Adopting Morphology Method in Camera Based EAN-13 1D Barcode Recognition using Simulink

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Abstract- This paper studies barcode recognition which implements using Simulink MATLAB 7.13. The proposed algorithms and the implementations of image are for EAN-13 barcode by using camera devices. A Barcode recognition process is based on image color conversion in order enhance visual quality of 1D EAN-13 barcode image. Each scan lines were processed by transforming it into a feature value to analyze. RGB to intensity color conversion block is approach to compute the feature extraction. Gaussian Filter is used to smooth the image gradient of barcodes which is consist of sequence of parallel, light and dark stripes printed. In barcode recognition, the symbols were up sampled and compared with codebook to determine the corresponding code. A result of barcode numbers saved in file.mat is used for product matching code. The percentage of success is 94.44% and failure of the system is 5.56%.

Keyword—Image Processing, Intensity, Gaussian filter, Image feature, Gamma Correction, Barcode Validation

I. INTRODUCTION

Barcodes are prevalently in everyday life, affecting the way consumers purchase products. At present, barcodes can also be designed as patterns of dots and hidden images [1]. There are over 300 types of barcode symbol, with the predominant being Code 39, UPC or EAN. Each barcode symbol are categories as either one-dimensional or two dimensional [2]. One dimensional barcode is data matrix code consisting of black and white cell. EAN barcode is arrangement of bar that pixel arranges in code of L, G and R. In general, barcode is just a different way of encoding numbers and letters by using a combination of bars and spaces of varying widths [3]. It is representation of data in the width and the spacing of parallel lines with a series number below the parallel lines. Laser bar code readers are most commonly used in applications, because of their excellent performances over the light pen bar code readers and the CCD bar code readers. However, they are still not free from disadvantages. Their mobile parts are prone to get biased or damaged. This reduces the service lifetime and raises the service price [8]. Barcode recognition system plays roles in Muslim life in order to reconfirm of HALAL product.

This project implement barcode recognition system which capable to recognize EAN-13. The project is proposed using Simulink MATLAB 7.13 software as its Video and Image Processing Blockset is easy to implement in order to be more users friendly. This paper studies barcode recognition based on the image processing method. Firstly image captured by using digital camera before improved the image quality by image processing technique. Barcode image that captured using digital camera devices at initially is RGB or 3D arrays true color. It is necessary to convert RGB image to intensity. Intensity or binary image is 2D arrays that assign one numerical value to each pixel which is representing intensity each point at the image which is used to extract the image features [11]. Feature extraction then will followed by process of barcode recognition until the output display at multimedia file.

If the noise and blurring level is too high, the parallel lines of barcode will touch each other as if there is no spacing in between them [10]. Thus, the barcode parallel lines fail to represent the data that it represented, which will cause the process of recognition becomes inaccurate. Gaussian filter is used to smooth the gradient which identifies the barcode region. It is require applying multiple scan lines in order to apply efficiency of sense to barcode. Furthermore, locate the scan lines on correct position of bar code area in order to detect the actual width of each white and black bar. Then decode part of the processed bar code to retrieve the information of the bar code [8].

II. BARCODE RECOGNITION

Nowadays, barcodes are used in many different applications and environments, for most such as access control, prices calculation, and etc. Linear barcodes are one of the oldest technologies related to Automatic Identification and Data Captured (AIDC) [12]. Barcodes were originally scanned by special optical scanners called barcode readers, once scanned then software interpreted the data to make it understandable humans. These days the ability to read Barcodes is available on a number of software and devices including desktop printers, JAVA and Smart phone [5]. Besides, there is Simulink software integrated in MATLAB also available in order to implement barcode recognition system.

Simulink is an environment for multi domain simulation and Model-Based Design for dynamic and embedded systems. It provides an interactive graphical environment and a customizable set of block libraries for design, simulate, implement, and test a variety of time-varying systems, including communications, controls, signal processing, video processing, and image processing. Simulink is integrated with MATLAB, providing immediate access to an extensive range of tools. So, it make easy to develop algorithms, analyze and visualize simulations, create batch processing scripts, customize the modeling environment, and define signal, parameter, and test data [4].

Barcode readers consist of laser scanner, light pen and CCD reader. Laser bar code readers are most commonly used in applications, because of their excellent performances over the light pen bar code readers and the CCD bar code readers. However, the mobile parts of laser are prone to get biased or damaged. This reduces the service lifetime and raises the service price. In this project, camera is used as input devices because it is low cost and easy to implement.

III. METHODOLOGY

Methodology employed and considerations taken into account for these studies. In this methodology chapter, process flow is developed in order to carry out this project in a manageable way. The algorithm is particularly designed to recognize barcode, where image may be of low quality, blurring, non-uniform illumination, and noise or color saturation. Barcode decoding is primarily based on edge detection. It is proposed to use multiple scan lines and the lines on the correct position of barcode area to prevent barcode parallel lines fail to represent the data that it represented.



Fig. 1 Flow chart of conventional barcode recognition system

A. From Multimedia File

Barcode from video image taken by general purpose hand held devices particularly challenging due to limitation of integrated imaging system and processing capability of the devices. The barcode images are taken using the digital single lens reflex camera which approach hand held method. The images of barcode convert to video in order to be easy to read by the multimedia file. In this section the block read video frames and audio samples from compressed multimedia file.



Fig. 2 Image of RGB in (a) convert to Intensity image in (b) using color space conversion

B. RGB to Intensity

This method particularly used color space conversion block for the conversion from the R'B'G' color space to intensity as in figure 2. The Color Space Conversion block converts color information between color spaces [4]. It used convert from an RGB color space to a grey-scale image using a simple transform [6]. Barcode image that RGB is 3D arrays true color. Intensity or binary image is 2D arrays that assign one numerical value to each pixel. When convert to intensity image, it simplifies the amount of information in the image. Although the information reduced, the image still maintains the majority of important feature such as edge, region and junction.

C. Gaussian Filter

The Gaussian filter is a very important one both for theoretical and practical reasons [7]. Gaussian filter is use to smooth the image gradient. Gaussian smoothing or filtering commonly forms the first stage of an edge-detection algorithm where it is used as a means of noise. The Gaussian function express as follow:

$$F(x, y) = \frac{1}{2\pi\sigma^2} exp\left(-\frac{x^2 + y^2}{2\sigma^2}\right)$$
(1)

Degree of smoothing is control by the choice of the standard deviation filter parameter. Gradient of scan lines is parameter of mask which consists of pixels in barcode region. The mean or average filter sums the pixels over the specified region of barcode which guided by rows of scan lines. This method guided by function of derivative filter is which is responding to return values at certain points of discontinuity in the image to detect edges of barcode. In order word, it's reducing noise and blurs edge.

D. Feature calculation

Feature calculation processing algorithms typically operate on the converted grayscale version of the image. The system is scan lines based, in the sense that applies edge detection along horizontal scan lines. In this part, morphological segmentation which texture segmentation is used to determine spatial arrangement of intensity. The determination of texture features of image which corresponds to lines and spaces labeled as black and white pixel region. At this level, barcode density is unknown. Assume the smallest possible density code is one pixel.



Fig.3 shows parts of barcode

E. Recognition

Recognizing the information carried by a barcode is done by reversely applying the coding theory. In this side of block, the images were going through to the process of bar detection. Proposed scan lines detected width that value in pixel. The process will go through with try to find width, sequences and its length, and total black and white bar. There are three types of code which are L, G and R [11]. Based on the similar-edge theory, algorithm reads the first six numbers after identifying the first bar. First bar detected will determine the next sequences of barcodes. From digit 0 until 9 of first bar had it own arrangement of codes of bar and each of it are totally differences. Bar is either white or black pixel value. Then, system will go through the process of threshold for bar width variance which the value proposed in 5 pixels. However, if there is no bar width detected, so the bar assume zero width. After that, process continue with detected the next bar width. In the process of the bar code recognition, the algorithm reads the first six numbers, and then the subsequent six numbers. After that, it identifies the precedence code based on the left or right six numbers of different parities. The parity of the first six numbers is used to determine whether this recognizing process is of a forward scanning or of a backward scanning The first bar detect from image recognize and compare with number of first bar that detected from calculation of check sum at barcode validation step process.

F. Barcode Validation

One part of barcode validation is checksum digit calculated by *Equation* (3) from the data digits. The checksum digits calculated taking a varying weight value times the value of each number in the barcode. The weight for a position in EAN-13 code is either 3 or 1, which alternate so that the final data digit has a weight of 3. For example as barcode below, digits 1,3,5,7,9,11 multiplied by weight 3 where digits 0,2,4,6,8 and 10 multiplied by weighted 1 [9].

$$d_{13} = 10 - \sum (3d_{2i-1} + d_{2i}) \mod 10$$
(3)



Fig.4 Image of EAN-13

Results of 76 modulo 10 will produce residue of 6. Then, 10 minus 6 equal to 4 makes 4 as check sum. The check sum, from calculation will compare with first digit detected from barcode from features calculation. If the system read the valid barcode, the switch will enable and display number of barcode reader. If only one digit is incorrect, there will be a checksum mismatch. If several digits are incorrect, it is possible that the checksum will report a false match because the separate errors may cancel each other out.

IV. PROPOSED METHOD BARCODE RECOGNITION SYSTEM

In this paper, some proposed method was attempted to the previous method which multiple scan lines and gamma correction.

A. Multiple Scan Lines

In order to improve robustness, multiple of scan lines which in five lines are approach to use in difference position in the image. Scan line in conventional method get worse to detect barcode. Multiple scan lines cross the barcode can improve robustness by combining the results of multiple scan lines in a majority voting pattern. An inaccuracy due to noise, dirt or reflected on one line can be compensated by two or more correct identifications on other lines.

B. Gamma Correction

This section provides gamma correction process before feature extraction.



Fig. 5 Flow chart of barcode recognition with proposed Gamma correction

Gamma correction is the term used to describe the correction required for the nonlinear output curve of computer displays [7]. When display a given intensity on a monitor we vary the analogue voltage in proportion to the intensity required. Input signal normalized between 0 and 1. Image with intensities can be process using an inverse power-law transform prior to output to ensure they are displayed correctly. In this process, gamma set to 2.2 and break point is set to 0.018. Some of parameters are illustrated by the following diagram. Furthermore, actual parameters of Gamma correction also determine the intensity image of intensity, I by equation (1) below:

$$I = f(x) = \begin{cases} \frac{I'}{S_{LS}'}, \ I' \le B_P \\ \left(\frac{I' + C_0}{F_S}\right), \ I' > B_P \end{cases}$$
(1)

 $S_{\rm LS}$ is the slope of the straight line segment. $B_{\rm P}$ is the break point of the straight line segment, which corresponds to the Break point parameter. $F_{\rm S}$ is the slope matching factor, which matches the slope of the linear segment to the slope of the power function segment. $C_{\rm O}$ is the segment offset, which ensures that the linear segment and the power function segments connect [10].

V. RESULTS AND DISCUSSION

The algorithm test again database of EAN 13 barcode image taken by digital camera. The images were taken in various lighting, orientation, distance and prospective condition. From figure below, there are some examples of images of barcode read on crumples plastic surface, on distortion shampoo paper, on horizontal curve surface and EAN13 on backward condition. The following figure shows some of the barcode that are decode successfully. Figure 11 show incorrect number of barcode before proposed gamma correction applied. This was effect of nonlinear relationship between input voltage and output intensity. Scan lines can't detect the actual bar width to encode it into sequence of correct barcode. Basically, number of barcode will display after the valid check sum enable the display text box of barcode. System enable when checksum value is less or equal to 0.7. Number of check sum below than threshold value will be ignoring by enable pin. After gamma correction applied with parameter of gamma set to 2.2 and break point is set to 0.018, scan lines detected the actual bar width with the valid check sum and give the right numbers of barcode. The percentage of success is 94.44% and failure of the system is 5.56% base on 57 samples. Table 2 show barcode results example in database. Accuracy is used to measure the percentage of successful:

 $Accuracy = \frac{No \ of \ Sample - No \ of \ Failure}{No \ of \ Sample} \times 100\%$

TABLE 1:
DATABASE BARCODE RESULT

No	Sample Of Barcode	Output	Valid
1	6926032317531	6926032317531	valid
2	4806508748057	4806508748057	valid
3	8998866998866	8998866998866	valid
4	9556001567307	9556001567307	valid
5	9771675050034	9771675050034	valid
6	9771675050041	9771675050041	valid
7	9555161009467	9555161009467	valid
8	9556113000013	9556113000013	valid
9	9557534654618	9557534654618	valid
10	8851932265188	8851932265188	valid
11	9556155410054	9556155410054	valid
12	9555216503063	9555216503063	valid
13	9555170407285	9555170407285	valid
14	6946537007973	6946537007973	valid
15	4936968185663	4936968185663	valid
16	0077043103753	0077043103753	valid
17	9300663458998	9300663458998	valid
18	4902430168915	4902430168915	valid
19	8901138504151	8901138504151	valid
20	8991380700043	8991380700043	valid
21	9555216529605	9555216529605	valid
22	4902806326055	4902806326055	valid
23	4902430401418	4902430401418	valid
24	9556024708589	3576424708589	invalid
25	8851932265118	8851932265118	valid
26	9556155410054	9556155410054	valid
27	8888240051165	8888240051165	valid
28	9557727212403	9557727212403	valid
29	9789675217609	9789675217609	valid
30	9789675217357	9789675217357	valid
31	9789675217357	9789675217357	valid
32	9789675217104	9789675217104	valid
33	9789833421411	9789833421411	valid
34	9789833421428	9789833421428	valid
35	4974052800986	4974052800986	valid
36	9556076202073	9556076202073	valid
37	8888008025759	8888008025759	valid
38	9557546903445	9557546903445	valid
39	9557007712098	9557007712098	valid
40	8888383813903	8167303357903	invalid
41	5051898801502	5050898800102	invalid



Fig. 6 EAN13 on backward condition



Fig. 7 EAN13 on crumpled plastic



Fig. 8 EAN13 on distortion shampoo bottle paper



Fig. 9 EAN13 on horizontal curve surface



Fig. 10 Failure

d Caracteria La Lawar Paragram, pp. 131 (1988) harry A 2017年7月17日 2018年4月19日1日の14日 (中(中国)有限公司 肥於許技术开发区優勝大道88号 (熱哉: 800-820-3158	สมส. โมษณะ เม็อสมหรือ สมสมุณและ อย่างสมหรือสมหรือสมหรือ 1011 (N. Accus, Bandar Ser Bagnan, Bran Bounsam, 108) - 14 โดยเหน, Bandar Ser Bagnan, Bran Bounsam, 108) - 149/104 การเมือง กลังการเมือง 108 การเป็นกร้างสมหรือ จำกัด 18 โดยการสินธ์ ปีกรุ หมะกร้อง จำกัด 18 โดยการสินธ์ ปีกรุ หมะกร้อง จำกัด กรุงสหหร จะไขเกิด 18 เมษณะปีสนัด เป็นของก็ปกรุงสหร
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Fig.11 Barcode of correct number output

VI. CONCLUSION

This has showed the alternative method for recognizing a one-dimensional barcode based on the image processing technique. It is easy to develop algorithms, analyze and visualize simulations in Simulink of MATLAB 7.13. Data retrieve from EAN-13 barcode because products in Malaysia mostly used this type of barcode. The image was taken in various lighting, orientation, distance and prospective condition result almost successful. The image of EAN-13 barcode that capture by digital image will go through the image processing technique. Data taken saved in file.mat for match with Jakim's database. The proposed methods had improved the conventional method. Thus, they are user friendly system interface, easy and no so expensive to implement. The important of reduces noise had been proved in order to come out with better result.

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