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QR Barcode tilt correction and recognition based on image processing

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ABSTRACT

Binarization is the process of Conversion of a picture to only black and white. Binarization approaches is difficult to difficult to directly apply barcode images captured by mobile device due to their low quality. In this paper proposes a novel scheme for the binarization of such images. Binarization of Low-Quality Barcode Images Captured by Mobile Phones Using Local Window of Adaptive Location and Size. A binary image is a digital image that has only two possible values for each pixel. The barcode and background regions are differentiated using the number of edge pixels in a search window. The balance of the number of object and background pixels can be achieved using window center to the nearest edge pixel. Window size is depended on the minimum distance to edges or minimum element width in the barcode. The threshold is also calculated using statistics in the window. Proposed method has demonstrated its capability in handling the no uniform illumination problem and the size variation of objects.

1. INTRODUCTION

A barcode reader also called a price scanner or point-of-sale (POS) scanner is a hand-held or stationary input device used to capture and read information contained in a bar code. A barcode reader consists of a scanner, a decoder (either built-in or external), and a cable used to connect the reader with a computer. Barcode image processing has drawn a lot of interests recently, owing to the wide usage and fast advancement of the mobile phones. Smart phones can be used to capture the barcodes and perform image processing tasks on the device. The mobile phones interact with the internet system. The mobile phones using the mobile capture for data transfer. Mobile phones using barcode decoder create lot of problems. Barcode images captured by mobile phones are low quality. The images generally undergo geometric distortions owing to the capturing angle between the mobile phone and barcode image. Then the images are generally not uniformly illuminated due to the uneven lighting in capturing the images. And excessive noise and blurriness usually exist due to the small sensor size, lack of auto-focus for most phones and small size of the printed barcodes. This issue, a blur distortion measure-based pre-filtering process can be employed to filter out those severe blurred barcode images and ask the user to retake the photos of the barcodes. This paper focuses on the binarization of barcode images captured by mobile phones by proposing different strategies to binarize the barcode region of interest and background region.

2. RELATED WORK

Some of the notable research efforts have been made in previous works. Many proposed methods are used for the binarization of the barcode images captured by mobile phones. Though, communication methods such as CDMA or GPRS, infrared, Bluetooth and cables have existed for many years Liu et al., (2006) discussed about a novel scheme which allows the camera to be repurposed to download data from an image or a series of images. Moreover, they proposed a camera based solution has various unique advantages. Chen et al., (2010) summarized a novel blurriness computes to categorize the samples according to their decodabilities and quality measure of 2D barcode image is estimated by utilizing distinctive histogram features. This method is not sensitive to noise, rotation and scaling. A data transfer method uses the camera in a smart phone as an alternative data channel was given in Liu et al., (2008). The data is encoded as a sequence of 2-D barcode images is displayed on a flat panel display, acquired by the camera and decoded in real time by the software embedded in the device. Kato et al., (2007) proposed the pervasive 2D barcodes for camera phone applications for reliability of the camera phone's captured image as a metric for gauging reading reliability. Zhanget al., (2006) focus on automatic localization, to propose a real time barcode localization method. In this method, the user needs to put a barcode in front of a camera at around 15 cm for common web cameras and the system then repeatedly locates and decodes the barcode. A new approach to barcode decoding that bypasses binarization was proposed in Gallo et al. (2011). It exploits all the gray level information of each pixel and use to relies deformable templates. In addition, it can perform maximum possibility estimation independently on each digit and enforce spatial coherence in a consequent step. Parikh et al., (2008) proposed an approach to localize and segment a 2D high capacity color barcode that is more robust or invariant to these variations. Furthermore, they focus on the four-colored HCCB, the four colors being black, red, green and yellow. And the method to locate the four extreme corners of bars codes in the images captured by mobile phones (Yang et al. 2010). To accomplish this goal, the two nearly-parallel outer boundary lines are first localized by utilizing the prior knowledge of the relative distances and angles between the lines, which are consequently employed to acquire the initial localized corners. Yang et al., (2010) proposed a dynamic window construction to establish the size of the binarization. It changes with the presence of the high gradient pixels in a search window centering the processing pixel. Moreover, the proposed method has demonstrated its capability in

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handling objects of different sizes and the uneven illumination problem. Additionally, it is not constrained to certain barcode types. Youssef et al., (2007) proposes a smart barcode detection and recognition system (SBDR) based on fast hierarchical Hough transform (HHT). The back-propagation neural network (BPNN) is selected as a powerful tool to perform the recognition process. It presents an effective method to consume the specific graphic features of barcodes for positioning and recognition purposes even in case of distorted barcodes.

3. EXISTING APPROACH

It is difficult to use a single threshold to binarize the barcode images captured by mobile devices under uncontrolled lighting conditions. Niblack's method is a good choice to the adaptive binarization. A key issue is how to choose an appropriate size of the window. This is especially true for the barcodes such as PDF417 where significant gap exists in size between the start/stop bars with the small modules in the data portion. The idea is motivated Using a window of fixed size to binarize the entire image cannot handle the size variation of the objects properly, A suitable center location is to be found instead of always centering the pixel to be binarized with a window of fixed size. For effective binarization of barcode images with uneven illumination, a smallest window in a proper location needs to be found such that the number of white and black pixels in the window is balanced. Edge pixels nearest to the candidate pixel are suitable candidates to construct such a window. And different strategies are needed to binarize the barcode region of interest (BROI) and that of the uniform background region.

4. PROPOSED APPROACH

This paper proposes a novel scheme for the binarization of images. The barcode and background regions are differentiated by the number of edge pixels in a search window. Proposed method has demonstrated its efficiency in handling the non-uniform illumination problem and the size variation of objects. The proposed system uses a window of fixed size to binarize the entire image that handles the size variation of the objects properly. Secondly, a suitable center location is determined instead of always centering the pixel to be binarized with a window of fixed size. Thirdly, for effective binarization of barcode images with uneven illumination, a small window in a proper location is detected such that the number of white and black pixels in the window is balanced. Fourthly, different strategies are used to binarize the barcode region of interest (BROI) and that of the uniform background region, considering the clear separation of the two regions. To get a good binarization threshold, we propose to center the window at the nearest edge pixel so that the numbers of the white and black pixels are balanced in the window. The window size is dynamic and adaptive to the minimum distance to edges. This not only addresses the uneven illumination problem, but also effectively handles the situation when small and large objects coexist in the image. The different binarization strategies are proposed for the barcode region of interest and background region.

4.1. "DW-E" Strategy (Dynamic-sized Window centering the nearest Edge pixel)

A window with adaptive size is chosen to center the nearest edge pixel based on the calculated minimum pixel-to-edge distance. Smallest integer which is not less than scaling factor is selected in the implementation, considering an extreme case that the pixel lays in the middle of the largest object in the image. The size of the window is chosen so that the pixel to be binarized is guaranteed to lie in the window. This is called "dynamic window" since the size of the window is dynamic and adaptive.

4.2. "FW-E" Strategy (Fix-sized Window centering the nearest Edge pixel)

A window with a fixed size of is employed to center the dynamically found edge pixel. This is called "shifted window" since the center of the window has shifted from the pixel to be binarized to the found edge pixel. Adaptive to the minimum element width of the barcode images, ensures the window size is at least two times that of minimum element width which can be easily obtained once the maximum element width is extracted due to their fixed relationship. In general, the illumination variation can be effectively handled and the number of black and white pixels after binarization can be better balanced in the small window.

4.3. "FOW-E" strategy (Fix-sized, Oriented Window centering the nearest Edge pixel)

This is similar to FW-E strategy, however, the window is oriented perpendicular to the line connecting the pixel to be binarized and the found nearest edge pixel.

4.4. "FW-B" strategy (Fix-sized Window centering the pixel to be binarized)

This conventional strategy is also defined here for the purpose of comparison. A window with a fixed size is employed to center the pixel to be binarized, which is generally chosen to be large. The barcode region is differentiated from that of the background region in the binarization process. The threshold for the pixel to be binarized that lies in the barcode region, i.e., by using a dynamic window (i.e., DW-E strategy), or a shifted window (i.e., FW-E and FOW-E strategies), or conventional window (i.e., FW-B strategy). A function for calculating the threshold using the pixel statistics, "weighted mean" is chosen in the implementation. Each adaptive or shifted window is of size and centered at the location and are the locations of the pixel to be binarized (e.g., for conventional FW-B strategy) or the nearest edge pixel (i.e., for our proposed DW-E, FW-E and FOW-E strategies). The weight equals to "1" for pixels in the window, i.e., it equals to "0" otherwise. The threshold for the barcode region is actually chosen as the middle point of the average gray values for the object and background pixels. This is a good threshold to separate the object pixels from that of the background pixels. On the other hand, block-based binarization is used to binarize the pixels in the background region. The threshold for the background region is chosen to ensure that all pixels in the window are binarized to white. It is worth noticing that the location information of the gradient and intensity value of the pixels is seamlessly integrated in the present approach.

5. BLOCK DIAGRAM

First we take the input image and the input image is converted into gray scale image (Figure 1). Then we discuss how to differentiate the barcode region from that of the background region so that different strategies can be applied. To identify whether or not a pixel lies in the *barcode region of interest (BROI)* or background region, the *maximum element width* and *edge map* are employed. After detecting the barcode then scan the image. Scan the image along several scan lines that are positioned in pre-defined distances from the image center. Obtain the line profile. The valid and the invalid profiles are defined to differentiate the scan lines that pass through the BROI and background regions. A line profile is valid if the number of transitions (i.e. a change from a black run to a white run, or vice versa) in the profile is not less than the minimum number of transitions.

6. IMPLEMENTATION STEPS

6.1. Detect barcode region from background

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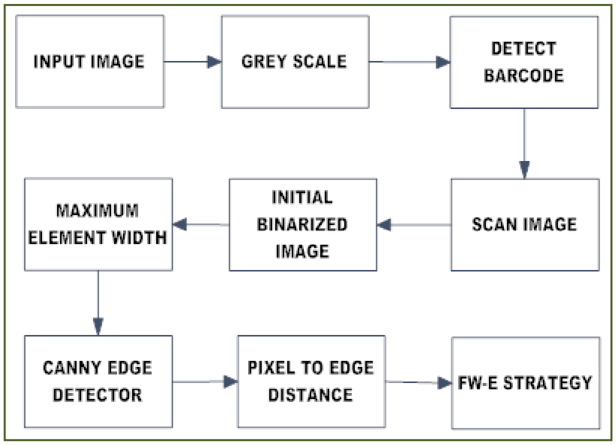

Figure 1
Architecture of the proposed approach

We firstly discuss how to differentiate the barcode region from that of the background region so that different strategies can be applied. To identify whether or not a pixel lies in the barcode region of interest (BROI) or background region, the maximum element width and edge map are employed.

6.2. Scan the image
Scan the image along several scan lines that are positioned in pre-defined distances from the image center. Obtain the line profile. The valid and the invalid profiles are defined to differentiate the scan lines that pass through the BROI and background regions. A line profile is valid if the number of transitions (i.e. a change from a black run to a white run, or vice versa) in the profile is not less than the minimum number of transitions.

6.3. Obtain initial binarized profile
Obtain line profile. Obtain initial binarized profile, by using mean of the gray values of the pixels as the initial threshold to binarize the line profile. The initial threshold is generally biased towards the background values considering the large white margin. A refined threshold is obtained by computing mean of the gray values of those black pixels to retain all the object pixels. This threshold is then used to binarize the profile.

6.4. Obtain the maximum element width
The maximum element width is obtained by taking the mean of the largest black runs of those valid profiles.

6.5. “Canny” edge detector
The edge pixel that gives the minimum pixel-to-edge distance is the nearest edge pixel. The edge map is obtained by applying “Canny” edge detector, where “1” and “0” represent “edges” and “non-edges”, respectively. A window is constructed to center the nearest edge pixel to include both object and background pixels. The minimum pixel-to-edge distance is defined as the minimum distance from the processing pixel to the edge pixels in the edge map. The edge pixel that gives the minimum pixel-to-edge distance is the nearest edge pixel.

6.6. Compute minimum pixel-to-edge distance
The minimum pixel-to-edge distance is defined as the minimum distance from the processing pixel to the edge pixels in the edge map. The edge pixel that gives the minimum pixel-to-edge distance is the nearest edge pixel.

6.7. “FW-E” binarization strategy
In “FW-E” strategy (Fix-sized Window centering the nearest Edge pixel) a window with a fixed size is employed to center the dynamically found edge pixel. This is called “shifted window” since the center of the window has shifted from the pixel to be binarized to the found edge pixel. Adaptive to the minimum element width of the barcode images, ensures the window size is at least two times that of minimum element width which can be easily obtained once the maximum element width is extracted due to their fixed relationship.

7. CONCLUSION
In this paper, we have presented a novel adaptive thresholding technique for the binarization of the barcode images captured by mobile phones. A dynamic search window centered at the nearest edge pixel of the pixel to be binarized is constructed. The window size is either adaptive to the nearest pixel-to-edge distance or the minimum element width of the barcode. The binarization is subsequently done based on the statistics of the pixels in the window.

The adaptive size and location of the window lead to a binarization approach robust to the variations in object size and illumination. Experimental results conducted on 350 images captured by five mobile phones in lab lighting achieve close to 100% recognition rate using Tasman and clear Image decoders. It achieves the recognition rates of about 95% and 83% using Tasman and clear Image decoders for home lighting at night. Comparisons with nine existing methods using 330 images show the advancement of our proposed method in terms of both visual quality of the binarized barcode images and recognition rates. One interesting future work is to integrate binarization with the barcode decoding to optimize the whole process.

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