ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

A NEW DIVIDE AND CONQUER APPROACH FOR BINARIZATION OF POOR QUALITY QR CODE IMAGES.

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Manuscript Info

Manuscript History:

Received: 14 December 2015
Final Accepted: 16 January 2016
Published Online: February 2016

Key words:

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Abstract

A novel approach for binarization of QR code, images was proposed in this paper. The proposed algorithm employs divide and conquer approach to binary the low quality and low illuminated QR code images. The image to be binarized is divided into segments and the threshold value for each segment is determined and the mean threshold value found from these individual segments is used for binarization. The experimental evaluation showcased that the proposed algorithm outscores the state of the art previous algorithms up to an order of magnitude in terms of quality and accuracy.

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Introduction:-

As decade has witnessed a significant increase for image analysis and processing. The major part involved in this analysis is to identify and retrieve foreground and background objects accurately. The best known method is to produce a binary image of ones and zero to differentiate the foreground and the background objects in the image, however this process is quite tedious and cumbersome to find the best thresholds because of change of illumination or noise presumed issues. Sezgin and Sankur's survey [1]revealed the difficulties present in this, many attempts have been made to find an efficient and relevant binarization method.

Many research works has been carried out in the past and few algorithms performs globally. Otsu's algorithm [2] is known to be the best in that category. Otsu algorithm finds an optimal threshold value for the whole image by maximizing the separation between two expected classes. Despite the speed of the Otsu algorithm, it is not suited to supportunevenly illuminated images and noises present in the images.

Binarizing an image epitomizes conversion of the image into black and white (i.e.,) intensity information will be decreased to only two values either '0' or '1' and this makes the processing very easier in the subsequent stages to consider the various components of performing manipulations particularly on QR code of the image.

In general there are various methods capable of performing the binarization on the images. Some of the existing methodologies of binarization include Histogram-based, Clustering-based, Entropy-based, Object attribute-based, Spatial binarization, Locally adaptive methods etc. The algorithms to binarize the image include Otsu, Berson, Niblack, savoula, and parker etc. The algorithms and the techniques which are discussed in the literature are

allsuitable for satisfyingspecific kind of application requirements. The existing algorithms are all applicationdependent.

Many efficient methods are implemented to convert the color/ grayscale images into binary images. But complexity is the main constraint that has to be considered while conversion. Complexity related to terms of time, space, implementation and type of image.

Related works:-

Chien-Hsing Chou et al.[3], had proposed a method for binarization by dividing the image into set of blocks and use the machine learning rules to classify the different blocks of the sub images. J. Sauvolaet. Al. [4] proposed a method which 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., [5] 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. EfthimiosBadekas et al [6], had proposed 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 image. M. Ramirez et. Al., [7] 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.B. Gatos et al., [8] implemented a preprocessing procedure using low pass Weiner filter that performs a rough estimation of foreground and back ground objects.

The balanced histogram thresholding method [10] is a very simple method used for automatic image thresholding similar to Otsu's method [2].Assuming that the image is divided into two main classes: the background and the foreground, this method tries to find the optimum threshold level that divides the histogram in two classes. This method weighs the histogram, checks which of the two sides is heavier, and removes weight from the heavier side until it becomes lighter. It repeats the same operation until the edges of the weighing scale meet. This method may have problems when dealing with very noisy images, because the weighing scale may be misplaced. The problem can be minimized by ignoring the extremities of the histogram.

Problem statement:-

Binarization can become a tedious job [9] under varying illumination and random noise levels. Plethora of factors contributes to complicate the thresholding scheme which includes ambient illumination, variance of gray levels within the object and the background of the image. A wrong selection of the threshold value might misinterpret the background and completely degrades the overall recognition process. The majority of binarization techniques are very complex and are amalgamated from filters and existing operations. At the same time manythresholding methods available cannot be applied to binarizationproblems specifically to recognize QR code images. So this paper deals with a new approach to binarize the low illuminated QR code images accurately and reduces the performance complexity to a greater extent.

Proposed approach:-

A novel divide and conquer approach is introduced in this paper to perform the binarization process. The divide and conquer approach first computes the center point of the image, identifies the area of interest to be binarized and divides the identifiedarea of the input image into segments and subdivisions depending upon the complexity of image and certain humans preferences. In the proposed approach accuracylevel and time complexity of the binarization algorithm has a direct impact on the preferences of the user incorporating the algorithm.

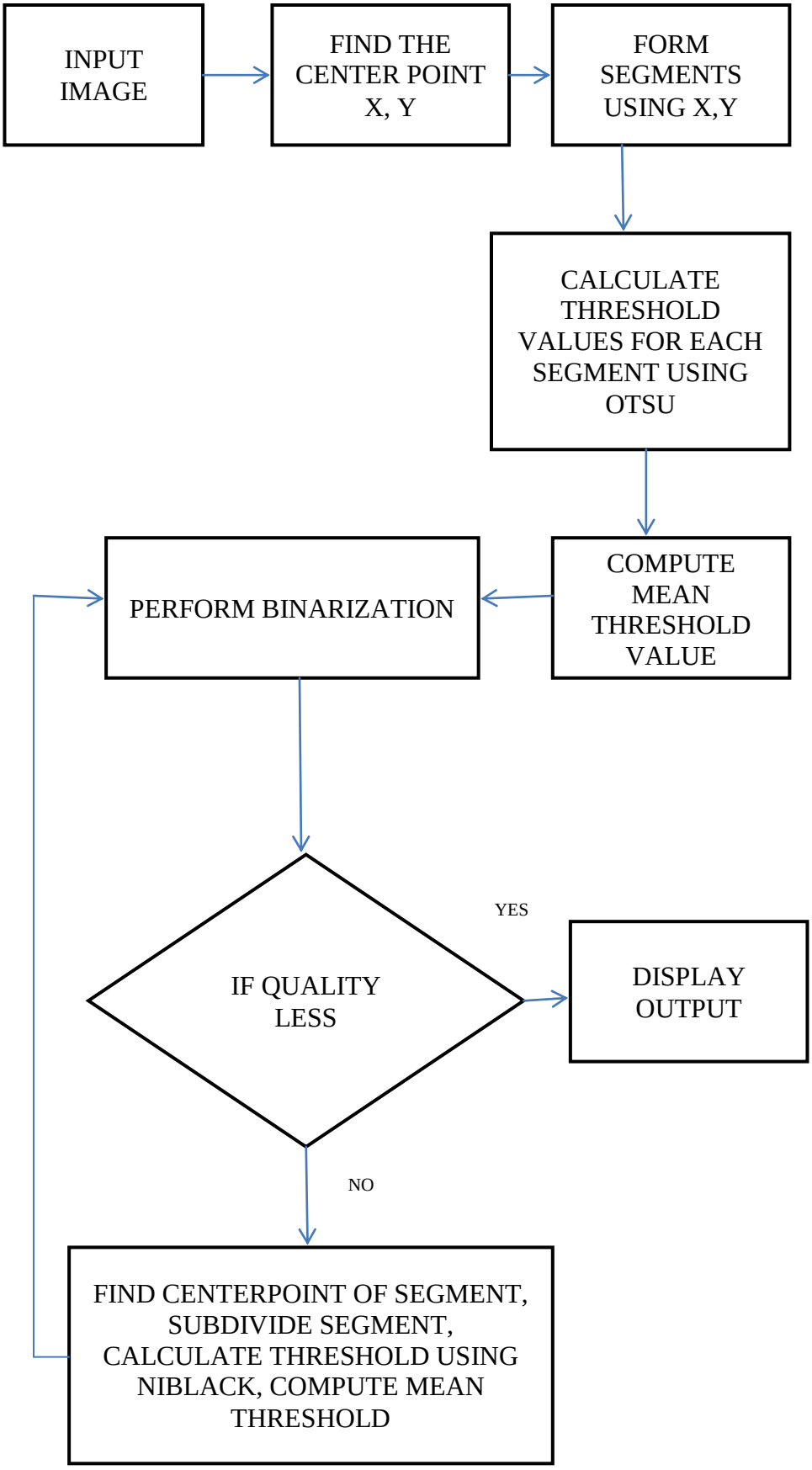
INPUT IMAGE
FIND THE CENTER POINT X, Y
FORM SEGMENTS USING X,Y
CALCULATE THRESHOLD VALUES FOR EACH SEGMENT USING OTSU
COMPUTE MEAN THRESHOLD VALUE
PERFORM BINARIZATION
IF QUALITY LESS
YES
DISPLAY OUTPUT
NO
FIND CENTERPOINT OF SEGMENT, SUBDIVIDE SEGMENT, CALCULATE THRESHOLD USING NIBLACK, COMPUTE MEAN THRESHOLD

Figure 1: Proposed approach

The divide and conquermethod uses a recursive approach that subdivides the segments recursively during binarization until the desired quality in the binarized output is attained. Every time the quality and the accuracy of the output binarized image is scrutinized to decide whether further subdivision is to be carried. The complexity level in this approach depends on the quality of the input image and it is quite obvious that for poorly illuminated or low quality image requires more number of iteration cycles to improve the quality of output.

Let us consider an image of *m* x *n* size, the center point of the image is computed using the formula,

X = (imageWidth – imageWidth /2) = *m – m/2*
Y= (imageHeight – imageHeight/2) = *n – n/2*

The X,Y co-ordinates is the center point of the image. Now a horizontal line and a vertical line through this X, Y co-ordinate will segment the image into four subdivisions. Find the threshold value of the each segment using Otsu and calculate the mean threshold value from this four threshold value found individually. After obtaining the mean threshold value, the binarized output of the image is found. The individual segment's center point is again found to subdivide the segment into four more divisions and the threshold value of the subdivided segment area is found. Now the mean threshold value for this is also calculated and the binarized output is attained. This process is recursively repeated until the desired accuracy in the binarized output is found.

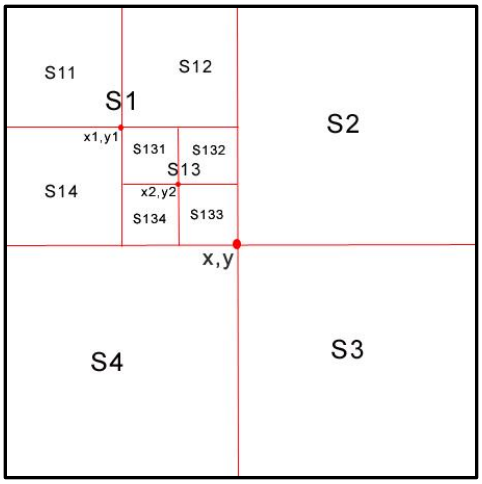

Figure 2: Segment portioning of input image

The threshold values for each segments are found T(S1), T(S2), T(S3) and T(S4). The mean threshold value is calculated from these segment threshold values,

$$\text{Mean threshold } T_M = \frac{1}{N}\sum_{i=1}^{N} T(i) \quad \text{——}$$

Where N is the total number of segments

The proposed approach utilizes the global threshold value and the local threshold values to improve the quality and accuracy of the binarization. Initially Otsu threshold value is found for binarization and if the quality of the binarized output is not up to the desired levels, the segments are further subdivided and Niblack local threshold value is calculated to improve the accuracy.

Table 1: Computation time details of proposed approach
The table 1 provides a complete breakup of average time required to binarize a QR code image of 50dpi with 1600 x 1200 pixels.

STEPS	**AVG TIME**
Image computation and sub sampling	0.41 s
Processing and global thresholding	0.53 s
Processing and local thresholding	0.58 s
Final Binarization	0.42 s
TOTAL TIME REQUIRED	1.94 s

Proposed algorithm
FUNCTION segmentwisebinarization
(Image I)

INPUT: Degraded Image I
BEGIN:

1. Load the Image and Read
2. Calculate the center point of the image
   X = imageWidth – imageWidth / 2
   Y= imageHeight – imageHeight / 2
3. Draw horizontal and vertical lines to divide the image using X, Y co-ordinates
4. Calculate the threshold value for each segment using Otsu
5. Find the mean threshold T_m
6. Perform binarization using T_m
7. IF binarized output ≠ desired quality
   Find the segment where quality is low
   Calculate the center point of the segment
   Xi = SegmentWidth – SegmentWidth / 2
   Yi= SegmentHeight – SegmentHeight /2
   Draw horizontal and vertical lines to divide the segment using Xi, Yi Co-ordinates

   Calculate the threshold values of sub-segments using Niblack
   Find the mean Threshold T_{sm}
   Repeat Step 6
   Display Binarized Output
   Else
   Display Binarized Output

END FUNCTION

Figure 3: Divide and conquer binarization algorithm:-

The proposed algorithm employs both global and local threshold values to binarize the QR code images and this method proved to outscore the previous methodologies by a huge margin.

Figure 4: Comparison of sample image1

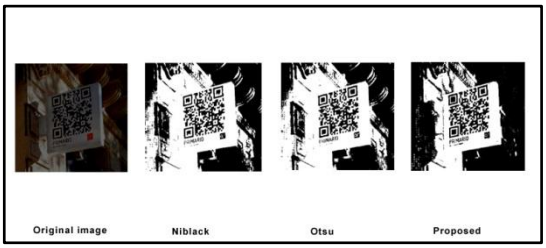

Figure 5: Comparison of sample image2

Evaluation measures:-

According to common evaluation protocols [18] we used the F-measure (FM) in order to compare our method with other approaches,

$$FM = \frac{2 \times Recall \times Precision}{Recall + Precision}$$

Where,

$$Recall = \frac{TP}{TP + FN}$$

$$Precision = \frac{TP}{TP + FP}$$

TP, FP, and FN respectively standing for true-positive (total number of well-classified foreground pixels), falsepositive (total number of misclassified foreground pixels in binarization results compared to ground truth), and false-negative (total number of misclassified background pixels).

METHOD	PRECISION	RECALL	FM	TIME(S)
OTSU	0.98	0.84	90.70	17
NIBLACK	0.89	0.92	88.86	21
PROPOSED	0.97	0.94	95.3	31

Table 2: Evaluationofresults over 10 QR code images

From the table2, it is obvious that the Otsu performs better than Niblack and this is quite understandable fact that Otsu performs well on clean images without any noises and poorly illuminated images. Niblack performs moderately on poorly illuminated images but the proposed method which combines both the Otsu and Niblack performs exceedingly well on poorly illuminated degraded QR code images but induces some performance costs as the time taken is almost double than that of Otsu. This is mainly because of the few extra steps involved in the proposed algorithm.

Conclusion and future work:-

In this paper Scholar propose an approach that significantly improves the results ofbinarization on low quality low illuminated QR code images. The accuracy of the proposed algorithm was tested on 50dpi images and the proposed approach showcased that the accuracy related to the output has increased credibly with a performance cost loss regarding time. The proposed approach can employ Sauvola'sbinarization threshold in future to check the accuracy levels and find a way to reduce the time complexity involved. Also instead of segmenting the image, either vertical slicing or horizontal slicing can be made on the images to binarize.

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