Stroke Extraction from Gray-Scale Character Image

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Abstract

In this paper, a topographic feature classification method based on 4-directional scanning, and a stroke extraction method from skeletal pixels are proposed. Combination of the proposed methods is relatively fast and the resulting strokes are more acceptable.

1. INTRODUCTION

To extract strokes from gray-scale character images, we should obtain a thin-line representation of the character image. Combination of binarization and thinning has been widely used for this purpose. However, binarization often fails in character separation from the background, and, therefore, produces bumpy boundaries. Pixels on the bumpy boundaries add some spurious strokes and holes with conventional thinning algorithms. It causes significant error in consequent stroke matching process.

On the contrary, combination of topographic feature classification and stroke extraction can produce strokes more very similar to character models in human mind. In addition, extracted topographic features can be utilized in the following recognition or segmentation steps. For example, a saddle point can be used as a segmentation candidate between two characters.

Topographic feature classification can be defined as the process to assign one of topographic features (such as peak, ridge, saddle, pit, ravine, ...) to each pixel on image. Stroke extraction is the process of extracting line segments from collection of skeletal pixels. *Skeletal pixels* are either of peak, ridge and saddle pixels, usually located in the center line of strokes.

In our approach, Topographic features are classified using 4-directional image scanning, and strokes are extracted utilizing “primary line” concept. In section 2 and 3, the proposed topographic feature classification and the stroke extraction methods are described, respectively. In section 4, experiment results are shown, and concluding remarks are followed in section 5.

2. TOPOGRAPHIC FEATURE CLASSIFICATION

One approach of topographic feature classification is to adopt mathematical framework about 3-dimensional surface description[1-3]. For derivative operation on the discrete image, it usually uses several convolution operations, which is time consuming.

The other approach is to classify pixels according to intensity configuration of neighborhood and appropriate heuristic decision rules [4-6]. The gray level of a center pixel is compared with those of neighboring pixels to decide its topographic feature. It is faster and simpler than the former. However, the classification highly depends on the size of neighborhood and the heuristic rules making the decision.

In our approach, which belongs to the second category, direction-dependent geometric features are assigned to each pixel by horizontal, vertical, right-diagonal and left-diagonal raster scanning. The geometric feature is one of local maximum, local minimum, ascending and descending. One pixel has four independent features for each direction. Since we use look-forward scheme to assign the geometric features in plateau, the results are more accurate than those by fixed-size neighborhood.

Topographic features are obtained by applying the classification rules to the combination of these directional features. For example, the classification rules for peak, ridge and saddle are

peak four local maxima
ridge only one local maximum and none of the local minima,
two adjacent local maxima and none of the local minima, or
three local maxima and none of the local minima.
saddle two adjacent local maxima and two adjacent local minima,
one local maximum and three local minima, or
one local minimum and three local maxima.

The time complexity of the method is only the summation of four times of the image scan time and the classification time. Our method is considerably faster than Lee's method which is based on convolution [3].

3. STROKE EXTRACTION

In real digital images, collection of skeletal pixels does not satisfy one-pixel-wide connectivity. Therefore, a sophisticated stroke extraction method is needed. In Wang and Pavlidis' work, a set of graph-structured strokes is extracted from skeletal pixels [1]. An edge is a chain of lines obtained using analysis of the adjacent ridge pixel region. Each of adjacent peaks and saddles is represented as a node on a graph. Toriwaki and Fukumura applied a thinning algorithm on the collection of ridge and peak pixels to obtain line representation [6].

Since our method produces much less number of spurious pixels than others, no sophisticated scheme needed for connecting the pixels. We use concept of *primary line* which is 8-connected, one-pixel-wide collection of adjacent skeletal pixels. If more than two skeletal pixels are in 8-connected position, the primary line is terminated there. In other words, primary line is connection of no dispute. The extracted primary line is approximated by chain of lines.

After extracting the primary lines, ends of every primary line are examined to find connectability between each other through remaining skeletal pixels. In the process, if saddle and peak points exist between the ends of the primary lines, they are used as stepping stones in connecting the ends. After that, all the end points which are connectable through remaining ridge pixels are connected each other.

In character image, there are many junctions by writing a stroke touching another. These junctions are usually consist of two ridges, connected through hillside of the upper stroke. To connect these strokes, a simple gap filling idea is applied. From the end points of each line, connectable line within certain distance is searched through hillside or remaining skeletal pixels.

4. EXPERIMENT RESULTS

Real images obtained from scanner have many low-level hills which can be classified to skeletal pixels. An intensity thresholding was applied to focus our attention to those points whose intensity is higher than the threshold. We used a convolution with 3 by 3 Gaussian mask to smoothing out noises. Experiment results show that the size of the mask is sufficient to filter high frequencies on the character image.

Figure 1 shows the surface of a Korean character and the result of topographic feature classification. 'o', '^', '+', and '.' mean peak, ridge, saddle, and hill-side pixel respectively.

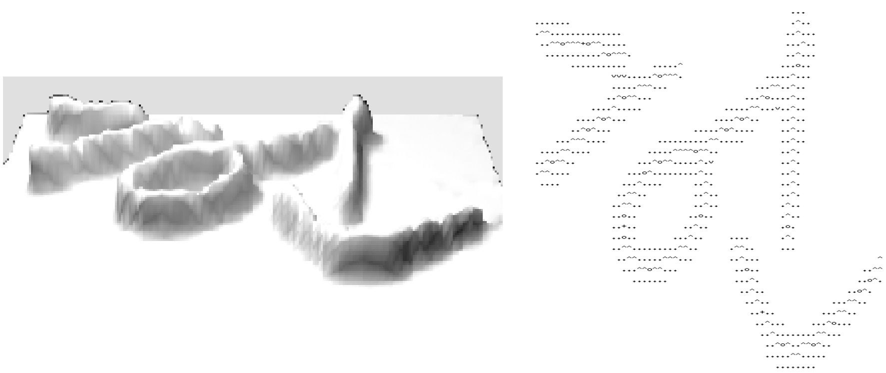

Figure 1. Topographic feature classification

Figure 2 shows the whole processing steps. The second image is a result of the primary line extraction, and the third is the final result. The gap filling step can be omitted if the connections of strokes are not critical in the following character stroke matching process.

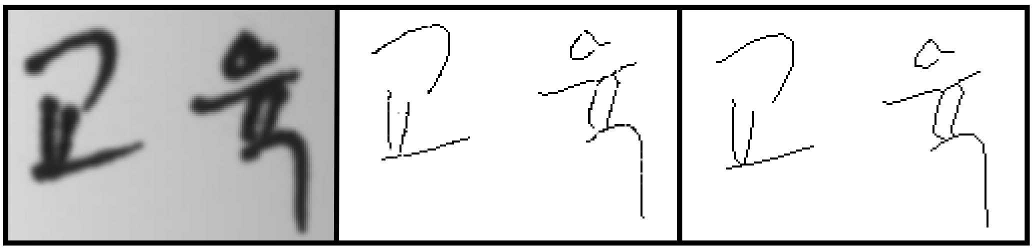

Figure 2. Stroke extraction steps

5. CONCLUDING REMARKS

Main problems on combination of topographic feature classification and stroke extraction are time complexity and difficulties in line extraction algorithm. With the proposed method, we can obtain key skeletal pixels suppressing spurious ones. Strokes are efficiently extracted from the skeletal pixels. Our approach can be used instead of conventional combination of binarization and thinning.

6. REFERENCES

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