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Line Object Recognition in Low Contrast Color Images

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Abstract: *An approach for line object recognition from low contrast color images is proposed. It consists of following main parts: posterization for noise elimination and highlighting of edges, boundaries extraction, morphological features detection and line object recognition and tracing.*

Keywords: *posterization, line object recognition, grayscale thinning.*

1. INTRODUCTION

Object extraction, description, classification and grouping are important problems of pattern recognition and image processing [1]. These problems become complicated essentially when attached to color image processing. There is a longstanding and continuing need to extract line objects from color images in a computer vision, artificial intelligence, remote sensing and image processing.

Some definition of color distance is required to support the measurement of colo~~u~~r gradient and implementation of segmentation. The RGB model is convenient when storing and transmitting colo~~u~~r information, but it can be difficult to design colo~~u~~r image processing algorithms in this space due to the high correlation between the three RGB planes. Human perception of colo~~u~~r qualities is reflected more accurately by the HSB and Lab. However low contrast images can contain noise and objects boundaries appear ~~are~~ blurred~~ing~~. We propose a posterization step to enhance image and place emphasis on object edges.

Accurate defined boundaries are important input data to line object extraction algorithm. Without the ability to distinguish different object types there is a danger that important information will be lost when an inappropriate representation is computed. Skeletons do not provide an adequate representation of area objects but are more efficient and better suited to line objects than contour-based techniques, which allow fast objects editing and coding [2]. That is why we use skeletons to represent line objects.

There are several approaches to detection of information loss through inappropriate representation and the classification of area and line objects [3, 4]. The technique ~~reported~~ proposed in [3] detects information loss during a thinning procedure by applying a threshold to the value R. Where R is a ratio between the number of contour and skeleton pixels in a connected component. If R is lower then the threshold a contour representation is chosen over a skeleton. However to estimate the threshold value the contour and skeleton representations must both be estimated.

This is too time consuming to employ within a system where real-time feedback is required. In [4] perimeter and square are used to estimate parameter of mean object width. The above approaches work well when attached to separate connected component. However there is extreme need to use knowledge about nearby components to extract complex line objects with large number of intersections.

Instead, we based area and line object recognition on the connected components boundary intersection with the thin line of correspondent component. In addition algorithm of automatic line object tracing is proposed which allows to construct complex line objects net. The knowledge about state of nearby objects extremely ~~improve~~improves the rate of line objects recognition and extraction.

2. THE PROPOSED APPROACH

Our approach is comprised~~s~~ of four stages: posterization for noise elimination and highlighting of edges, boundaries extraction, morphological features detection and line object recognition and tracing (Fig. 1).

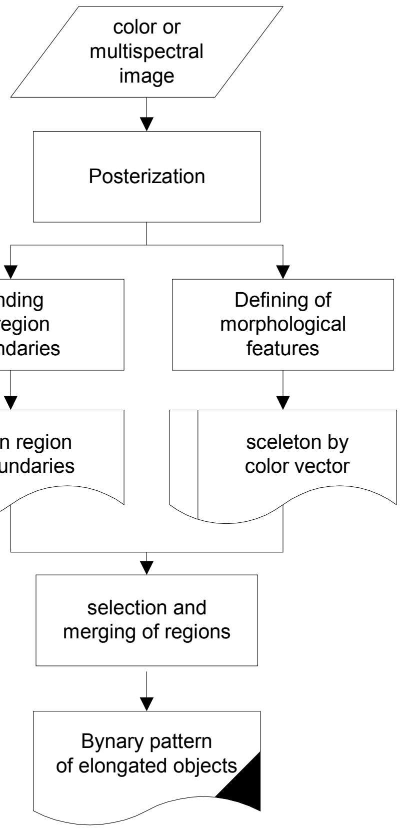

Fig. 1 The flowchart of the method~~Architecture of proposed approach~~

The morphological features can describe the recognized object by simple and efficient way. However

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these features can be corrupted by noise and optical ~~distortion which~~distortion, which leads to essential color image degradation.

Due to color space dimension reducing a lot of noise can be eliminated. In addition the original color space should be close in with human perception for clear boundaries detection. For these reasons the combination of Lab and HSB color spaces was chosen to carry out the posterization ~~is~~on —the first step of the proposed ~~approach~~method.

3. POSTERIZATION

Reducing of spectral features allows to cut a noise and to define boundaries of the supposed objects more accurately. However using of pseudo color spaces brings far better quality of defining features.

Behavior of perceptual color attributes has been defined with chromatic coordinates of chosen model while studying different color models. It allows to apply successfully the proposed algorithm of color separation of pseudo HSB space and image posterization (color space) without loss of semantic load of color or multispectrality.

In recent years, the term “posterization” appeared in foreign papers related to image processing and information visualization [5]. It means the phenomenon that comes into being during representation of the halftones in real scenes by a limited set of colors. The posterization is the process of roughening the image by gradation masking, i.e., of lessening the colors while preserving information about objects in the image.

The total number of colors in the image postered in k-dimensional space to n levels will be:

$$Nc = \frac{1}{n}\prod_{i=1}^{k} P_i, \qquad (1)$$

where *Pi* is the ith coordinate plane.

We choose two planes of posterization: HS and HB (HSB space). It is very appropriate to separate the lines of gamut on these planes from the standpoint of intuitive understanding of color, and, moreover, the brightness and saturation are the characteristics which make it possible to easily determine the most significant and evident colors.

From the analysis of the plots in [6] we can deduce that the acceleration of the ascent of curve L (from Lab color space) can specify the limits of the posterization segments. Let us assume that the intervals of the rectifiable curve for each of the segments are equal. Then the projections of the boundaries of these intervals are the threshold values of brightness.

The conditions of the obtaining the threshold values are set by:

$$l_{\max} = \int_0^{B_{\max}} \sqrt{1+[L'(x)]^2}\,dx;$$
$$dl_1 = \ldots = dl_i = \ldots = dl_{n-1}, l_n = l_{\max}, \qquad (2)$$

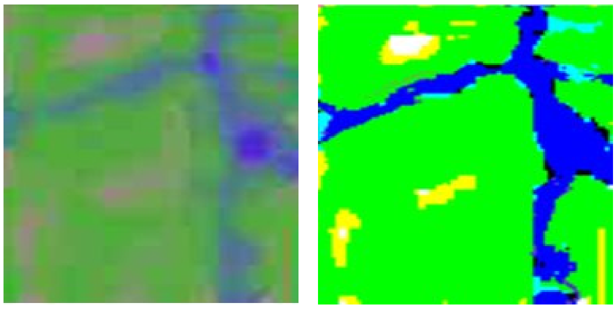
where *Bmax* is the maximum value of brightness for a given curve.

The projections of the interval boundaries B(i) can be found according to the following algorithm:~~ at Fig. 2.~~

```
for n=0:Bmax
    if (l(n) = l(i))
        B(i)=B(n);
            n=n+1;
    end;
end;
```

~~**Fig. 2 Algorithm of poszterization**~~

The results of operation of the algorithm are represented in Fig. 2~~3~~, where HS plane is separated into 2 segments which, in turn, are separated by the gamut lines of brightness.



a) b)

Fig. 2~~3~~ 2-level posterization:~~.~~ a) initial low-contrast image; b) posterized image

Applying of posterization brings color or multispectral image with defined object regions which have clear-cut boundaries.

4. MORPHOLOGICAL AND EDGE FEATURES EXTRACTION

Edge detection is the process which attempts to capture the significant properties of objects represented in the image. These properties include the discontinuities of the photometrical, geometrical and physical characteristics of objects [7].

The purpose of edge detection is ~~the~~ localization of these features and ~~the~~ identification of ~~the~~ physical ~~phenomena which~~phenomena, which gave rise to them. However, it is difficult to derive a general ~~algorithm which~~algorithm, which is optimal for color and multi-channel images, since the image is a discrete and noisy function.

We propose to use the posterization step to eliminate noise and grayscale edge detection technique for problem solution. The grayscale image is constructed from posterization one by appropriate mixing the color features.

Due to rapid changes of grayscale value and equality of background and object pixels the threshold segmentation techniques produce a lot of errors. The correspondence of object thin line and image spines should be taken into account. The grayscale thinning algorithms [8-10] can be suggested for image segmentation basis (Fig. 3~~4~~).

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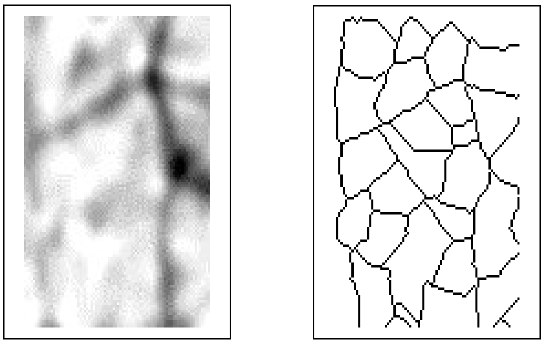
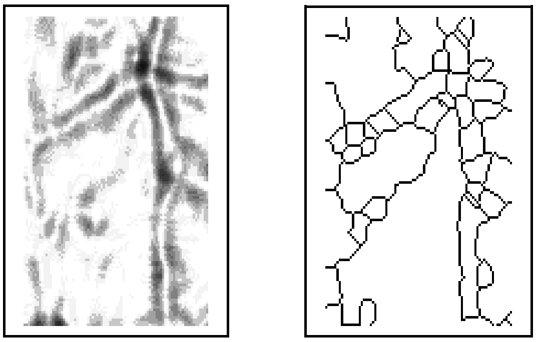


a) b)

Fig. ~~4~~3 Grayscale image (a) and thinning result (b)

Nevertheless grayscale thinning is insufficient for thick line objects extraction since these objects have a real width which should be taken into consideration. As a result of spines thinning which characterize object burrs the redundant thin line can appear. The obtained skeleton can be corrupted which leads to inadequate representation of line object.

To overcome the problem we propose to extract object edges by ~~the~~ morphological gradient (Fig. ~~5a~~4a) with followed grayscale thinning and burrs elimination (Fig. 4b) [9].



a) b)

Fig. ~~4~~5 Gradient morphological filtration (a) and area image of thinning (b)

The number of areas can be achieved (Fig. 4b). Some of them characterize the line objects. Profile for perpendicular cut of line object is similar to Gaussian distribution and have only one supremum. Thus, only one thin line can belong to corresponding object area. The rule for area preservation can be formulated in a following way. Area should be preserved if next condition is true:

$$\begin{cases} Bl < B < Bh \\ S = 1 \end{cases}, \qquad (3)$$

where B_l and B_h are the minimum and maximum width of line object, S is a number of thin lines.

The binary intersection procedure is used for constructing the combined image from thin and area images. This image is applied for number estimation of connected thin objects in corresponding areas. Areas are eliminated if preservation condition is false. To construct the complete line representation we propose recognition algorithm which combines line objects together.

5. LINE OBJECT RECOGNITION

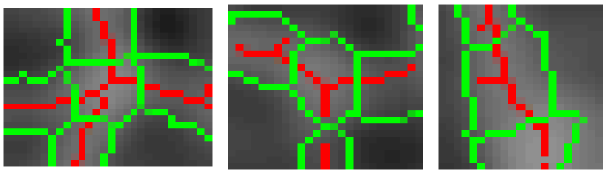
We propose an iterative tracing algorithm for line object recognition. The ~~purpose~~ idea is to determine the right contact ~~path which~~path, which corresponds to line object skeleton [10, 11]. The tracing of ~~objects which consist of area and thin lines~~objects, which consist of area and thin lines, can solve this problem.

The main difficulties for recognition are the intersection and branching of line objects. The direction parameter is able to solve these problems. In addition line object can be characterized by the following properties [11]:

- the permanence of direction;
- the permanence of width;
- the profile for perpendicular cut of line object is similar to Gaussian distribution. Some line objects profiles are similar to double symmetric Gaussian distribution.

Thus tracing procedure uses the skeleton and area image for estimation of number S which correspond to thin line intersection with corresponding area. We determine the following groups of areas depend of S (Fig. ~~6~~5):

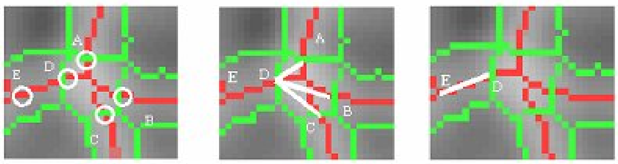
- Intersection group (S>3)
- Branching group (S=3)
- Continuation group (S=2)



a) b) c)

Fig. ~~6~~5 Example of intersection (a), branching (b) and continuation (c) areas

For the line object recognition it is necessary to take into account nearby areas (Fig. 6~~7~~a). The angle between line which connects intersection point with center mass point of corresponding area (Fig. ~~7~~6c) and horizontal axis is estimated. This angle we call the continuation angle.



a) b) c)

Fig. ~~7~~6 Example of thin line intersection with area (a); the main direction lines of skeleton for point D (b); line connects point D and center of the mass of the area (c)

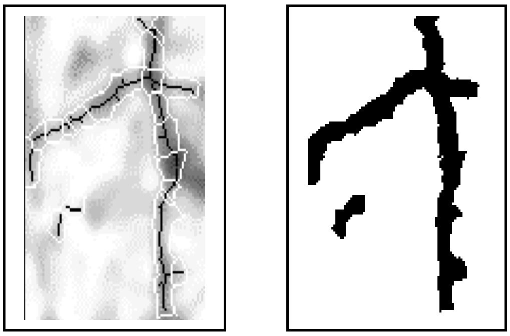
For executing of continuation operation the threshold value for angle deviation for unit length should be assigned. The angle deviation of possible continuation direction (angles <EDA, <EDB, <EDC at Fig. 6~~7~~) should be get to threshold angle. We deal with cosines and sinuses rather angles for simplification of calculation.

The rule for areas intersection is formulated in a following way. There is intersection between areas if next condition is true:

$$\begin{aligned}&(\cos(\alpha) > (\sin(Lu)\cos(\beta) - \cos(Lu)\sin(\beta))OR\\&(\cos(\alpha) < (\sin(Lu)\cos(\beta) - \cos(Lu)\sin(\beta))),\end{aligned} \tag{4}$$

where α is continuation angle of nearby area (Fig.~~7e~~6c), β *is* continuation angle of checking area (Fig. 6~~7~~b)). The areas belong to current line objects if there is intersection between them.

After the tracing the final result of recognized line objects can be achieved either in binary or skeleton representation (Fig. 7~~8~~).



a) b)

Fig. ~~8~~7 Grayscale image (a) and result of line objects recognition (b)

Due to the complex processing of areas there is no need to estimate the directional vector for thin lines and edges like in [10,11]. In addition the problem of skeleton deposition by reason of noise, illumination and optical artifacts is overcome by areas processing and the direction of line object can be estimated more precisely.

6. CONCLUSION

The proposed approach provides an accurate and efficient way of complex line objects recognition in low contrast color and multi-channel images. The HSB posterization step allows for human perception and digital noise. With the combination with line object algorithm the complex line objects can be extracted from SAR, medical and color cartographic images.

7. REFERENCES

[1] A.K. Jain, R. P.W. Duin, J. C. Mao. Statistical Pattern Recognition: A Review. *IEEE Transactions on Pattern Analysis and Machine Intelligence*. 22(1) (2000). –p. 4-37

[2] V. Bucha, S. Ablameyko (2004), Direct Color Objects Processing In Cartographic Images, *Proceeding of International Conference Modeling and Simulation MS'2004*, Minsk, Belarus 2004, -p. 183-188.

[3] L. Huang, G. Wan, C. Liu. An Improved Parallel Thinning Algorithm. *Proceedings of the Seventh International Conference on Document Analysis and Recognition*, Canada 2003.

[4] S. Ablameyko, T. Pridmore. *Machine Interpretation of Line Drawings Images.* Springer, 2000

[5] D. Palomaki *et al.*, Posterization (Contouring Examination). *http://www.dvinfo.net/canon/articles/article10.php*

[6] A.M. Belotserkovsky, S.V. Ablameyko Adapted Color Image Posterization in HSB Space *Proceeding of 7th Intern. Conf. on Pattern Recognition and Image Analysis: New Information Technologies*, 2004, St. Petersburg, Russian Federation, Vol. 1, pp. 170-173.

[7] D. Ziou, A. Koukam. Knowledge-based assistant for the selection of edge detectors. *Pattern Recognition*, 31 (5) (1998), p. 587-596.

[8] T. Naruse, J. Toriwaki, T. Fukumar.a Comparative study of thining algorithms for gray pictures. *Transaction. IECE*. 60(12) (1977), p. 1093-1100.

[9] L. Lam, S. Lee S., C. Suen. Thinning Methodologies-A Comprehensive Survey. *IEEE Transaction On Pattern analysis and Machine intelligence*. 14(9) (1992).

[10] A.Nedzved, S.Ablameyko Thinning gray images by successive analysis binary layers. *Scientific works «Digital image processing» Institute of Engineering Cybernetics of The National Academy of Sciences of Belarus*, Minsk, 1997.

[11] A. Frame, P. Undrill, J. Olson. Structural analysis of retinal Vessels. *Sixth international conference on image processing and its application IPA97*. 2 p. 824-827.