figure 2. Block diagram of the proposed character segmentation module

C. OCR Module

The proposed OCR algorithm uses a multi-layer feedforward Neural Network (NN) to translate scanned character images into machine encoded text. Typically, an N-layer NN consists of a set of input vectors, N-1 hidden layers, one output layer and a set of output vectors. Each layer consists of a set of neurons and corresponding transfer function (e.g. sigmoid, linear).

1.2 Significance of the study

According to the latest statistics released by the Ministry of Public Security, as of September 2021, the number of motor vehicles in China reached 390 million, including 297 million cars, and the number of new energy vehicles reached 6.78 million, accounting for 2.28% of the total number of cars. 27.53 million new motor vehicles were registered in the first three quarters of 2021, an increase of 4.363

million or 18.83% year-on-year. The large total volume and high growth rate are the two main characteristics of the number of motor vehicles in the country.

Meanwhile, a set of data published by the Institute of Traffic Management Science of the Ministry of Public Security in 2016 indicated that there are five colors of domestic license plates, which are blue, yellow, white, black, and green. Blue is a representative of the license plate of private cars, issued to the people by the local DMV. Yellow indicates the license plate used by large vehicles, agricultural vehicles or coach vehicles, also used on the test vehicle license plate of some new products. White generally stands for military vehicles or police car class. Black indicates the license plate of foreign enterprises. Green indicates the license plate of new energy vehicles.

The current situation of motor vehicles in China brings great challenges to the identification and statistics of license plate information. License plate recognition through image sensing has an indispensable role as an important component in modern intelligent transportation system. On application scenarios such as monitoring and alarming, speeding violation punishment and intelligent toll collection, intelligent license plate recognition has great advantages over traditional manual recognition, significantly improving the efficiency of traffic management, social management and property management and saving human and material resources. However, the domestic license plate detection research project started late compared to foreign countries, and the complex traffic scenes in China lead to more difficulties. It is still a long way to go to realize the license plate recognition that adapts to any scenes.

1.3 Objectives of the Project

The project aims to achieve vehicle license plate recognition in a low-interference environment through license plate positioning, character segmentation, and character recognition steps. The results are presented as outputting the image data as digitized standard license plate information.

2 System Architecture

This project is an FPGA based license plate recognition system. To implement the project we specifically need to divide into three major steps: 1) **license plate positioning, 2) character segmentation, and 3) character recognition**.

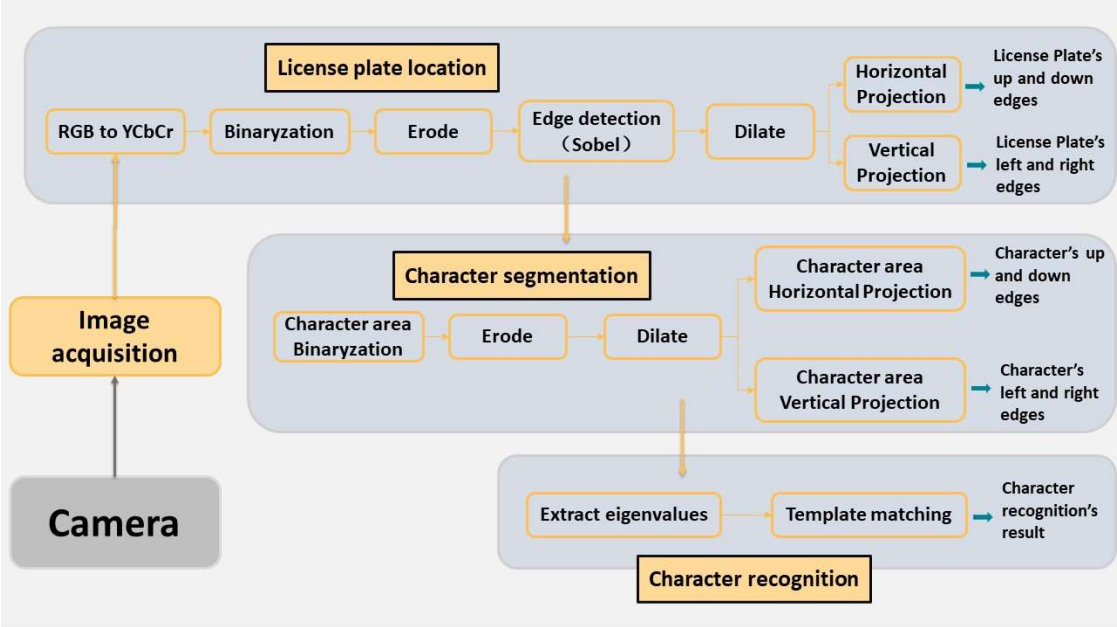

Figure 3. System Architecture

2.1 License plate location

To locate the license plate, we need to determine the top, bottom, left and right boundaries of the license plate by taking pictures of the plate image with an external camera on the FPGA and processing the image in turn with grayscale, binarization, erosion, Sobel edge detection, expansion, horizontal and vertical projection, etc.

Figure 4. License Plate Demo

A. RGB to YCbCr

Usually, the colors obtained from cameras and scanners, as well as the colors used for computer displays, are in RGB mode. Without conversion, RGB pictures take up a large amount of bandwidth and storage during transmission and processing, which is not conducive to transmission and processing. And because people are more sensitive to changes in luminance than to changes in chromaticity, the color loss caused by reducing bandwidth is small and barely perceptible to the human eye. YCbCr uses luminance (Y) and two chromaticity signals (Cb and Cr) to represent color and converting a picture from RGB to YCbCr color space reduces the number of dimensions of chromaticity and facilitates further subsequent processing.

The picture with the Cb channel component converted to YCbCr is obtained to complete the grayscale processing.

Figure 5. Grayscale

B. Binarization

Binarization: choose a suitable value, if the gray value of a point in the picture is greater than this value, set the point to the maximum 255, and vice versa if the gray value of a point in the image is less than this value, the value of the point will be set to the minimum 0.

Figure 6. Binarization

The binarization of the image can reduce the workload of subsequent license plate recognition.

C. Erode

Convolution calculation is carried out through convolution kernel B and image a, and "and" operation is carried out with template elements and binary image elements. If both are 1, the target pixel is 1, otherwise it is 0. Then the minimum value of the pixel of the B coverage area is obtained, and this minimum value is used to replace the pixel value of the reference point.

Image corrosion is similar to "the field is eroded", which reduces and refines the highlighted area or white part in the image, and the operation result image is smaller than the highlighted area of the original image. This step can help the binarized picture to eliminate noise.

Figure 7. Erode

D. Edge detection (Sobel)

Sobel operator is a typical edge detection operator based on first derivative, and it is a discrete difference operator. The operator can smooth the noise and eliminate the influence of noise.We use Sobel operator for edge detection to help determine the rectangular area where the license plate is located.

Figure 8. Edge Detection

E. Dilate

Convolution calculation is carried out through convolution template B and image A. each pixel in the scanned image is "and" calculated with template element and binary image element. If both are 0, the target pixel is 0, otherwise it is 1. Thus, the maximum pixel value of the B coverage area is calculated, and the pixel value of the reference point is replaced with this value to realize expansion.

Expansion is similar to "domain expansion", which expands the highlighted area or white part of the image, and the operation result image is larger than the highlighted area of the original image. This step is conducive to the boundary division of subsequent projection detection.

Figure 9. Dilate

E. Horizontal (Vertical) Projection

Observe the image projection to determine the peak and valley coordinates, and then divide the edge of the license plate. The horizontal projection helps to determine the upper and lower boundaries of the license plate, and the vertical projection helps to determine the left and right boundaries of the license plate.

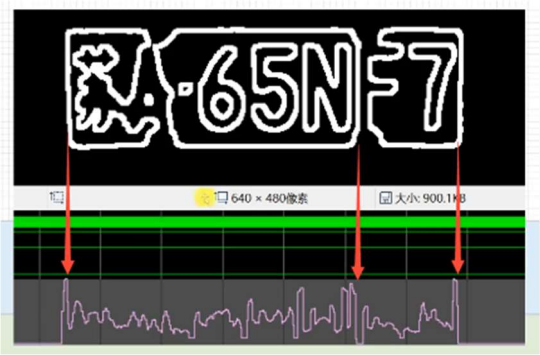

Figure 10. Horizontal Projection

2.2 Character segmentation

Extract and binarize the located license plate area, then carry out corrosion and expansion operations to remove noise and irrelevant areas (rivets, etc.), and finally segment a single character by horizontal and vertical projection of the character area.

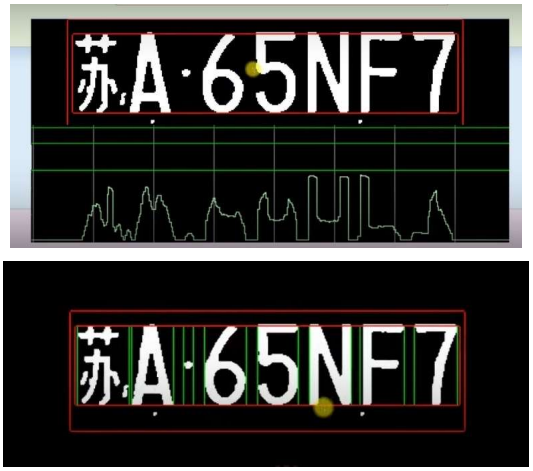

Figure 11. Character Segmentation

2.3 Character recognition

The segmented characters are matched by convolution template, and then the character recognition results are obtained. Divide each character into 5 * 8 pixel matrix and determine the element composition of each matrix according to the white pixel as 1 and the black pixel as 0. Finally, the matrix is convoluted with the standard character template to obtain the corresponding recognition results.

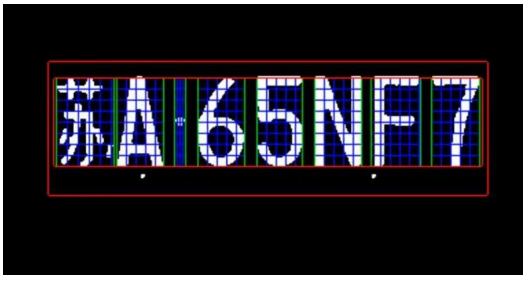

Figure 12. Character Recognition

3 Schedule of the Project

2022.3.25~2022.3.31 Select the system hardware specifications and complete the hardware construction, including the selection of FPGA chip, camera, motherboard, and overall circuit design.

2022.4.1~2022.4.7 Complete the grayscale and noise reduction of the image.

2022.4.7~2022.4.14 Complete the binarization of the image.

2022.4.14~2022.4.19 Realize the edge detection and recognition of license plate.

2022.4.19~2022.4.25 Complete the code part of license plate character segmentation.

2022.4.25~2022.5.20 Complete the code part of license plate character recognition (including Chinese character recognition, letter recognition and number recognition).

2022.5.20~2022.5.21 Complete the license plate recognition and output the recognition result.

2022.5.21~2022.5.31 Test system, optimize code.

4 Task Assignment and Equipment

4.1 Team member task assignment

雷伦昊: Control the progress of the team and complete the conception of the project, participate in part of the code writing, and perform the presentation

武嘉闻: Participate in the code writing and mainly responsible for the license plate positioning part, construct the mechanical structure, and write part of the thesis.

钟金辉: Participate in code writing and mainly responsible for the character segmentation part and write part of the thesis.

李崇灏: Participate in code writing and mainly responsible for the character

recognition part and write part of the thesis.

4.2 List of technical equipment requirements

- FPGA development board
- Camera
- DuPont cable
- LCD display
- …….

Reference

[1] X. Zhai, F. Bensaali and K. McDonald-Maier, "Automatic Number Plate Recognition on FPGA," 2013 IEEE 20th International Conference on Electronics, Circuits, and Systems (ICECS), 2013, pp. 325-328, doi: 10.1109/ICECS.2013.6815420.

[2] S. Connor. (2005, Oct). Surveillance UK: why this revolution is only the start. Available: http://www.independent.co.uk/news/science/surveillance-uk-why-thisrevolution-is-only-The-start-520396.html.

[3] A. O. Yerdut, Y. B. Eldeniz, and H. G. Ilk, "Automatic license plate recognition based on a projection method, " in IEEE 19th Conference on Signal Processing and Communications Applications (SIU), 2011, pp. 182-185.

[4] C. N. E. Anagnostopoulos, I. E. Anagnostopoulos, I. D. Psoroulas, V. Loumos and E. Kayafas "License plate recognition from still images and video sequences: A survey, " IEEE Transaction Intelligent Transportation System vol. 9, pp. 377-391, 2008.

[5] T. Kanamori, H. Amano, M. Arai, D. Konno, T. Nanba, and Y. Ajioka, "Implementation and Evaluation of a High Speed License Plate Recognition System on an FPGA, " in 7th International Conference on Computer and Information Technology, 2007, pp. 567-572.

[6] H. Xiangjian, Z. Lihong, W. Qiang, J. Wenjing, B. Samali, and M. Palaniswami, "Segmentation of characters on car license plates, " in IEEE 10th Workshop on Multimedia Signal Processing, 2008, pp. 399-402.