Extraction of loess shoulder-line based on object-based image analysis

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Abstract—**Based on the morphological characteristics of loess hilly and gully areas, a simple and effective method for extracting loess shoulder-lines based on object-based image analysis is proposed. A case study is conducted in the northern Shaanxi Loess Plateau of China and the digital elevation model with a grid size of 5 m is applied as original data in this research. In order to get clear edge of DEM slope, the convolution filter by Gauss Blur is applied to the original DEM. The slope image is calculated on the smoothed DEM. Then the landform DEM objects are obtained by contrast split segmentation. For the standard deviation values between gully-slope land and loess interfluve are obvious different, the basic loess shoulder-lines could be extracted. While there are still small areas and other disturbing objects, the shoulder-lines will be refined by context and area values. At last, the final results are merged and exported. According to the accuracy assessment, the average extraction accuracies are about 88.7% and it is applicable in the loess area analysis.**

INTRODUCTION

The Loess Plateau of China is a significant topographic area for its typical loess hills and gully landforms (Fu et al., 2000). Many researches have been carried out in the region over the last half a century, including soil erosion (Hessel and van Asch, 2003; Huang, 1955), land evaluation (Qiu et al., 2010; Shi and Shao, 2000) and topographic features (Jiang and Li, 1988; Lo, 1956; Xie et al., 2003), etc. Especially, each loess landform possesses peculiar slope composition which creates corresponding terrain texture on a particular spatial scale, such as platycladus-like texture, petal-like texture and finger-like texture and so on (Liu et al., 2012).

Shoulder-line, one important kind of the structural properties, has great geomorphologic significance in characterizing spatial distribution of terrain elements. The existence of loess shoulder-lines divides the loess surface into positive and negative terrain areas which occupy smooth top ridge land against steep rough valley land respectively. In addition, this zigzag shoulder-line that is a macro and instinctive topographic feature exhibits diverse morphology with different landform. Such similarity and diversity of the key structure lines in their spatial distribution could be used for analyzing terrain texture characteristics, which are essential basis for landform recognition and classification.

In recent years, many researches have focused on methods of extracting loess shoulder-lines and their geomorphology significance (Li et al., 2008; Tang et al., 2007; Xiao and Tang, 2007). In this paper, a simple and effective method for extracting loess shoulder-lines based on object-based image analysis (OBIA) is proposed. OBIA usually applies an image segmentation method which divide whole image into image objects. And then the image objects are classified by certain classification and extraction rules. Compared with traditional methods that use grid cell or pixel-based principles, OBIA conduct the operation in the way that reflects the human's vision when identifying image features.

STUDY AREA AND METHODOLOGY

A. Study Area

The study area is Yijun that situated in the middle of the Loess Plateau, Shaanxi province, China. Yijun is loess residual tableland area and centered on 35°25'22''N, 109°38'52''E. The elevation is from 1125 m to 1742 m, and the gully density is 4.2 km/km2. This landform is the residual state of loess tableland and in the later geologic development stage of the landform. Although with a flat top surface with approximately alike height, the overall tableland surface is actually dissevered into separated blocks. The shoulder-lines are in petaloid and finger like structure. The DEM data of Yijun in this research is from the contours of 1:50000 topographical maps and produced by the National Geomantic Center of China with a spatial resolution of 5 m.

B. Work flow of method

Fig. 1 summarizes the methods we used for the extraction method of loess shoulder-lines based on OBIA. The work flow of method is divided into 6 parts.

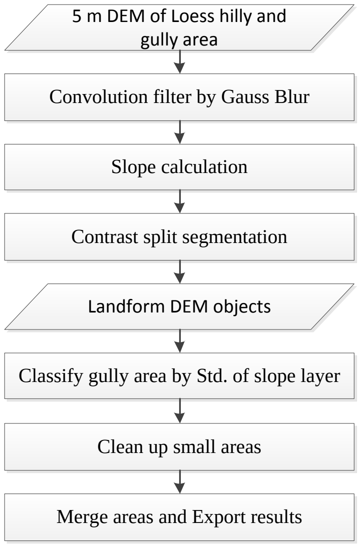


Fig. 1. Work flow of method

C. Contrast Split Segmentation

The contrast split segmentation algorithm divides an image into dark and bright regions. It is based on a threshold that maximizes the contrast between the resulting bright objects (consisting of pixels with pixel values above the threshold) and dark objects (consisting of pixels with pixel values below the threshold). Actually, a DEM is grid cell-based dataset which could be regarded as a specific image, and the common segmentation approach is also suitable for DEM based structural lines extraction.

It achieves the optimization by considering different pixel values as potential thresholds. The test thresholds range from the minimum threshold to the maximum threshold, with intermediate values chosen according to the step size and stepping type parameter. If a test threshold satisfies the minimum dark area and minimum bright area criteria, the contrast between bright and dark objects is evaluated. The test threshold causing the largest contrast is chosen as the best threshold and used for splitting. In this paper, the software eCognition 8.7 is used with this segmentation for the test.

C. Classification by standard deviation

The texture between gully-slope land and loess interfluve is obvious different, as shown in Fig. 2, the overall terrain of gully-slope land is more flat than loess interfluve. As a result, the standard deviation (Std.) values of DEM objects that obtained by segmentation are also different. According the analysis and test, the Std. of DEM objects could be a classification criterion for gully-slope land and loess interfluve. If the loess interfluve has been classified, the loess shoulder-lines are also obtained.

The classification method here is using threshold method. Assign the DEM objects to the class specified by the use class Std. values.

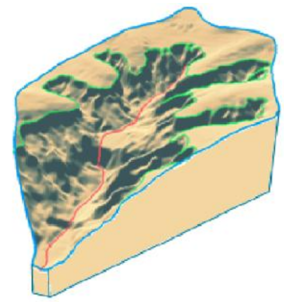


Fig. 2. An illustration of loess gully.

RESULT AND DISCUSSION

To demonstrate the procedure and result of the extraction method proposed, a test region is selected and performed (Fig. 3). As show in Fig.3 (a), this region is located in Yijun and it is one part of loess residual tableland. First of all, the DEM is smoothed by convolution filter with Gauss blur operator (Fig.3b). Then the slope is calculated (Fig.3c). Based on the slope image, the contrast split segmentation is applied (Fig.3d). Then we classify gully area by Std. of slope object layer and refine the classification with context and area values (Fig.3e). At last, the edge of gully area is the shoulder-lines and exported as the final result. Fig. 4 shows the results of other gullies.

In order to verify the extraction accuracy of this paper, the Euclidean Distance Offset Percentage (EDOP) is used for the accuracy assessment. The manually extracted products delineated with high-resolution digital orthophoto map are employed as the criterion which will assess the extraction accuracy. The assessment result is shown by Table 1.

TABLE 1 ACCURACY ASSESSMENT

	Figure Name			
	Fig. 3f	***Fig. 4a***	***Fig. 4b***	***Average***
LS	150.2	318.0	340.0	269.4
LS in EDSL	136.8	277.6	298.2	237.5
EDOP	91.1%	87.3%	87.7%	88.7%

Note: LS= Length of shoulder-lines(m); LS in EDSL= Length of shoulder-lines within EDSL

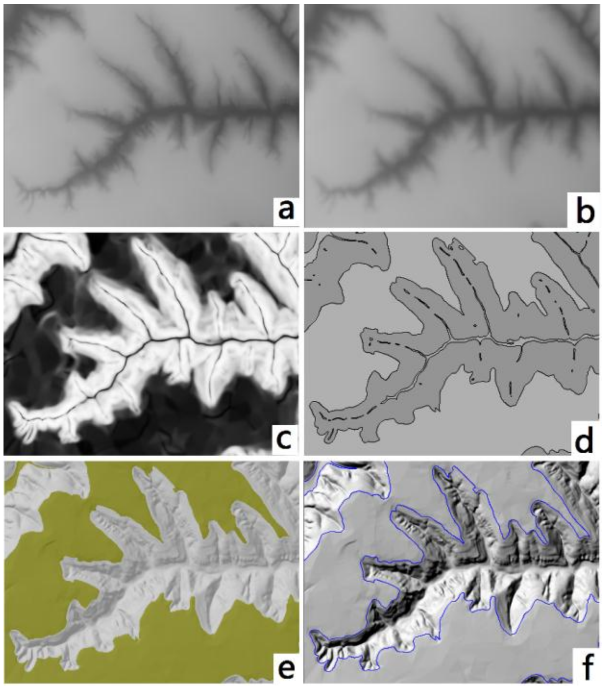
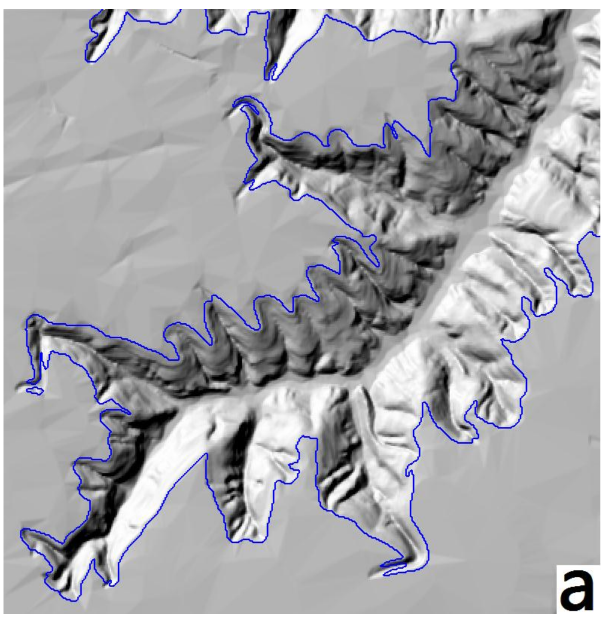


Figure 3. An example of extraction for loess shoulder-lines. a) original DEM; b) results by convolution filter; c)slope image; d) image objects by contrast split segmentation; e)classification result; f)final result.



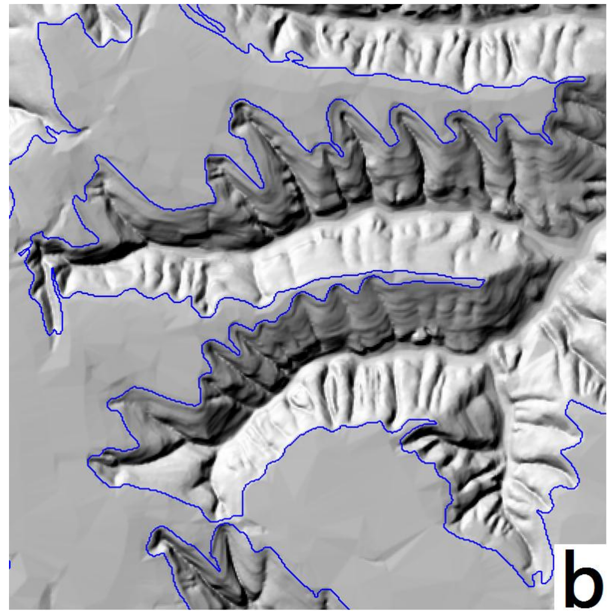


Fig. 4. Results of other gullies.

CONCLUSION

In this paper, a simple and effective method for extracting loess shoulder-lines based on object-based image analysis is proposed. The main conclusion is as follows.

1. The OBIA method offers a simple and effective extraction process of loess shoulder-lines, and its average extracted accuracy is about 88.7%, which is applicable in the loess area analysis.

2. The contrast split segmentation algorithm is useful in the DEM slope. The DEM objects obtained by this segmentation provide fine basis for extraction of loess shoulder-lines.

3. The texture between gully-slope land and loess interfluve is obvious different. As a result, the Std. of DEM objects can be a classification criterion for loess gully.

It should be noted that our research has focused on small region. Therefore, further researches are expected to testify the large area and complex regions. In addition, the formation and development mechanism of loess shoulder-lines are expected to be investigated.

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