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A Novel Approach towards Computation and Memory Efficient Implementation of Convolution-based Binarization Techniques

Ayatullah Faruk Mollah[a], Subhadip Basu[a] and Mita Nasipuri[b]

[a]School of Mobile Computing and Communication, Jadavpur University, Kolkata 700 032, India.
Contact: afmollah@gmail.com

[b]Department of Computer Science and Engineering, Jadavpur University, Kolkata 700 032, India.

Binarization of document images is an extensively studied topic. Among the binarization techniques, locally adaptive ones are most popular and majority of them are convolution-based. Computational requirements of such techniques make them unsuitable for low computing platforms and handheld mobile devices such as cell-phones, Personal Digital Assistants, etc. In this paper, we have presented a novel implementation approach for making convolution-based locally adaptive binarization techniques computationally efficient as well as low memory usage while keeping the performance comparable to the algorithmic implementation. The computational complexity has been reduced from $O(W^2N^2)$ to $O(WN^2)$ where $W \times W$ is the window size and $N \times N$ is the image size. Moreover, an automatic window size selection schema has been proposed. Experiments over benchmark datasets show that the computation time has been reduced by 5 to 15 times depending on the window size without consuming additional memory with respect to the state-of-the-art algorithmic implementation. This approach is specially useful for handheld device based image analysis applications.

Keywords : Adaptive Binarization, Convolution, Efficient Implementation, Handheld Device.

1. INTRODUCTION

Image analysis leads to wide range of applications. The application areas include image processing, pattern recognition, computer vision, image indexing and retrieval, mobile computing, multimedia, *etc.*. It is still an active area of research. One of the most important steps of any document processing systems is binarization. Over the past decades, binarization of images has been extensively studied.

Binarization is defined as a process of converting a multi-chromatic digital image into a bi-chromatic one. A multi-chromatic image also called as *color image* consists of color pixels each of which is represented by a combination of three basic color components *viz.* red (r), green (g) and blue (b). The range of values for all these color components is 0-255. So, the corresponding gray scale value $f(x, y)$ for a pixel located at (x, y) may be obtained by using Eq. (1).

$$f(x, y) = w_r \times r(x, y) + w_g \times g(x, y) + w_b \times b(x, y) \tag{1}$$

where, w_r= 0.299, w_g= 0.587 and w_b= 0.114. As $\sum w_i$ =1, the range of $f(x, y)$ is also 0-255. So, a gray scale image can be represented as a matrix of gray level intensities $F_{M\times N} = [f(x, y)]_{M\times N}$ where M and N denote the number of rows *i.e.*, the height of the image and the number of the columns *i.e.*, the width of the image respectively. Similarly, a binarized image $G_{M\times N}$ can be represented as $[g(x, y)]_{M\times N}$ such that $g(x, y) \in \{0, 255\}$.

Document image binarization techniques developed so far can be categorized into two types - *global binarization techniques* and *lo-*

schema for fast determination of sampled window pixel locations by the use of pixel location array has been presented.

Experiments show that the computational complexity has been reduced from $O(W^2N^2)$ to $O(WN^2)$ and the time computation has been reduced by 5 to 15 times depending on the window size without using additional memory space.

This type of implementation is especially useful in image analysis and document processing systems for real-time systems and on handheld mobile devices having limited computational facilities. The presented technique is highly relevant and useful, as the trend in designing camera based applications on mobile devices has recently increased considerably.

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Ayatullah Faruk Mollah received his B.E. degree in Computer Science and Engineering from Jadavpur University, Kolkata, India in 2006. Then he served as a Senior Software Engineer in Atrenta (I) Pvt. Ltd., Noida, India for two years. He is now a Ph.D student in the School of Mobile Computing and Communications of Jadavpur University. His research interests include Image Processing and Pattern Recognition on Low Computing Platforms.

Subhadip Basu received his B.E. degree in Computer Science and Engineering from Kuvempu University, Karnataka, India, in 1999. He received his Ph.D.(Engg.) degree thereafter from Jadavpur University (JU) in 2006. He joined JU as a Senior Lecturer in 2006. His areas of current research interest are OCR of Handwritten Text, Gesture Recognition, Real-Time Image Processing.

Mita Nasipuri received her B.E., M.E., and Ph.D (Engg.) degrees from Jadavpur University, in 1979, 1981 and 1990, respectively. Prof. Nasipuri has been a faculty member of JU since 1987. Her current research interest includes image processing, pattern recognition and multimedia systems. She is a senior member of the IEEE, USA, Fellow of I.E (India) and W.A.S.T., Kolkata, India.