LOCAL THRESHOLDING METHODS - NIBLACKS'S

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Abstract

Historical document images are more problematic to binarize than modern scanned documents, due to the fact that it has degraded, and it has low contrast. Document binarization is essential for information acquisition. Document image binarization is the process that segments an image into text and non-text by removing any existing degradations. It's an essential pre-processing phase of the document image processing and analysis pipeline that affects further stages as well as the final Optical Character Recognition (OCR) stage (K. Ntirogiannis et al, 2014). This is an essential when processing of such historical documents. Image binarization is method in which we can remove noise from an image, which then enables the document to become more meaningful and give us a better understanding. In this report I will focusing on thresholding Niblacks method. Additionally, I will evaluate numerous images to show the effect of the algorithm, whilst also comparing it to the ground truth image.

Introduction

Image segmentation is the method assigning an image into different portions. The aim of image segmentation is to adjust the representation of an image to enable better human insight whilst also making it easier to analyse. Image Segmentation enables us to distinguish boundaries (or edges) in images. For instance, Medical scan distinguishing between particles boundaries. Furthermore, image segmentation is a procedure where a threshold is assigned to every pixel in an image, and those pixels with the same threshold would share similar attributes.

There are many different image binarization techniques, the three I will discuss are Global/ Local Thresholding methods, Hybrid thresholding methods and Adaptive thresholding methods and automatic thresholding. The Adaptive thresholding methods calculates a limit for each pixel in the image depending on the size of its neighborhood. This method computes the local threshold value by using the mean value of the maximum and minimum intensities inside a local neighborhood. Global thresholding methods use the same threshold value for the entire image. According to (Omar Boundraa et al,2019), Otsu's method is known to be one of the most used and best global thresholding methods. This method assumes that an image follows a bimodal histogram and attempts to classify the image pixels into a foreground or background pixels, in other words, text and non-text. It then it computes a threshold splitting those two segments so that the intra-class variance is insignificant (Omar Boundraa et al,2019). However, local thresholding methods only which assigns a threshold for each pixel or a small region of the document images. Nevertheless, Automatic thresholding techniques set a threshold for all the pixels after analysing the image.

However, in this report I will analysing Niblacks methods and applying it to the test images.

Algorithm

This report thoroughly analyses the Niblacks technique. Niblack thresholding is a widely used algorithm established in 1986. Its A local thresholding technique and this is advantageous for an image where the background is not uniform, for instance Text recognition. Instead of calculating a single global threshold for the whole image, several thresholds are calculated for each pixel by using specific formula that considers the mean and standard deviation of the local neighbourhood (Mahesh & Shashidhar,2017).

Niblacks Algorithms has various application and can be used binarizing historical images or medical images. (Ramudu et al ,2015), used Niblack Method segmenting microscopic imagery. “Testing results show that the Niblack method can achieve better performance in challenging cases. Though targeted here for microscopic image analysis only, it will be a good candidate for other kinds of applications as well like MRI image processing, scene processing and image segmentation.” (Ramudu et al, 2015).

How the algorithm works

The algorithm involves finding a threshold value for each pixel, in order to achieve that we must find the local mean and standard deviation following this formula:

T (x, y) = mean + (k * standardDeviation).

Here k is a constant, meaning a preselected coefficient. It is normally set at between -0.1 and -0.2. this is depending upon the noise still live on the background. [4]

Evaluation

Niblack is a good local binarization technique for images containing text. This technique is good for historical documents that may have degraded and have a lot of noise, because in this method you are able to set a unique threshold for each pixel rather than the whole image. In Other words, it does not involve a unique threshold for the whole image and therefore adaptable for local particularities, which makes it ideal for microscopic images.

Furthermore, According to (J. Sauvola, M. Pietikäinen., 2000).” This method does not work well for cases in which the background contains light texture as the grey values of these un-wanted details easily exceed threshold values”.

However, (J. Sauvola, M. Pietikäinen., 2000), tests showed “In the latter case the proposed Niblack's algorithms performance and adaptivity was highest in all test categories in graphical and textual cases”. This suggests that this algorithm is one of the best for noisy and degraded images because of its adaptability.

Results

A contrast of 4 images before and after utilising Niblacks method. The 4 images are then compared to the ground images. This report will thoroughly analyse the effect Nibalck's method has on the set of images. The K level is set at 0.2, 'recommended by Wayne Niblack'. However, the images have different neighbourhood sizes, as shown in all figures below.

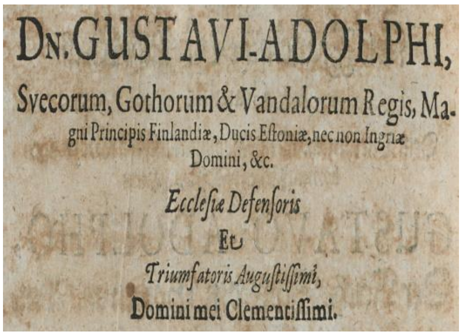
In Fig 1 demonstrations and shows that the image is fully binarized. The Pixel values that are black have remained the similar. Fig.1 (test image) displays some background noise and yellowy background, which suggests a degraded image. The Niblacks method has extracted the background noise from the image, only capturing the text. The image also shows that the texts darker are displayed more clearly in Fig 1. The Niblacks method has enabled me to set a neighbourhood size, which calculates the intensity the image could be set at, which is 895 for this image. This is set at that value to produce the least noise whilst also producing clear readable text.

Fig 2 shows that the image is almost fully binarized apart from a bit noise/ shaded area on the right. Nevertheless, the text on the left side remained the similar and is readable after binarization. This method has heavily reduced the shadow area on the right side, but this image could not be completely binarized using Niblacks, some of the darker areas succeeded to bypass the algorithm. When the neighbourhood size is lowered the image starts to produce more unwanted noise. However, Niblacks method has overall proven that it is able to binarize images like this, as it is very close to the ground truth version of this image.

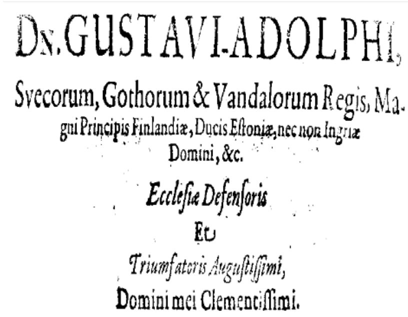
For Fig 3, Niblacks method has binarized the image considerably well. The image has not lost any features, and text is clear. However, the background noise is not complete extracted, thus it was not fully successfully for this image, the neighbourhood PSNR level was 965, if it was lowered the image would have had more unwanted noise and if it was higher it would have lost some text. Therefore, it was more difficult to binarize this image. Nevertheless, the image once compared to the ground truth image still look similar.

The image in Fig 4 shows that the background noise has been removed. However, the darker pixels displayed more clearly, and little detail was lost when the text was lighter. Nevertheless, in contrast to the ground truth, the image looks very similar to the wanted result.

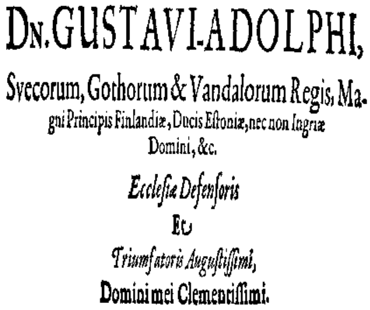
Considering all the images (fig1, fig2, fig3 and fig4) we can see that all the images are very similar to their ground truth versions, apart from some noises in some images. The main problem was that when text was similar colour to the background (fig, 2, fig 4), some details where lost. However, when there was a higher contrast between the images, the results tended to be better. From all the test images the one best binarized using Niblacks method was fig 1, as it was almost identical t the ground truth image.



[A] PR4 Test Image

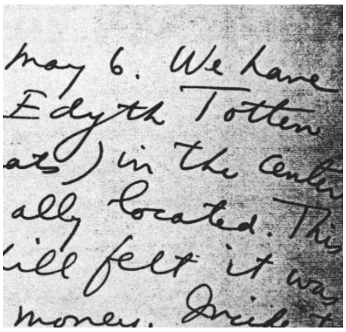


[B]PR4 was binarized using Niblack's Algorithm with a neighbourhood size of 895

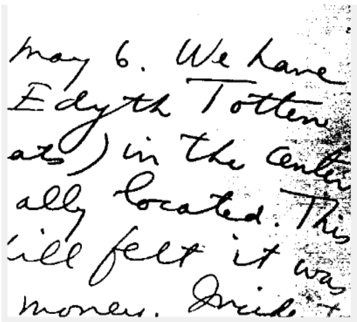


[C] PR4 GT Image

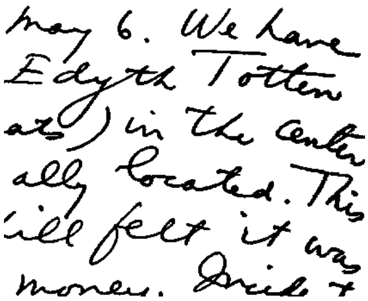
Fig 1: PR4 Image



[A] HW1 Test Image

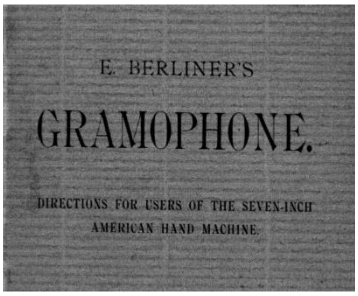


[B]HW1 was binarized using Niblack's Algorithm with a neighbourhood size of 875

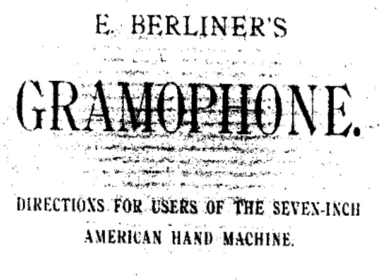


[C] HW1 GT Image

Fig 2: HW1 Image



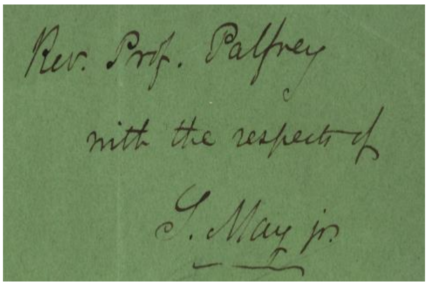
[A] PR6 Test Image



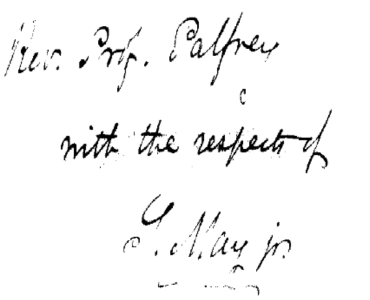
[B]PR6 was binarized using Niblack's Algorithm with a neighbourhood size of 965

[C] PR6 GT Image

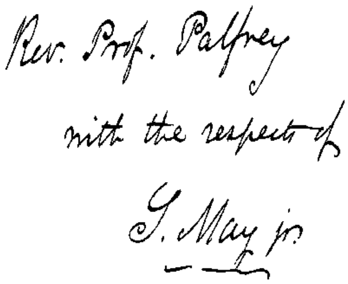
Fig 3: PR6 Image



[A] HW8 Test Image



[B]HW8 was binarized using Niblack's Algorithm with a neighbourhood size of 435



[C] HW8 GT Image

Fig 4: HW8 Image

Conclusion

To conclude, the results obtained from the test tests have proven that Niblacks method is a great image binarization technique. It is good for historical documents and microscopic images. However, a limitation of this method is that it may produce and some unwanted white noise in the binarized image (fig4).

Nevertheless, the results suggest that this method is an accurate image segmentation technique, especially in images where there is a contrast between background and text, its also extremely good at segmenting background noise. Niblack's method is reliable and proven to produce an image identical the ground truth version of the image.

References

1. K. Ntirogiannis et al., (2014). A combined approach for the binarization of handwritten document images. Pattern recognition letters, Volume 35, pp.3-15. ISSN 0167-8655,
2. Omar Boudraa et al, (2019). Degraded Historical Documents Images Binarization Using a Combination of Enhanced Techniques.
3. Mahesh, Shashidhar., (2017), A review paper on restoring the degraded images using different thresholding techniques. Special issue – SACAIM – 633-635.
4. Ramudu et al., (2015). Niblack method based segmentation for microscopic imagery. International Journal of Electrical and Electronics Engineers. IJEEE, Volume 07, Issue 01, Jan-June 2015. ISSN- 2321-2055 (E).
5. J. Sauvola, M. Pietikäinen., (2000). Adaptive document image binarization. Pattern Recognition, Volume 33, Issue 2, Pages 225-236, ISSN 0031-3203,

Appendix A

Niblack.m

```
%This function Performs Niblack's method to binarize the test images.
function binarizeImage = niblack(image, neighbour_Size, k)

% This function will use Niblack's method on the image by calculating
%a threshold for each pixel then applying it.

%  The Niblacks's fromula for calulating the threshold  =  mean + (k * standardDeviation)
%then the intensity of the neighbourhood size inputed by manually.

   average_filter = fspecial('average', neighbour_Size); % this will create an average filter,
that we will use to average imgage
   average_Image = imfilter(image, average_filter); % This will Average the image
   standardDevImg = stdfilt(average_Image, true(neighbour_Size)); % this will take in
everage image and neighbourhood , then compute standard deviation we will use to
multiply with the K
   resultK_Img = k .* standardDevImg;   %multiply K with the the standard deviation, part of
niblacks method.
   niblacks_Tvalue = double(average_Image) + resultK_Img; % set the threshold.
   binarizeImage = thresholdingIMG(image, niblacks_Tvalue);% return the result back to
function
end
```

thresholdingIMG.m

```
function thresh_matrix = thresholdingIMG(img_matrix, threshold)
%ThresholdingIMG takes in img_matrix and a threshold.
% It would look at each pixel and if that specific pixel intensity
% (neiorhood lvl) is smaller thann the threshold value then that pixel will be black;
%However, if the pixel intensity is  not smaller than the threshold and it is
%the same or more than the threshold then the pixel will be white.
   thresh_matrix = img_matrix;
   % this method is creating a lower threshold
   thresh_matrix(thresh_matrix<threshold) = 0;
   %the maximim threshold is normally 255
   thresh_matrix(thresh_matrix>threshold | thresh_matrix == threshold) = 255;
end
```

generate_result.m

```
clear;
% This is Calling the file that will load the greyscale input images
%load_greyImages;
cd 'images\test_images'; %location of the input images
%rgb2gray converts the image RGB to the grayscale image. then saving to variable relevant
etc(PR4 )
PR4 = rgb2gray(imread('PR4.png'));
HW1 = rgb2gray(imread('HW1.png'));
PR6 = rgb2gray(imread('PR6.png'));
HW8 = rgb2gray(imread('HW8.png'));

cd ../../;

k = -0.2;
%K will  be set at -0.2, as recomended by wayne Niblack


%binarizing images using Niblack's method, with neigbourhood size passed in. required for
niblacks method.
PR4NiBlackMethod = niblack(PR4,  895, k);
HW1NiBlackMethod = niblack(HW1 ,875, k);
PR6NiBlackMethod = niblack(PR6, 965, k);
HW8NiBlackMethod = niblack(HW8, 435, k);

clear k;
% this clears k from memory



%The matlab code below displays the test images binarized using niblacks method with
diffrent neighnbouthood sizes size.
figure, image(PR4NiBlackMethod), axis off, colormap gray(2), title('PR4 binarized with
neighbourhood size of 895');
figure, image(HW1NiBlackMethod), axis off, colormap gray(2), title('HW1  binarized  with a
neighbourhood size of 875');
figure, image(PR6NiBlackMethod), axis off, colormap gray(2), title('PR6  binarized with a
neighbourhood size of 965');
figure, image(HW8NiBlackMethod), axis off, colormap gray(2), title('HW8  binarized  with a
neighbourhood size of 435');
```