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Screen Tone Processing for Black and White Manga

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1. Introduction

To reedit paper comic on computer digitally, the abilities to process regions and objects of the comic such as operations of selecting and cutting out these elements are required. One dominant characteristic of *manga* - Japanese monochrome comic is the wide and intensive use of tone effects. Up-to-date there are no dedicated techniques for conveniently processing manga tone. This paper introduces a half-auto approach to process screen tone for monochromatic manga. User selects screen tone region of input manga simply by appointing a point in the region, then this region or regions with the same tone pattern can be accurately extracted without detraction from line arts. We adopted LoG (Laplacian of Gauss) and Sobel operators to obtain line drawings of screen tone region, preserving line arts faithful to original draft or enhancing line width into even. A region growing algorithm based on texture, gray histogram, and contour features was developed to do tone region extraction.

2. Screen Tone

Screen tone, which is used for applying textures and shades to drawings, may be transferred to paper from preprinted sheets, or simulated in computer graphics. Different styles of screen tone exist, variously intended to depict clothing, clouds, emotions, backgrounds, gradients, and so far as to objects like trees. The size and spacing of black dots, lines, pattern, or hatches determine how light or dark an area will appear.

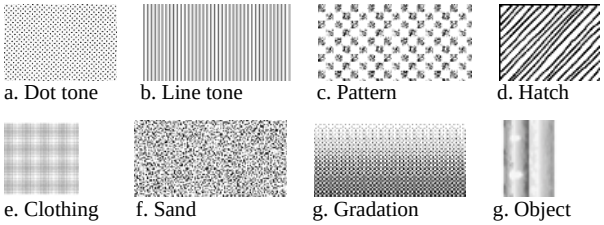


Figure 1. Screen Tone Samples

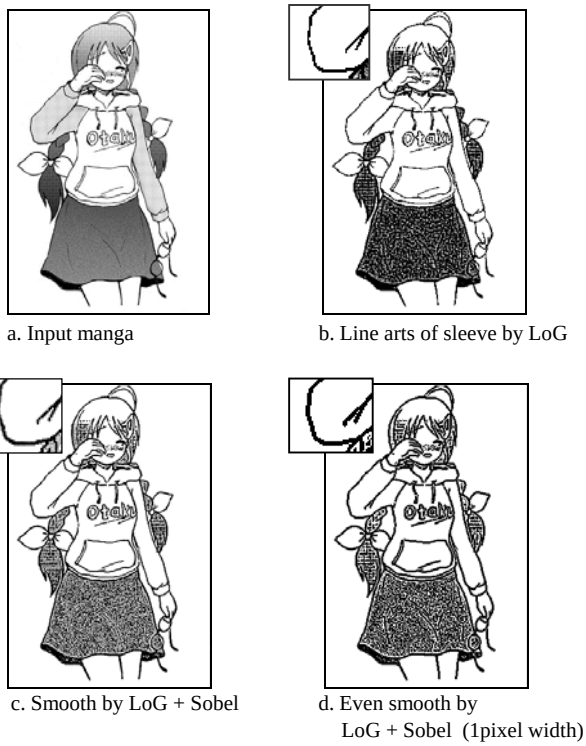
In this paper screen tone region refers to connected region containing foreground pattern with its background, not focusing on structure details in it

3. Algorithm and Result

Sketches in tone region are required to be kept as same as those in original manga so that extracting line-drawing step is necessary besides screen tone region extraction. This section describes extraction methods on line arts and screen tone region, and system framework for manga processing.

Line art extraction

After noise reduction preprocessing by using low-pass linear smoothing filter, LoG edge detector is exploited to extract line arts whose background is cleared by mask created via gray level thresholding dependent on histogram analysis of local region around the pixel that user appointed in input manga. To smooth the line arts, Sobel operator is exploited to add double line art edges to the above result. If even smooth line arts are expected, thinning the width of double line art edges can obtain the effect. Fig 2. b.-d. show the three types of extracted line arts when user appoints a point of the girl's longsleeve in draft manga, while Fig 2. e.-g. show how to set threshold for the line art extraction of skirt. The first wave hollow on the left of the wave peak in histogram of the local region in skirt is selected as the threshold value.



a. Input manga
b. Line arts of sleeve by LoG
c. Smooth by LoG + Sobel
d. Even smooth by LoG + Sobel (1pixel width)

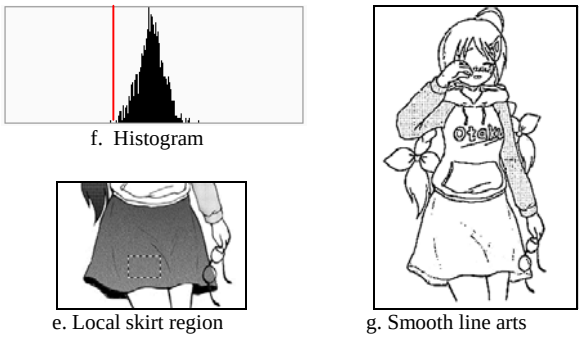


Figure 2. Line Art Extraction

Table 1. Algorithm of Line Art Extraction

Algorithm	Result	Function
LoG	Line arts	Edge detector
Sobel	Double edges of line arts	Adding to the result of LoG to get smooth line arts
Thinning	line art edges of 1 pixel width	To get even line arts
Thresholding	Background clear	Make a mask to delete background of the result of LoG or Sobel

$$\begin{pmatrix} 0 & 0 & -1 & 0 & 0 \\ 0 & -1 & -2 & -1 & 0 \\ -1 & -2 & 16 & -2 & -1 \\ 0 & -1 & -2 & -1 & 0 \\ 0 & 0 & -1 & 0 & 0 \end{pmatrix} \qquad \begin{pmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix} \qquad \begin{pmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{pmatrix}$$

LoG 5×5 template Sobel 3×3 vertical & horizontal template

Screen tone region extraction

We apply *region growing* method because it can give good segmentations that correspond well to the observed edges and texture. By this way an initial set of small areas will be iteratively merged according to similarity constraints.

- The algorithm starts by choosing the pixel that user appointed as seed pixel and compare it with neighboring pixels.
- Region is grown from the seed pixel by adding in neighboring pixels that are similar in texture of filter window (≧ 3×3 pixels) via calculation and comparison of (1) entropy based co-occurrence matrix,

$$W_E = -\sum_{g1}\sum_{g2} P(g1,g2)\log P(g1,g2)$$

where $P(g1,g2)$ is co-occurrence matrix, and
(2) cumulative statistical histogram based on CDF (cumulative distribution function),

$$P_c(S_k) = \sum_{k=0}^{k} \frac{ni}{N} \qquad k = 0,1, \ldots, L\text{-}1$$

where S_k is value of No. k level, n_i is the number of pixels with S_k, N is total number of image pixels, and
(3) increasing the size of the region not beyond contour edges.

- When the growth of one region stops, another seed pixel is chosen based on texture analysis which does not yet belong to any grown region and start again.
- This whole process is continued until all pixels belong to some region.

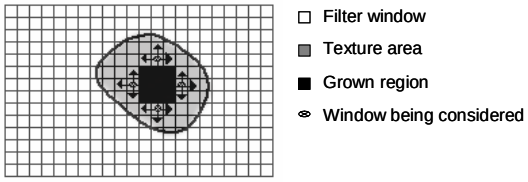


Figure 3. Region Growing

Figure 4. a shows the skirt region user appointed. For sleeve, the region may be the one appointed region (Fig 4. b.) or all sleeve regions with the same texture (Fig 4. c. or d. decided by size of filter window) controlled through GUI.

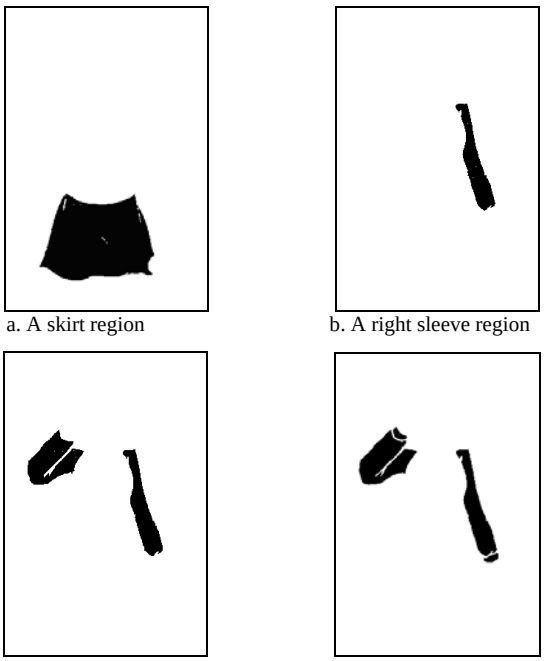


Figure 4. Screen Tone Extraction

System Framework

The framework for system development contains each step function of tone cut, all of which are concentrated in one main menu item, as well as basic Digital Image Processing (DIP) functions in connection with tone cut which are grouped in respective main menu items.

4. Conclusion

Current common method to do tone cut is a tedious job for user by selecting object along its boundary with basic tools of DIP package (Photoshop etc.). Our research provides technique for supporting speedy and convenient tone cut function to counter this problem.

Reference

[1] "Contour and Texture Analysis for Image Segmentation", Jitendra Malik, Serge Belongie, Thomas Leung and Jianbo Shi, International Journal of Computer Vision, 43(1), 7-27, June 2001.

[2] Digital Image Processing, 2nd Edition, Rafael C. Gonzalez, Richard E. Woods, Addison-Wesley Longman Publishing Co., Inc. Boston, MA, USA, 1992