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Segmentation of Korean Words on Korean Road Signs

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***Abstract*—**This paper introduces an effective method of segmenting Korean text (place names in Korean) from a Korean road sign image. A Korean advanced directional road sign is composed of several types of visual information such as arrows, place names in Korean and English, and route numbers. Automatic classification of the visual information and extraction of Korean place names from the road sign images make it possible to avoid a lot of manual inputs to a database system for management of road signs nationwide. We propose a series of problem-specific heuristics that correctly segments Korean place names, which is the most crucial information, from the other information by leaving out non-text information effectively. The experimental results with a dataset of 368 road sign images show 96% of the detection rate per Korean place name and 84% per road sign image.

***Keywords*—**Segmentation, road signs, characters, classification.

I. Introduction

ROAD signs are a class of traffic facilities that gives instructions or provides information to road users. An advanced directional road sign in an urban area in Korea is composed of visual information such as arrows, place names in Korean and English, route numbers, and distance advanced, as shown in Fig. 1. A new place name is occasionally added or old one is erased or replaced as a new one when a road is opened or the road circumstances are changed. The change of place names, which happens all over the nation irregularly, has been inputted manually into a database system that manages information of road signs nationwide [1]. A new management system is under development that enables to make the update process efficiently and on-line. The system is supposed to update the place names changed upon reception of a picture that has been taken on the spot to capture a road sign changed. To accomplish this, the management system should be able to detect and recognize place names from a road sign image. Commercial optical character recognition (OCR) software, however, fails to detect and recognize the text information correctly because the place names are mixed with non-text information as well as their layout is completely different from usual documents [2]. Hence, a domain-specific solution that detects and recognizes place names from a road sign image is required as a crucial component of the management system. Segmentation of place names from a road sign image is a primary step before the recognition since the text is seldom recognized successfully on a whole image. For the correct segmentation, other symbol-type information such as arrows and bounding boxes than text blobs are removed beforehand. Then, text blocks constituting of place names are constructed by grouping the text blobs appropriately so that Korean place names are finally segmented from the image by locating text blocks containing Korean text only.

There has been much research on detection of traffic signs [3], but not on this topic, to our knowledge. Wu et al. presented a complete framework for localizing road signs from video and detecting text on the road signs based on spatio-temporal information [4]. Vavilin and Jo attempted to detect a road sign from an input image in real time based on color and shape of road signs [5]. For text detection on road signs, Ha introduced problem-tailored heuristics to correctly categorize the content on a road sign by utilizing relative differences of geometric features of text and symbols [6]. Soetedjo et al. also presented a color-based heuristics to extract text information on Japan road signs [7]. Gonzalez et al. introduced a domain-tailored method for detecting and recognizing English text on road signs [8], [9].

In this paper, we present an effective method of the segmentation of Korean place names from a road sign image based on problem-specific heuristics. To our knowledge, the method suggested here achieves higher performance than the few attempts that have been made earlier in Korea. This work also differs from previous ones in that it has been evaluated on a large-scale. The remainder of this paper is organized as follows. Section II introduces road signs in Korea, and the proposed method for segmentation of Korean place names is described in detail in Section III. Section IV discusses experimental results and conclusion is made in Section V.

II. Road Signs in Korea

Fig. 1 shows a road sign in Korea that says 3-way advanced direction information. Road signs in Korea are rectangular with white text and dark green or blue backgrounds. The road signs have four categories of information, depending on sign types:

- Place name. It is written in both Korean and English. Korean one appears first in the left-to-right and top-to-bottom patterns. Tourist attraction such as national park is highlighted by enclosing it with a different-colored rectangle.
- Road number. It is enclosed by oval-shaped symbols and is positioned to the left or above the corresponding place name.
- Direction arrow. It is positioned at the center of the sign and may be overlapped with a box/circle having a road number.
- Distance. It is located at the bottom of the direction arrow.

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Fig. 1 A road sign in Korea

Typical processes of pattern matching should be made to extract the desired information from a road sign image. For an example of Fig. 1, the information that we want to collect eventually is shown in Fig. 2. It should be emphasized that place names in Korean (hereinafter, Korean words) should be segmented correctly to make the Korean words be recognized at the later step by an optical character recognition (OCR) algorithm.

STRAIGHT: "평택", road no. #45

LEFT: "아산", road no. #39

RIGHT: "현충사"

Fig. 2 The desired information for road sign of Fig. 1

III. Segmentation of the Korean Words

It is the first step to locate and classify the information of a road sign into groups of place names, direction arrows, and digits (road numbers and distances). The flowchart of the step is as shown in Fig. 3. Given a road sign image, stroke width transform (SWT) [10], which is a well-known algorithm for text detection from natural images, is performed to categorize the content from the image after grayscale conversion. Combined with heuristics based on blobs' width and stroke width information, it was demonstrated in [11] that SWT is more effective than heuristics based on shape information such as size and area in [6] in dividing blobs into two classes of text and non-text. Then, after some filtering, the text blobs are grouped into a Korean character or just assigned to text blocks without grouping, each corresponding to a place name either in Korean or in English. Each text block is examined if it contains Korean or English character and blocks having Korean words are finally segmented from the image.

A. Finding Korean Words with Geometric Templates

Given text blobs, it is not simple to distinguish Korean letter blobs from English letter ones. There have been studies [6] that adopt heuristics utilizing different geometric features of Korean and English characters such as their sizes and heights, as well as relative locations in a road sign layout. The size information is not enough even though Korean text is written larger than English one in size (height and width). To find Korean character blob correctly, two distinct methods were implemented and evaluated. One is to use the geometric pattern templates of Korean characters of Fig. 4. Unlike English characters, a Korean character consists of two or more letters. It is determined whether each text blob is Korean one or English one by matching both it and its neighboring blobs with the six geometric templates. The height and width of each blob, the spacing between neighboring text blobs, and the relative positions are considered when the matching process in which all of the information are checked if they are satisfied with predetermined thresholds of the templates. In practice, it happens not infrequently that Korean letter blobs are connected to each other in low-resolution images. Hence, the matching procedure has been tuned to deal with the cases of connecting text blobs. A single Korean character candidate is constructed during the template matching process. Then, a Korean word is finally detected by concatenating the character candidates that have similar heights and widths and are also adjacent to each other on the same text line.

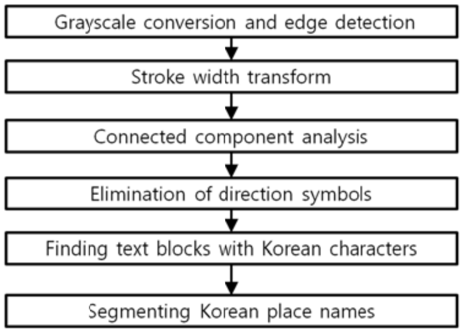


Fig. 3 Flowchart of segmentation of the Korean words

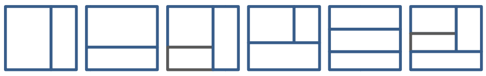
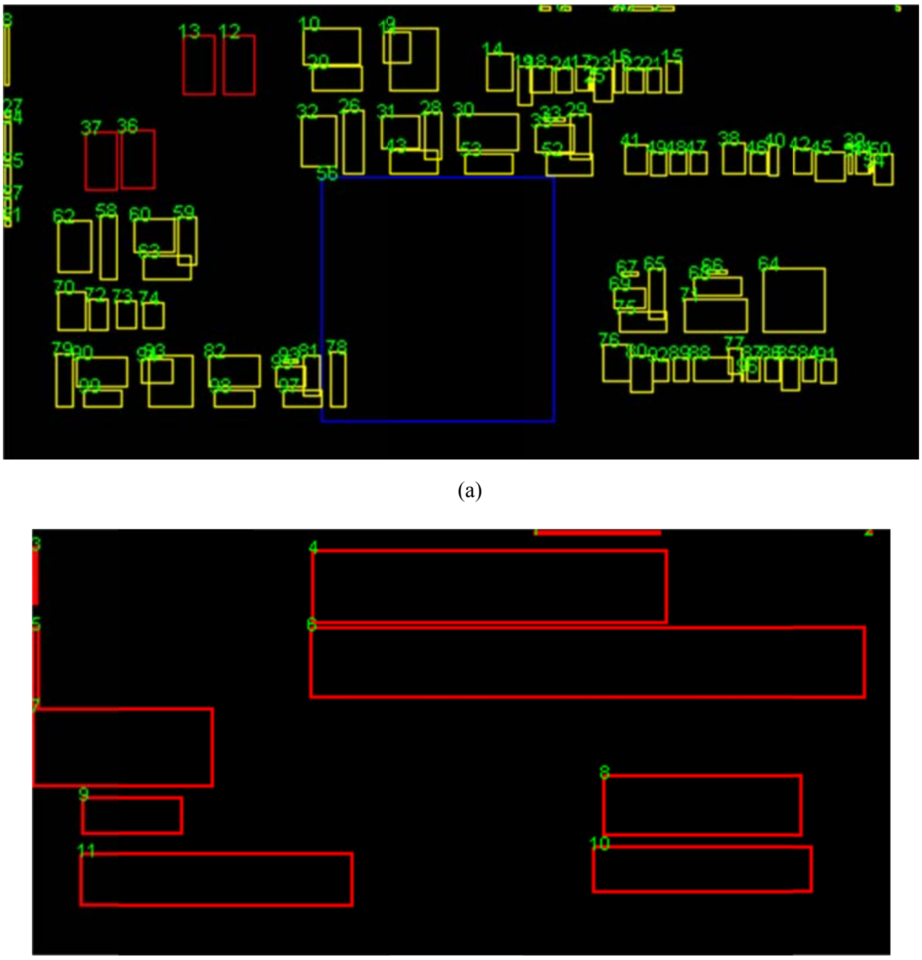


Fig. 4 Six geometric templates of Korean characters

B. Finding Korean Words by Projection

As another method, we developed a problem-tailored heuristic, so called, incremental blob projection (IBP) that makes use of two important cues for place names on road signs. A place name appears from left to right on the same line and it is also written as away in the left-to-right and top-to-bottom directions as possible from another place name. Specifically, all text blobs are sorted by leftmost coordinate from left to right. Each text blob is then projected in the sorted order onto the left axis of a road sign. During the incremental projection, each blob belongs to a text block if it is overlapped on the left axis with blobs projected previously. Otherwise, it belongs to a text block created newly. A vertical distance threshold on the left axis is used to determine whether or not a text blob belongs to the existing text block. Text blobs constituting a part of a place name results in belonging to a single text block since they are all on the same text line. It should be noted that text blobs that have similar text line but belong to different place names must be separated into distinct text blocks. A text blob belongs to a new text block if distance between the blob and the right side of the existing text blocks is larger than a horizontal distance threshold. IBP's thresholds are tuned from a training image set. Fig. 5 illustrates text blobs of the road sign image of Fig. 1 and the text blocks detected by IBP. As shown Fig. 5, IBP found seven text blocks (excluding noisy ones) by projection of the text blobs of Fig. 5 (a). Five Korean words on the road sign of Fig. 1 were found correctly. It should be, however, noted that the two other text blocks are constructed due to English text blobs ("Asan" and "Hyeonchungsa" in Fig. 1) and also that the two upper text blocks include Korean and English words together. Generation of a single text block containing both Korean word and English one is caused by narrower spacing between them than normal.



(a)

(b)

Fig. 5 (a) Text blobs (marked with yellow color) for road sign of Fig. 1, (b) Text blocks detected by IBP

Therefore, a post-processing of the text blobs detected is required to adjust a text block having Korean words from the text blocks with mixed language letters and also to discard text blocks consisting of English text. The flowchart of the post-processing is shown in Fig. 6. Given all of the text blocks detected by IBP, it is first checked whether or not there are vertically-overlapping text blocks. If they are the case, they are merged into a single text block. Then, a text block having two text lines (upper text line for Korean word and lower one for English word), which is produced by a narrow vertical spacing between them due to the space constraint, is separated into two distinct text blocks. At the next step, each text block is examined if it includes English text at its right side and if so, the block is adjusted to exclude the part of English word. To be specific, Korean word appears ahead of English one and Korean characters are larger than English ones in size according to layout rule of road signs in Korea. Based on the layout rule, a heuristic is built to eliminate an English word at the right side of a text block. A final step is to choose and remove text blocks containing English word only. A crucial cue for the removal is that English letters are never positioned in the top-to-bottom direction while Korean characters usually consist of vertically-positioned Korean letters (Refer to Fig. 4). If there are no vertically-positioned text blobs, the block is regarded as English one and is then discarded. Given all of the Korean word blocks, the regions on a road sign image corresponding to the text block are segmented for recognition step.

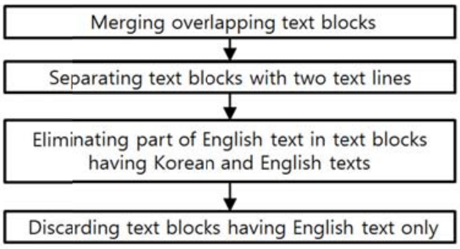


Fig. 6 Flowchart of text blob post-processing

C. Verification of Korean Text Block with OCR

In practice, all of the English text blocks are not filtered out completely by the heuristic because it happens not infrequently that an English letter is divided into two or more blobs in a low-resolution image and the splitted blobs could be regarded as Korean letters. To solve the problem, we append a verification stage to the final step of the flowchart of Fig. 6 to exclude English text blocks more accurately. It is quite reasonable that recognition-level decision makes much more accurate classification than pattern-level approach in discriminating English text from Korean text. Fig. 7 shows a basic idea of our recognition-based verification scheme. Here, we adopt Tesseract optical character recognition (OCR) [12], the only open source OCR software that has capability of enabling users to tune the OCR core with their own language datasets. To be specific with the scheme, two distinct datasets (one for Korean/English/Digit and the other for English/Digit) are used to build Korean dedicated OCR and non-Korean dedicated OCR modules, respectively. Each OCR module produces not only recognition results for each language but also certainties of the results. A decision is made whether a text block is English text only or not by comparing both averages and the minimum values of the two sets of certainties.

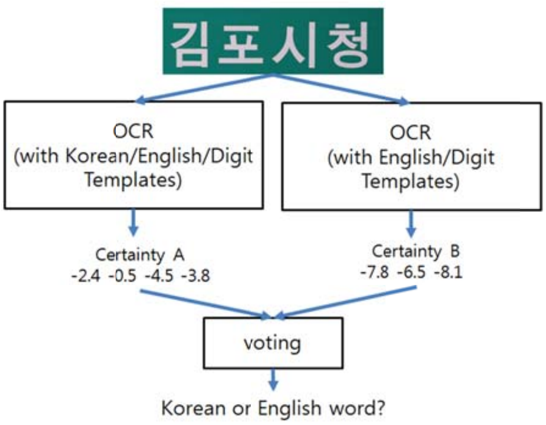


Fig. 7 Classification of a text block based on OCR's results

IV. Experimental Results

A set of 368 road sign images that were retrieved from the database system [1] was used to evaluate the performance of the proposed segmentation method. The images were manually collected at urban areas and national roads. Table I summarizes the success rate of the segmentation of place names in Korean by the series of heuristics (SWT, IBP, the post-processing, and the verification scheme). The proposed method succeeded in detecting all of the Korean place names of 311 images out of 368 images without any miss, resulting in 84.5% of detection rate per image. For 1,744 Korean place names from the 368 images, the method achieved 96.0% of the detection rate per Korean place name. The segmentation based on the Korean character templates and post-processing showed poor performance by about 20% than the IBP-based one. It seems that the inferiority of the template-based segmentation results from matching failure of Korean letter blobs that are connected to each other due to low-resolution, which is not rare in the dataset. On the other hand, the IBP-based method is less vulnerable to the Korean letter blobs linked to each other, thereby achieving a higher detection rate. Another advantage of the IBP-based method over the template-based one is that the number of parameters is relatively small, which means that the former is more robust than the latter and also that their tuning can be made more reliably and readily with a small number of images. Table II shows some segmentation results of various types of road sign images (2-way and 2-way advanced directional road signs at urban area and national routes). As can be seen in Table II, all of Korean place names were detected correctly without any miss for upper five images. The lower two images show representative examples of partial failure. The first one is caused by failure of excluding a graphic symbol positioning ahead of a place name. The other represents the failure because of very narrow the left-and-right and top-and-bottom spacing between neighboring place names. Some segmentation failure could be resolved by using OCR as an inspection step to examine whether non-text exists or not, which is under investigation.

TABLE I
Success Rate of Segmentation of Korean Place Names

No. of road signs	Detection rate per road sign (%)	No. of place names	Detection rate per place name (%)
368	84.5	1,744	96.0

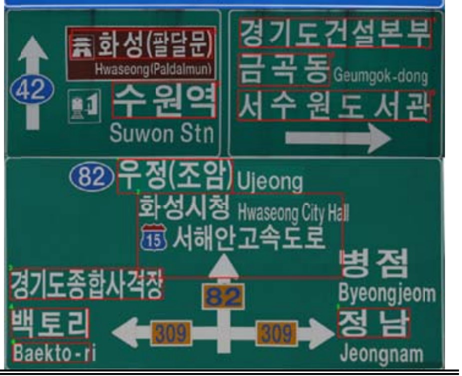
V. Conclusion

This paper has introduced an effective method of segmenting place names in Korean on Korean road sign images. The segmentation of Korean place names is a key component for elimination of manual operation of inputting to the database system of road signs in Korea. The proposed method leaves out non-text information such as direction arrows and symbols by using stroke width transform, detects text blocks through a problem-specific heuristic or so-called incremental blob projection, and localizes Korean place names out of the text blocks detected by applying a problem-tailored post-processing. The experimental results with a dataset of 368 road sign images show 96% of detection rate per Korean place name and 84% of detection rate per road sign image. Recognition of Korean place names with a road sign-tailored Tesseract OCR is under development.

TABLE II
SEGMENTATION RESULTS OF KOREAN PLACE NAMES
(SEGMENTATION ENCLOSED BY RED RECTANGLES)

Success

Partial failure



REFERENCES

[1] Road Sign Management System, *Tech. Report*, Ministry of Land, Infrastructure, and Transport, pp. 219-299. 2002.

[2] E. Kim, D. Cho, K. Chung, and S. Kim, "Efficient methods for road sign database construction," *J. of the Korean Society for Geo-Spatial Information System*, vol. 19, no. 3, pp. 91-98, 2011.

[3] A. Ruta, Y. Li, and X. Liu, "Real-time traffic sign recognition from video by class-specific discriminative features," *Pattern Recognition*, vol. 43, pp. 416~430, 2010.

[4] W. Wu, X. Chen, and J. Yang, "Detection of text on road signs from video," *IEEE Trans. on Intelligent Transportation Systems*, vol. 6. no. 4. pp. 378~390, 2005.

[5] A. Vavilin and K-H Jo, "Road guidance sign recognition in urban areas by structure," *Int. Forum on Strategic Technology*, pp. 293~296, 2006.

[6] J.-E. Ha, "Grouping contents on Korean road signs," *Int. J. of Control, Automation, and Systems*, vol. 9. no. 6, pp. 1187~1193, 2001.

[7] A. Soetedjo, K. Yamada, and F. Y. Limpraptono, "Segmentation of road guidance sign symbols and characters based on normalized RGB chromaticity diagram," *Int. J. of Computer Applications*, vol. 3, no. 3, pp. 10~15, 2010.

[8] A. Gonzalez, L. M. Bergasa, J. Yebes, and M. A. Sotelo, "Automatic information recognition of traffic panels using SIFT descriptors and HMMs," *Conf. on Intelligent Transportation Systems*, Portugal, September, pp. 1289~1294, 2010.

[9] A. Gonzalez, L. M. Bergasa, J. Yebes, and J. Almazan, "Text recognition on traffic panels from street-level imagery," *Intelligent Vehicles Symposium*, Spain, June, pp. 340~345, 2012.

[10] B. Epshtein, E. Ofek, and Y. Wexler, "Detecting text in natural scenes with stroke width transform," *IEEE Conf. on Computer Vision and Pattern Recognition*, pp. 2963-2970, 2010.

[11] L-J Park, M. Cho, J. Yoon, and K-S Chung, "Detection of Hangul texts and symbols on road signs on stroke width transform," *Fall Conf. of Korea Information Processing Society*, pp. 1318-1320, 2013.

[12] R. Smith, "An overview of the Tesseract OCR," *Conf. on Document Analysis and Recognition*, pp. 629-633, 2007.