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Building Vietnam's License Plate Recognition System Based on OpenALPR

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Abstract**—** *In this research, we proposed a solution for Vietnam's license plate recognition include many stages based on OpenALPR with OCR incremental training. This paper describes a practical approach for constructing an OpenALPR-based license plate recognition system. This paper outlines the procedures that must be taken in order to construct the system, including data gathering, detector training, OCR training, and system deployment. The test findings demonstrate that the system can recognize license plates with a high degree of accuracy and can be installed on a variety of platforms, thus satisfying users' practical requirements.*

Keywords**—** *Vietnam's license plate recognition, OpenALPR.*

I. INTRODUCTION

In Vietnam in general and Ho Chi Minh City in particular, the use of surveillance cameras is growing. Surveillance camera systems in Vietnam [1], however, only have recording capabilities and let users watch recorded footage in the event of an incident or a complaint. In order to increase the effectiveness of camera use, intelligent computer vision features must be integrated into cameras.

Vietnamese license plates [2] come in a variety of styles, including long and short plates for automobiles and old (8 characters) and modern (9 characters) plates for motorcycles. The long plates have a ratio of 4:1, while the short plates have a ratio of 4:3. Despite this, they have several things in common.

The license plate [3] has a white background with black letters and numbers. It contains one of the 20 letters A, B, C, D, E, F, G, H, K, L, M, N, P, S, T, U, V, X, Y, Z (motorcycles over 50cc do not use the letter A) combined with one of the following numbers: X, Y, Z (motorcycles over 50cc use letters instead). They are given out to personal automobiles, business project management boards, social groups, professional associations, non-public career units, and driving testing and training facilities. The second set of numbers is the registration order for the car, which has 05 natural digits and ranges from 000.01 to 999.99.

Specific dimensions are as follows:

- Width of the license plate: 190 mm
- Height of the license plate: 140 mm
- Width of letters and numbers: 22 mm
- Height of letters and numbers: 55 mm
- Space between the characters and the top of the plate: 6 mm
- Space between the characters and the bottom of the plate: 6 mm
- Thickness of the letters and numbers: 7 mm
- Space between characters and numbers: 5 mm
- Space between registration numbers: 12 mm.

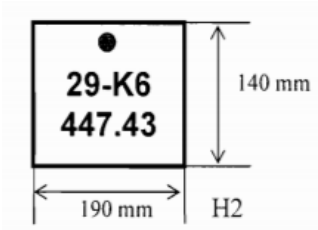

Fig. 1. Specifications of a motorbike license plate

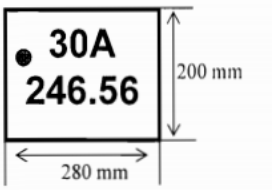

Fig. 2. a car's short license plate

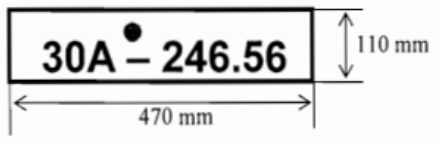

Fig. 3. a car's long license plate

Specific dimensions are as follows:

- Height of letters and numbers: 80 mm
- Width of letters and numbers: 40 mm
- Thickness of the letters and numbers: 10 mm
- Space between characters and numbers: 10 mm.
- Short license plate:
  - The width of the license plate: 280 mm
  - The height of the license plate: 200 mm
- Long license plate:
  - The width of the license plate: 470 mm
  - The height of the license plate: 110 mm

Numerous camera systems, including those made by ASTEC in Vietnam, Hikvision in China, and KBVISION in the US, are integrated into solutions that can run continuously, around-the-clock, in any weather. The cameras' shutter speeds can be automatically changed to accommodate various lighting situations, such as direct sunlight, light rain, or low light at night. To make sure the photos are of a high enough standard to be processed, the cameras are additionally attached

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to high-power infrared transmitters. However, there aren't many open-source camera systems available right now that can be modified for the Vietnamese market. The US, Europe, and the Arab world are the only regions for which the OpenALPR [4,5] system can currently be customized for license plate recognition and vehicle type identification. The research topic focuses on adapting OpenALPR for Vietnamese automobiles and incorporating it into building systems like the campuses of Ho Chi Minh City University of Education's surveillance camera systems.

The aim of this research is to use OpenALPR to create a high-precision license plate recognition system employing security cameras:

- Investigate and apply OpenALPR for Vietnam's license plate recognition.
- Integrate into surveillance camera systems.
- Build the feature of recognizing Vietnamese license plates.

This research aims to improve the efficacy of surveillance camera systems and partially address the problems found in the application problem based on my contributions and suggestions.

II. Background and Related Work

A sequential mechanism governs how OpenALPR works. The output is the text from the license plate in the input image after multiple processing stages and input image processing.

i. License plate detection

For each input image, the detecting stage is performed once. To identify probable license plate regions (x, y, width, and height), it employs the LBP algorithm, which is frequently used for face recognition. The subsequent stages receive each of these regions for additional processing. GPU acceleration can be used to increase performance because the detection stage typically requires the most work [6,7].

ii. Binarization

There will be several occurrences of this step (and every stage that follows), one for each potential region for a license plate. For each area of the license plate, the binarization process will generate several black and white images. The best probability of locating every character is provided by using many black and white photos. For instance, if a single black and white image is too dark or too bright, characters may be missed. Different parameters are used with the Sauovola and Wolf-Jolien methods during binarization. The following steps involve processing each black and white image.

iii. Character Analysis

Character-sized matching regions will be sought after in the license plate area during the character analysis stage. This will be accomplished by locating all linked color blobs in the vicinity of the license plate. The next step is to search for color blobs with peaks and valleys that are lined up with those of other blobs of a similar size and that are around the same width and height as characters from a license plate. The license plate area will see several iterations of this study. First, smaller character cells will be recognized, then gradually larger characters. A prospective license plate area will be eliminated immediately if nothing is discovered there. If any viable characters are discovered, the character region will be preserved, and processing will move on to the next phase.

iv. Plate Edges

In this stage, the edges of the license plate will be searched for. The Detection stage will be responsible for identifying a region that may contain a license plate. Usually, a region slightly larger or smaller than the actual license plate will be detected, but the exact top/bottom/left/right edges of the license plate will not be searched for. [8]

The first step is to find all the lines for the license plate region. In the platelines.cpp class, the license plate image will be processed, and a list of horizontal and vertical lines will be computed. The platecorners.cpp class will use this list, as well as the height of the characters (calculated in Character Analysis) to find the most suitable edges of the license plate. It will use some configurable weights to determine which edge is the most reasonable. It will try to use a default edge (based on the ideal width/height of the license plate) to see if it fits.

v. Deskew

The deskew step [4] will remap the area of the license plate to a standard size and orientation using the results of the plate edges. This will result in a perfectly straight license plate image that is not rotated or tilted.

vi. Character Segmentation

The character segmentation stage [9] aims to separate every character from the image of the license plate. To identify spaces between the characters on the license plate, it will employ a vertical histogram. Additionally, during this stage, the character cells will be cleaned up by having minor blemishes, broken pieces, and irregular character areas removed.

vii. Optical Character Recognition (OCR)

Each character box will be independently analyzed by the OCR step. It will determine all potential characters and their confidence level for each character image. [10]

viii. Post Processing

The character segmentation stage will attempt to isolate all characters in the license plate image. It will use a vertical histogram to find gaps between the characters of the license plate. This stage will also clean up the character cells by removing small spots, broken fragments, and non-standard character regions.

The OCR stage will analyze each character cell independently. For each character cell image, it will calculate all possible characters and their confidence level.

Given a list of all characters and their confidence levels, this step will determine the best possible letter combinations. Post-processing will remove all characters below a specific confidence threshold. It will also have a soft threshold defined by the programmer, where characters within this threshold will still be added to the list of possibilities. However, a blank character may be added because a low-confidence character may not actually be part of the license plate.

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Post-processing will also handle license plate region verification if requested. For example, if you tell OpenALPR that a certain plate is a Vietnam plate, it will try to match the result with the Vietnam format template (for example: [digit] [digit] [letter] [letter] - [digit] [digit] [digit] [digit]). For example, if the top three results are:

- 63B2 - I804I
- G382 - 18041
- 63B2 - 18041

The third result will match the template, while the other two will not. Therefore, this step will mark the third result as the best match.

Fig. 4. A sample of license plate

III. VIETNAM'S LICENSE PLATE RECOGNITION FRAMEMEWORK

If you are using *Word*, use either the Microsoft Equation Editor or the *MathType* add-on (http://www.mathtype.com) for equations in your paper (Insert | Object | Create New | Microsoft Equation *or* MathType Equation). "Float over text" should *not* be selected.

A. Technical stack

Use the links below to get the scripts required for training Vietnamese license plate recognition as well as the OpenALPR open-source code:

- github.com/openalpr/train-ocr
- github.com/openalpr/train-detector
- github.com/openalpr/openalpr/releases/tag/v2.2.0

The scripts must also be run on Python 3.x/2.x and OpenCV 3.0.0 for Detection training.

B. Data processing

Gathering the Vietnam's license plate as follow:

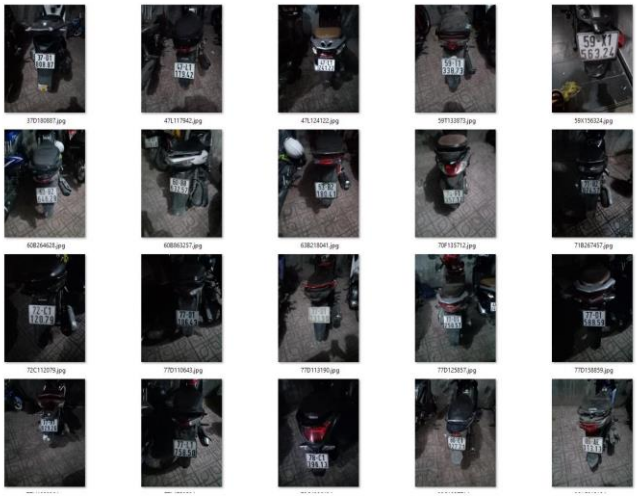

Fig. 5. Gathering license plate photo data

Run the openalpr-utils-binarizefontsheet.exe program to create the boxes from each image.

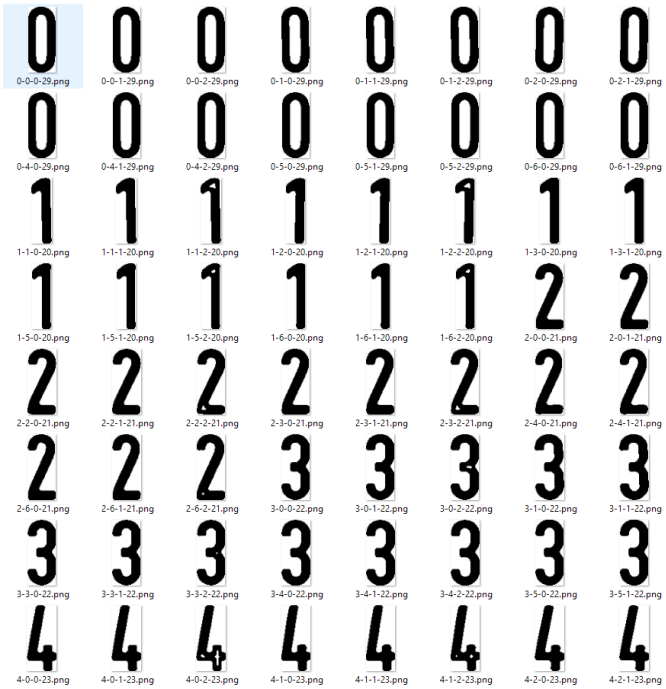

Fig. 6. Valid character output

C. OCR training

Perform character recognition training for license plates using OCR and OpenALPR.

```
0D9VOPR1HS791GPVXAYNBQBAMTCBR2VZJCJL6RX9X9LKKYSFOVGNR3V
MVAGJX31KAM7AMOSKLB4B95LQIENVZVL63RUVPXPQ3Q19R1STZTOLPOS
GFGGR8FSMT6A8BF1YE5FYZDBPCVH9OORHJXHVAPW65ZCPO9HSQDLIT1W
XQ9MYR1AD8HEHUZNLQ4UG976AW77OAPWNEB871SI3K1DSK2TJ5MIO4UG
6JY8TBR131TOQSJVOGE98PR39P982RW9MSB5OHGNFWO5VAZ2TKBC160B
F3FNZWFMQ7YORE94UJ1GBXPK9GGHUG3DR1DUW78OVPBFOHEW7X1D22U4
1WUBQO2GLTGODUBGXQ15AOQZX2XA1OOUOMKVOXROGCR6AE6GC7GSAS1Z
N9X24RZZ4RDL9786CMQNT1U1JY5U1YCN6QZD7PMVS9Y4QE2A63BCS5OV
HS4K8YOO18TLZWJ5ECCFROT3M1K9B2H37Z4SWJTMGW3DBU4J1VQPCE57
9LL8P7L2AAP4PLAJ1B8CZ3SWBI18543KMSO5926NTBFT79NXQ424FDJ6
0T86TADOG59JXAGTU9617350V8EVCY614311TLXS5KI14FELAVI1WO5QP
Y11HXY8MEXBKCVLJ4K1E5P9M66QE9OLG8964M9BN96KGWAL62R8LX34S
JDRUB6OOOE5TRWV1FWHLLH5BP1QMR1U8QJLYYL2OGD4O1SYGQ6EE3SEJ
Y6C7EW8QBRVJ1HXZXM9XOG8O1756VXORFO16M7J1Y1FSJ5P2HXRCBQMZ
VNCU194Z1F6GFZVDRSECBL6LVQO6MKVOE87QTLUT57SBVOKDDIPSX2LY
GKU93NT7F2QA972YOVKJUOBUJ1P2YOO7OM2GGZU4JHQNYLWDDRDLGBO7
SPK2DSANLU5OC2ZKD4SOMU1Z7YOU1WMV4QWRXC92JLXTA9GDWDD9QLPO
R7ZD7MKO5OHRD7AZEG8X371LHDOHDZA1LW7J68G5D9M4FEN4OGD6YN1N
F9VTQYUYOONPGXRBKFA3PTOQAU6GSKXUREAJBQ55BRX7TAE6QU21B8J
SXK182OEFDV69V7Z8FRER7L1DQQTYHPQMBE7O3CWGE1MKFX3BDBUY92
GTDHLU8A3CQYM39RSN39GCQMZINFZ76Q1UQK3O8JMO99UF9ZQRW3D4HD
VADFMKWU443JW4TL3KARF86695UC6ENXGSF4BPGP2XQPGGIG91T85OI9
6N62FXHHYHTHOO9XBOU94PYADCCORSJC6OS2C8Q7QUNQLRUVCVSXF3U
MG7AM176NLPJYRT
```

Fig. 7. A sample of OCR training file

D. License plate detection training

The common location of the license plate in the image will be found by the detector. The Local Binary Pattern (LBP) technique is used to determine the license plate region. Both negative and positive pictures are necessary to train the detector.

The following stage is to train the detector after gathering

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hundreds to thousands of photos of license plates. The training command must first be set up to use the exact size.

Change the variables WIDTH, HEIGHT, and COUNTRY in the prep.txt command to reflect Vietnam (WIDTH: 28, HEIGHT: 20, and COUNTRY: "vn"). The total number of pixels should be close to 650px, and the width and height must be appropriate to the size of the license plate.

E. Vietnam's license plate recognition system

Number equations consecutively with equation numbers in parentheses flush with the right margin, as in (1). First use the equation editor to create the equation.

The Windows operating system or a webserver can be used to deploy the Vietnamese license plate recognition system.

Fig. 8. Vietnamese license plate recognition system for Windows OS

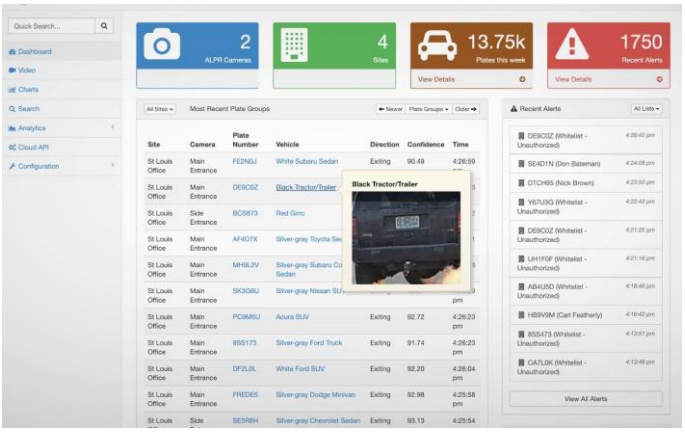

Fig. 9. Vietnamese license plate recognition system for webserver

IV. EXPERIMENTAL RESULTS AND DISCUSSION

A. Experimental Enviroment

The program is written using the Visual Studio 2019 Express application in C# language and tested on the Asus Vivobook S15 S510UQ laptop with Core i5 8250 3.4GHz, 12GB RAM, NVIDIA Geforce GTX 940M.

The OpenALPR source code used for research is the open-source version OpenALPR 2.2.0 and was customized on Visual Studio Code, compiled on Python 2.7.

B. License plate recognition workflow

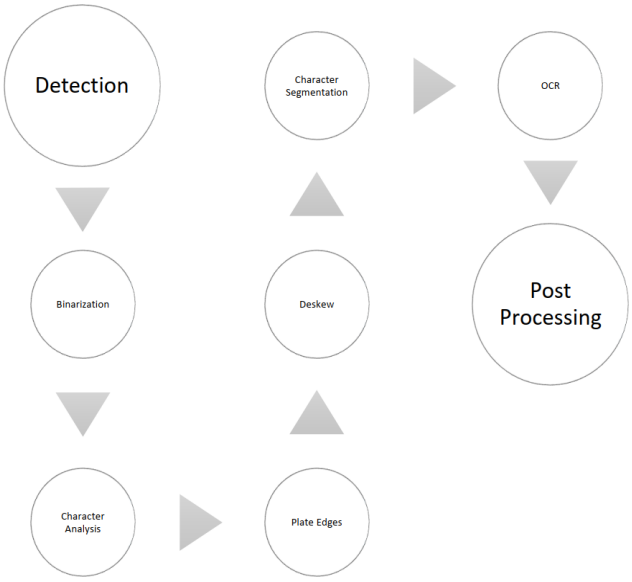

Fig. 10. License plate recognition workflow

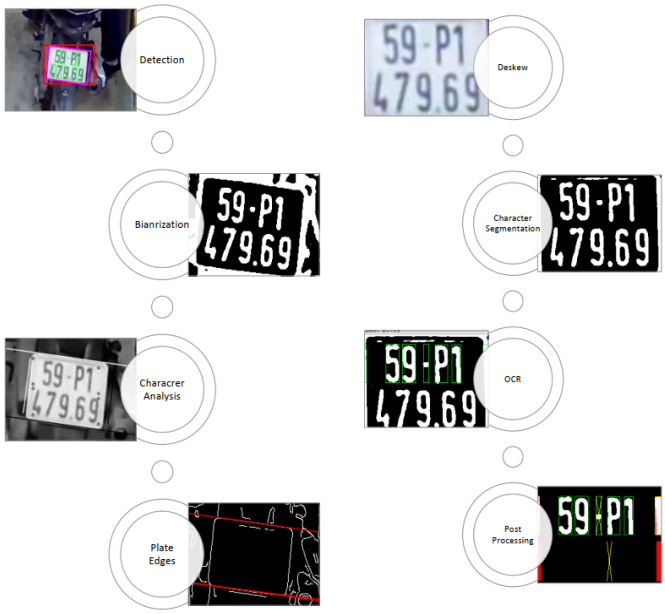

Fig. 11. An example of license plate recognition workflow

B. Experimental results

120 images of vehicles going through the parking lot scanner are included in the test dataset.

V. CONCLUSION

In this research, we proposed a solution for Vietnam's license plate recognition include many stages based on OpenALPR with OCR incremental training. The experimental result in the real application shows the feasibility of the proposed solution in Vietnam application environment.

This paper emphasizes the need for programming abilities, familiarity with software development tools, and open-source libraries in order to design a license plate recognition system. However, creating a license plate recognition system is now simpler and can be implemented on a variety of platforms

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thanks to the strong technologies and development tools that are readily available today.

TABLE I. 120 test image recognition results

Filename	Plate	Results	Conf	Filename	Plate	Results	Conf
Tên file	Biển số	Kết quả test	Độ tin cậy	Tên file	Biển số	Kết quả test	Độ tin cậy
0000_05696_b.jpg	59L2-06377	59L2-06377	89,9606%	0133_02608_b.jpg	66P1-5967		
0000_08244_b.jpg	59T1-08264	59T1-08264	90,8947%	0137_01124_b.jpg	59L1-59150	59L1-59150	89,2690%
0001_05318_b.jpg	59T1-08264	59T1-08264	89,3640%	0138_04418_b.jpg	54U5-1223	54U5-1223	88,0871%
0002_02183_b.jpg	52U7-8693	52U7-8693	89,9177%	0144_01003_b.jpg	59X2-77399		
0003_02063_b.jpg	63B9-57926	63B9-57926	90,5622%	0144_02600_b.jpg	59X2-78848		
0003_07398_b.jpg	59V1-07473	59V1-07473	87,4138%	0147_05075_b.jpg	59H1-74864	59H1-74864	86,6924%
0004_06801_b.jpg	59H1-54986	59H1-54986	91,6243%	0147_08012_b.jpg	59B1-33968		
0005_00490_b.jpg	59F1-13060	59F1-13060	87,9324%	0150_04096_b.jpg	70B1-55132		
0006_06035_b.jpg	59U1-39619	59U1-39619	89,1553%	0151_08171_b.jpg	72K1-25476		
0006_06797_b.jpg	59C1-65331	59C1-65331	84,0292%	0153_02530_b.jpg	59N1-60077		
0007_02188_b.jpg	60B5-55723	60B5-55723	88,6176%	0159_02577_b.jpg	79H1-2911	79H1-2911	87,3851%
0009_00490_b.jpg	59F1-1380	59F1-1380	82,0678%	0200_05891_b.jpg	56P2-5963	56P2-5963	90,4768%
0009_02194_b.jpg	51FB-4779	51FB-4779	85,5704%	0200_08375_b.jpg	63H3-1295		
0010_00004_b.jpg	59F1-07509	59F1-07509	92,3449%	0205_07100_b.jpg	77D1-12938	77D1-12938	89,5547%
0010_02063_b.jpg	63B9-57926	63B9-57926	90,5916%	0208_04293_b.jpg	59H1-52850	59H1-52850	90,2869%
0011_00515_b.jpg	60X4-6482	60X4-6482	83,2743%	0209_04147_b.jpg	71S3-5600	71S3-5600	89,8490%
0013_05647_b.jpg	59F1-16711	59F1-16711	86,1604%	0209_06894_b.jpg	79C1-22177		
0014_02176_b.jpg	52U4-4702	52U4-4702	88,5760%	0210_04345_b.jpg	59S1-10393		
0019_01137_b.jpg	59V1-84031	59V1-84031	86,7011%	0210_04510_b.jpg	77Y3-4619	77Y3-4619	88,6510%
0019_02163_b.jpg	59E1-13417	59E1-13417	91,5635%	0223_07200_b.jpg	51H3-8092		
0019_06895_b.jpg	59H1-54986	59H1-54986	89,5007%	0224_02215_b.jpg	54L4-2443	54L4-2443	81,6247%
0020_02063_b.jpg	63B9-57926	63B9-57926	88,1693%	0244_05322_b.jpg	51R5-27-01		
0022_01753_b.jpg	66C1-15723	66C1-15723	89,1893%	0226_06210_b.jpg	59C2-49200	59C2-49200	88,9620%
0027_06458_b.jpg	83F1-00417	83F1-00417	86,9359%	0228_06205_b.jpg	77M6-3369		
0028_00196_b.jpg	65S2-1319	65S2-1319	89,2194%	0229_04927_b.jpg	59P1-47969	59P1-47969	84,3122%
0028_07031_b.jpg	59V2-00285	59V2-00285	90,5590%	0240_04445_b.jpg	59Z1-13930	59Z1-13930	91,4287%
0028_08102_b.jpg	59C1-00307			0241_06978_b.jpg	59S2-29969	59S2-29969	90,9270%
0038_01762_b.jpg	54L2-4264	54L2-4264	87,2619%	0242_06436_b.jpg	94E1-19317	94E1-19317	86,0968%
0038_08198_b.jpg	59K1-90300	59K1-90300	92,0092%	0247_06037_b.jpg	81G1-13556	81G1-13556	86,7142%
0039_04131_b.jpg	59K1-90300	59K1-90300	90,7896%	0249_02212_b.jpg	54P7-2138	54P7-2138	88,5805%
0041_00486_b.jpg	68H7-4213	68H7-4213	85,1692%	0256_06559_b.jpg	54H3-5581	54H3-5581	83,1126%
0041_00951_b.jpg	62V1-6814	62V1-6814	86,3079%	0257_03048_b.jpg	59F-00982	59F-00982	86,7036%
0041_05679_b.jpg	68H7-4213	68H7-4213	83,7632%	0257_04207_b.jpg	59V2-33522	59V2-33522	87,5850%
0042_01141_b.jpg	59T1-88808	59T1-88808	90,8756%	0259_06228_b.jpg	53S3-9152	53S3-9152	90,1444%
0043_01879_b.jpg	59C1-16274	59C1-16274	88,0166%	0307_04743_b.jpg	52U4-9980	52U4-9980	88,5353%
0044_04330_b.jpg	84K3-4900	84K3-4900	87,7716%	0311_06191_b.jpg	59P1-71756	59P1-71756	91,2509%
0045_01558_b.jpg	59U1-70392	59U1-70392	86,2949%	0313_06899_b.jpg	59S2-26754	59S2-26754	85,8502%
0047_01152_b.jpg	59F1-70424	59F1-70424	89,7516%	0316_06166_b.jpg	60T7-7586	60T7-7586	85,7687%
0047_01868_b.jpg	51L4-1138	51L4-1138	88,5585%	0316_06385_b.jpg	50H1-02654	50H1-02654	90,6163%
0048_01264_b.jpg	59G1-98907	59G1-98907	88,1698%	0320_04051_b.jpg	83C1-2223	83C1-2223	87,8955%
0048_01752_b.jpg	59L1-97457	59L1-97457	90,5304%	0333_05790_b.jpg	59F1-32210	59F1-32210	91,4495%
0049_04098_b.jpg	60B1-57122	60B1-57122	85,8478%	0359_05454_b.jpg	59T1-73281	59T1-73281	87,1390%
0049_04676_b.jpg	59P1-4118	59P1-4118	85,8802%	0418_05686_b.jpg	71S3-7611	71S3-7611	87,1647%
0051_00959_b.jpg	59V2-1023	59V2-1023	86,1682%	0421_07168_b.jpg	59H1-97580	59H1-97580	89,5140%
0053_01877_b.jpg	59X2-68327	59X2-68327	88,0266%	0421_08091_b.jpg	59C2-62872	59C2-62872	87,0480%
0054_00940_b.jpg	59L1-54063	59L1-54063	90,2823%	0427_06378_b.jpg	59D1-78262	59D1-78262	87,8714%
0054_04076_b.jpg	54X4-5969	54X4-5969	81,5500%	0429_05375_b.jpg	59H1-32122	59H1-32122	86,3970%
0054_05482_b.jpg	59S2-16555	59S2-16555	84,2548%	0444_06918_b.jpg	51F6-9090	51F6-9090	89,0390%
0054_05705_b.jpg	51L7-3998	51L7-3998	90,0487%	0450_06152_b.jpg	59H1-11811	59H1-11811	86,4252%
0054_06642_b.jpg	84G1-22393	84G1-22393	83,9821%	0459_07112_b.jpg	59B1-33872	59B1-33872	85,2884%
0055_01981_b.jpg	52P5-0334	52P5-0334	88,4624%	0500_01639_b.jpg	72H1-17359	72H1-17359	87,0040%
0101_07107_b.jpg	71S3-5011			0501_06978_b.jpg	59H1-52576	59H1-52576	87,7114%
0105_01594_b.jpg	59F1-49271	59F1-49271	88,3006%	0504_05562_b.jpg	54X8-2567	54X8-2567	89,7751%
0111_05692_b.jpg	59L1-77693	59L1-77693	89,0814%	0505_04350_b.jpg	59X1-69592	59X1-69592	82,1048%

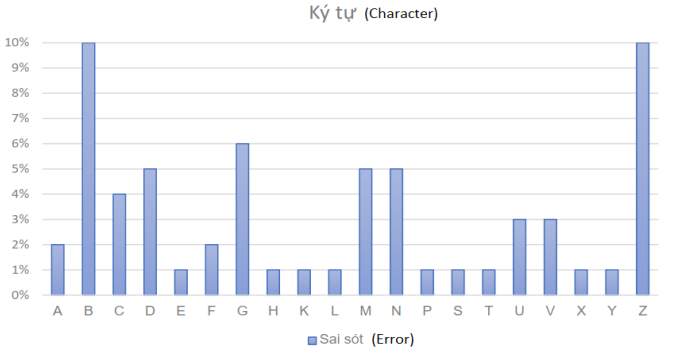

Fig. 12. Incorrect character recognition data

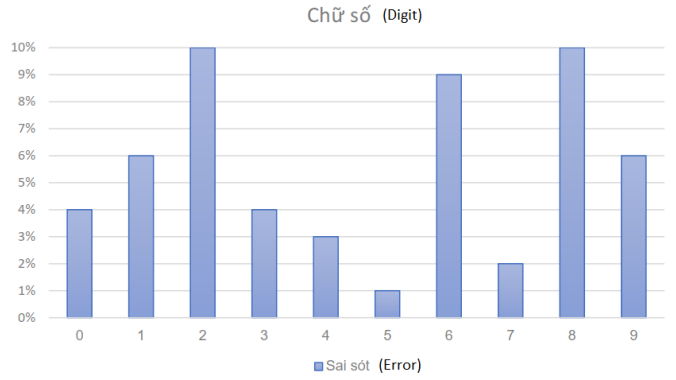

Fig. 13. incorrect digit recognition data

This paper has described a practical approach for constructing an OpenALPR-based license plate recognition system. The outcomes demonstrate that the system is highly accurate at recognizing objects and that it can be used on a variety of platforms to accommodate users' practical requirements.

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