IMPLEMENTATION OF BERNSEN'S LOCALLY ADAPTIVE BINARIZATION METHOD FOR GRAY SCALE IMAGES

Can EYUPOGLU

Istanbul Commerce University, Department of Computer Engineering, Istanbul-Turkey

ceyupoglu@ticaret.edu.tr

Abstract: In digital image processing, binarization (two-level thresholding) is a commonly used technique for image segmentation. It is the process of converting a gray scale image to a binary image. Furthermore, binarization methods are divided into two groups as global binarization and locally adaptive binarization. A number of binarization techniques have been proposed over the years. Bernsen's method is one of locally adaptive binarization methods developed for image segmentation. In this study, Bernsen's locally adaptive binarization method is implemented and then tested for different gray scale images.

Keywords: Digital Image Processing, Image Segmentation, Binarization, Thresholding, Locally Adaptive Binarization, Bernsen's Method

Introduction

Binarization is a well-known method for image segmentation due to applicability to many fields in digital image processing (Sahoo et al., 1988). In order to separate objects from background, it is an effective technique. A number of binarization applications have been proposed over the years such as document image analysis for extracting printed characters, logos, graphical content or musical scores, map processing for finding place of lines, legends or characters, scene processing for detecting a target, quality inspection of materials, extraction of edge field and spatio-temporal segmentation of video images (Sezgin and Sankur, 2004).

In recent years, the field of document image analysis has received significant attention and has become one of the important parts of digital image processing. There are various researchers which are seeking to design systems for extracting information from extensive documents as maps, magazines, newspapers, engineering drawings, forms and mails. In most of these systems, binarization is applied as the first step (Trier and Taxt, 1995a). The aim of the binarization of document images is extracting text from images, removing noise and reducing image size. This process is performed with removing useless information in order to increase visibility of useful information in an image (Bataineh et al., 2011). In the work of Kefali et al. (2010), it is asserted that the purpose of binarization is to decrease the existence of undesirable data and conserve the desired data in document images. This operation is done by converting all gray levels of images into two levels as black and white.

Binarization techniques are divided into two groups. These are global binarization and locally adaptive binarization (Singh et al., 2011). Global binarization methods compute a single threshold value for the entire image. Pixels having a gray level darker than the threshold value are marked as black (foreground). In the contrary case, the other pixels are labeled as white (background) (Trier and Jain, 1995). Some of the global binarization methods existing in the literature are Abutaleb's method (Abutaleb, 1989), Kapur et al.'s method (Kapur et al., 1985), Kittler and Illingworth's method (Kittler and Illingworth, 1986) and Otsu's method (Otsu, 1979). Besides, locally adaptive binarization methods calculate a threshold value for each pixel on the basis of information contained in a neighborhood of the pixel. Some of these methods compute a threshold surface over the entire image. In the input image, if a pixel (x, y) has a higher gray level than threshold surface evaluated at (x, y), then the pixel (x, y) is marked as background, otherwise it is marked as foreground (Trier and Jain, 1995). In the literature, some of the locally adaptive binarization methods are Bernsen's method (Bernsen, 1986), Chow and Kaneko's method (Chow and Kaneko, 1972; Nakagawa and Rosenfeld, 1979), Eikvil et al.'s method (Eikvil et al., 1991), Mardia and Hainsworth's method (Mardia and Hainsworth, 1988), Niblack's method (Niblack, 1986), Taxt et al.'s method (Taxt et al., 1989), Yanowitz and Bruckstein's method (Yanowitz and Bruckstein, 1989), White and Rohrer's dynamic threshold algorithm (White and Rohrer, 1983), White and Rohrer's integrated function algorithm (White and Rohrer, 1983), Parker's method (Parker, 1991) and Trier and Taxt's method (Trier and Taxt, 1995b).

The rest of the paper is organized as follows. In materials and methods section, Bernsen's locally adaptive

binarization method is explained. In results and discussion section, the results of applying Bernsen's method on gray scale images are showed for different neighborhood values and contrast limits. Finally, conclusions being under study are summarized in conclusion section.

Materials and Methods

In this paper, Bernsen's locally adaptive binarization method is used in order to extract texts from gray scale images. Furthermore, it is implemented and tested for different neighborhood values and contrast limits. In Bernsen's method (Bernsen, 1986), the threshold value is calculated for each pixel (x, y) according to the following equation (1).

$$T(x, y) = (Z_{low} + Z_{high}) / 2 \quad (1)$$

where Z_{low} and Z_{high} are the lowest and highest gray level pixel values in a square r x r neighborhood centered at (x, y). The contrast measure is calculated for each pixel (x, y) according to the following equation (2).

$$C(x, y) = Z_{high} - Z_{low} \quad (2)$$

If the contrast measure $C(x, y) < l$, then the neighborhood consists only of one class, foreground or background. In addition, r and l values vary depending on the used images and areas. Applying Bernsen's method for gray scale images is shown in Figure 1.

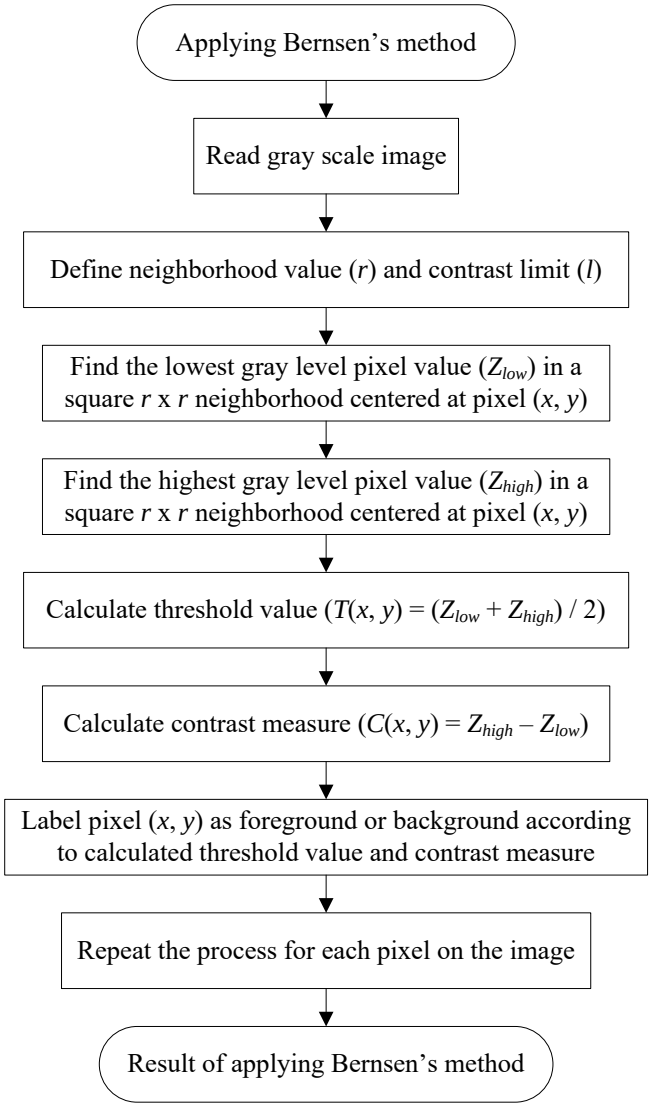

Figure 1. Flowchart of applying Bernsen's locally adaptive binarization method for gray scale images.

As seen in the flowchart, firstly, the gray scale image used for testing is read. Secondly, the neighborhood value

and contrast limit are defined. After that the lowest and highest gray level pixel values in a square r x r neighborhood centered at (x, y) are found and then the threshold value and contrast measure are computed. In the sequel, the pixel (x, y) is labeled as foreground or background according to calculated threshold value and contrast measure. Finally, this process is repeated for each pixel on the image.

Results and Discussion

In this study, in order to extract texts from gray scale images, Bernsen's locally adaptive binarization method is used. The application used for binarization is implemented using MATLAB R2014a. The application is tested for different neighborhood values and contrast limits on various gray scale images. The neighborhood values are chosen as 3, 5 and 15. Moreover, the contrast limits are selected as 15 and 50 for testing the performance of Bernsen's method. As an example, one of the original gray scale images used in this work is shown in Figure 2. The size of this gray scale image is 202 x 202 pixels.

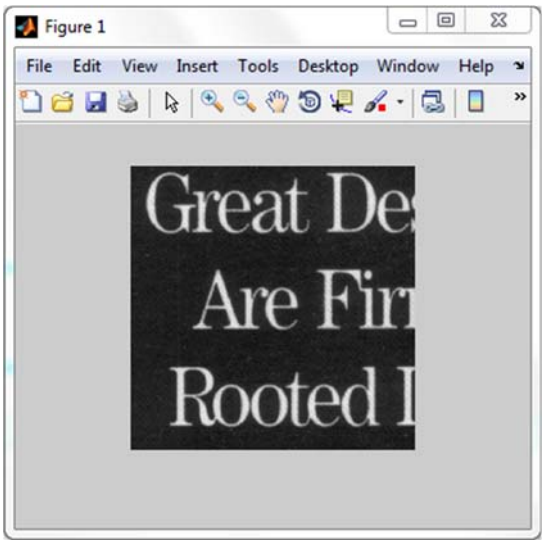

Figure 2. Orijinal gray scale image used for testing Bernsen's method.

The results of applying Bernsen's method on the original gray scale image for r=3 are shown in Figure 3.

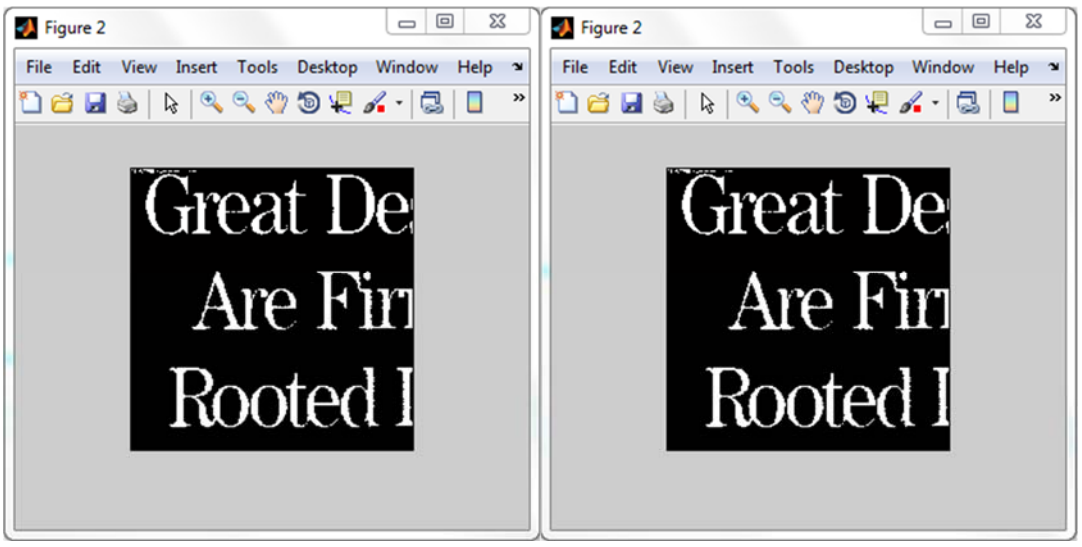

Figure 3. Applying Bernsen's method on the original image for r=3 (l=15 and l=50 respectively).

The results of applying Bernsen's method on the original gray scale image for r=5 are shown in Figure 4.

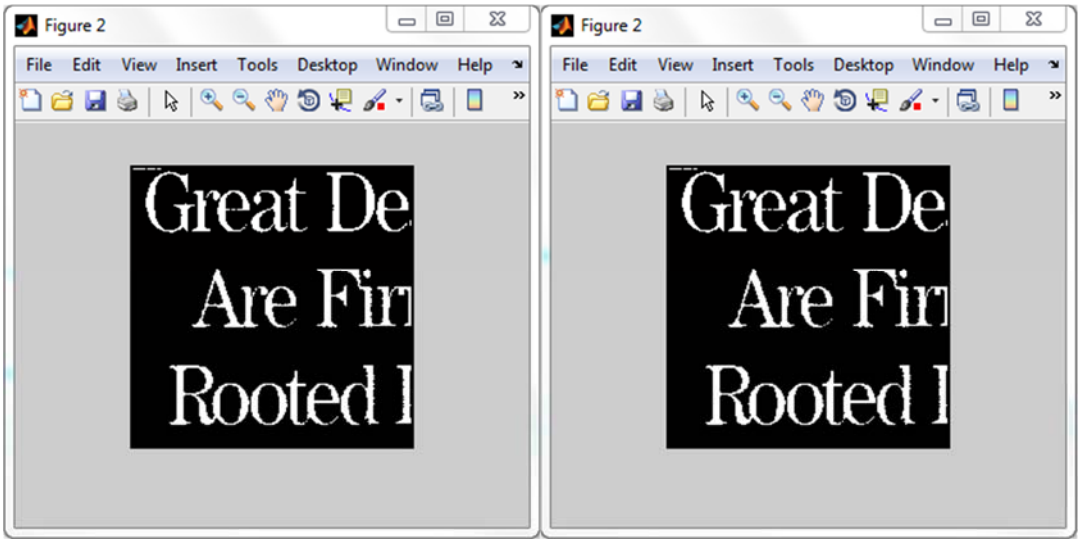

Figure 4. Applying Bernsen's method on the original image for *r*=5 (*l*=15 and *l*=50 respectively).

The results of applying Bernsen's method on the original gray scale image for *r*=15 are shown in Figure 5.

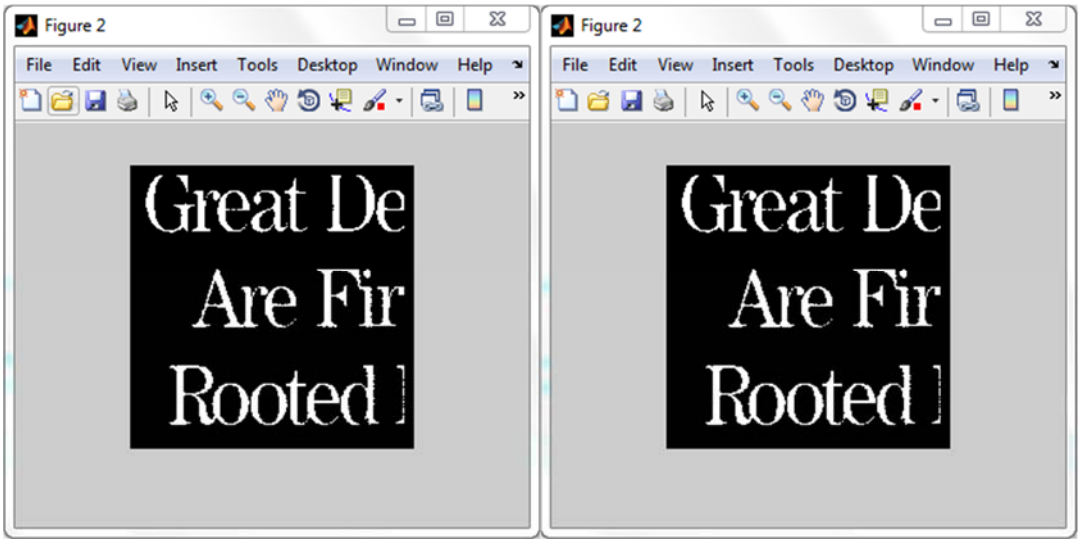

Figure 5. The results of applying Bernsen's method on the original image for *r*=15 (*l*=15 and *l*=50 respectively).

As seen in Figure 3, 4 and 5, the useless information is removed from the original gray scale image and the visibility of the useful information is increased. Consequently, the texts are successfully extracted using Bernsen's binarization method. It is observed that this method is efficient for different *r* and *l* values. However, the increase of neighborhood value and contrast limit raises the process time of the method. Besides, the process time is inversely proportional to the processing speed of Bernsen's method.

Conclusion

In recent years, document image analysis has become a significant research topic in the area of digital image processing. Binarization is applied as the first step in most of the document image analysis applications. The purpose of the binarization of document images is to remove useless information and noise in order for extracting text and useful information from images. In this paper, Bernsen's locally adaptive binarization method is implemented and then it is evaluated for different neighborhood values and contrast limits. According to the study results, it is seen that the texts are successfully extracted and Bernsen's method is effective for various neighborhood values and contrast limits. In addition, the more neighborhood value and contrast limit raise, the more the process time of the method increases.

References

Abutaleb, A.S. (1989). Automatic thresholding of gray-level pictures using two-dimensional entropy. *Computer Vision, Graphics and Image Processing, 47*, pp. 22-32.

Batainehb, B., Abdullah, S.N.H.S., & Omar, K. (2011). An adaptive local binarization method for document images based on a novel thresholding method and dynamic windows. *Pattern Recognition Letters 32*, pp. 1805-1813.

Bernsen, J. (1986). Dynamic thresholding of grey-level images. *Proc. Eighth Int'l Conj Pattern Recognition*, pp. 1,251-1,255, Paris.

Chow, C.K., & Kaneko, T. (1972). Automatic detection of the left ventricle from cineangiograms. *Computers and Biomedical Research, 5*, pp. 388-410.

Eikvil, L., Taxt, T., & Moen, K. (1991). A fast adaptive method for binarization of document images. *Proc. First Int'l Conf. Document Analysis and Recognition*, pp. 435-443, Saint-Malo, France.

Kapur, J.N., Sahoo, P.K., & Wong, A.K.C. (1985). A new method for gray-level picture thresholding using the entropy of the histogram. *Computer Vision, Graphics and Image Processing, 29*, pp. 273-285.

Kefali, A., Sari, T., & Sellami, M. (2010). Evaluation of several binarization techniques for old Arabic documents images. *The First International Symposium on Modeling and Implementing Complex Systems (MISC'2010)*, pp. 88-99, Algeria.

Kittler, J., & Illingworth, J. (1986). Minimum error thresholding. *Pattern Recognition, 19* (1), pp. 41-47.

Mardia, K.V., & Hainsworth, T.J. (1988). A spatial thresholding method for image segmentation. *IEEE Trans. Partern Analysis and Machine Intelligence, 10* (6), pp. 919-927.

Nakagawa, Y., & Rosenfeld, A. (1979). Some experiments on variable thresholding. *Pattern Recognition, 11* (3), pp. 191-204.

Niblack, W. (1986). *An Introduction to Digital Image Processing*, pp. 115-116. Englewood Cliffs, N.J.: Prentice Hall.

Otsu, N. (1979). A threshold selection method from gray-level histograms. *IEEE Trans. Systems, Man, and Cybernetics, 9* (1), pp. 62-66.

Parker, J.R. (1991). Gray level thresholding in badly illuminated images. *IEEE Trans. Pattern Analysis and Machine Intelligence, 13* (8), pp. 813-819.

Sahoo, P.K., Soltani, S., & Wong, A.K.C. (1988). A survey of thresholding techniques. *Computer Vision, Graphics, and Image Processing, 41* (2), pp. 233-260.

Sezgin, M., & Sankur, B. (2004). Survey over image thresholding techniques and quantitative performance evaluation. *Journal of Electronic Imaging, 13* (1), pp. 146-165.

Singh, T.R., Roy, S., Singh, O.I., Sinam, T., & Singh, K.M. (2011). A New Local Adaptive Thresholding Technique in Binarization. *International Journal of Computer Science Issues, 8* (6), pp. 271-277.

Taxt, T., Flynn, P.J., & Jain, A.K. (1989). Segmentation of document images. *IEEE Trans. Pattern Analysis and Machine Intelligence, 11* (12), pp. 1,322-1,329.

Trier, O.D., & Jain, A.K. (1995). Goal-Directed Evaluation of Binarization Methods. *IEEE Transaction on Pattern Analysis and Machine Intelligence, 17* (12), pp. 1191-1201.

Trier, O.D., & Taxt, T. (1995a). Evaluation of Binarization Methods for Document Images, *IEEE Transaction on Pattern Analysis and Machine Intelligence, 17* (3), pp. 312-315.

Trier, O.D., & Taxt, T. (1995b). Improvement of 'integrated function algorithm' for binarization of document images. *Pattern Recognition Letters, 16* (3), pp. 277-283.

White, J.M., & Rohrer, G.D. (1983). Image thresholding for optical character recognition and other applications requiring character image extraction. *IBM J. Research and Development, 27* (4), pp. 400-411.

Yanowitz, S.D., & Bruickstein, A.M. (1989). A new method for image segmentation. *Computer Vision, Graphics and Image Processing, 46* (1), pp. 82-95.

