Simplification of Raster Images to Extract Visual Information

Nebras N. Hasson,*   *S. A. Aljunid*,**   *R. Badlishah Ahmad*,**

*Multimedia University, Faculty of Information Science and Technology, Jalan Ayer Keroh Lama, 75450 Bukit Beruang, Melaka, Malaysia.
**Northern Malaysia University College of Engineering, School of Computer and Communication Engineering, Jalan Kangar-Arau, 02600 Jejawi, Perlis, Malaysia

Summary

Simplification of raster images is a relatively mature subject in the image analysis and recognition field, but it is yet quite far from being perfect. The purpose of our approach is to provide contrast and edge enhancement, followed by a thresholding process that yields a binary version of the original image. Then, we apply a noise reduction algorithm followed by a thinning step to produce a simplified image which can be analyzed with less consuming time and decreasing the cost of searching.

Key words:

Document Analysis and Recognition, Line Drawings, Contrast Enhancement, Thinning.

Introduction

A raster image usually contains many details that are not relevant for a visual query and increase the cost of searching. Simplification of raster images is a process to eliminate most useless elements, while retaining the perceptually dominant elements and shape, this will speed up queries [13].

Simplification of raster images is a widely used process in the area of document analysis and recognition as a preprocessing step for high-level object recognition, such as optical character recognition (OCR) and graphic objects recognition [10].

Until now no methods devised can be considered as sufficiently stable and robust to work as standalone [11]. According to Karl Tombre et al. [8], one important factor for robustness is to minimize the number of parameters and thresholds needed in the simplification process. Thus, in our work we intend to achieve an acceptable simplification results.

In figure 1 we depict steps we followed to simplify the raster images starting form contrast enhancement and ended with thinning.
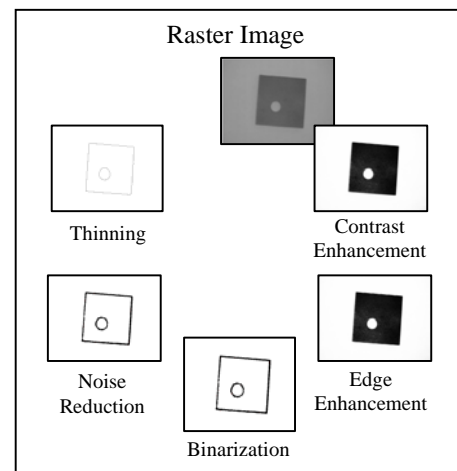

Fig. 1 Steps of raster image simplification.

2. Contrast Enhancement

Accurate visual interpretation of images depends to a great extent on their visual contrast [AMJM04]. To improve the appearance of images and effectiveness of analysis we use sigmoid activation function. This function is used because of its nonlinearity.

By using this sigmoid function, the output unit is constrained to generate values between zero and one. The sigmoid function helps a system reaching desired outputs. It's defined as follow:

$$\text{Enhanced Image} = \frac{1.0}{\left(1 + e^{(\text{gain} \times (\text{cutoff} - \text{img}))}\right)} \qquad (1)$$

Where:

> *Img* : A raster image to be processed.
> *Gain* : Controls the actual contrast.
> *Cutoff*: Represents the (normalized) grey value about which contrast is increased or decreased.

Depending on the original image quality we might change the value of the parameters *Cutoff* and *Gain*. In our approach we considered an initial value for *Gain* is 10 to increase the contrast about 2.5 times, and the initial value for *Cutoff* is 0.5 (the midpoint of the grey

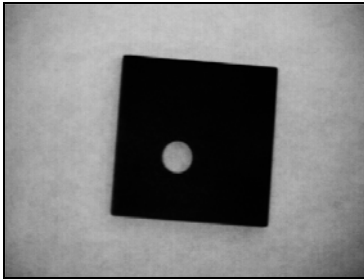scale). However different images may require different points of the grey scale to be enhanced.
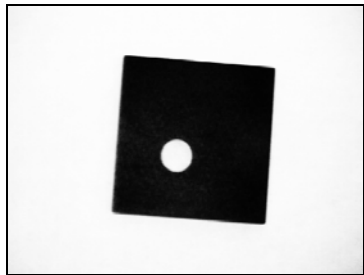

Fig. 2 Results for Cutoff=0.8 and Gain=7.

Fig. 3 Results for Cutoff=0.5 and Gain=10.

3. Edge Enhancement

Among the techniques that may be used to improve the appearance of an image, sharpening by enhancement of edges and contours plays an important role.

The primary objective in enhancing edges and other localized features is to give an image a crisper appearance. To accomplish this, we apply the edge enhancement algorithm suggested in [12], using a high-pass filtering technique. The expression below shows an unsharp masking used in edge enhancement algorithm.

$$\frac{1}{(\alpha+1)}\begin{bmatrix} -\alpha & \alpha-1 & -\alpha \\ \alpha-1 & \alpha+5 & \alpha-1 \\ -\alpha & \alpha-1 & \alpha-1 \end{bmatrix}$$

The enhancement of background noise is a common side effect of high-pass filtering. It may thus be desirable to perform noise reduction as a prior step [12].

4. Binarization

A grey-scale image often contains only two levels of significant information, namely the foreground level constituting objects of interest (shading and textures are not relevant to the presented approach) and the background level against which the foreground could be discriminated. Since we are only interested in performing line detection, therefore grey-scale image must be converted to a binary image.

Binarization methods can be divided into two main categories: *global techniques* and *locally adaptive techniques*, both described in [12]. *Global techniques* applied with drawings that are having good quality, use a global threshold for all pixels, ignoring their context. On the other hand, drawings that have poor quality may require *locally adaptive techniques* that change the threshold dynamically over the image.

In our approach, the choice between *global* and *locally adaptive techniques* is taken by the user during the simplification process.
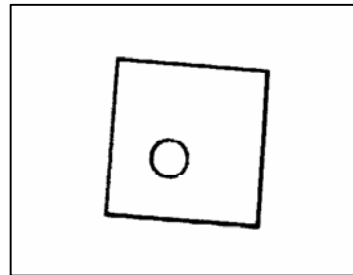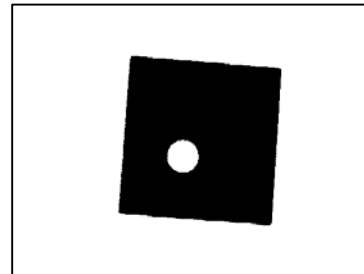

Fig. 4 Global thresholding results.

Fig. 5 Local adaptive thresholding results.

5. Binary Noise Removal

Most image analysis methods benefit greatly from the reduction of noise in the preprocessing step. A noise reduction means a substantial improvement in the reliability and the robustness of feature detection and objects recognition and may serve to reduce the memory requirement for image storage.

Noise in a grey-scale image is usually understood as single pixel or very small areas containing very different grayscale values from their environment. Averaging is probably the most basic noise reduction method.

In our approach we use the binary noise removal algorithm based on median filter described in [9]. This algorithm arranges the grayscale values of a chosen area in increasing order, and set one of these values to the current pixel value. Basic median filter chooses the middle value. We provide three types of pixel matrixes 3×3, 5×5, and 7×7. In Figure 6 we depict the noise reduction operation.
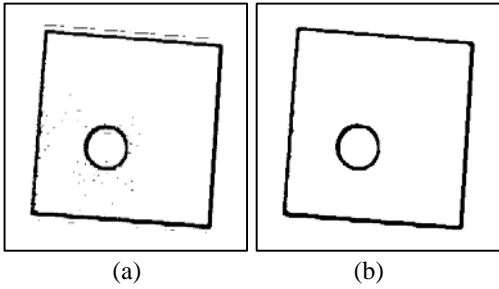

(a)   (b)

Fig. 6 Illustration of noise reduction. (a) Sample noisy image, (b) Sample image, averaged with 5×5 matrix.

6. Thinning

Thinning is an image processing operation in which binary-valued image regions are reduced to skeletons of the regions. These skeletons approximate center lines with respect to the original region boundaries.

Since our purpose is to find a simplified version of a raster image, the thickness of the lines that composes the original drawing is not important.

Tamura [1], Smith [3], and Lam et al. [6] provide comprehensive surveys of thinning algorithms, and conclude that there is no general thinning algorithm.

We have decided to use the thinning algorithm described in [6]. This algorithm divides the image into two distinct subfields in a checkerboard pattern. Iteration could be provided to delete pixel "*P*" from the first and second subfields if and only if the following three conditions are all satisfied.

Condition 1:

$$X_H(P) = 1 \tag{2}$$

Where

$$X_H(P) = \sum_{i=1}^{4} b_i \tag{3}$$

$$b_i = \begin{cases} 1 \text{ if } x_{2i-1} = 0 \text{ and } (x_{2i} = 1 \text{ or } x_{2i+1} = 1) \\ 0 \text{ otherwise} \end{cases} \tag{4}$$

x_1, x_2,…, x_8 are the values of the eight neighbors of *P*, starting with east neighbor and numbered in counter-clockwise order.

Condition 2:

$$2 \le \min\{n_1(P), n_2(P)\} \le 3 \tag{5}$$

Where

$$n_1(P) = \sum_{k=1}^{4} x_{2k-1} \vee x_{2k}$$

$$n_2(P) = \sum_{k=1}^{4} x_{2k} \vee x_{2k+1} \tag{6}$$

Condition 3:

$$(x_2 \vee x_3 \vee \bar{x}_8) \wedge x_1 = 0 \tag{7}$$

7. Experimental Results

We developed a prototype which integrates all components described above. Figure 7 shows the user interface of the prototype, which is divided in three main areas: the buttons area which comprises control buttons, parameterized area which allows users to change the values of the parameters to get best results of enhanced image, and the results area where the original and enhanced images are displayed in the boxes titled *Original Image* and *Enhanced Image*.
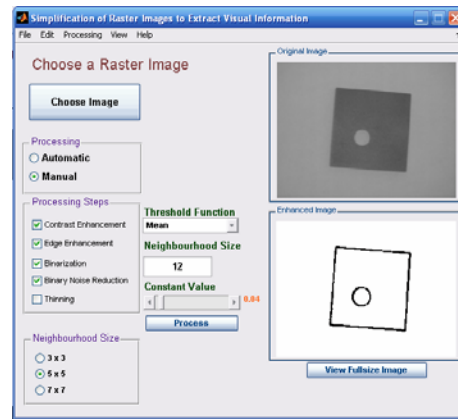

Fig. 7 Simplification of raster image prototype.

8. Conclusion and Future Work

We have presented an approach to simplify raster images to extract visual information that can be analyzed with less consuming time and more decreasing the cost of searching. The simplification process is the most fundamental operation in document analysis, recognition and interpretation of line drawings (vector drawings) in general and technical document in particular.

It has to be implemented using methods that better suits the needs of the system. Good methods should preserve the shape information, which includes line width, line geometry, and intersection junction, as much as possible. This information is important for post processing.

Due to users' comments and suggestions, and from our observations, we suggest using other elements to improve our prototype by adding new algorithms to extract the textual information. Then the system will be able to simplify different types of raster images with or without textual information. Another suggestion is to produce a vectorized drawing from the system by adding one more operation called *Polygonization* to be used after the *Thinning* step.

References

[1]   Tamura H. A, "Comparison of Line Thinning Algorithms for Digital Geometry Viewpoint". In proceedings of the 4th International Conference on Pattern Recognition, Kyoto, Japan, 1978, pp 715-719.

[2]   Huang, T. S., G. J. Yang, and G. Y. Tang, "A Fast Two-Dimensional Median Filtering Algorithm". IEEE Transactions on Acoustics, Speech and Signal Processing, Vol. ASSP 27, No. 1, February 1979.

[3]   Smith RW. Computer Processing of Line Images: A survey. Pattern Recognition 1987, 20(1):7-15.

[4]   Pratt, William K., Digital Image Processing. John Wiley & Son, Inc., 1991.

[5]   Haralick, Robert M., and Linda G. Shapiro, Computer and Robot Vision. Volume 1, Addison-Wesley, 1992.

[6]   Louisa Lam, Seong-Whan Lee, and Ching Y. Wuen, "Thinning Methodologies-A Comprehensive Survey". IEEE TrPAMI, Vol. 14, No. 9, pp. 869-885, 1992.

[7]   Louisa Lam, Suen C., "An evaluation of parallel thinning algorithms for character recognition'. IEEE TPAMI 17 (1995), 914–919.

[8]   Tombre K., Ah-Soon C., Dosch P., Habed A., Masini G., "Stable, robust and offthe-shelf methods for graphics recognition". In Proc. of the 14th Int. Conf. on Pattern Recognition (Australia, 1998), IAPR, pp. 406–408.

[9]   Lim, Jae S., Two-Dimensional Signal and Image Processing, Englewood Cliffs, NJ, Prentice Hall, 1999, pp. 469-476.

[10] Liu Wenyin, Dov Dori, "From Raster to Vectors: Extracting Visual Information from Line Drawings". Pattern Analysis and Applications (PAA), 1999.

[11] Tombre K., Ah-Soon C., Dosch P., Masini G., Tabbone S., "Stable and robust vectorization: How to make the right choices", In Proc. of the 3rd IAPR Intl. Workshop on Graphics Recognition (Jaipur, India, 1999), IAPR, pp. 3–16.

[12] Seul M., O'Gorman L., Sammon m. J., Practical Algorithms for Image Analysis. Cambridge University Press, 2000.

[13] A. Ferreira, M. J. Fonseca, J. A. Jorge, and M. Ramalho, "Mixing Images and Sketches for Retrieving Vector Drawings". The 7th Eurographics Workshop on Multimedia (EGMM04), China, 2004.

[14] Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, Digital Image Processing Using MATLAB. Pearson Education, Inc., 2004.

Nebras Alattar received the B.Sc. in Computer Science from Nasser University/Libya in 1999 and M.Sc. in Computer Science from University Putra Malaysia/Malaysia in 2002. He is currently working toward the Ph.D. degree in the School of Computer and Communication Engineering, Northern Malaysia University College of Engineering, and he is a lecturer in the Faculty of Information Science and Technology, Multimedia University, Malaysia.