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Enhancement of an Ancient Documents by Using Phase Based Binarization Approach

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Abstract: A phase-based binarization model is applied for the binarization of an ancient document images , in addition a post-processing method is used to improve any binarization method. From the phase information of an input document image three features are derived, these features constitute the core of this binarization model. The features are the maximum moment of phase congruency covariance, a locally weighted mean phase angle, and a phase preserved denoised image. Three standard steps that are used in the paper are 1) pre-processing, 2) main binarization, and 3) post-processing. In first two steps, the features used are mainly phase-derived, while in the post-processing step, specialized adaptive Gaussian and median filters are considered. Outputs of the binarization step, which have high recall performance, is used as input to a post-processing method to improve other binarization methodologies. The experimental results on the different data sets, that is DIBCO, PHIBD, and BICKLEY DIARY show the robustness of the proposed binarization method on different types of degradation.

Keywords: binarization, phase-derived features, ground truth, document enhancement.

I. INTRODUCTION

Libraries the world over store an abundance of old and historically important documents and manuscripts. These documents are significant heritage for next generations. But because of many environmental factors, improper handling, and the poor quality of the materials used in their preparation these are suffer with a high degree of degradation of various types. For this reason, the contents of the documents are digitized for next generations. Many researchers have been carried out to solve the problems that arise in the binarization of documents effected by many types of degradation. Hand-written and machine-printed documents, which adds difficulties associated with the binarization of old document images. Fig. 1 shows some of the degraded document images. In this, an efficient phase-based binarization method is used for the binarization and improvement of an ancient documents and manuscripts. The three main steps used in this are: pre-processing, main binarization, and post-processing.

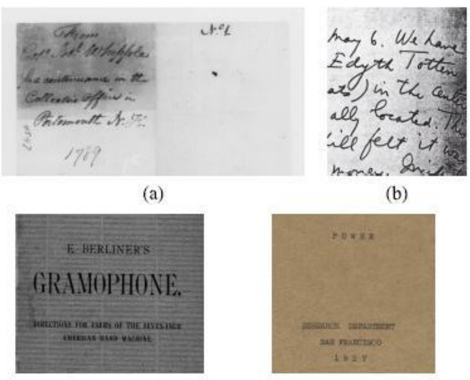

Fig.1.Degraded document images

The preprocessing step mainly involves denoising of image with phase preservation [3]. Phase congruency features [7] are used for the main binarization step. Foreground of ancient documents can be modeled by using phase congruency. After completing these steps on the input images some enhancement processes are applied.

II. RELATED WORK

In previous works, a self training document method [4] was used, in this the input pixels are divided into three categories, that are foreground, background, and uncertain. Then, foreground and background pixels are clustered into different classes using the k-mean algorithm. Finally, uncertain pixels are classified with the label of their nearest neighbouring cluster. Compared with previous work, this method shows even more improvement about 5%.

III. PHASE-DERIVED FEATURES

Three phase-derived feature maps of the input document image are used in this paper. Those are two phase congruency feature maps and a denoised image. The details are provided below.

A) Phase Congruency-Based Feature Maps:

It is shown that by using phase information of an image, magnitude information will observe. This indirectly means that phase information is the very important feature of images. this paper uses two phase congruency-based feature maps from input images. These are based on the Kovesi's phase congruency model [5], [6], [7]. In phase

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congruency, the main interest of pixels are at those points where the phase of the Fourier components is maximal. Let Meρ and Moρ denote the even symmetric and odd symmetric log-Gabor wavelets at a scale ρ, which are known as quadratic pairs. f(x) as a one-dimensional input image signal, the response of each quadratic pair of filters at each image point x forms a response vector by convolving with f (x).

$$[e_p(x), o_p(x)] = (\ f(x) * Me_p + f(x) * Mo_p\ )$$

where eρ (x) and oρ(x) are real and imaginary parts of a complex-valued wavelet response. By using this, compute the local phase φρ(x) and the local amplitude Aρ(x) of the transform at a given wavelet scale ρ,

$$\varphi_p(x) = \arctan2(\ o_p(x), e_p(x)\ )$$

$$A_p(x) = \sqrt{e_p(x)^2 + o_p(x)^2}$$

The fractional measure of spread s(x) and phase congruency weighting mean function W(x) are defined as follows

$$S(x) = \frac{1}{N}\left(\frac{\sum_p A_p(x)}{A_{max}(x)} \right)$$

$$W(x) = \frac{1}{1+e^{\gamma(c-s(x))}}$$

Where N denotes the total number of filter scales, $A_{max}(x)$ denotes the amplitude of the filter pair with the maximum response, W(x) is constructed by applying a sigmoid function to the filter spread, c is a cut-off value of the filter response spread below which phase congruency values are penalized and γ is a gain factor that controls the sharpness of the cut-off. Δφp which is a sensitive phase deviation function, where φρ(x) - φ(x) is the phase deviation at scale ρ, and φ(x) indicates the mean phase angle. Let PC1D denote the one-dimensional phase congruency:

$$PC_{1D} = \frac{\sum_p W(x)[Ap(x)\Delta\emptyset p(x)]}{\sum_p Ap(x)}$$

Where Aρ(x) is the local amplitude at a given scale ρ. This PC1D is highly sensitive to noise. To overcome this problem, Rayleigh distribution is used for modeling the distribution of noise energy

$$R(x) = \frac{x}{\sigma G^2} \exp^{\frac{-x^2}{2\sigma G^2}}$$

where σG denotes the Rayleigh distribution parameter. The mean μR, the standard deviation σ2R, and the median R˜of the Rayleigh distribution can be expressed based on σG , The median R˜, and all the other parameters of the Rayleigh distribution, can be estimated using the expected value of the magnitude response of the smallest filter scale. In this, a noise threshold of the following form is used

$$T = \mu R + k\sigma R$$

where k is the number of σR to be used. By applying the noise threshold on PC1D, we have

$$PC_{1D} = \frac{\sum_p W(x)[Ap(x)\Delta\emptyset p(x) - T]}{\sum_p Ap(x)}$$

where T is the estimated noise modeled by the Rayleigh distribution. Using PC1D, two-dimensional phase congruency is calculated by

$$PC_{2D,r}(x) = \frac{\sum_p Wr(x)[Apr(x)\Delta\emptyset pr(x) - Tr]}{\sum_p Apr(x)}$$

B) Phase Preserving Denoising:
An image denoising method suggested by Kovesi [3] is used in this, which is based on phase information. This method is used to preserve the important phase information in signal. It uses non orthogonal, complex valued log-Gabor wavelets, which extract the local phase and amplitude information at each point in the image. In denoising process, find a noise threshold at each scale and shrinking the magnitudes of the filter response vector accordingly, while leaving the phase unchanged. Automatic estimation of noise thresholds, using the statistics of the smallest filter scale response, is the most important part of denoising. The distribution of the noise amplitude is estimated based on these statistics, because they give the strongest noise response.

IV. BINARIZATION MODEL

The output binarized image is obtained by processing the input image in three steps: preprocessing, main binarization, and post processing. Denoised image is used as another phase-based feature to the binarization model, and achieved 5% improvement, on average. The flowchart of the proposed binarization method is shown in Fig. 2.

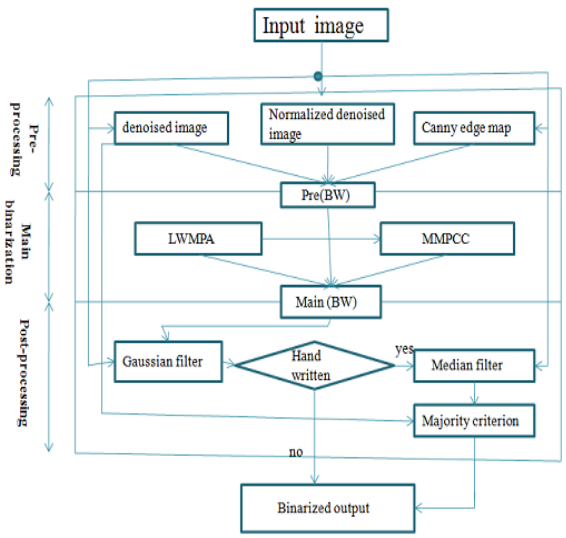

Fig.2. Flow chart of binarization method

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1. Preprocessing:

In this step, Denoised image is used instead of original image to obtain a binarized image in approximate form. The denoise image [3] is used as input to preprocess step. The parameters that effect the quality of the denoised output image are the noise standard deviation threshold to be rejected (k), number of filter scales (Nρ) and the number of orientations (Nr) to be used. The Nρ parameter controls the extent to which low frequencies are covered. Normalized denoised image is obtained by using a linear image transform on the denoised image. Canny operator applied on original document image to generate edge map and combine this binarized image with an edge map. A convex hull image of the combined image is computed.

By using preprocessing, the structure of foreground and text is determined. However, some noise is still present in the image, and the Image is affected by some types of degradation. So have to include some additional steps to deal with them.

2. Main Binarization:

In main binarization, phase congruency features used are

(i)Maximum moment of phase congruency covariance (IM)

(ii) Locally weighted mean phase angle (IL)

Maximum moment of phase congruency covariance map is used to measure the edges strength. We can get the values between [0 1], where a larger value represents a stronger edge. This can be represented as

$$IM = maxr\ PC2d, r(x)$$

This is used to separate the background from potential foreground parts. This step performs very well, even in badly degraded documents; it can reject a majority of badly degraded background pixels. To get this, set the number of 2Dlog-Gabor filter scales ρ to 2, r to 10 and , the number of standard deviations k used to reject Noise is estimated as follows

$$k = 2 + [\alpha \times (\frac{\sum_{n,m} Iotsu,bw(n,m)}{\sum_{n,m} Ipre(n,m)})]$$

Here α is a constant , Iotsu,bw is the binarization result of Otsu's method on the input image, and Ipre is the output of the preprocessing step. The minimum possible for k is 2. Another measure of phase congruency is local weighted mean phase angle at every point in the image which is calculated using below equation.

$$IL(x) = \arctan 2[\sum_{p,r} Epr(x), \sum_{p,r} Opr(x)]$$

This can be used to estimate the structure of foreground text. The values of this map are between -π/2 and +π/2, where –π/2 represents the dark line and +π/2 represents the bright line.

3. Postprocessing:

In this, enhancement processes are applied. First, a bleed through removal technique is applied. A Gaussian filter is used to improve the binarization output and to separate background from foreground, to remove background noise and objects an exclusion process is applied, based on a median filter and IM maps. The individual steps are explained below.

A) Global Bleed-Through Exclusion:

In this, bleed-through is categorized in two classes

i) Local bleed-through

ii) Global bleed-through.

In this, the existence of global bleed-through is checked. If it exist, the parameters of the Canny edge detector is used to ensure the output edge map contains only the edges of text region, that expect to be located in a specific part, or parts of the image.

B) Adaptive Gaussian Filter:

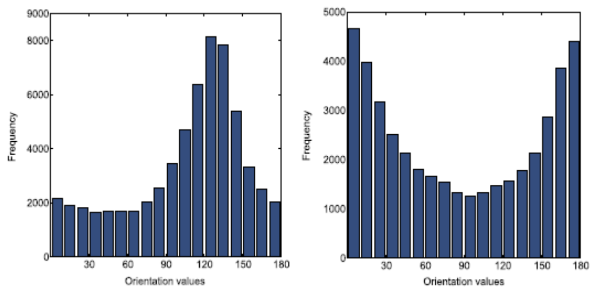
In this, each pixel produces threshold based on Gaussian smoothing filter. A rotationally symmetric Gaussian low-pass filter (G) is used. Local thresholds can be calculated using the following two-dimensional correlation.

$$T(x,y) = \sum_{i=-s}^{s} \sum_{j=-s}^{s} G(i,j) \times I(x+i, y+j)$$

Where I(x,y) is gray level input image, and T(x,y) is filtered image which stores the local thresholds.

Document type detection:

In this, the type of input document is needed to deal with. The enhancement method after this step is applied only for the handwritten documents. During calculation of phase congruency features find the standard deviation of the orientation image. For handwritten document images the standard deviation value of orientations for these pixels is low and for machine-printed documents it is higher.



(a) (b)

Fig.3 (a) Histogram of orientations of a handwritten document (b) a machine-printed document

C) Object exclusion map image :

Construct this based on a combination of a median filter and a binary map of IM .Any object with out reference in this map will be removed from the final results. By using this noise, local bleed through and interfering patterns are removed.

D) Majority criterion:

By using early binarization steps, near optimal recall values were obtained, In this for each foreground pixel in

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Ibwout, its adjacent background pixel in ID are checked, if its value is less than that of ID then that pixel is removed from the foreground. This works good on noise, unwanted lines.

V. RESULTS AND DISCUSSION

The binarization method used in this paper is evaluated on a number of datasets. These are suffered with different types of degradation, and challenging in terms of evaluation to enable a meaningful examination of various algorithms. First, compare the performance of this method with that of leading binarization methods in the literature.

A. Subjective Evaluation

In this, compare the outputs of the method with those of top-placing methods in each contest, whenever possible. Our method performs a smooth binarization of the document images.

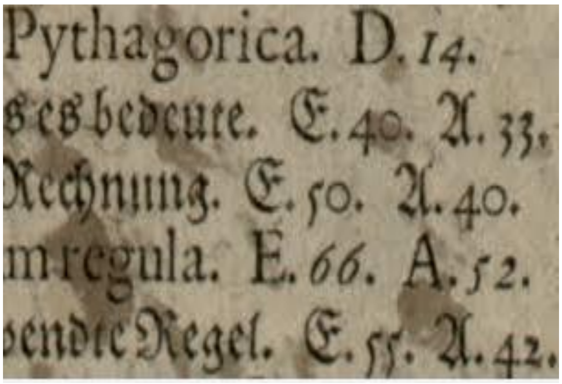

Fig.4.Original document 1

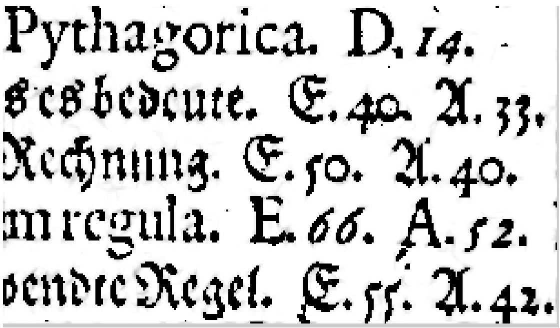

Fig.5. Binarized image

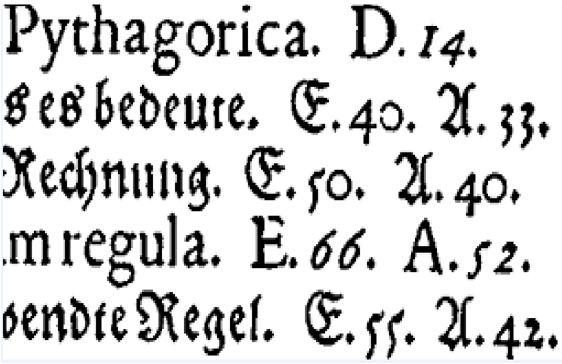

Fig.6. Ground truth image

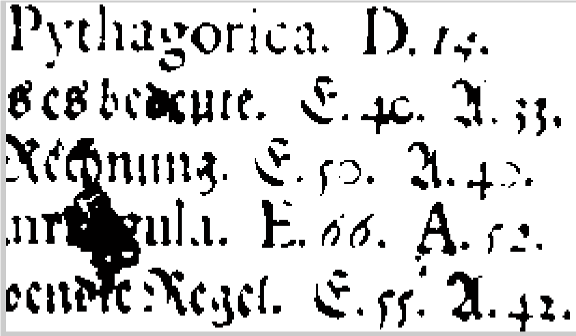

Fig.7.Niblack's method

Fig.8. Original document 2

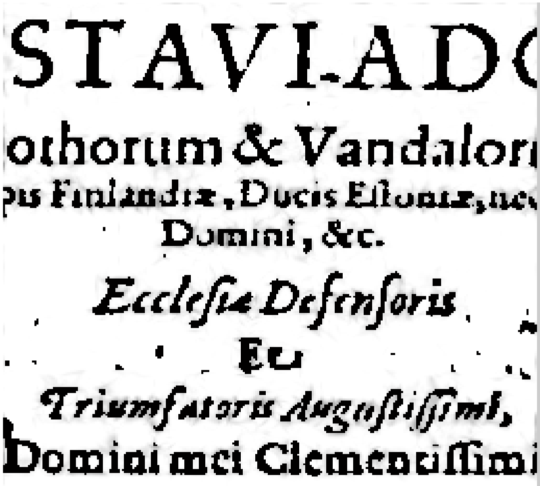

Fig.9. Binarized image

B. Objective Evaluation:

The well-known measures F-measure (FM) and Peak signal to noise ratio(PSNR) are used to evaluate various algorithms. The results show that the method achieved some improvement over our earlier results.

The table shows the improvement of present method for Fig4 and Fig8,

Fig 4	Niblack's method	Present method
F-measure	87.18545	90.45262
PSNR	12.97709	14.40454

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Fig 8	Niblack's method	Present method
F-measure	81.43917	84.11659
PSNR	14.03502	15.31628

VI. CONCLUSION

In this paper, Phase preserving denoise image is used instead of original image to improve feature extraction, and include a few steps to filter various types of degradation. In particular, a median filter has been used to reject noise, unwanted lines, and interfering patterns. Because some binarization steps work with individual objects instead of pixels, a Gaussian filter was used to further separate foreground from background objects, and to improve the final binary output. The method has been tested on various datasets covering numerous types of degradation. Our experimental results demonstrate its performance, and also that of the post processing method to improve other binarization algorithms.

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