Automatic Extraction of Direction Information from Road Sign Images Obtained by a Mobile Mapping System

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Abstract

Road signs are crucial infrastructures for safe driving. For systematic management of road signs, construction of a road sign database and implementation of a road sign management system are essential for local governments. In this paper, we deal with automatic extraction of direction information from road sign imagery obtained by a mobile mapping system. Our approach starts with image pre-processing and binarization. Next, arrow regions are extracted by the proposed four-direction contiguous pixel measures, so called line scan method. Corner points are detected by using a "good features to track" algorithm based on an extended Newton–Raphson method. Some of the detected corner points clearly show the arrow heads. Lastly, a least squares matching (LSM) algorithm is applied to the corner points to extract direction information. For the LSM algorithm, eight directional arrow head shape templates are used. As a result, we can automatically extract direction information from road sign imagery.

1. Introduction

Road signs are communicating information to secure smooth road traffic flow, and provide safe and easy driving environments for drivers. The signs, that provide information to drivers, include road signs and traffic signs. The main role of traffic signs is to warn/regulate/direct traffic or to provide information on road conditions. The main role of road signs is to provide information for the correct movement of drivers and for smooth traffic flow. Redundant implementation or incorrect placement of road signs must be minimized, because road signs have to provide relevant real-time information to drivers. In addition, it is necessary to manage information on loss occurrence (Lee and Yun, 2013).

Managing current road sign management system wastes time and money, because content modification and renewal work are typically carried out manually (Kim et al., 2011). There is a need to automatically manage this work for timely and accurate management of road signs. Particularly, the direction information of road signs performs an important role when a driver heads to an unfamiliar destination, and incorrect direction information can cause great confusion for the driver.

An automatic technique for reading road signs is an important component of the base technique for constructing an intelligent transportation system (ITS) with automatic recognition of number plates and traffic signs using image processing and computer vision techniques. These automatic techniques can be divided into automatic panel detection methods and automatic recognition of sign information. This has been studied by many researchers, but most studies have been on automatically detecting traffic signs within an image (Fang et al., 2004; Hu, 2013). Yang (2012) presented an effective image improvement method to distinguish the existence of traffic signs automatically in natural images. Kahn et al. (2011) developed a method that can automatically recognize traffic signs by comparing them with a template of known traffic signs using segmentation and shape analysis. Recently, research results on methods to acquire location information automatically from traffic safety signs using the Mobile Mapping System (MMS) are presented to construct a database (Choi and Kang, 2012). They showed that it is possible to manage and recognize sign information effectively using their research results because the shapes and colors of traffic signs are fixed(i. e. it is generated based on the standard) in each country. Road signs express intersection structure, including directional information by using colors, shapes, symbols, and text. Consequently, it is difficult to apply recognition techniques directly to road signs because the information included in signs takes many different forms. However, informational road sign recognition and related research results are still mostly at a more fundamental level than traffic sign recognition research.

The automation of content updates and modifications for the management of road sign information can be divided into two fields: automatic recognition of text information in the road sign and automatic recognition of graphic direction information. The automatic recognition of text information in a road sign applies a method of continuous form including segmentation, boundary detection, color analysis, and character outline analysis. Studies on recognizing information through word extraction or characteristic extraction methods to recognize detected characters have been conducted (Wu and Yang, 2005; Reina et al., 2006; Epshtein et al., 2010; Gonzalez et al., 2012; Huang et al., 2012). Diverse research related to direction information recognition within road signs has not yet been conducted domestically or in foreign countries. Sastre et al. (2005) conducted research on automatic recognition of direction information as a way of determining the Hausdorff distance in an ideally formed skeleton model by applying a skeleton algorithm to a simple one-way direction sign. However, it cannot be applied when more than one piece of direction information exists within a sign. Vavilin and Jo (2006) applied a direction information template to downtown road signs using an algorithm that detects direction information within the sign. They presented a result that extracts complex downtown intersection structure information from a road sign by merging the images obtained from three cameras using different exposures. The direction that the road sign points and consideration of a connecting plan was omitted.

The present paper describes an automatic recognition method for direction information in a road sign. Since direction information is formatted according to a certain standard, detection of direction information in an image was done with an image matching method by converting the direction information using a detection template that conforms to a domestic road sign manufacturing standards database. Furthermore, it describes a faster effective image matching method by applying a characteristic extraction algorithm and a line-scan-form direction information field detection algorithm.

2. Road Sign Direction Information Automatic Recognition Method

The images took on the road are not only of road signs but also include various backgrounds along the roads. In order to extract panel including road signs from the imagery captured by MMS, one can use color information in the imagery. However, this method may be affected by background images such as billboards, so criteria based on the size and form of the extracted surface relative to the MMS direction are required. Moreover, a hybrid method that applies these criteria by extracting information from horizontal surfaces perpendicular to the direction of travel based on MMS and ground LiDAR can be applied. Various studies on this are currently being conducted. In this research, only the image processing step was conducted, assuming that only the road sign panel was extracted from the road imagery captured by MMS. The automatic extraction of direction information from the imagery applied in this paper is divided into three stages: input image generation (preprocessing), arrow region extraction, and direction recognition through image matching. Figure 1 shows the algorithm process for the automatic extraction of direction information applied in this paper.

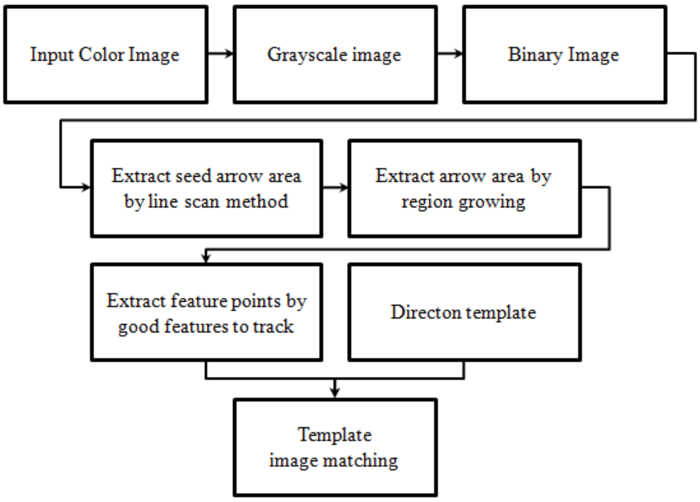
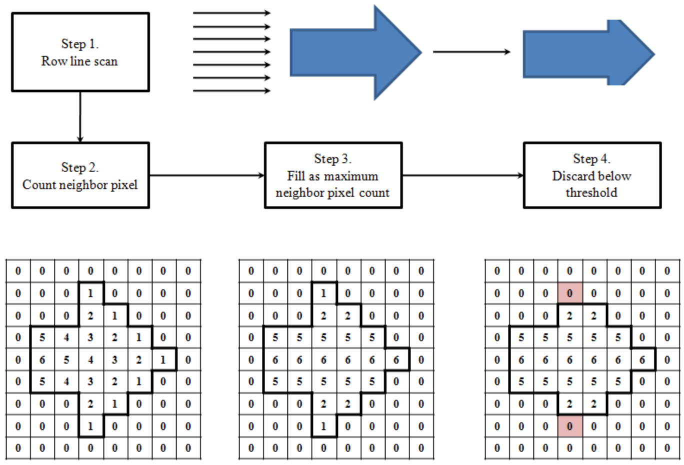


Fig 1. Scheme of automatic extraction of direction information

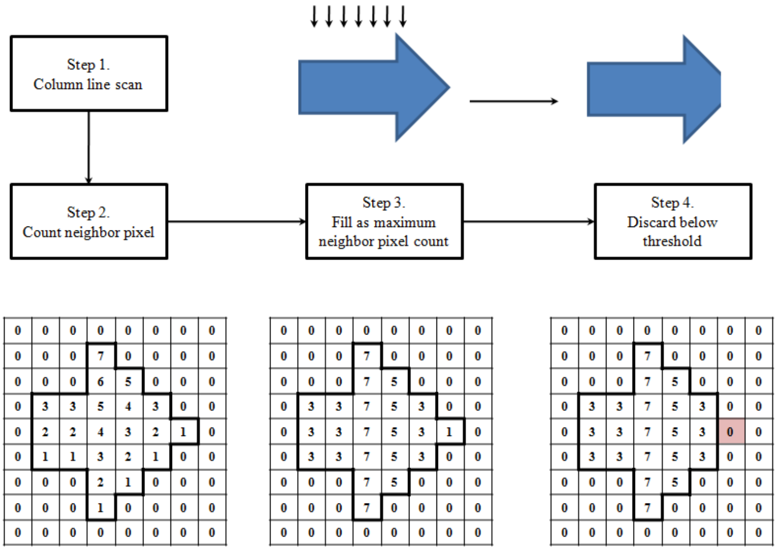
Input image generation involves extracting a black-and-white image from the original color image. The original color input image is converted to grayscale, and the grayscale image is enhanced to convert it ultimately into a black-and-white image. The methods that can be used for black-and-white conversion include using a simple threshold value, an adaptive threshold value that can characterize the image section, and a color-based threshold value by analyzing each specific of RGB color value in the original color image. In this study, we perform binary image conversion by applying a threshold value of 128, which is the median brightness value of an 8-bit grayscale image, after enhancing the road sign image that is converted from the original color image using the fan-shaped stretching method.

The arrow regions within a road sign generally have a continuous brightness value in the vertical and horizontal directions. Thus, arrow regions are detected by applying a contiguous pixel detection method using line scanning. Contiguous pixel detection using line scanning is a method that changes the cell value that contain the maximum number of contiguous pixels with similar brightness values in the vertical and horizontal direction by inputting the binary image. Figure 2 shows the line scan method for extracting the seed field of the direction indicating field detection. As shown in Figs. 2(a) and 2(b), first executes a search along individual lines in the vertical and horizontal directions and calculates the number of contiguous pixels. Then, the calculated non-zero cells (i.e., cells containing contiguous pixels as the target) are converted to the maximum value of the number of contiguous pixels among the neighboring cells. Next, the threshold value is applied to the converted pixels. Cells with a value below 128 are assigned a brightness value of 0, and those above 128 are assigned a value of 1 for the vertical and horizontal detection. Lastly, the seed field for direction information field detection is extracted by finding the intersection of the vertical and horizontal line scan detection results. Based on this seed field, the region-growing method is applied to detect the arrow regions within the road sign.

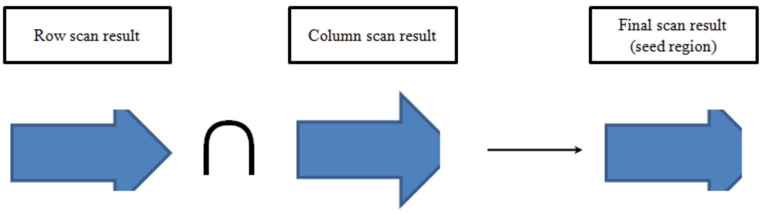
Because the number of contiguous cell for the arrow regions within the road sign is larger than a character or symbol in the image, the arrow region and character/symbol region within an image can be separated by using the method. For partial images, the text characters might overlap, and there might be a case where this satisfies the contiguous cell threshold value for the diagram information. In this case, the problem can be solved by additionally considering the contiguous cells along the diagonals that are 30° and 60° to the vertical and horizontal directions.



(a) Row line scan for detecting contiguous cells in the row direction.



(b) Column line scan for detecting contiguous cells in the column direction.



(c) Intersection of row line scan result and column line scan result.

Fig. 2. Line scan method for extracting the seed area of an arrow region.

In the direction recognition phase, the template matching technique, which is a type of region-based image matching technique, is used to extract the direction information from the detected arrow regions. In addition, the effectiveness of image matching algorithm is increased by extracting the corner points around the arrow regions. In order to extract the corner points, "good features to track" algorithm is applied. The good features to track algorithm is an object-tracking algorithm for which the Newton–Raphson method was extended based on the similarity transformation of the image. Usually road signs are generated based on the standard, the templates, which expresses the head of the arrow is used for template matching. The arrow-head templates are presented in Fig. 3. Since search area for image matching algorithm is limited around the extracted corner points, calculation time can be decreased. Near each corner points, the west, east, north, south, northwest, southwest, northeast, and northwest templates are prepared. The location and direction information feature can be recognized by matching it to the template that has the highest correlation coefficient.

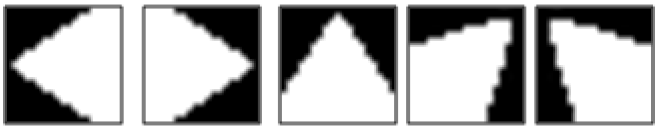


Fig. 3. Arrowhead template images.

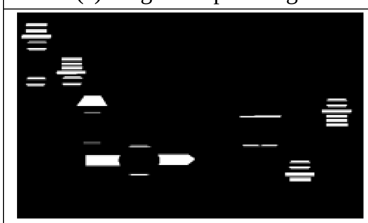
4. Direction Information Automatic Recognition Algorithm Construction and Recognition Experiment Result

To show the feasibility of the proposed algorithm, we implemented the pilot system using the C++ language-based Open CV Library which included image enhancement, image binarization, vertical and horizontal contiguous pixel detection, image composition, field extension, corner point extraction, template image matching, and matching result extraction function. The experiment was performed using a personal computer with an Intel i5-3550 3.30-GHz CPU and 8 GB of RAM. The images used in the experiment were the same as those in Fig. 5(a) and were sized 479 × 286 pixels. Figure 4 shows the results of the direction information recognition experiment for road signs by applying the method suggested in this paper.

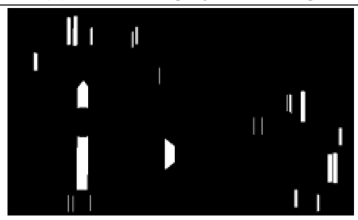
(a) Original input image

(b) Stretched grayscale image

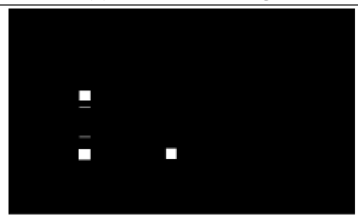
(c) Two-color image



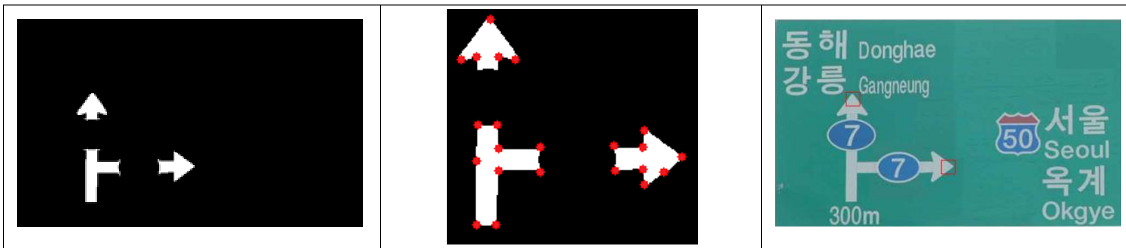
(d) Result of row line scan



(e) Result of column line scan



(f) Seed area of arrow regions



(g) Extracted arrow regions	(h) Extracted feature points	(i) Template matching

Fig. 4. Arrow recognition in road guidance signs.

As shown in Figs. 4(d) and 4(e), the horizontal and vertical line scans methods detects the candidate parts of the arrows. By combining two results, the seed areas of the arrow region are extracted in Fig. 4(f). Based on the detected seed area, region growing method is applied to exactly extract the arrow regions as shown in Fig. 4(g). Then, corner points are extracted using Newton–Raphson method as shown in Fig 4(h). In the Fig. 4(h), all the corner points, which include corner of the arrow head and other corners, are extracted. The number of extracted corner points is 22. Since not all the corner points are for the arrow heads, template matching algorithm is applied to match the arrow directions. Matching results are shown in Fig. 4(i). It was matched with a correlation coefficient of 0.937 in the north direction and 0.930 in the east direction. The processing time was 0.6 second. As a result, it was possible to automatically recognize the direction and location of the arrow, and they are direction information (north and east). The results of applying this algorithm to other images are shown in Figs. 5–8. Here, the thickness of the arrow shape and the coefficient correlation were set to be greater than 10 pixels and 0.83, respectively.

Fig. 5. Arrow recognition in various images (1).

Fig. 6. Arrow recognition in various images (2).

Fig. 7. Arrow recognition in various images (3).

Fig. 8. Arrow recognition in various images (4).

5. Conclusion

This paper attempted to extract direction information automatically from road sign imagery by applying various computer vision techniques. The algorithm was implemented using the C++ language-based Open CV Library, and direction information was automatically extracted from road sign images through processes such as image conversion, vertical and horizontal contiguous pixel detection, image combination, field extension, corner extraction, and template matching method. In this paper the possibility for automatic direction information extraction from images was proved only under relatively ideal conditions. For accurate extraction of direction information from road sign images obtained under inferior conditions (damaged signs, backlit reflective signs, or signs with nonstandard figures or markings). it is thought that an improved algorithm with better image binarization, direction information field extraction, and image matching is required.

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References

Choi, J. S. and Kang, J. M. (2012), A study of effective method to update the database for road traffic facilities using digital image processing and pattern recognition, Journal of the Korean Society for Geospatial Information System, Vol. 20, No. 2, pp. 31-37

Epshtein, B., Ofek, E., and Wexler, Y. (2010), Detecting text in natural scenes with stroke width transform, 2010 IEEE Conference on Computer Vision and Pattern Recognition, 13-18 June, San Francisco, USA, pp. 2963-2970.

Fang, C. Y., Fuh, C. S., Yen, P. S., Cherng, S., and Chen, S. W. (2004), An automatic road sign recognition system based on a computational model of human recognition processing, Computer Vision and Image Understanding, Vol. 96, pp. 237-268.

Gonzalez, A., Bergasa, L. M., Yebes, J., and Almazan, J. (2012), Text recognition on traffic panels from street-level imagery, 2012 Intelligent Vehicles Symposium, 3-7 June, Alcala de Henares, Spain, pp. 340-345.

Hu, Z. (2013), Intelligent road sign inventory (IRSI) with image recognition and attribute computation from video log, Computer-Aided Civil and Infrastructure Engineering, Vol. 28, No. 2, pp. 130-145.

Huang, X., Liu, K., and Zhu, L. (2012) Auto scene text detection based on edge and color features, 2012 International Conference on Systems and Informatics, 19-20 May, Yantai, China, pp. 1882-1886.

Khan, J. F., Bhuiyan, S. M. A., and Adhami, R. R. (2011), Image segmentation and shpae analysis for road-sign detection, IEEE Transaction on Intelligent Transportation Systems, Vol. 12, No. 1, pp. 83-96.

Lee, J. S. and Yun, D. G. (2013), The road traffic sign recognition and automatic positioning for road facility management, International Journal of Highway Engineering, Vol. 15, No. 1, pp. 151-161.

Reina, A. V., Sastre, R. J. L., Arroyo, S. L., and Jimenez, P. G. (2006), Adaptive traffic road sign panels text extraction, Proceedings of the 5th WSEAS International Conference on Signal Processing, Robotics and Automation, 15-17 February, Madrid, Spain, pp. 295-300.

Sastre, R. J. L., Arroyo, S. L., Siegmann, P., Jimenez, P. G., and Reina, A. V. (2005), Recognition of mandatory traffic signs using the hausdorff distance, Proceedings of the 5th WSEAS International Conference on Signal Processing, Computational Geometry & Artifical Vision, 15-17 September, Malta, pp. 216-221.

Wu, W. and Yang, J. (2005), Detection of text on road signs from video, IEEE Transactions on Intelligent Transportation Systems, Vol. 6, No. 4, pp. 378-390.

Vavilin A. and Jo, K. H. (2006), Road guidance sign recognition in urban areas by structure, The 1st International Forum on Strategic Technology, 18-20 October, Ulsan, Korea, pp. 293-296.

Vavilin A. and Jo, K. H. (2009), Graph-based approach for robust road guidance sign recognition from differently exposed images, Journal of Universal Computer Science, Vol. 15, No. 4, pp. 786-804.

Yang, X. (2013), Enhancement for road sign images and its performance evaluation, Optik - International Jounal for Light and Electron Optics, Vol. 124, No. 14, pp. 1957-1960.