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Evaluating the performance of different image binarization techniques

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Abstract: Image binarization is the methodology of separating of pixel values into dual collections, dark as frontal area and white as background. Thresholding has discovered to be a well-known procedure utilized for binarization of document images. Thresholding is further divided into global and local thresholding technique. In document with contrast delivery of background and foreground, global thresholding is discovered to be best technique. In corrupted documents, where extensive background noise or difference in contrast and brightness exists i.e. there exists numerous pixels that cannot be effortlessly categorized as foreground or background broad foundation. In such cases, local thresholding has significant over available techniques. The principle target of this paper is to evaluate the performance of the distinct image binarization strategies and to discover the best technique among some well-known existing methods.

Index terms: Documents, Binarization, thresholding, Binary image.

1. Introduction

Document binarization is characteristically carry out in the pre-processing phase of numerous document image processing allied fields such as optical character recognition (OCR) and document vision retrieval. Image binarization interactions a picture up to 256 gray levels to a black and white picture. The simplest advance to pertain image binarization is to favour a threshold value and systematize all pixels with values above this threshold as white and all other pixels as black.

Adaptive image binarization is requisite where an optimal thresholding is certain for each picture area. Thresholding is the simplest method of image segmentation, from gray scale image. Thresholding can be used to make binary images. Document images often practice from divergent types of degradation that renders the document binarization an exigent charge.

2. Thresholding

Thresholding is the basic mode of image segmentation. as a greyscale image, thresholding can be used to figure binary images. Thresholding make binary images as of grey-level ones by rotating all pixels, below a only some threshold to zero and all pixels concerning that threshold to one. If $g(x, y)$ is a threshold version of f (x, y) at some global threshold T. g is equal to 1 if $f(x, y) \geq T$ and zero otherwise.

(a) Global Thresholding:

Global thresholding utilize a stiff threshold for all pixels in the picture and subsequently works only if the deliberation histogram of the input image hold well neurotic peaks subsequent to the favoured subjects and backgrounds. So, it cannot convention with images containing, such as, a strong enlightenment gradient. A histogram of the input image attention is invented to rendering two peaks, subsequent respectively to the signals from the background and the object. Global thresholding consists of setting a deliberation value such that all pixels having deliberation value below the threshold belong to one phase, the residue belong to the other. Global thresholding is the same as the scope of deliberation separation between the two peaks in the image. It is a primitive segmentation selection. The global thresholding alternative in 3DMA permit the consumer to choose a particular global threshold for a 3D image or split thresholds for every 2D slice in the image. Some provisional preference has also been provided to give consistent choice of threshold by performing a binomial fit to the two-peak histogram and locale a threshold at the inner peak lowest as determined by the normal fits. The thresholding substitute outputs the segmented image sidewise, in a packed bit (0, 1) format. All pixels having deliberation below the threshold value are set to 0; the rest are set to 1.

(b)Adaptive Thresholding:

Adaptive thresholding convert the threshold actively over the image. This more convoluted version of thresholding can afford adjustment varying enlightenment circumstances in the image. Adaptive thresholding frequently acquire a greyscale or color image as input and, in the simplest implementation, outputs a binary image significant the segmentation. For every pixel in the image, a threshold has to be proposed. If the pixel value is lower than the threshold it is set to the background value, or else it suppose the foreground value. There are two major approaches to finding the threshold: (i) the *Chow and Kaneko* approach and (ii) *local* thresholding. The theory after both processes is that less significant image regions are more possibly to have approximately uniform illumination, so being more suitable for thresholding. Chow and Kaneko split an image into an array of be associated sub images and subsequently determine the most favourable threshold for each sub image by inspecting its histogram. The threshold for every exacting pixel is originated by interpolating the conclusion of the sub images. The consequence of this procedure is that it is computational restricted and, for that reason, is not appropriate for real-time applications. Another approach to determine the local threshold is to statistically examine the deliberation values of the local neighbourhood of every pixel. The value which is generally appropriate depends essentially on the input image. Straightforward and rapid functions include the mean of the local intensity distribution. The scope of the neighbourhood has to be outsized adequate to enclose sufficient foreground and background pixels, or else an regrettable threshold is selected. On the other hand, selecting regions which are too enormous can flout the assumption of something like uniform enlightenment. This procedure is fewer computationally determined than the Chow and Kaneko approach and produce good results for some applications. Adaptive thresholding is used to divide gratifying foreground image objects from the background based on the difference in pixel intensities of each region.

(c) Local Adaptive Thresholding:

Local adaptive thresholding, prefer an individual threshold for each pixel based on the diversity of deliberation values in its local neighborhood. This permits for thresholding of an image whose global deliberation histogram doesn't seize typical peaks.

3. Base paper

Segmentation of text from badly degraded document an image is very challenging tasks due to the high inter/intravariation between the document background and the foreground text of different document images. In this paper, a novel document image binarization technique that addresses these issues by using adaptive image contrast. The adaptive image contrast 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 the proposed technique, an adaptive contrast map is first constructed for an input degraded document image. The contrast map is then Binarized and combined with Canny's edge map to identify the text stroke edge pixels. The document text is further segmented by a local threshold that 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. It has been tested on three public datasets that are used in the recent document image binarization contest (DIBCO) 2009 & 2011 and handwritten-DIBCO 2010 and achieves accuracies of 93.5%, 87.8%, and 92.03%, respectively that are significantly higher than or close to that of the best performing methods reported in the three contests. Experiments on the Beckley diary dataset that consists of several challenging bad quality document images also show the superior performance of this method, compared with other techniques.

4. Performance Metrics

Performance is measured using the parameters such as Precision, F-measure, Bit Error Rate, and Geometry Accuracy.

Precision:

Precision is the fraction of retrieved instances that are relevant, the precision for a class is the number of true positives (i.e. the number of items correctly labelled as belonging to the positive class) divided by the total number of elements labelled as belonging to the positive class (i.e. the sum of true positives and false positives, which are items incorrectly labelled as belonging to the class).

$$\text{Precision} = \frac{\textbf{Number of true positives}}{\textbf{Numbers of true positives+false positives}}$$

F-measure:

F-measure is determining a test's accuracy. It consider both the precision p and the recall r of the test to compute the score: p is the number of accurate results divided by the number of all returned results and r is the number of accurate results divided by the number of results that should have been returned. The F-measure can be understand as a weighted average of the precision and recall, where an F_1 score arrive at its best value at 1 and worst score at 0. The traditional F-measure is the harmonic mean of precision and recall:

$$F_1 = 2.\frac{\text{precision . recall}}{\text{precision + recall}}$$

Bit Error Rate:

A bit error rate is defined as the rate at which errors occur in a transmission system. This can be directly translated into the number of errors that occur in a string of a stated number of bits. The definition of bit error rate can be translated into a simple formula:

$$\text{BER} = \frac{\textbf{Number of errors}}{\textbf{Total number of tarnsmitted bits}} \ldots .4$$

Geometry Accuracy:

Accuracy is the capacity acceptance, or transmission of the mechanism and describe the restrictions of the errors made when the mechanism is used in normal operating conditions, *Accuracy* is also used as a arithmetical evaluate of how well a binary classification test properly recognize or reject a condition. The accuracy is the quantity of proper results in the population. To create the situation clear by the semantics, it is often referred to as the "Rand Accuracy". It is a parameter of the test. Here T.P is defined as true positives, T.N is defined as true negatives, F.P is defined as false positives and F.N is defined as false negatives.

$$\text{accuracy} = \frac{\textbf{number of t.p} + \textbf{number of t.p}}{\textbf{number of t.p} + \textbf{f.p} + \textbf{f.n} + \textbf{t.n}}$$

5. Experimental results:

Design and implementation is done in MATLAB by using Image Processing Toolbox. This image enhancement approach is tested on different 11 images of different format and size. We have shown the results on image 4. Fig 5.1 is showing the input image for experimental analysis.

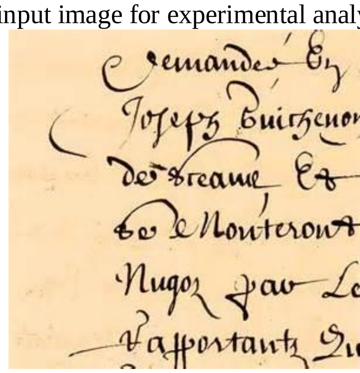


Fig 5.1 Input Image

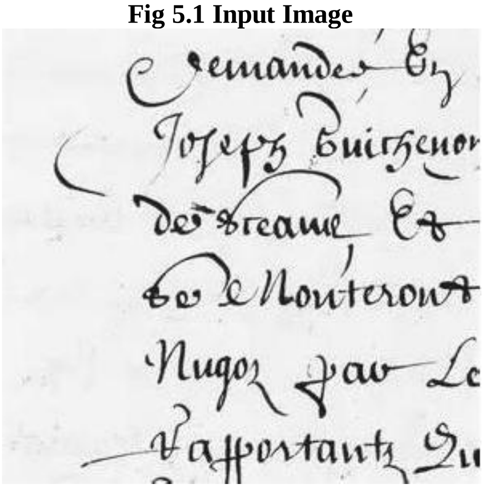


Fig5.2 Contrast Adjusted Image

Fig 5.2 has shown the output image taken by contrast adjusted. The output image has better contrast and has shown other details.

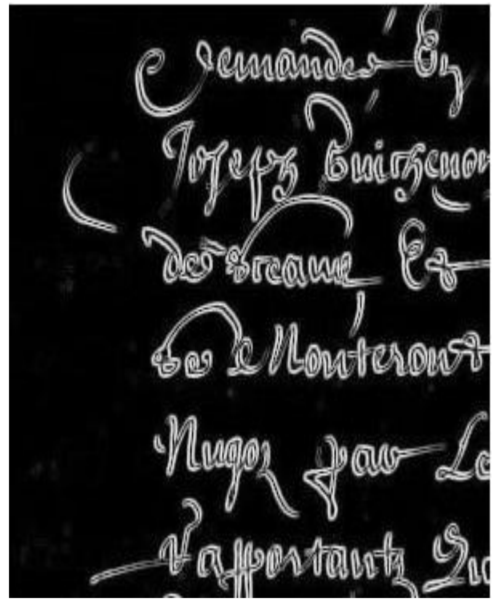


Fig5.3 Gradient Magnitude

Fig 5.3 has shown the output image taken by gradient magnitude.

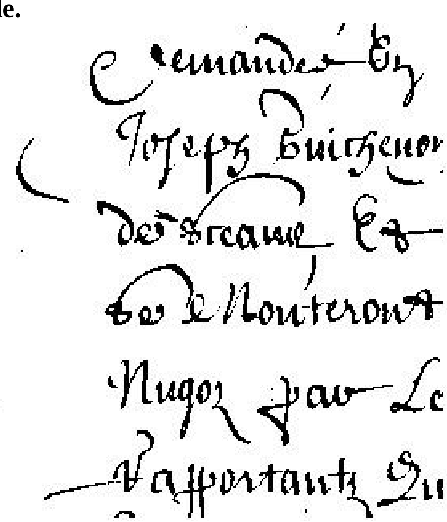


Fig 5.4 Base paper

Fig 5.4 has shown the output image taken by base paper method.

6 Performance analysis

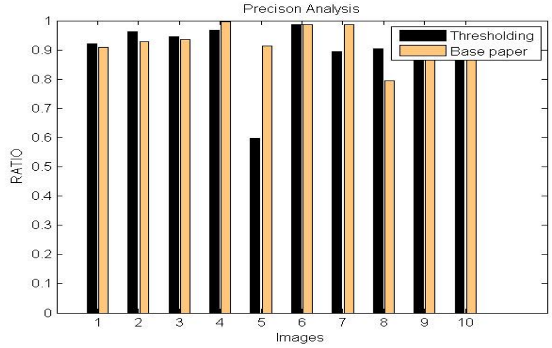
This section contains the cross validation between base paper and other techniques. Some well-known image performance metrics for digital images have been selected to prove that the performance of the base paper is quite better than the other methods.

6.1 Precision:

Table 6.1 is showing the relative analysis of the Precision. Table 6.1 has clearly shown that the Precision is minimum in the case of the base paper therefore base paper is providing better results than the available methods.

Table: 6.1: Precision

Test images	Thresholding	Base Paper
1	0.92169	0.90979
2	0.96141	0.92810
3	0.94612	0.93500
4	0.96787	0.99528
5	0.59641	0.91434
6	0.98653	0.98679
7	0.89451	0.98653
8	0.90488	0.79473
9	0.89759	0.97731
10	0.94299	0.97695



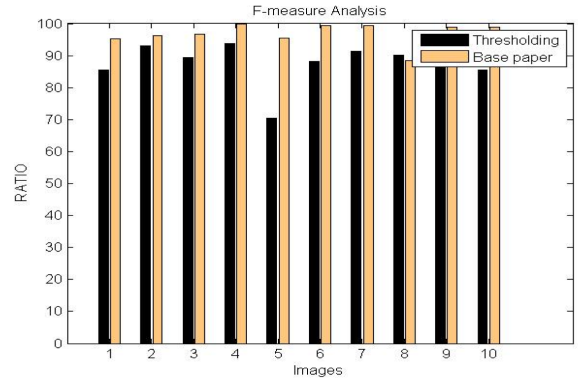
Graph 6.1: Precision of thresholding Stretching and base paper for different images

It is very clear from the plot that there is decrease in precision value of images with the use of base paper method over other methods. This decrease represents improvement in the objective quality of the image.

F-measure: Table 6.2 is showing the quantized analysis of F-measure. As F-measure need to be reduced therefore the base paper method is showing the better results than the available methods as F-measure is less in every case.

Table 6.2: F-measure

Test images	Thresholding	Base Paper
1	85.56629	95.27663
2	92.95976	96.27086
3	89.31121	96.64072
4	93.76772	99.76342
5	70.54292	95.52555
6	88.17981	99.33511
7	91.26053	99.32195
8	90.26053	88.56292
9	88.76533	98.85249
10	85.51820	98.83394



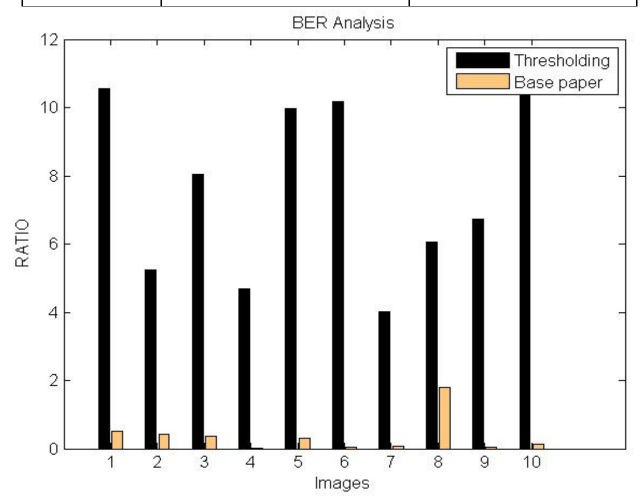
Graph 6.2: F-measure of thresholding Stretching and base paper for different images

It is very clear from the plot that there is decrease in F-measure value of images with the use of base paper method over other methods. This decrease represents improvement in the objective quality of the image.

6.3Bit Error Rate: **Bit Error Rate (BER)**
Table 6.3 is showing the quantized analysis of bit error rate.

Table 6.3: Bit error Rate

Test images	Thresholding	Base paper
1	10.54664	0.51353
2	5.23781	0.42688
3	8.03522	0.36022
4	4.69934	0.02415
5	9.95970	0.31181
6	10.17286	0.03102
7	4.01249	0.06823
8	6.04974	1.79162
9	6.74227	0.05745
10	11.23292	0.11929



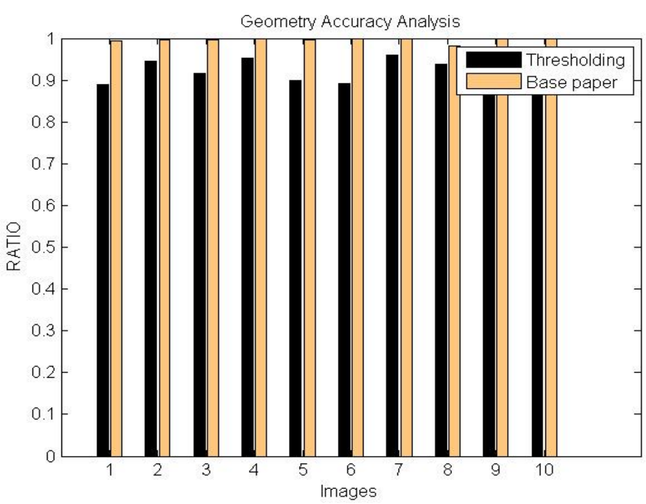
Graph 6.3: BER of thresholding Stretching and base paper for different images

It is very clear from the plot that there is decrease in bit error rate value of images with the use of base paper method over other methods. This decrease represents improvement in the objective quality of the image.

Geometry Accuracy: Table 6.4 is showing the quantized analysis of bit error rate.

Table 6.4: geometry accuracy

Test images	Thresholding	Base paper
1	**0.88936**	**0.99485**
2	**0.94642**	**0.99572**
3	**0.91667**	**0.99639**
4	**0.95200**	**0.99976**
5	**0.89963**	**0.99688**
6	**0.89256**	**0.99969**
7	**0.95945**	**0.99932**
8	**0.93856**	**0.98192**
9	**0.93098**	**0.99943**
10	**0.88140**	**0.99881**



Graph 6.4: Geometry Accuracy of thresholding Stretching and base paper for different images

It is very clear from the plot that there is decrease in geometry accuracy value of images with the use of base paper method over other methods. This decrease represents improvement in the objective quality of the image.

7. Conclusion

This paper has concentrated on the degraded document binarization technique. Document binarization is a vital application of vision processing. The main aim of this paper is to find the deficiencies of algorithms for degraded image binarization. By designing and implementing the current binarization techniques; it has been discovered that every procedure has its own benefits and limitations; no system is best for each case. The principle limitation of existing work is the noise and low intensity images. In future we will propose a new algorithm which will utilize more reliable method to improve the work. We will propose novel algorithm which will utilize nonlinear enhancement as a pre-processing procedure to enhance the results further.

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