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Graphic-based character grouping in topographic maps

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ABSTRACT

In topographic maps, only the complete text strings can accurately express the properties of the geographic elements, so individual characters should be grouped into text strings before recognition. This paper presents a novel character grouping method based on the graph model. In this method, undirected graphs are used to describe different words, where the color and size of the characters are served as the properties of the nodes, while the distance and angle between the characters are served as the weights of the edges connecting pairs of characters. Therefore, the nodes can be connected to construct undirected graphs according to their properties. Then the constructed graphs are simplified according to the weights of the edges. Finally, we can get the final results corresponding to the grouped characters. Experimental results show that this method can especially group the characters with significant wide spacing. Moreover, it has higher efficiency with graphic processing instead of image processing.

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1. Introduction

Text recognition is active in both academic researches and commercial software development; yet effective text recognition techniques have been widely used. In classic text recognition systems, most methods aim to extract and recognize the single character, which fail to express the meaning of the whole words [1]. Especially in topographic maps, only the entire text strings can express the accurate meaning of the geographic elements. Besides, recognizing the grouped characters can take advantage of the word contexts. Thus, character grouping is helpful for text understanding and text recognition.

At present, there are several works about character grouping. Most texts are on horizontal or straight text lines, and their background is simple, so some morphological operations [2] or clustering methods [3,4] can achieve these tasks. These previous methods apply to the homogeneous texts or some others in specific cases, such as straight text lines, multi-oriented but similar-sized characters. However, in some other images, especially for the texts in topographic maps, there exists various complex distribution of texts, the character color and size diversity, the distance and directions of different strings discrepancy, as well as lots of non-texts remained after text extraction. For example, the map shown in Fig. 1 contains multi-oriented, multi-sized, and curved texts. All these facts adversely affect character grouping, and it is possible for most previous methods that some characters are mistakenly grouped into other text strings or leaved out, typically when some text strings are on curved lines.

In order to address the texts with complex distribution, Chiang has done much work for text processing in topographic maps [2]. He proposed a conditional dilation algorithm for character grouping [1] in 2011, which can deal with the multi-oriented, curved and straight text lines of multi-sized characters. But it still has some problems, for example, it cannot deal with the beginning or the end characters of the two adjacent texts due to the disadvantages of the string curvature condition, and the color information is not considered. Besides, Chiang said that his method and other previous methods typically handle characters with narrow spacing, but the text strings containing wide spacing characters can not be identified correctly [1], as the string "Hindu Kush" shown in Fig. 2. However, there often are characters with wide spacing in most topographic maps, so we need to handle these texts by some new methods.

To solve the problems mentioned above, various character features such as character distribution, color, size, and orientation in topographic maps are analyzed carefully combined with the

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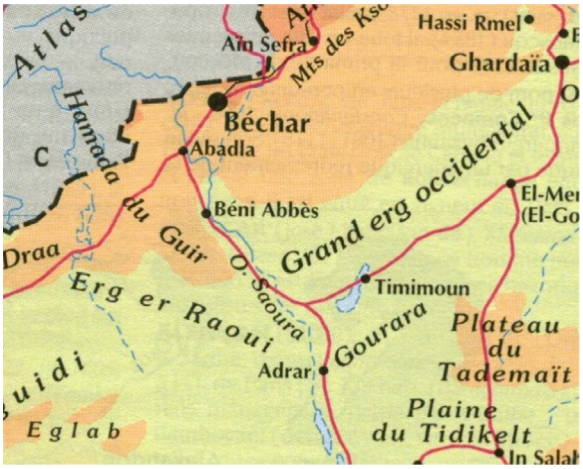

Fig. 1. The topographic map.

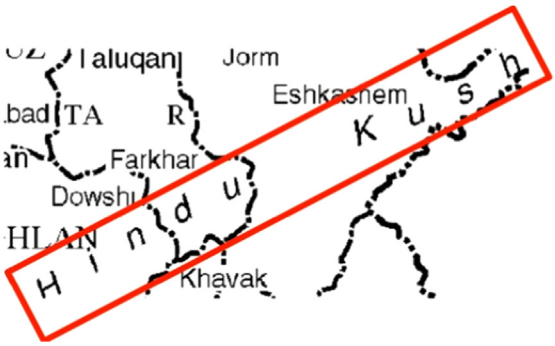

Fig. 2. The texts in the topographic map.

relative merits of the previous methods. And inspired by the ideas of the construction and the simplification of undirected graphs, we present a novel character grouping method by introducing the graph model into the grouping process, which is named as graphic-based character grouping (GCG). GCG can deal with the characters in various complex cases effectively, especially for the characters with significant wide spacing.

2. Related work

Text recognition of the non-homogeneous texts from topographic maps is a difficult task, and hence much of the previous research only works on specific cases. In 1988, Fletcher and Kasturi [5] presented a text string separation algorithm, and they used Hough transform to group components into logical character strings. This method is robust to the changes in text font style, size, and orientation, but the Hough transformation detects straight lines only, so their method cannot be applied on curved strings. Based on the character neighborhood connected components, Li [6,7] proposed a method to assemble characters into word boxes to form the longest possible aligned strings according to the constraint that they lie on a straight line and their centroids are separated by about 1.4 times their average width. Generally, the length of a gap between the characters is small, so Lu [8] used a method to group these characters together just like “brushing” them with a pen in the horizontal and vertical directions. In Italian army topographic maps, Caprioli grouped characters into strings according to the constraints of the string directions, the distance between characters and the character size [9]. In 1999, Goto proposed a method called extended linear segment linking, which could extract text strings in arbitrary orientations [10]. This method works on touching characters effectively, and requires that the size of the characters is similar. Cao [11] assumed that the gaps between words are larger than those within words, and a dilation operation with a square structuring element is performed on the character images. As a result, the characters of each word will form a connected component. This method can group curving labeled road names with higher efficiency compared with the methods based on Hough Transformation. But it may group two close words incorrectly. A bottom-up approach was proposed by Pal [12] to identify the text lines of arbitrary orientations. This method labeled the connected components firstly, and then clustered them into word groups. But it cannot work on the curved text strings. In 2004, a method for separating and recognizing the touching/overlapping characters was proposed by Velázquez [13]. In this method, OCR was applied to defining the coordinates, size and orientations of the character strings, and four straight or curved lines were extrapolated to separate those attached symbols. In 2007, the idea of undirected graphs is introduced to character grouping by Pouderoux [14] for the first time. But, unfortunately, only the size of the characters is considered to validate the adjacent characters in possible strings (graph). In 2008, Roy proposed a method based on the foreground and background information of the characters to extract individual text strings from multi-oriented and curved text documents [15], and the isolated characters are clustered into individual words according to the fact that the gaps between words are larger than those between characters in one word [16]. In 2009, another method was presented to separate English multi-oriented touching strings into individual characters by using convex hull information [17]. It could deal with curved strings, but the directions of the strings were detected only in 4 directions. In respect of text extraction and recognition in topographic maps, Pezeshk has done a lot of research work. Based on his own previous work in 2010 [18,19], he proposed a method to group the individual characters into their respective strings using pyramid decomposition with Gaussian kernels [20,21], but this method could not distinguish different text strings when they were nearby.

According to the analysis above, it is known that most researchers focused on the research of text separation and recognition, but they ignored the problems of character grouping. Chiang had made great efforts on word processing in topographic maps [22,23], including individual character extraction, character grouping and text recognition, and in 2011, a conditional dilation algorithm was presented for grouping characters into text strings [1]. Compared with other methods, Chiang's method can get better results, where the multi-oriented, curved and straight text lines of multi-sized characters can be handled well with only three parameter settings. But there are still some problems, such as not using the character color. All the methods mentioned above have their individual advantages and disadvantages, but they are all lack of the ability of handling the strings containing wide spacing characters. In response to the proper time and conditions, we present a robust technique based on the graph model to complete character grouping in various complex cases, for example, the text strings may be multi-colored, multi-oriented, multi-sized and curved, even the character spacing in one string is significantly wide.

The remainder of this paper is organized as follows: In Section 3, we make an analysis of introducing graph model for character grouping in topographic maps. In Section 4, GCG is described in detail. And the experimental results and analysis of the performance are given in Section 5 before the conclusion in Section 6.

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