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SCTMS: Superpixel based color topographic map segmentation method ☆

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ABSTRACT

Different from natural image, topographic map is a complex manually generated image which has amount of interlaced lines and area features. Because of the frequent intersection and the overlap between geographic elements, the misalignment in scanner and other disturbances like inappropriate preserving, false color, mixed color and color aliasing problems occur in the raster color maps. These problems could cause serious challenges in segmentation process. In this work, we present a color topographic map segmentation method based on superpixel to overcome these problems. Firstly, the finest partition is obtained based on double color-opponent boundary detection method and watershed approach. Then, a strict region merging method is introduced to prevent mis-merging while superpixels generated. This merging method could make the superpixel partition accurately adherent the boundary between different geographic elements. Finally, luminosity, color and texture information are combinative applied to classify the superpixel into different layers based on support vector machine. The experimental results show that the proposed method outperforms other state-of-art topographic map segmentation approaches.

1. Introduction

Topographic maps contain valuable cartographic information and cover large areas over long periods of time for many regions in the world [1,2]. They record the changes taken place in natural features and human active and owns the unique value for the extraction of spatial information about the landscape [3]. Today, however, most historical topographic maps are saved as raster format which cannot be accessed, processed, and maintained in a GIS environment conveniently [1]. To vectorize geographic features from raster maps, a number of research efforts have been done for the extraction and recognition of geographic features from topographic maps [3].

The biggest challenge in topographic map rather than nature images is the complex distribution of geographic elements. The frequent overlaps between different elements lead to amount of color aliasing in color maps. Meanwhile, the size of a paper topographic map is very large. E.g. an USGS topographic map owns the size of 109.79 cm × 91.54 cm. Its scanned digital image could be 25,935 × 21,623 pixels with the scan resolution in 600 dpi. Such a large image is difficult to be saved or processed. Thus a scan resolution in 300–400 dpi could be more acceptable. However, a low scan resolution will result in small raster map as well as thin lines. As shown in Fig. 1, the width of some line elements in the map is one or two pixels. In addition, the longtime preservation and the ordinary scanning process can blur the boundaries of elements which can be seen from Fig. 1 as well.

Besides the challenges described above, there are four other challenges in segmentation of scanned topographic map [4]. Aliasing is the major problem, which induced by scanner's point spread function [5]. Even in gray-level image, the edge between white and black would occur aliasing. Closely spaced geographic elements lead to the second problem. Geographic elements are usually separated by the background. However, when two elements are closely spaced, the background is eroded by scanner which induced aliasing to cause the difficulty to use background to split those elements. The existence of false colors is the third challenge, which depends on the scanning method in used. False color is caused by RGB misalignment in the scanner occurs whenever the red, green, and blue color planes are not well registered. The false color could change the color characteristics of pixels which make the segmentation inaccurate. The fourth challenge is the intersection and overlap of geographic elements. Mixed color which increases the difficulty of segmentation in the overlapping region will appear.

In order to overcome these challenges above, we present a superpixel based topographic map segmentation method. In the next section, we introduce some related works of topographic map segmentation. In Section 3, the proposed method will be

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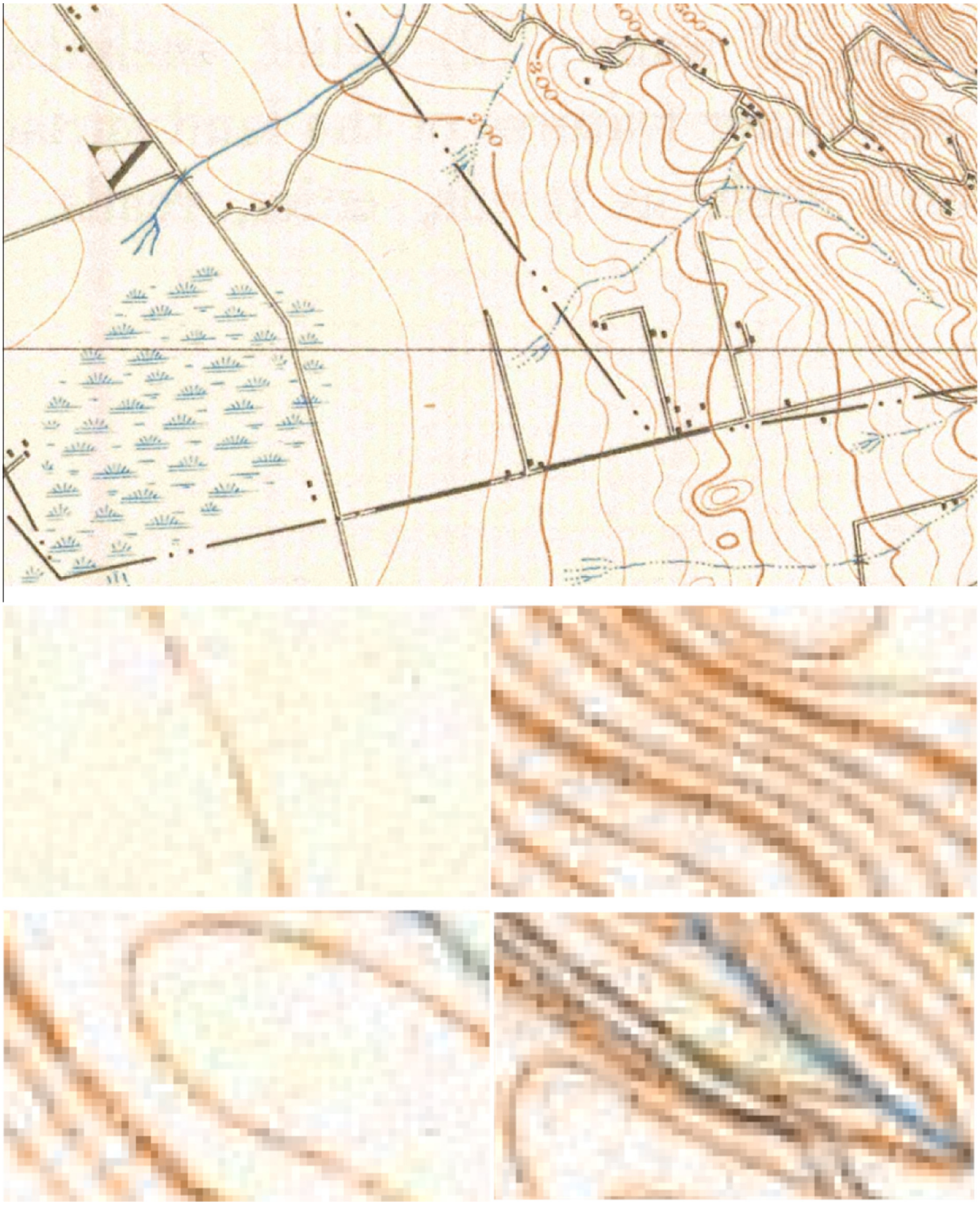

Fig. 1. Some amplifying patches in a topographic map which have 400 dpi scan resolution.

described in detail with regard to boundary detection, superpixel generation and supervised classification. The experimental performance of our method will be shown in Section 4 and the conclusions will be discussed in Section 5.

2. Related work

In the whole vectorization of topographic map, image segmentation represents a crucial preprocessing step of which the result directly influences subsequent processing steps. Thus, numerous algorithms of color topographic map segmentation were proposed in recent years.

Mello et al. [6] proposed an automatic method for image segmentation of old topographic maps. This method creates a grayscale image and then a thresholding algorithm is applied to convert this grayscale image into binary image. It focuses on text extraction, thus the other feature layers of topographic map cannot be obtained. Dhar and Chanda [7] apply image enhancement to