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REVIEW ARTICLE

COMPARISON OF VARIOUS BINARIZATION TECHNIQUE FOR DEGRADED DOCUMENTS

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ABSTRACT

Binarization is the process that converts an image into black-and-white a threshold value is defined and the colors above that value are converted into white. While the colors below it is converted into black. This is a very simple process in digital image processing when one has a document with black ink written on a white paper. Document image binarization is an important step in the document image analysis and recognition pipeline. The performance of a binarization technique directly affects the recognition analysis. The quality of the images however has a significant impact on the OCR performance. Since most historical archive documents images are of poor quality due to aging and discolored cards and ink fading. In recent years this method has gamed popularity over its competitors due to its simplicity superior convergence characteristics and high solution quality. Two algorithms are presented, that are suitable for scanning document images are high-speed. They are designed or operate on a portion of the image while scanning the documents, thus, they fit pipeline architecture and lend themselves to real-time implementation. The first algorithm is based on adaptive thresholding and uses local edge information to switch between global thresh holding and adaptive local thresholding determined from the statistics of a local image window. The second thresholding algorithm is based on tracking the foreground and background levels using clustering based on a variant of the K-means algorithm. The two approaches may be used independently or may be combined /or for improving performance.

Key words: K-means, Binarization, Adaptive Thresholding, Pipeline.

INTRODUCTION

Binarization is the starting step of most document image analysis systems and refers to the conversion of the gray scale image to a binary image. Binarization is a key step in document image processing modules since a good binarization sets the base for further document image analysis. Binarization usual distinguishes text areas from background areas, so it is used as a text locating technique.

Images and Digital Images

An image is a single picture which represents something. It may be a picture of a person, of people or animals, or of an outdoor scene, or a microphotograph of an electronic component, or the result of medical imaging. A digital image differs from a photo in that the (x, y) and f (x. y) values are all discrete. Usually they take on only integer values; x and y ranging from 1 to 256 each and the brightness values also ranging from 0 (black) to 255 (white). A digital image can be considered as a large array of discrete dots, each of which has a brightness associated with it. These dots are called picture elements, or more simply pixels. The pixels surrounding a given pixel constitute its neighborhood. A neighborhood can be characterized by its shape in the same way as a matrix

Types of Digital Images

We shall consider basic four types of images:

- Binary Images.
- Grayscale.
- True color or RGB.
- Indexed.

Image Acquisition: Briefly, discussing the meaning for getting picture into a computer.

CCD camera: Such a camera has, in place of the usual film, an array or photo sites; these are silicon electronic devices whose voltage output is proportional to light falling on them. For a camera attached to a computer, information fronts the photo sites is then output to a suitable storage medium. Generally this is done on hardware as being much faster and more efficient than software using a frame-grabbing card. This allows a large number of images to be captured in a very short time in the order of one ten—thousandth of a second each. The images can then be copied onto a permanent storage device at some later time. Digital still cameras use a range of devices, from floppy discs and CD's, to various specialized cards and memory sticks. The information can then be downloaded from these devices to hard disk.

Fig. 1.1. Images Capture By Digital Camera

Flatbed Scanner: This works on a principle similar to the CCD camera. Instead of the entire image being captured at

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once on a large array, a single row or photo sites is moved across the image, capturing it row-by –row as it moves. Since this is much smaller process than taking a picture from the camera, this is quite reasonable to allow all capture and storage to be processed by suitable software.

Fig.1.2. Images Taken By Scanner

Binarization Techniques

Document image binarization is an important area or say active area in the field of image processing and pattern reorganization. It converts the gray scale image into binary image as extracting text and eliminating the background. Binarization plays the important role in document processing since its performance is quite critically the degree of success in subsequent character segmentation and recognition.

Block Diagram

In order to reduce storage requirements and to increase processing speed, it is often desirable to represent gray scale or color images as binary images by picking a threshold value. Binarization algorithms are classified into global and local methods. Fig 1.3 shows the block diagram of the binarization method.

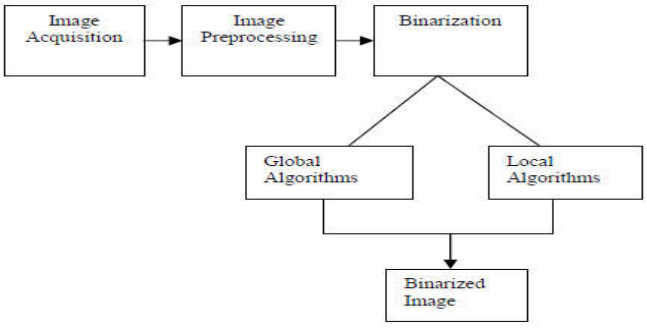

Fig. 1.3. Block Diagram of Image Binarization Method

In general, the document binarization deals with the two categories: Global Method and Local Method. Our main focus is to digitize the document images by applying binarization techniques to suppress the background noise and to retain information without any distortion.

Global Method

In global approach, a single threshold value is selected for the entire image and is processed with value it mainly result good in separation of foreground and background intensity but in poor contrast, variable intensity of foreground - background these method fails to binarized the image. Mainly used global method is Otsu method.

Local Method

Problem with global thresholding is that changes in illumination across the scene ma cause some parts to be brighter (in the light) and some parts darker (in the shadow) in ways that have nothing to do with the objects in the image. We can deal, at least in part, with such uneven illumination by determining threshold locally. Ni-black and Sauvola techniques are used.

Importance of Binarization

Binarization of an image is carried out to convert it to 256 gray levels. By using binarization techniques, documents processing, degraded images, fingerprints image and, help in performing segmentation in OCR as it is mainly used for pre-processing of an image. For example, it is used for degraded document images to enhance it so that these images can be used for fingerprint identification system. The quality of binarization is measured from several criteria objectively.

Literature Survey

BOLAN SU (2013), degraded document of Segmentation text images is a very challenging difference between the document background and the foreground text of different document images. In this paper, a novel document image binarization technique is addresses to adaptive image contrast i.e is a combination of the local image contrast and the local image gradient that is tolerant to text and background variation caused by different types of document degradations. In this, document text is estimated based on the intensities of detected text stroke edge pixels within a local window. The proposed method is simple, robust, and involves minimum parameter tuning. Here they, achieves accuracies of 93.5%, 87.8%, and 92.03%, for Dibco-2009, 2010, 2011. This paper presents an adaptive image contrast based document image binarization technique that is tolerant to different types of document degradation such as uneven illumination and document smear [1].

Jagroop Kaur (2014), author describes that Image binarization is the method of separation of pixel values into dual collections, black as foreground and white as background. Thresholding technique used for binarization of document images is has found to be best technique. In degraded documents, where extensive background noise or difference in contrast and brightness exists i.e. there exists many pixels that cannot be effortlessly categorized as foreground or background. They said in future new algorithm which will use as nonlinear enhancement pre-processing technique to improve the results further [3].

VIKUL J. PAWAR (2014), here authors presents that an improved binarization technique is used for improving the quality of text from poorly degraded document images with good efficiency and accuracy. The degraded document images are consisting of various noises, illumination because of old age and many more reason. The proposed method here addresses issues by using accommodative image contrast which is a combination of the local image contrast and the local image gradient for constructing binarized contrast map

then pooled with Canny's edge map detection to identify the text stroke edge pixels by using Segmentation to perform with in minimum parameters and efficiency [7]. Prof. S. P. Godse (2014), author said here that Recovering of text from badly degraded document images is a very difficult task due to the very high inter/intra variation between the document background and the foreground text of different document images. In this, a robust document image binarization technique that addresses the issues by using inversion gray scale image contrast by first converting the input image to invert image and then finding the contrast of the inverted image to differentiate text and background variation caused by different types of document degradations. This paper presents an adaptive image contrast based document image binarization technique that is tolerant to different types of document degradation such as uneven illumination and document smear with few parameters by use of the local image contrast as maximum and minimum. The proposed method has been tested on the various datasets. [5]

P. S. Jonesherine (2015), here in this a Mean shift algorithm is proposed for ancient document images, as well as a post processing method that can improve any Binarization method. It introduce an approach, a local-global Mean Shift based colour image segmentation. In this steps works such as, the first step consists in shifting each pixel in the image according to its R-Nearest Neighbor Colors (R-CC) in the spatial domain. The second step process shifts only the previously extracted local modes according to the entire pixels of the image. Binarized model is made efficient by including mean shifting technique in the image. While in the post processing step, specialized adaptive Gaussian and median filters are considered. The result of proposed method shows the output binarized image which is more efficient and provide better computed PSNR values comparing to the prior art [4]. Sushilkumar N. Holambe (2015), Image binarization is the separation of each pixel values into two collections, black as a foreground and white as a background. Thresholding technique is used for document image binarization. Here proposed a technique to address the issues of degraded images using adaptive image contrast with combination of the local image contrast and the local image gradient as to tolerant the variation of text and background. The proposed technique, constructs adaptive contrast map for degraded image that is combined with Canny's edge map, for the identification of text stroke edge pixels with global and local thresholding technique on recent document image binarization contest (DIBCO) 2009 & 2011 and handwritten-DIBCO 2010**.**

Techniques worked out

The goal of Image Binarization is to convert an image of up to 256 gray levels to a black and white image. Usually, binarization techniques are used for processing which lead to the clear extraction of useful information in the images as these techniques differentiate between foreground and background. The simplest way to get an image binarized is to choose a threshold value and classify all pixels with values above this threshold as white and all other pixels as black. The problem then is how to select the correct threshold. There are mainly two categories of methods, the global thresholding, and local or adaptive thresholding. The process of binarization is completed by following steps:

Preprocessing

Preprocessing is mainly used to smooth the image. It is used as the noise is there in image. Mainly five categories of pre-processing filters will be studied: mean filters, median filter, Wiener filter, Total Variation filter and Non-local Means filter. Most of these categories have a selection of variations in implementation.

Wiener Filter

The Wiener filter implemented in the spatial domain is also evaluated. Wiener filter, known as "Minimum mean square error filter", is an adaptive linear filter, applied to an image locally, by taking into account the local image variance. When the variance in an image is large the Wiener filter results in light local smoothing, while when the variance is small, it gives an improved local smoothing. The filtered image is computed through

$$I_{filt}(x,y)=n+(a^2-b^2)(Iorig_{(x,y)}-n)/a^2 \qquad (1)$$

Where n and a^2 are the local mean, variance respectively, and b^2 is the estimate of the noise variance.

(a) **(b)**

Fig. 1.4. Wiener Filter (a) original image (b) wiener filter

Binarization Techniques

Global Thresholding

This method, applies threshold for the entire image. The pixels are separated into two classes. Foreground and background. This can be expressed as in the equation (1).

$$I_b(x,y)=\begin{cases} black & if \quad I_f(x,y)\le Thr \\ white & if \quad I_f(x,y)>Thr \end{cases} \qquad (1)$$

Where If(x, y) is the pixel of the input image and I_b(x, y) is the pixel of the binarized image and the image can be separated into foreground and background [1].

Method

Otsu Technique: Otsu is an often used global thresholding method. It is based on treating the gray level intensities present in the image as values to be clustered into two sets. One foreground (black) and one background (white). To carry out this, the algorithm minimizes the weighted sum of within-class

variances of the foreground and background pixels to establish an optimum threshold. This is equivalent to maximizing the between-class scatter. From this a scalar number, K, is returned. This is then used to binarize the image through the following equation.

$$I_{bin}(x,y) = \begin{cases} 1, & if\ I_{gray}(x,y) \le K \\ 0, & if\ I_{gray}(x,y) \le K \end{cases}$$

Local Thresholding

Local thresholding method calculate a threshold for each pixel based on the information contained in a neighborhood of the pixel as in global it is for entire image. If a pixel(x, y) in the input image has a higher gray level than the threshold surface, evaluate at (x, y) and to set to white, otherwise black. These types of approaches are window-based, which means that the local threshold for a pixel is computed from gray values of pixels in a window centered at (x, y). Many researchers proposed various techniques to compute the local threshold based on the minimum and the maximum gray values in each window, some are based on the mean and the standard deviation as follows:

T=m+k*s

Where,

- T is the threshold for the central pixel of a rectangular window which is shifted across the image,
- M is the mean,
- 's' is the variance of the gray values in the window.
- 'k' is a constant.

All the method implemented and result were seen are qualitatively (visual effects). Methods are explained with algorithms below:

Global Method

Otsu Algorithm

Otsu's method is used to automatically perform histogram shape-based image thresholding or, the reduction of a gray level image to a binary image. The algorithm assumes that the image to be threshold contains two classes of pixels or bi-modal histogram (e.g. foreground and background) then calculates the optimum threshold separating those two classes so that their combined spread (intra-class variance) is minimal. The extension of the original method to multi-level thresholding is referred to as the Multi Otsu method. Otsu's method is named after Nobuyuki Otsu.

Otsu Threshold Method

- **Based on a very simple idea:** Find the threshold that minimizes the weighted within-class variance.
- This turns out to be the same as maximizing the between-class variance.
- Operates directly on the gray level histogram [e.g. 256 numbers, p(i)], so it's fast (once the histogram is computed).

Otsu Assumption

- Histogram (and the image) are bimodal. No use of spatial coherence, nor any other notion of object structure.
- Assumes stationary statistics, but can be modified to be locally adaptive.
- Assumes uniform illumination, so the bimodal brightness behavior arises from object appearance differences only.

Algorithm

- Compute histogram and probabilities of each intensity level
- Set up initial $\omega_i(0)$ and $\mu_i(0)$
- Step through all possible thresholds $t = 1 \ldots$ maximum intensity
- Update ω_i and μ_i
- Compute $\sigma_b^2(t)$
- Desired threshold corresponds to the maximum $\sigma_b^2(t)$

Otsu's thresholding method involves iterating through all the possible threshold values and calculating a measure of spread for the pixel levels each side of the threshold, i.e. the pixels that either falls in foreground or background. The aim is to find the threshold value where the sum of foreground and background spreads is at its minimum.

Iterative Method

In this we repeat one step again and again until it reaches to a convergence level, as the name suggest iterative.

Algorithm

- An initial threshold (T) is chosen; this can be done randomly or according to any other method desired.
- The image is segmented into object and background pixels as described above, creating two sets:

- = {f(m,n):f(m,n)>T} (object pixels)
- = {f(m,n):f(m,n)T} (background pixels)
- (Note, f(m, n) is the value of the pixel located in the column, row)
- The average of each set is computed.
  (a) = average value of
  (b) = average value of
- A new threshold is created that is the average of and
  1. T' = (+)/2

Go back to step two, now using the new threshold computed in step four, keep repeating until the new threshold matches the one before it (i.e. until convergence has been reached).

Local Method

Ni-black Method

Niblack's algorithm calculates a pixel-wise threshold by sliding a rectangular window over the gray level image. The computation of threshold is based on the local mean and the standard deviation s of all the pixels in the window.

Algorithm

- Simple and efficient method for adaptive thresholding
- The local threshold is set at: T(i,j) = (i,j) + w * o(i,j)
- The values for local mean and standard deviation is calculated over a local M x N window.
- The parameters are the weight *w* and the window size.

Sauvola Method Algorithm

Sauvola method introduced by Jaakko Sauvola is an efficient image binarization technique. The Sauvola method for local binarization does quite well, and we implement it with tiling for efficiency. The basic idea behind Sauvola is that if there is a lot of local contrast, the threshold should be chosen close to the mean value, whereas if there is very little contrast, the threshold should be chosen below the mean, by an amount proportional to the normalized local standard deviation. Sauvola is implemented efficiently by using "integral image" accumulators for the mean and mean-squared pixel values. The latter requires 64 bit floating point arrays, which are expensive for large images. Consequently, we give a tiled version. This gives the identical results as the non-tiled method, but only requires accumulator arrays to be in memory for each tile separately. For document image binarization, Sauvola proposed a new method that first performs a rapid classification of the local contents of a page to background, pictures and text. Two different approaches are then applied to define a threshold for each pixel: a soft decision method (SDM) for background and pictures, and a specialized text binarization method (TBM) for textual and line drawing areas. The SDM includes noise filtering and signal tracking capabilities, while the TBM is used to separate text components from background in bad conditions, caused by uneven illumination or noise. Finally, the outcome of these algorithms is combined. New threshold formula:

T=m*(1-k*(1-s/R)),

Where,

- T is the threshold for the central pixel of a rectangular window which is shifted across the image,
- M is the mean,
- 's' is the variance of the gray values in the window.
- 'k' is a constant.
- R is the dynamic range of the standard deviation.

Algorithm

Step 1: Create the window of size Sx * Sy traverse it on original X*Y as window centered on the pixel(x, y),

Step 2: Compute the local mean m(x, y) and local standard deviation s(x, y)

Step 3: Compute the threshold value by formula: T=m*(1-k*(1-s/R)),

Where, value k=-0.2, R=31.

Step 4: Repeat the above two step for each local window until it has traversed whole image.

Localots Method

It is same as Otsu method but there is only one difference that this is applied on parts of image in this we took the threshold value locally. We divide the image in small windows.

Conclusion and Future scope

It is evident that no algorithm work's well for all types of document images. Sauvola gives good results for document images with dark spot and at low illumination. Ni-Black captures maximum noise along with the text detail. Otsu one of the oldest binarization techniques gives best overall results for document images. Document images with non-uniform brightness require binarization methods with delicate local thresholds that must be determined according to various conditions. There is no effect of resolution on binarization.
We conclude the advantages and limitations:

Advantage

- Simple to implement
- Low computational complexity

Limitations

- Only useful when objects have constant gray values.
- Uneven illumination requires compensation.
- Throws away spatial information.
- Global nature of histograms limits application to complex images.
- Quite often does not have spatial coherence.

Further research can focus on the challenges that merge from the binarization of historical manuscripts such as broken edges and smoothening of these manuscripts so that it can be useful for further processing in OCR.

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