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Automated Data Digitization System for Vehicle Registration Certificates Using Google Cloud Vision API

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Abstract

This study aims to develop an automated data digitization system for the Thai vehicle registration certificate. It is the first system developed as a web service Application Programming Interface (API), which is essential for any enterprise to increase its business value. Currently, this system is available on "www.carjaidee.com". The system involves four steps: 1) an embedded frame aligns a document to be correctly recognised in the image acquisition step; 2) sharpening and brightness filtering techniques to enhance image quality are applied in the pre-processing step; 3) the Google Cloud Vision API receives a prompt to proceed in the recognition step; 4) a specific domain dictionary to improve accuracy rate is developed for the post-processing step. This study defines 92 images for the experiment by counting the correct words and terms from the output. The findings suggest that the proposed method, which had an average accuracy of 93.28%, was significantly more accurate than the original method using only the Google Cloud Vision API. However, the system is limited because the dictionaries cannot automatically recognise a new word. In the future, we will explore solutions to this problem using natural language processing techniques.

Keywords: Thai Vehicle Registration Certificates; Optical Character Recognition; Google Cloud Vision; Service; API; Transportation.

1. Introduction

The world is now being rapidly driven into the digital era. Digital technology influences every aspect of human life, including business, education, health, and government. This rapid change has forced many public and private organizations to digitize their work processes [1, 2]. In this transformation, digitization is an essential process for converting analogue or physical data such as photos, documents, or books into digital data [3]. The benefits of digitizing include quick access to information and data accessibility at any place or time. In addition, unlimited data storage and retrieval is possible, leading to increased resolution and accuracy and reductions in duplicative work and costs.

Regarding document digitization, organizations must digitize documents containing crucial information to simplify automated processing and improve the quality of their services. Several automatic tools have been developed to support an organization's needs in various areas, such as civil [4], environmental [5], medicine [6, 7], travel [8], and finance [9, 10]. Additionally, Google Cloud Vision is potentially one of the most widely used cloud services and is presently used in applications such as autonomous vehicles [11], visually impaired applications [12], and content-based image retrieval [13].

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Many studies in Thailand have focused on applying optical character recognition (OCR) [14, 15] or machine learning technology [16]; however, findings demonstrate that Thai character recognition is still less effective than that of English characters. Somboonsak [17] found detecting new words that were not in the dictionary and adding new words to the dictionary difficult. Chomphuwiset [16] identified problems with memorizing two Thai words that combine into one word, indentation, and space and considered developing post-processing techniques to solve this problem in the future. Mookdarsanit & Mookdarsanit [15] found homophones, slang, and image noise problems. These problems led to a comparative study of practical tools in Thai language recognition. The study compared Google Cloud Vision and Tesseract OCR, which are commercial and non-commercial tools [18], respectively. Results indicated that the Google Cloud Vision API recognized Thai characters with an efficiency of 84.43%. The quality of preprocessed documents using adjustment and sharpening techniques improved with an increased efficiency at 88.90%. However, consistent with other studies, this study found problems with Thai character recognition such as watermarks on documents, significant noise, image size, and sharpness.

Therefore, this study focuses on improving the efficiency of Thai character recognition based on a previous study by Thammarak et al. [18], which used the Google Cloud Vision API and adjustment and Sharpening techniques. Presently, improved post-processing efficiency is the focus, including developing the whole process into an automated document extraction system to benefit multiple profit and non-profit organizations. The carjaidee.com platform, a private organization, was involved in the study. As a local startup in Thailand, this platform was created to develop an SME business, provide efficient car maintenance services, and reach consumers in the digital age. Here, the platform invoked an automated data digitization system to increase customer convenience when they enter their car profile. The details are presented in three sections: a literature review, the four steps of the proposed method, and the results and discussion, including the conclusions and proposed future work.

2. Literature Review

Digitization is a broad topic in modern society and has widespread use because of environmental motives, cost reduction, availability of new technology, and even the preservation of a corporate image [19]. As dematerialization is available in many forms, our study discusses the development of an automated system for digitizing document data and improving pre-existing techniques. Many studies have focused on applying OCR or machine learning technology, and through modern research, an automated system with commercial cloud services, such as Tesseract, Google Cloud Vision, and Huawei Cloud OCR, has been developed. Sugadev et al. [11] applied Google Cloud Vision to identify obstacles for rough-terrain autonomous robots. Putra et al. [6] presented a web and mobile application for people with limited knowledge of medical images or no medical expertise. Moreover, this technology has been increasingly applied in mobile financial applications [20], visual landscape assessment [21], and the generation of pharmaceutical drug labels [22]. In addition, it has been popular in developing tools for many languages, both English and foreign, as presented in Table 1.

Table 1. Available digitization methods in various languages

Source Format	Language	Method	Accuracy (%)	Reference
General Document	Hindi	Google Cloud Vision OCR	100.00	Vaithiyanathan & Muniraj [12]
	English	Gray Scaling/ Binarization/ Tesseract OCR	99.00	Zaki et al. [23]
	Bangla	Tesseract OCR, Raspberry Pi, Google's Text-to-Speech Application	97.40	Rajbongshi et al. [24]
	Thai	Hierarchical Cross-Correlation ARTMAP	82.42	Thammano & Duangphasuk [25]
		Google Cloud Vision OCR	75.38	Chumwatana & Rattana-Umnuaychai [14]
		Thai Character Clusters (TCC), Longest Matching, Maximum Matching, Left and Right Conditional Probability, and Feature-Based Approach	86.51	Somboonsak [17]
Book	English	Google Cloud Vision OCR	97.00	Arief et al. [26]
Form-Financial	German	RNN+CRF	99.00	Biesner et al. [27]
Form-Banking Transaction	English	OCR, NER System	91.84	Sahin et al. [28]
Form- Business	English	OCR, Google Cloud Vision, Tesseract, Approximate and Exact String Matching, Index Pairing	90.06	de Jager & Nel [29]

The most widely used potential cloud service is Google cloud vision API. A Google Cloud platform leverages technology capabilities to facilitate image analysis using machine learning [30]. As presented in Figure 1, the cloud function is executed when a user uploads an original image to the cloud storage. The API extracts the image from the storage and sends an output stream to the Pub/Sub service. The cloud function then calls the translation API to translate the output stream and sends the results to the cloud storage for standby use. Other features of Google Cloud Vision were defined in the research of Hosseini et al. [31] and Kaur & Veer [32]. In Thailand, Google Cloud Vision has been used widely for many purposes such as in bus route number readers [33] and guiding foreign visitors [34].

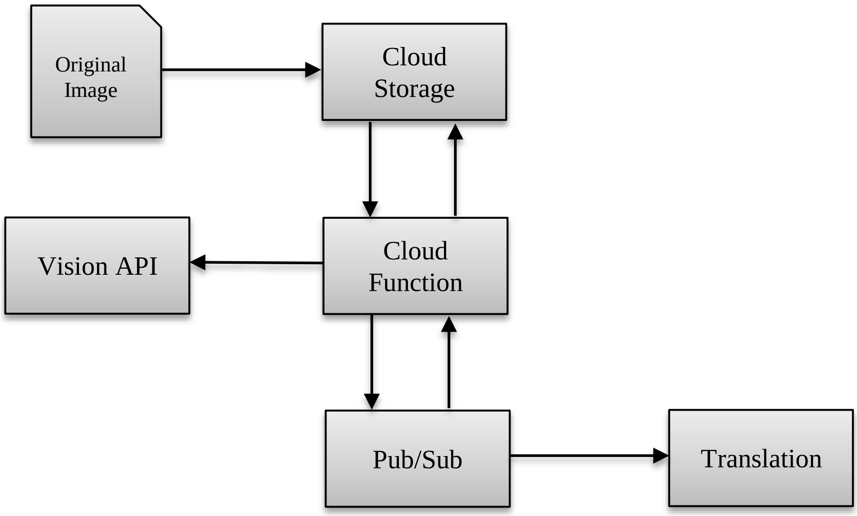


Figure 1. Google Cloud Vision API architecture

The Thai language consists of forty-four letters, twenty-one vowels, thirty-two sounds, and four tone marks. The letters can be classified into five types: Head-in (ฌ ญ ฒ ณ ค ต ถ ผ ฝ ย ล ว ส อ ฮ), Head-out (จ ฉ ฎ ฏ ฐ ท น บ ป พ ฟ ภ ม ร ษ ห ฬ), Double head or Broken head (ข ช ฆ ฑ), and Headless (ก ธ). Moreover, Thai text can be divided into three parts, namely letters, vowels, and tones, with each part on one of three lines. For example, Figure 2 shows a Thai word consisting of letters, vowels, and tones, where the top, bottom, and middle lines contain the tones (่), vowels (ู), and letters (อย), respectively.

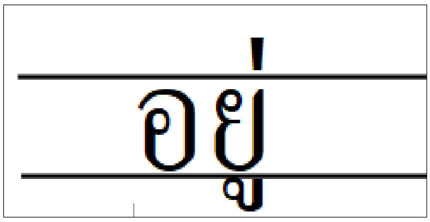


Figure 2. Example of a Thai word with three elements: letters, vowel, and tones

The Thai language is more challenging to understand than the English language because it does not have a symbol for ending sentences like English has with the full stop (.) Furthermore, differences in the translation order and spacing of the letters usually contribute to the errors made by tools that are used to recognise Thai characters from images or documents. Thai character recognition has also been studied using various techniques. For example, Chumwatana and Rattana-Umnuaychai [14] proposed OCR technology to recognise Thai text from a physical document in a digital format. Mookdarsanit & Mookdarsanit [15] presented a combination of hate speech in Thai text memes using Thai OCR. Furthermore, Chomphuwiset [16] presented a technique for recognising printed Thai characters using a feature-based technique and a convolutional neural network (CNN). Other related studies have also found techniques to improve the accuracy of Thai character recognition such as using string matching [35], histogram of gradients (HOG) [36, 37], color layout descriptors [36], normalised correlation coefficients [36], and circular-scan histograms [38]. Regarding the level of accuracy, available techniques for Thai character recognition from images have an accuracy rate of 75–98%; Chomphuwiset [16] applied his method to actual cases, achieving an accuracy of 98.00%. Thammano & Duangphasuk [25] used a technique to recognise both the Thai sign and car license plate, producing an accuracy of 82.42%.

However, this trend has increased rapidly over the years, and there are limitations in the quality of the input data and character formatting. Thammarak et al. [18] found that many factors reduced the efficiency of the character recognition tool such as small text, watermarks, file size and resolution, darkness, brightness, blurriness, wrinkles, and improperly positioned images. In several studies, techniques and methods to increase both the efficiency of the tool and pre-processing and post-processing steps have been applied. Pre-processing the image aims to improve the chances of successful recognition [39]. For example, Vaithiyanathan & Muniraj [12] applied binarization thinning and skewness correction to improve the image quality. Kaothanthong et al. [38] applied the circular-scan histogram to improve Thai OCR. Jirattitichareon & Chalidabhongse [40] used a Gaussian mixture model for the detection and segmentation of text in low-quality Thai sign images. In addition, Kraisin & Kaothanthong [37] applied the HOG feature descriptor to improve the accuracy of provincial name recognition on a Thai license plate.

Alternatively, post-processing involves data-cleaning steps for digitised documents. According to the human dependence level, Nguyen et al. [41] grouped existing techniques into manual, semi-automatic, and automatic. Khosrobeigi et al. [42] applied a context-based post-processing technique to improve Persian OCR performance and increased accuracy by 93%. Aliwy and Al-Sadawi [43] aimed to reduce noise in character recognition by using the combined text of corpus files. In addition, they constructed a dictionary and N-gram language model for detecting and correcting errors at the post-processing step, and results improved up to 98%. Somboonsak [17] used the longest matching, maximum matching, left and right conditional probabilities, and a feature-based approach to create an application for correcting Thai grammatical errors. Kesorn & Phawapoothayanchai [35] enhanced the performance of OCR using an approximate string-matching technique.

3. Proposed Method

The automated digitization system comprises four steps: image acquisition, pre-processing, recognition, and post-processing. In image acquisition, a camera captures the physical document, and then the image quality is improved at the pre-processing step. Subsequently, the system calls the Google Cloud Vision API to digitise the digital data. The output from the previous step is detected, and any error is corrected using the post-processing technique, as presented in Figure 3.

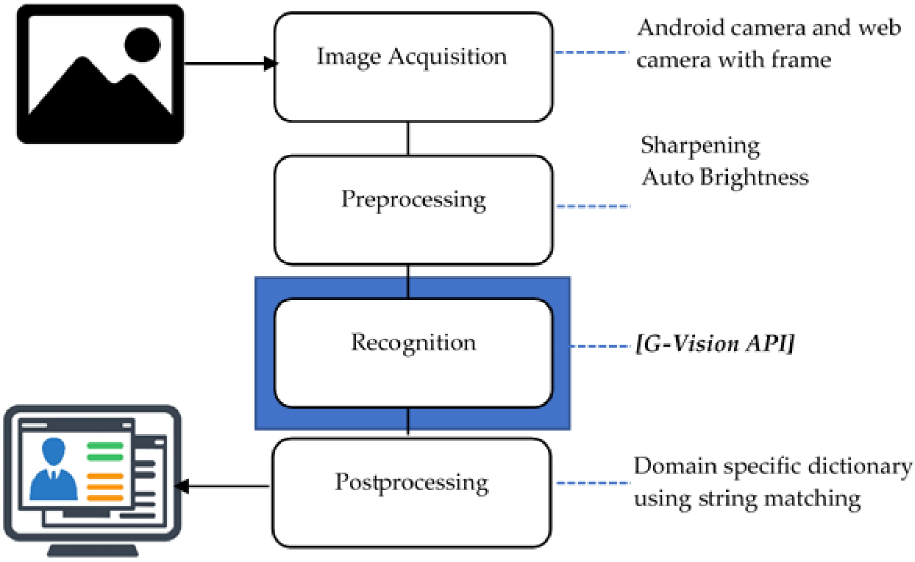
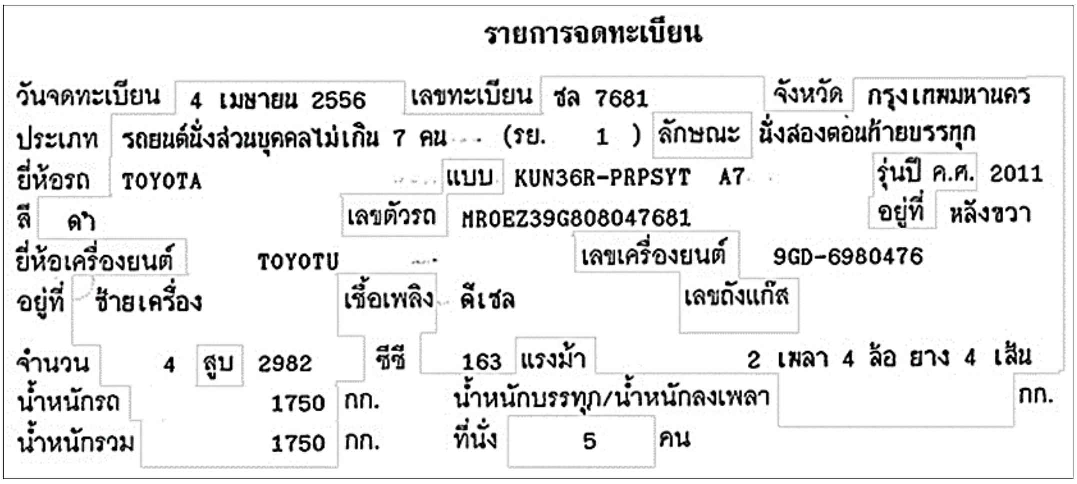


Figure 3. Framework of the proposed method

In the first step, the method creates a camera frame to align the image position, which can deteriorate the recognition performance of the tool. The camera frame is a marker for the user to place the vehicle registration certificates [44] in the specified field before taking a picture to prevent skewed or misaligned images, as presented in Figures 4 and 5. The proposed method defines 28 markers according to the Thai vehicle registration certificate label such as register date, license plate, and province (Figure 4).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น้ำหนักรวม 1750 กก. ที่นั่ง 5 คน

Figure 4. Camera frame to correct a skewed image

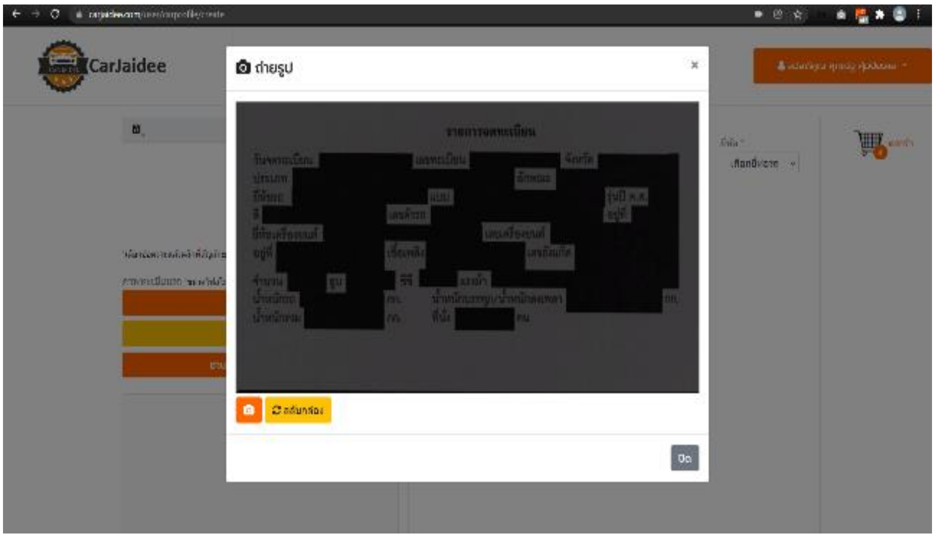
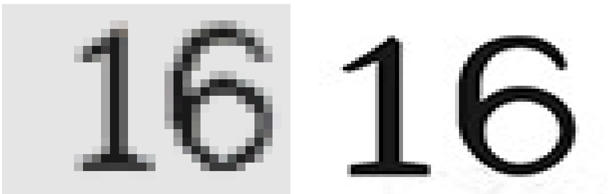


Figure 5. Screen for taking the picture

In previous studies [18], sharpening and brightness adjustment techniques were found to be appropriate for enhancing image quality before processing. Therefore, the above two techniques are combined in the pre-processing step to enhance image quality before sending it to the next step. This combined method uses a 3×3 kernel size and -255 and 255 brightness ratios. Figure 6 shows that after the pre-processing step, the image's quality has higher sharpness and brightness than the original image. After that, the system will call the Google Cloud Vision API, which we developed as the caller mechanism using PHP 7.0. The system is computed on an Intel Core i7-0750H CPU 16 GB (8GBX2) DDR4 and NVIDIA GEFORCE RTX 2060 platform.



(a) (b)

Figure 6. Sample image using enhancement technique. (a) Sample image before applying the technique and (b) improved image after applying the technique

After the recognition step, the Google cloud vision API produced a word stream readable from the original image. This word stream will be introduced into a mechanism to improve accuracy in the post-processing step, as presented in Figure 7.

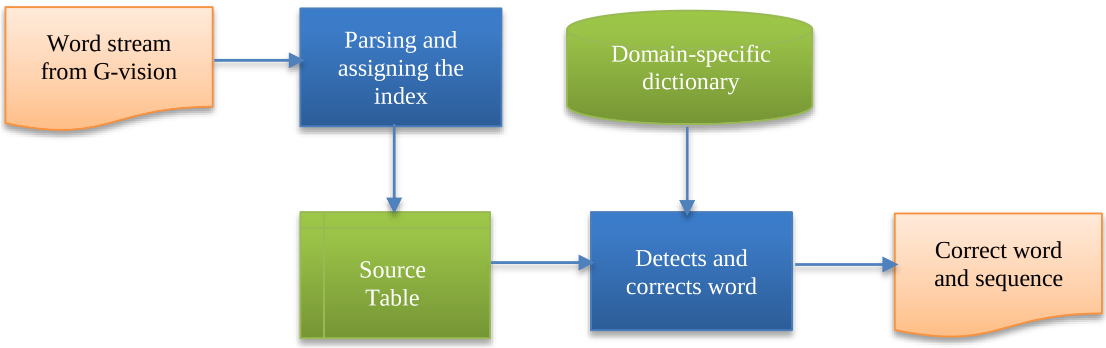


Figure 7. The post-processing workflow for improving the result accuracy after the recognition step

This proposed method starts its workflow by parsing the word stream into a word, assigning an index to indicate the order for each word, and then saving them to the source table. Next, the system queries data from the domain-specific dictionary and related table for detecting and correcting the incorrect word in the source table using a string-matching algorithm and producing the output as a list of correct words and their sequence. A domain-specific dictionary contains the domain-specific words, word's index, prefix word index, and postfix word index, as presented in Figure 8. Another related table is the car's model, brand, year of manufacture, and a specific word on the Thai vehicle registration certificate of about 1,833 words. Simultaneously, the string matching algorithm, an indexing method, pre-processes the text. This study defined the matching accuracy as 85%.

```php
function merge_array($arrStr){
    $str = "";
    foreach ($arrStr as $k => $v) {
        $str .= $v." ";
    }
    return $str;
}

function getTextArray($arrStr){

    $result = [ ···
    ];

    $template = [
        "วันจดทะเบียน", "เลขทะเบียน", "จังหวัด", "ประเภท", "ลักษณะ", "ยี่ห้อรถ", "แบบ", "รุ่นปี", "สี",
        "เลขตัวรถ", "อยู่ที่", "ยี่ห้อเครื่องยนต์", "เลขเครื่องยนต์", "อยู่ที่", "เชื้อเพลิง", "เลขถังแก๊ส",
        "จำนวน", "สูบ", "ซีซี", "แรงม้า", "น้ำหนักรถ", "น้ำหนักบรรทุก", "น้ำหนักรวม", "ที่นั่ง"
    ];

    foreach ($template as $k => $v) {
        $s_index = array_search($v, $arrStr);
        $e_index = 0;
        if($s_index){
            for ($i=$s_index+1; $i < count($arrStr); $i++) {
                if(in_array($arrStr[$i],$template)){
                    $e_index = $i-1;
                    break;
                }
            }

            for ($i=$s_index+1; $i <= $e_index; $i++) {
                $result[$k] .= $arrStr[$i]." ";
            }
        }
    }
    return $result;
}
```

Figure 8. Domain-specific dictionary and string-matching function

The final result is presented in Figure 9. The right panel presents the test image, and the left panel shows the incorrect word, correct word, index, and accuracy rate.

Google Vision

คำ	dictionary	index	เปอร์เซนใกล้เคียง
รายการจดทะเบียน	รายการจดทะเบียน	0	100%
วันจดทะเบียน	วันจดทะเบียน	1	100%
มกราคม	มกราคม	72	100%
เลขทะเบียน	เลขทะเบียน	265	100%
จังหวัด	จังหวัด	95	100%
นครศรีธรรมราช	นครศรีธรรมราช	209	100%
ประเภท	ประเภท	3	100%
รถยนต์บรรทุกส่วนบุคคล	รถยนต์บรรทุกส่วนบุคคล	4	100%
ยี่ห้อรถ	ยี่ห้อรถ	20	100%

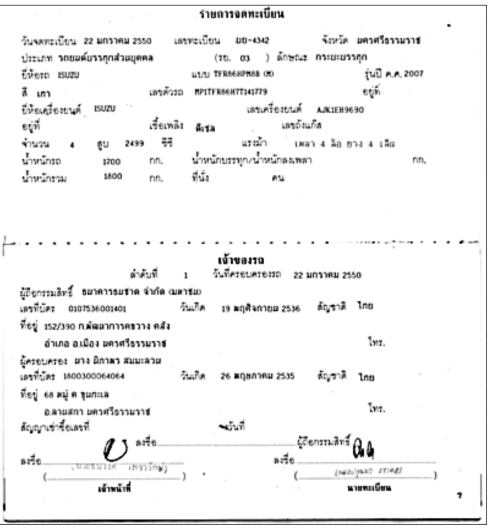


Figure 9. Result of the post-processing step when using a domain-specific dictionary and the string matching algorithm

In the auto mapping step, presented in Figure 10, the corrected word is automatically mapped to the desired field with four items: car brand, model, year, and registration number. The system also provides a manual selection service. This service allows users to select the desired word manually, and each word is assigned a different color to map it to the corresponding form.

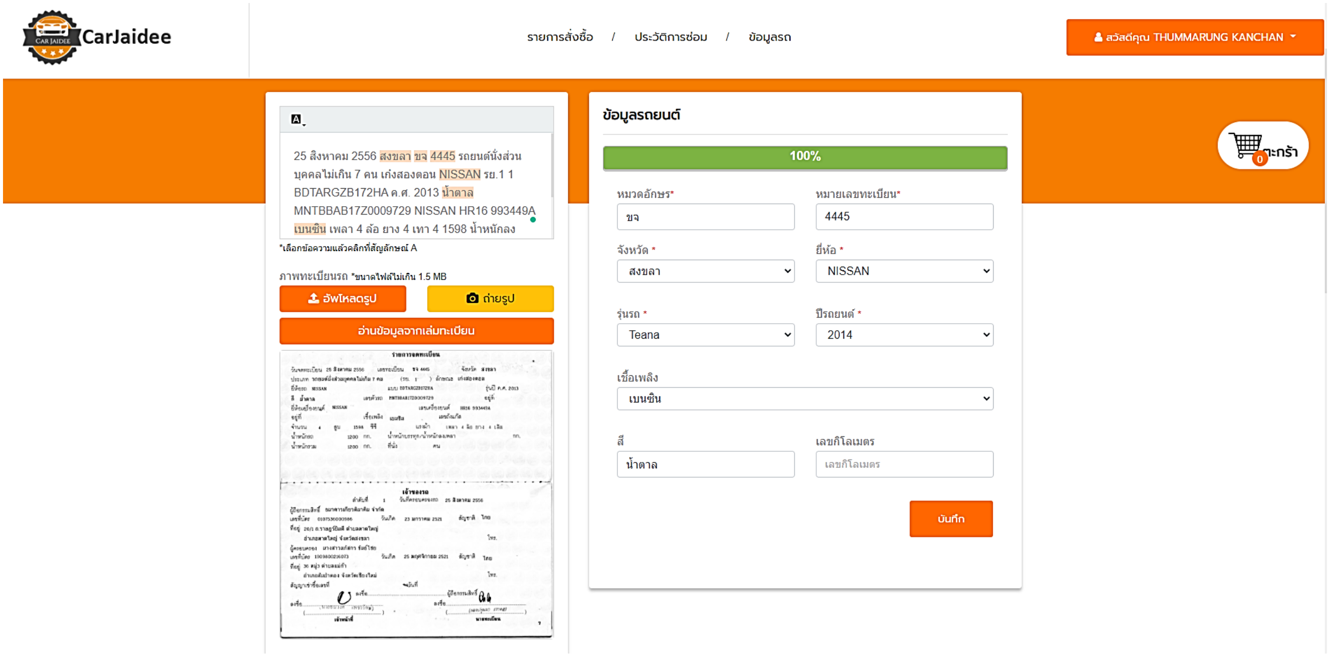


Figure 10. Examples of actual use on www.carjaidee.com

Additionally, this study provides a system as a service API for execution by other programs, which can be called from:

Endpoint: https://carjaidee.com/ocr/g_ocr.php
Method: POST
Request:

```
        Data : { "image64": "data:image/png;base64,iVBORw0KGgo…"}
        Content-Type: application/json
Response:
        result[0] = Register date            result[1] = Licence Plate
Number  result[2] = Province
        result[3] = Usage Type        result[4] = Feature
        result[5] = Vehicle Name            result[6] = Model
        result[7] = Version
        result[8] = Color             result[9] = Body Number
        result[10] = Address of Body Number       result[11] = Brand
        result[12] = Enging Number    result[13] = Address of Enging
Number        result        [14] = Fuel        result[15] = Gas Number
        result[16] = No. pump         result[17] = CC
        result[18] = Horsepower
        result[19] = Vehicle weight   result[20] = Payload
        result[21] = Total weight
        result[22] = Seat
```

The other program can call the service at the endpoint using the POST method from the above service description. The service requires an image as input, and the output is 22 parameters containing the results exploited for processing such as License plate number, Province, Brand, Model, CC, and Horsepower.

4. Results and Discussion

4.1. Experimental Results

This study defines 46 high-quality images with an image resolution of 300 dpi or an image size greater than or equal to 1024×768 px and 46 standard-quality images with an image resolution of 120 dpi or below or an image size of 640×480 px. Moreover, this study defines 16 damaged images (with different characteristics), including low-brightness or dark images, images with blurs or glares, and improperly positioned images, to check the system performance. We counted the words and specific terms on the Thai vehicle registration certificate and compared the accuracy of the proposed and existing methods, as presented in Table 2.

Table 2. Comparison of accuracy among the original Google Cloud Vision method, preprocessing using sharpening+brightness, and the proposed method

Categories	Accuracy		
	Original Google Cloud Vision method (%) [18]	**Pre-processing using sharpening+brightness (%) [18]**	**Proposed method with Pre+Post processing using domain-specific dictionary (%)**
Image size/resolution			
Large size/high resolution	97.95	96.87	99.33
Standard size/medium resolution	80.29	84.89	87.23
Average	**89.12**	**90.88**	**93.28**
Image characteristics			
Low brightness image	72.44	84.09	84.73
blurs or glares image	55.19	68.69	70.37
Improperly positioned image	83.15	81.21	86.74
Average	**70.26**	**77.99**	**80.61**

As Table 2 indicates, with an accuracy of 99.33% for high-quality images and 87.23% for standard-quality images, the proposed method was significantly more accurate than the original method, which used Google Cloud Vision. In addition, the overall accuracy was 93.28%. Given the image characteristics, the proposed method was more effective than the original method. The proposed method had the highest accuracy rate for recognising the low-brightness images at 84.73%. For the images with blurs or glares, the accuracy was 70.37%.

However, the proposed method provided a high recognition rate for improperly positioned images at 81.21%. Regarding the performances of 1) the original Google Cloud Vision method, 2) Google Cloud Vision + pre-processing, and 3) Google Cloud Vision + pre-processing + post-processing (proposed method), the original Google Cloud Vision method had an average accuracy of 84.43% for exact matches of the words. When the system added the pre-processing technique, the accuracy increased to 90.88%. After applying the string matching technique using a domain-specific dictionary in the post-processing step, the accuracy further increased to 93.28% indicating that the system could find the exact matches of the words better, as presented in Table 2.

4.2. Discussion

The aforementioned findings demonstrated efficiency and usability in real-world environments. The method presented at each step contributes to better recognition of Thai characters in Thai vehicle registration certificates. In the image acquisition step, the development of the image frame contributes to the alignment of the document's position to reduce skewed or misaligned images often causing character recognition errors. As presented in Table 2, the proposed method with skewed or misaligned images has an accuracy of 86.74%, which is 83.15% higher than the original Google Cloud Vision API. The proposed method can enhance the quality of these images with sharpening and brightness filter techniques for the low brightness and the blurred images. This improved accuracy compared to only using the original Google Cloud Vision API approach by 12.29% when tested on low-brightness images and 15.17% on blurred images. Another highlight of this study is the design and development of the domain-specific dictionary using a string-matching algorithm to detect and correct the incorrect word at the post-processing step. This method improves overall character recognition accuracy by 93.28%.

After examining the results obtained from 46 high-resolution images used in the experiment, seven images contained incorrect words, which are all Thai words. Concurrently, numbers and English words did not result in any errors. It is consistent with other studies such as Vaithiyanathan & Muniraj [12], Zaki et al. [23] and Thammarak et al. [18]. In addition, Thai characters that often result in error include headless characters, such as ก and ธ, and letters with slightly different shapes, such as ค and ด- and ฎ and ฏ, which is consistent with the study of Somboonsak [17], Mookdarsanit & Mookdarsanit [15] and Thammarak et al. [18].

Compared with the other studies, this study ranked sixth among eleven highly efficient articles in Table 1. In contrast, the first rank is the study of Vaithiyanathan and Muniraj [12], which implemented a SMART book reader using the Google Cloud Vision API in the Hindi language. However, the proposed method was the most effective in Thai character recognition, especially when compared with that of Chumwatana & Rattana-Umnuaychai [14], which also applies the Google Cloud Vision API. When considering the type of source format, the proposed method is the best to use in the form format, especially compared to the system developed by de Jager et al. [29] that also applies the Google Cloud Vision method and the approximate and exact string matching and index pairing methods for a business form. However, the proposed method produced a decreased accuracy compared to Arief et al. [26], which used Google Cloud Vision to extract large-scale scanned documents. Consistent with results from previous studies, conversions of English documents provided higher accuracy than other language documents [17].

This study developed an automated digitization system as a Web Service API, which is a programming approach that allows other organizations to use it for further development. Currently, the system is used on the carjaidee.com platform for both car repairs and servicing spare parts. The study was conducted to facilitate customers' entering the vehicle registration data into the database. A user satisfaction survey of 100 customers who used the service at carjaidee.com found that the system had an average usability satisfaction score of 4.31 out of 5.00.

Vehicle registration certificates help in solving car-related crimes and can be used to increase business value. This study is an implementation allowing organizations to access information easily and quickly through Web service API calls. Therefore, here, we expect improvement in the system's efficiency through accuracy and expansion to support the demand from users in other organizations, such as government agencies, private sectors, or any non-profit organizations, by helping to promote the utilization of vehicle registration information that can prevent car-related crimes and increase business value.

However, this study has a few limitations. For example, the most incorrect classification of Thai letters is without head letters such as ก and ธ. The post-processing step works well with well-formed documents such as ID cards, passports, and invoices. However, it does not fit with books or textbooks. In addition, the domain-specific dictionaries still rely on human interactions and cannot automatically learn new words.

5. Conclusion

This study develops an automated digitization system for Thai vehicles as a Web Service API. This study employs the result of a previous study, which indicated that Google Cloud Vision API outperformed Tesseract OCR for Thai character recognition in Thai vehicle registration certificates. Sharpening and brightness adjustment techniques used in the pre-processing step are also employed to enhance the image quality. Furthermore, in the final step, a domain-specific dictionary and string matching algorithm to detect and correct are used to improve the accuracy of the automated digitization system. However, the proposed method produces significantly greater accuracy, 99.33% for high-quality images and 87.23% for standard-quality images, than the previous study. In addition, the presented methods are now implemented in the carjaidee.com platform to facilitate the automated digitization of vehicle profile data, which is specified in the Thai vehicle registration certificates, accurately and rapidly. Since the automatic digitization system is created in the form of a web service API, other applications may invoke this API for the vehicle information digitization services. The results suggest that the adoption of the Google Cloud Vision API in the automated digitization system of vehicle profiles is beneficial for increasing speed and accuracy and reducing operating costs pertaining to widespread digitization applications. However, the limitation of this system is the number of words used in domain-specific dictionaries; therefore, natural language processing techniques must be implemented for the automatic addition of new words in the future.

6. Declarations

6.1. Author Contributions

Conceptualization, K.T., Y.S. and S.I.; methodology, K.T., and Y.S.; software, P.K.; validation, Y.S., S.I., P.K., and K.T.; formal analysis, K.T., and Y.S.; investigation, K.T.; resources, K.T.; data curation, K.T.; writing—original draft preparation, K.T., and Y.S.; writing—review and editing, K.T., Y.S., and S.I.; visualization, K.T.; supervision, K.T.; project administration, K.T.; funding acquisition, K.T. All authors have read and agreed to the published version of the manuscript.

6.2. Data Availability Statement

The data presented in this study are available in the article.

6.3. Funding

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6.5. Conflicts of Interest

The authors declare no conflict of interest.

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