A Quad Tree Based Binarization Approach to Improve quality of Degraded Document Images

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***Abstract*— This paper proposes a novel binarization algorithm for converting the grayscale and color images into black and white images. The binarization is one of the very important process in all the researches pertaining to the field of the Document image processing and Pattern recognition. Since quality of binary image plays a critical role in the further processing of the document, especially in the area of researches belonging to the field of Optical character recognition the accuracy of the character recognition mainly depends upon the binarized image. It is very important to perform Binarization accurately and with lowest time complexity. This paper attempts to devise a simple and an efficient algorithm for binarization in order to improvise the outputs in the process of character recognition of various scripts with reduced time complexity.**

Keywords- ***Binarization, Degraded documents, Quadtrees, Character recognition, image subdivisions***

I. INTRODUCTION

Binarization is an initial stage of the all the researches of document image processing. The binarization is mainly performed to reduce the amount of the data like intensity definitions of the image which is taken into consideration while processing the Image. Binarizing an image reduces the complexity of the image processing system in terms of time, space by upgrading the performance of the system.

Binarizing an image represents converting the image into black and white i.e., intensity information will be reduced to only two values respectively '0' and '1'. This makes the processing very easier in the succeeding stages to consider the various components of performing manipulations particularly on foreground objects of the image.

An efficient Binarization of an image also depends upon the quality of scanned image. The scanned image might be captured at different illumination conditions and at lower resolutions which may reflect some kind of adverse effects on the quality of document images. Binarization of such degraded images still degrades the image quality, and that might become useless to proceed into the further stages of character recognition or any image processing experimentation. Therefore it requires an efficient algorithm to perform Binarization accurately even on low quality degraded images. This paper attempts to propose a simple and efficient Binarization algorithm using quad trees which will be useful to convert the color or grayscale images into binary images.

In the theory of the image processing and as well as in the literature there are various methods of performing the Binarization on the images. Some of the existing techniques of Binarization include Histogram-based methods, Clustering-based methods, Entropy-based methods, Object attribute-based methods, Spatial binarization methods, Locally adaptive methods [2] etc. The algorithms to binarize the image include Berson, Niblack, savoula, Eikvil and parker etc. The algorithms and the techniques which are dicussed in the literature are all suitable for satisifying certain kind of application requirements. The existing algorithms are all application dependent.

II. LITERATURE SURVEY

Many efficient methods are implemented in the literature to convert the color/ grayscale images into binary images. But the main constraints that should be considered while choosing a certain algorithm to perform the task efficiently is complexity. Complexity can be considered in terms of time, space, implementation, type of documents. The risk factors are very important while performing any kind of operation. Some of the techniques used in literature are as follows.

Chien-Hsing Chou et al.[1], had propped a method for Binarization by dividing the image into set of blocks and using the machine learning rules to classify the different portions of the sub images. J. Sauvola et. Al. [2] propped a method J. Sauvola performs a rapid classification of the local contents of a page to background, pictures and text using the soft decision method and Text Binarization methods.

Bolan Su et al., [3] had devised a method using an adaptive contrast map of input degraded document image. The contrast map is then binarized and combined with Canny's edge map to identify the text stroke edge pixels. Efthimios Badekas et al [5], had devised a method for Binarization of color images using dominant color features of the image. In each dominant portions of image connected components are extracted and then filtered using grouping procedure. The direction of connection property is used to classify the text and non text areas of the document. M. Sezgin et. Al.,[6] had performed a detailed review on various procedures of thresholding techniques of image processing. M. Ibrahim Sezan et. Al., [7] had proposed an algorithm that uses peak detection signal derived either from the image histogram or the cumulative distribution function to locate the peaks in the image histogram. Rosenfeld et. Al., [8] had proposed a method of histogram concavity analysis to perform the threshold selection in the image. B. Gatos et al., [12] implemented a preprocessing procedure using low pass weiner filter that performs arough estimation of foreground and back ground objects. Morteza Valizadeh et. Al. [13] had propped a method of using map the image into a 2D feature space in which the text and background pixels are separable, and then we partition this feature space into small regions. These regions are labeled as text or background using the result of a basic binarization algorithm applied on the original image. K Ntirogiannis et. Al., [14] had devised a method of evaluating performance of a Binarization methodology. Marte A et. Al., [15] had proposed a method based on the concept of transition pixel, a generalization of edge pixels. Such pixels are characterized by extreme transition values computed using pixel-intensity differences in a small neighborhood. M. Ramirez et. Al., [15] had devised a threshold-based local algorithm for image binarization. The main idea is to compute a transition energy using pixel value differences taken from a neighborhood around the pixel of interest.

Many of the researches had been carried successfully and directed the path to the accurate outputs of the succeeding stages of document analysis. Each and every method has its own depth in its complexity in various terms like implementation ,time and space etc. As preprocessing is a very initial stage of character recognition process, considering the aspect of complexity at initial stages is very prominent and that leads to improved system performance. Thus a simple approach is required for performing the Binarization of the image with less time complexity. This paper introduces a very simple method of Binarization using the technique of quad trees for image subdivisions with respect to the depth of degradations in the image.

III. PROPOSED METHODOLOGY

Binarization of the document images plays a critical role on the performance of the optical character recognition. Many of the researches had proposed the efficient algorithms to improve the results of the binarization of a document. The algorithmic complexity is also concerned with each and every proposed methodology, that is about how fast or slow particular algorithm perform. Therefore an efficient methodology with less complexity is required to perform binarization of any type of images associated with varying application requirements.

Our proposed methodology introduces a novel algorithm using the constructs of data structures like Quad trees to perform the binarization process. The quad tree based area subdivisions are carried out for the input image depending upon only the complexity of image subject to certain constraints and humans preferences. In the proposed methodology level of accuracy of output in the binarized image and time complexity of the binarization algorithm has a direct impact on the preferences of the user who is incorporating this algorithm in their work. The quad tree subdivision of the image is a recursive approach that subdivides the images into four partitions for each cycle of execution in the binarization stage. Every time the quality of the output binarized image is analyzed to determine whether the further subdivision is to be carried out or not. The level of complexity in this algorithm also depends on the quality of the input image considered for binarization. It is very obvious that for very poorly illuminated or degraded images requires average number of cycles to improve the quality of outputs. The following section gives the details of Quad tree approach of Binarization.

A. Description of proposed methodology:

Initially scanned input image is subdivided in to four partitions based on the quad tree approach. The threshold value of each partition is determined using the Otsu's thresholding algorithm or any other basic thresholding techniques like, Bernsen, Sauvola, Niblack etc. Compute the average of all the thresholds identified for each of the partition and perform the binarization with weighted average threshold value of all partitions. Once the output is obtained determine whether the attained outputs are upto the expectation or not. For any further improvisation in the output again perform the subdivisions with respect to only the partition which requires improvement. Before applying the quad tree algorithm for further subdivisions, the image is clearly inspected by user to check whether further subdivisions is required for any of the quadrant or not. If required then only the poorly binarized quadrant undergoes succeeding subdivisions.

B. Mathematical Treatment:

Consider an image of size *m x n* such that it is partitioned again into quadrants *q1, q2, q3* and *q4*. Then, identify the thresholds *T(q1), T(q2), T(q3), T(q4)* using Otsu's thresholding algorithm or any of the suitable thresholding technique as discussed in the above section. The average of the thresholds *T(q1), T(q2), T(q3)* and *T(q4)* gives an weighted average threshold T(I) of an image to perform the binarization.

$$\textit{i.e., } T(I) = \frac{1}{n} \sum_{i=1}^{n} T(qi)$$

$$\textit{where } i = 1, 2, 3 \ldots n$$

and 'n' is the number of the partitions in the image.

The recursive computations of thresholding is given by

$$T(I) = \frac{1}{n} \sum_{i=1}^{n} \left(\frac{1}{n} \sum_{i=1}^{n} T(qi) \right)$$

C. Algorithm:

1. Read the scanned input image(Color/ Grayscale)
2. Divide the image into four quadrants using quad tree algorithm.
3. Determine the thresholds of each quadrant using Otsu's Thresholding or any suitable technique.
4. Compute the average of all thresholds of quadrants obtained from step3.
5. Perform the binarization using average threshold value obtained in step4.
6. Test the outputs of binarized image in step5.
7. If quality is not as expected then

   Repeat the steps 2 to step 6 w.r to one quadrant.
   Calculate average threshold of quadrant poorly binarized.
   Improve output only that quadrant.
   Display output

   Else

   Display output Image
8. Stop

D. Algorithm for Partitioning Image:

1. Read the image.
2. Determine the mid row using minimum row number and maximum row number.

   ```
   rowmid=(rlow+rhigh)/2
   ```
3. Determine the mid column using minimum column number and maximum column number.

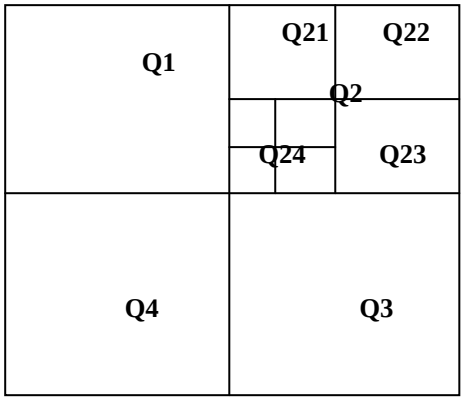
   ```
   colmid=(clow+chigh)/2
   ```
4. Partition the image into four equal sized quadrants with obtained values (by applying properties of rectangle for calculating partition vertex coordinates).

```
Q1=I(rlow:rowmid,clow:colmid)
Q2=I(rowmid:rhigh,clow:colmid)
Q3=I(rlow:rowmid,colmid:chigh)
Q4=I(rowmid:rhigh,colmid:chigh)
```

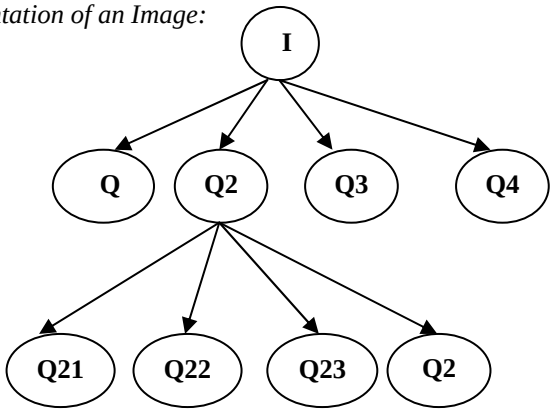
5. Identify the threshold individually for each quadrant using any of the basic threshold techniques.
6. Compute the average of all the thresholds.
7. Binarize the image using average threshold value.
8. Stop

E. Quad tree representation of Image subdivisions:

Consider an image I Subdivisions



F. Quadtree Representation of an Image:



I - > Image
Q1, Q2, Q3, Q4 -> Quadrants of Image I
Q21, Q22, Q23, Q24 -> Sub Quadrants of Quadrant Q2.

G. Samples of Original Image:

ಕಾರ್ಯಾಗಾರ ಉದ್ಘಾಟನೆ

ಪ್ರಜಾವಾಣಿ ವಾರ್ತೆ

ಕೃಷ್ಣರಾಜಪೇಟೆ: ಸ್ವತಂತ್ರ ಹಾಗೂ ಉಚಿತ ಕನ್ನಡ ವಿಶ್ವಕೋಶವಾದ ವಿಕಿಪೀಡಿಯಾವನ್ನು ಬೆಳೆಸಲು ಎಲ್ಲರೂ ಮುಂದಾಗಬೇಕು ಎಂದು ಖ್ಯಾತ ಗಣಕ ಪರಿಣಿತ ಡಾ.ಯು.ಬಿ. ಪವನಜ ಸಲಹೆ ನೀಡಿದರು.

ತಾಲ್ಲೂಕು ಕನ್ನಡ ಸಾಹಿತ್ಯ ಪರಿಷತ್ತು ಮತ್ತು ಬೆಂಗಳೂರಿನ ಸೆಂಟರ್ ಫಾರ್ ಇಂಟರ್ನೆಟ್ ಸೊಸೈಟಿ ವತಿಯಿಂದ ಪಟ್ಟಣದ ಶ್ಯಾಮ್ ಕಂಪ್ಯೂಟರ್ ಸೆಂಟರ್ ಆವರಣದಲ್ಲಿ ಭಾನುವಾರ ಏರ್ಪಡಿಸಿದ್ದ 'ಕನ್ನಡ ವಿಕಿಪೀಡಿಯಾ ಕಾರ್ಯಾಗಾರ' ಉದ್ಘಾಟಿಸಿ ಅವರು ಮಾತನಾಡಿದರು. ವಿಕಿಪೀಡಿಯಾ 3.5 ಕೋಟಿ ಓದುಗ ಸಮೂಹವನ್ನು ಹೊಂದಿದೆ. ಈ ವಿಶ್ವಕೋಶವನ್ನು ನಿಯಮಿತವಾಗಿ ಸಂಪಾದಿಸುವ, ಅನುವಾದಿಸುವ, ಪರಿಷ್ಕರಿಸುವ ಕಾರ್ಯ ಆಗಬೇಕಿದೆ. ಕೇವಲ ಕವಿತೆ, ಕಥೆ, ಕಾದಂಬರಿ ಮತ್ತಿತರ ಸಾಹಿತ್ಯ ಪ್ರಕಾರಗಳಿಂದ ಭಾಷೆಯ ಉಳಿವು ಸಾಧ್ಯವಿಲ್ಲ. ಕನ್ನಡ ಭಾಷೆಯಲ್ಲಿ ಜಾಗತಿಕ ಮಟ್ಟದ ಜ್ಞಾನ ನೀಡುವ ಪುಸ್ತಕಗಳು ರಚನೆಯಾದಾಗ ಮಾತ್ರ ಕನ್ನಡ ಭಾ..ಯ ಉಳಿವು ಸಾಧ್ಯವಾಗುತ್ತದೆ. ಈ ನಿಟ್ಟಿನಲ್ಲಿ ಕನ್ನಡದ ಲೇಖಕರು ಮುಂದಾಗಬೇಕು ಎಂದು ಹೇಳಿದರು.

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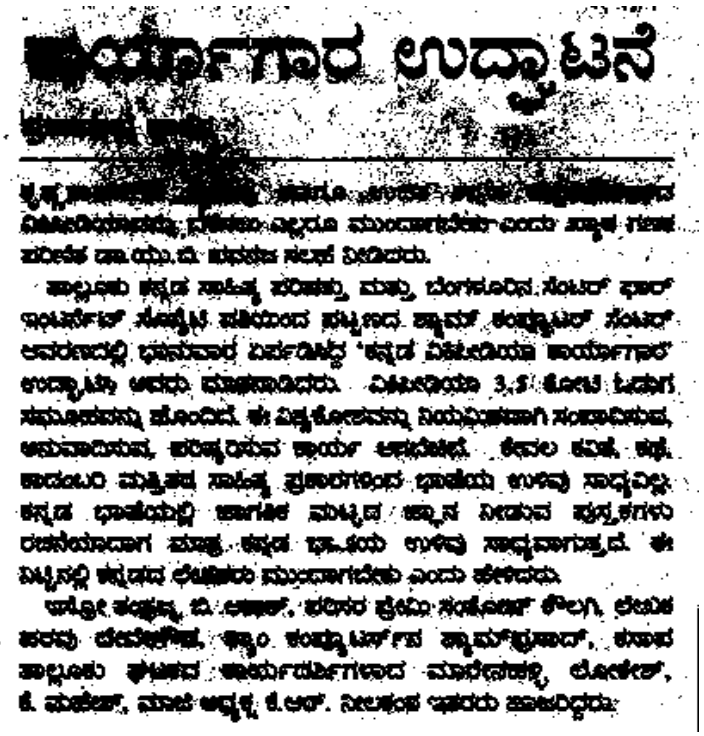
Incorrectly binarized image due to variation in Threshold value:

Poorly binarized Image with very higher Threshold:



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Quadtree approach of Binarization:

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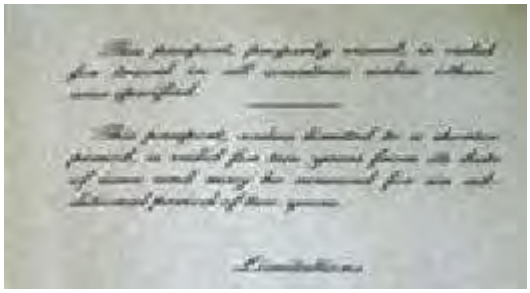
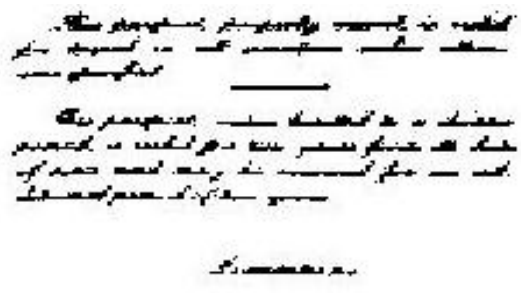
ಇಸ್ರೋ ತಂತ್ರಜ್ಞ ಬಿ. ಆಕಾಶ್, ಪರಿಸರ ಪ್ರೇಮಿ ಸಂತೋಷ್ ಕೌಲಗಿ, ಲೇಖಕ ಹರವು ದೇವೇಗೌಡ, ಶ್ಯಾಂ ಕಂಪ್ಯೂಟರ್ಸ್‌ನ ಶ್ಯಾಮ್‌ಪ್ರಸಾದ್, ಕಸಾಪ ತಾಲ್ಲೂಕು ಘಟಕದ ಕಾರ್ಯದರ್ಶಿಗಳಾದ ಮಾರೇನಹಳ್ಳಿ ಲೋಕೇಶ್, ಕೆ. ಮಹೇಶ್, ಮಾಜಿ ಅಧ್ಯಕ್ಷ ಕೆ.ಆರ್. ನೀಲಕಂಠ ಇತರರು ಹಾಜರಿದ್ದರು.

Highly degraded Image



Binarized with Quadtree approach



Binarized with Otsu's Thrsholding technique

IV. EXPERIMENTAL ANALYSIS

The proposed methodology gives good quality outputs with out loss of information. It seems that algorithm works with less time complexity for even the highly degraded images also, and the best time complexity of this algorithm is obtained if the expected results are obtained at initial subdivision. The worst case is the maximum number of subdivisions that are carried out to improve the results. The algorithms can also be refined by averaging thresholds of only some particular quadrants randomly like taking average only [Q1 and Q2] or [Q1 and Q3] or [Q1 and Q4] or [Q1 and Q2 and Q3] etc. in order to obtain the accurate results especially in case of highly degraded documents as considered in the above example.

V. CONCLUSION

The quad trees are very good data structures to be used in multiple application requirements. This paper proves that quad trees are efficient enough to deal with the recursive tasks. The algorithm performs well for both the grayscale and color images. The algorithm devised in even capable of handling degraded images and attain the quality outputs at initial subdivision itself. The algorithm gives an accuracy of 90% and above in many cases of degraded documents and gives 100% accuracy in the case of quality scanned documents.

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