Automatic Detection and Recognition of Thai Vehicle License Plate from CCTV Images

Wichan Thumthong
Faculty of Information Technology and Digital Innovation
King Mongkut's University of Technology North Bangkok
Bangkok, Thailand
wichan.t@mail.kmutnb.ac.th

Phayung Meesud
Faculty of Information Technology and Digital Innovation
King Mongkut's University of Technology North Bangkok
Bangkok, Thailand
pym@kmutnb.ac.th

Pita Jarupunphol
Department of Digital Technology
Phuket Rajabhat University
Phuket, Thailand
p.jarupunphol@pkru.ac.th

***Abstract*—Detection and recognition of Thai vehicle license plates is a challenging area of research. We propose an automatic detection and recognition system for Thai vehicle license plates using CCTV images. For system development, we performed three steps: 1) license plate detection, 2) character segmentation, and 3) character recognition. In step 1, we used YOLOv4 and TensorFlow models as a feature extraction method for Thai license plate detection from CCTV. In this step, we separated data into training and test sets, 3,000 images and 3,000 images, respectively. The dataset had two classes. The test results were with an accuracy of 96.20%. In step 2, we applied OpenCV for character segmentation, and we obtained an accuracy result of 98.40%. In step 3, we used the characters' points of interest for character recognition. In this step, we converted images into text using the Tesseract OCR engine. The results showed that the number recognition could reach an accuracy of 94.20%, while the Thai character recognition has an accuracy of 75.46%.**

Keywords—Deep Learning, Thai License Plate Detection, Thai License Plate Recognition

I. INTRODUCTION

New vehicles are registered every year, resulting in several issues associated with parking spaces, entering premises, vehicle security, and surveillance. A vehicle license plate is therefore required for vehicle identification and tracking. A vehicle license plate comprises letters and numbers. In some countries, the name of the province registered must also be included. Recently, automatic number plate recognition techniques have been implemented in many countries [1, 2, 3, 4, 5]. Each country has different typefaces making license plate recognition topics become challenging and engaging.

In Thailand, vehicle license plates are categorized according to the type of registered vehicle, such as passenger cars, pickup trucks, trucks, local agricultural vehicles, and public transport vehicles. These categories are identified by a group of Thai characters. Nevertheless, the license plates are frequently modified to prevent the plates from being detected. These modifications are often associated with malicious purposes. For instance, bypassing checkpoint, transporting drug, and delivering explosive devices.

Nowadays, CCTV has played a crucial role in transport security and crime prevention as it can count and identify the vehicle [6]. The vehicle's speed can also be detected from CCTV installed on the road [7]. The license plate characters can also be analyzed by CCTV for various purposes (e.g., security areas, vehicle tracking, and parking management). Therefore, this research aims to develop a system to detect and recognize Thai characters and numbers from Thai license plates from CCTV images, diagram is shown in Fig. 1.

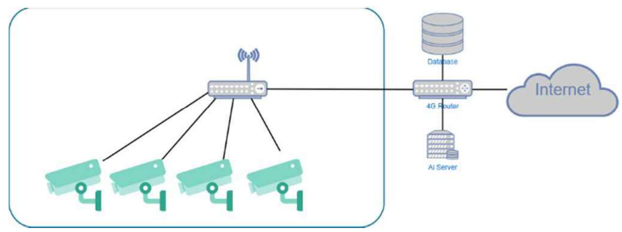

Fig. 1. Network diagram of this study

This research focuses on three stages to achieve the research objective, including license plate detection, character segmentation, and character recognition. Accordingly, related algorithms are developed in three stages, including detecting license plates from input images, segmenting the characters from the license plate, and recognizing Thai characters and numbers. The recognized characters and numbers will eventually be converted from image to data. All these three important stages after CCTV images have been acquired are displayed in Fig. 2.

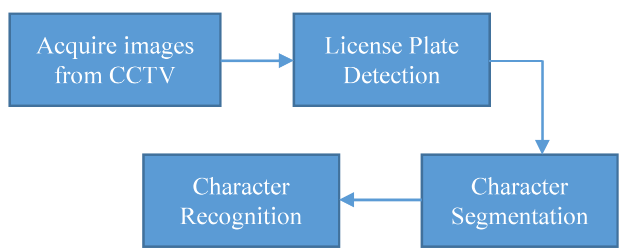

Fig. 2. All essential stages of this research

II. RELEATED WORK

This section reviews several algorithms that have recently been used for license plate detection and recognition in different countries. For example, Montazzolli and Jung [5] developed a real-time Brazilian license plate detection and recognition using deep convolutional neural network architectures. A publicly available dataset of Brazilian plates was utilized. The authors claimed that the system could detect and recognize all seven characters correctly. The segmentation of each character can reach an accuracy of 99%, and the recognition of the character has an accuracy of 93%.

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Laroca et al. [8] introduced a real-time automatic license plate recognition based on the YOLO detector. This research studies the detection and recognition of vehicle license plate numbers from video input data. At the first step, the plate numbers were detected using YOLOv2 and Fast-YOLO with 99% and 97.3% accuracy, respectively. The next step applied the CNN to segmentation and recognition of the character, with a recognition rate of 78.33% [8].

Agbemenu et al. [9] proposed an automatic license plate number recognition system using OpenCV and Tesseract OCR engines. The authors of this research used edge detection and feature detection techniques to locate the plate. The Tesseract OCR engine was used to identify the detected characters. The accuracy of license plate detection reached 90.8% and 60% for the plate number recognition.

Hendry and Chen [10] presented an automatic license plate recognition system via sliding window darknet YOLO Deep Learning and formed a tiny YOLO with 13 convolution layers. The plate number detection and recognition could reach 98.22% and 78% accuracy.

Setiyono et al. [11] presented a vehicle plate number recognition using YOLOv3 to automate the process of character and number identification from the license plate. The highest number plate recognition accuracy obtained 88%, and the character recognition accuracy was 98.2%.

In 2020 Alexey Bochkovskiy et al. presented about YOLOv4: Optimal Speed and Accuracy of Object Detection [14]. YOLO is an advanced model for multiple object detection that repurposes classifiers to perform detection. Can process images in real-time at ~65 FPS on Tesla V100. In YOLO various bounding boxes are used for predicting the output. In this research, the YOLOV4 method has been developed to identify a vehicle's license plate.

Based on the above reviews, most techniques utilize a combination of algorithms classified into three stages: 1) license plate detection (CNN [5], ANN, YOLO [8] [10], template matching [9] and edge detection [9]); 2) character segmentation (CNN [8], YOLO [10] [11] and OpenCV [9]); and 3) character recognition (CNN [8], YOLO [10] [11] and OCR Engine [9]). Therefore, this research proposes license plate detection from CCTV images using the YOLOv4 method for character segmentation, OpenCV for contour extraction, and Tesseract OCR engine for character recognition.

III. Methodology

Since license plate detection, Thai character and number recognition are the main research components of this work, the proposed system is composed of three main methodological steps below.

A. License Plate Detection

At this stage, YOLOv4 and TensorFlow models are used as feature extractor for Thai license plate detection from CCTV images.

1) License plate dataset: The dataset contains 300,000 vehicle images passing on the road. There were taken from CCTV cameras and traffic cameras installed on the highway from different angles and times.

Fig. 3. Vehicle license plate dataset

2) Data Annotation: In the labelling process, 3,000 vehicle images from the dataset were conducted for training. The vehicle license plate is manually labelled with a bounding box using Supervise.ly as shown in Fig.4 for labelling [11]. There are two classes corresponding to car and motorcycle license plates. This labelling process is also applied to other training datasets such as the Large-scale CompCar dataset [12], UFPR-ALPR dataset [8] to confirm the algorithm validity.

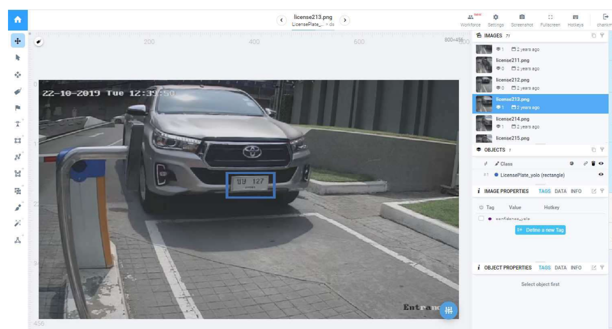

Fig. 4. License plate annotation with Supervise.ly

3) YOLOv4 Taining and Testing Model: YOLOv4 model were experimented on Google Colab using the training dataset of 3,000 vehicle license plate images with two classes to obtain YOLO weights for the license plate recognition process. During the testing process, about 1,500 images were collected to test the method accuracy. Fig. 5. shows the average loss and iteration of the model.

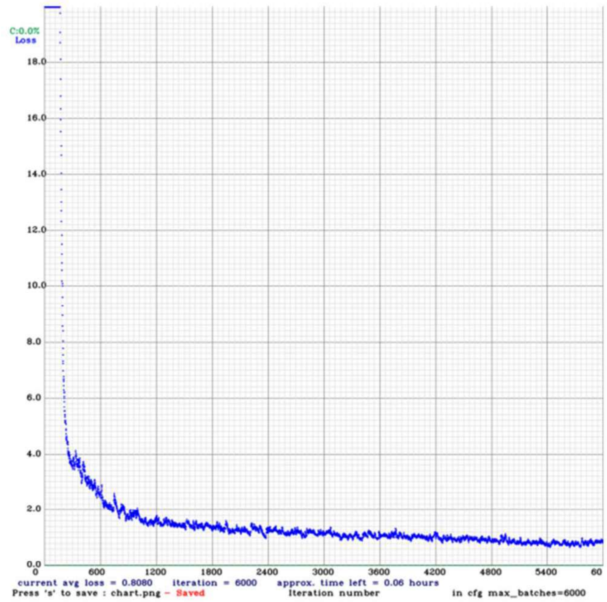

Fig. 5. Average loss and iteration of model

B. Character Segmentation

After the detection stage, the license plate image is cropped or 'segmented' with a bounding box coordinating from YOLOv4 as shown in Fig. 6.

Fig. 6. The bounding box coordinates from YOLOv4

The image will be cropped from the bounding box and resized using the OpenCV resize function, converting the image to grayscale. After that, the image is thresholded to white text and black background. Fig.7 illustrates the image converted to grayscale and thresholded.

Fig. 7. The grayscale and thresholded image of the license plate

After that, the system extracts Thai characters and numbers from the thresholded image for the character segmentation process using OpenCV to extract the contours from each character and number [13]. Fig.8 shows the cropped contour of Thai characters and numbers.

Fig. 8. The contours of Thai charecters and numbers extracted by OpenCV

After all of the contours have been identified, the contour of necessary characters within the license plate number must be selected. On the other hand, the unnecessary contours are filtered out using width, height, ratio parameters, and area of detected contour. Fig. 9 illustrates unnecessary contours that have been removed from the license plate.

Fig. 9. Filter out unwanted contours

C. Character Recognition

After the contours of selected Thai characters and numbers in the license plate have been extracted, they are passed on to the character recognition stage. At this stage, the images containing Thai characters and numbers of license plates will be retrieved from the contour using OpenCV, shown in Fig.10.

Fig. 10. Thai characters and number retrieved from the contours

The images retrieved from this stage are retrained. The Tesseract OCR engine converts the image from the license plate into text with 54 classes (Thai character 44 classes and number 10 classes). The Tesseract OCR engine is further applied to recognize the character. In this case, the output of this stage is text data converted from the license plate image.

After the conversion, the output text data of the detected license plate, including the image and location of CCTV cameras, will be stored on the web application using AngularJs for front-end and NodeJS with MySQL databases for back-end. The user interface of the web application containing detected license plates is shown in Fig. 11.

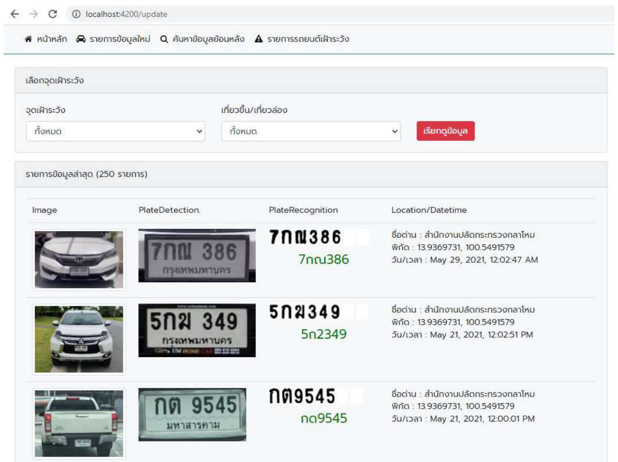

Fig. 11. Detail of vehicle license plates displayed on web application

IV. Result and Discussion

The experimental results are consistent with the research aims. Thai characters and numbers on the vehicle license plate can be detected using YOLOv4, OpenCV and Tesseract engine. A total of 500 images of different sizes, backgrounds, lights, distances and camera angles are used to test the system. The experimental results of this study are shown in Table 1.

All three stages represent more than 94% accuracy. The accuracy of license plate detection using YOLOv4 algorithms is 96.20% based on training 3,000 vehicle images. In particular, the accuracy of character segmentation using OpenCV is 98.40%, considered the highest accuracy. The accuracy of the number plate recognition phase using Tesseract engine is 94.20%. In terms of the Thai character recognition phase, however, the accuracy can be observed at 75.46%.

TABLE I. RESULTS OF THIS STUDY

Stages	**Results**		
	Phase	***Technique***	***Accuracy***
1	License Plate Detection	YOLOv4	96.20%
2	Character Segmentation	OpenCV	98.40%
3	Number Plate Recognition	Tesseract	94.20%
	Thai Character Recognition	Tesseract	75.46%

Based on the results, this system can be applied to different aspects of the smart transport system, such as parking management and traffic monitoring system in Thailand. This research is among the first stage of research regarding Thai license plate recognition. Although the accuracy of Thai character recognition is lower than others, experimenting on YOLOV4 algorithms or training algorithms with a new dataset may be optimistic for understanding and addressing this problem. In the next stage, the researchers will implement a system for main traffic road and compare Tesseract OCR with Object Detection algorithms to find the best accuracy for Thai characters recognition.

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