An Efficient Braille Cells Recognition

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***Abstract*—This paper presents a new algorithm for Braille cells recognition using image processing technique. Scanned Braille document is composed from three classes of gray-level: (i) background, (ii) recto dots, and (iii) verso dots. We segment the Braille image using a stability thresholding method with a mixture of Beta distributions. To ensure correct detection and extraction of dots composing Braille cells, a grid is formed to contain the Braille dots. We identified a recto dot by a light region that exists above a dark region using the segmented image. In the same way, we identify a verso dot in double sided document by a light region that exists below a dark region. After having recto and verso dots, Braille cells are then recognized based on the standard regrouping of dots. Experimentation showed that Braille cells composing are automatically identified from those grids with excellent accuracy.**

Keywords-recto dots; verso dots; Braille cells; segmentation; grid formation.

I. INTRODUCTION

Visually impaired people are part of the society and it has been a must to provide them with means and systems through which they may communicate with the world. Many systems have been developed to achieve this purpose; the most famous system that is based on touching is Braille system [1, 4, 5]. Braille is a writing system that enables blind and partially sighted people to read and write through touch. It was invented by Louis Braille, a French teacher of the blind [1, 5]. For some years, there has been an increasing trend to use computers for entering, editing and printing Braille documents using special purpose software and printers. An Optical Braille Recognition (OBR) allows reading volumes of typewritten documents with the help of flatbed scanners and OBR software [1, 2, 3, 4, 7]. Braille document is composed from cells; each cell is formed by at most of 6 dots (see Figure 1a and 1b). The Braille dots detection is the main step in OBR, Braille copy Machine, and other application [1, 2, 8, 9, 10, 11]. Image acquisition is the first and most important step in any pattern recognition system. In OBR systems, data is provided to the system in the form of images of Braille embossed pages. The process of acquiring these images digitally can be achieved by using a number of different equipments such as scanners or digital cameras, both of which have been used by developers and researchers [1, 2, 3, 5].

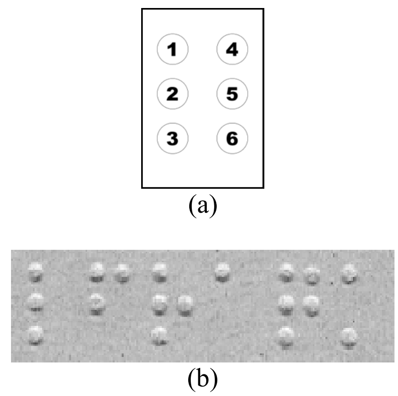

Figure1: (a) One Braille cell and (b) Real Braille cells.

The core of the proposed method is the use of stability thresholding for a mixture of Beta distributions to estimate threshold values. Segmented Braille image is then used to form a grid that contains recto dots and another one that contains verso dots. The main steps involved in the development process are described as follows: (i) Image acquisition and Understanding the Braille image: an image of a single/double sided Braille page is obtained using a flatbed scanner. The Braille page is converted into a digitized image array. Each dot in a scanned Braille image is composed of light and dark areas separated by background. (ii) The scanned image is segmented so that only three classes of regions exist: dark, light and background. (iii) Recto and Verso Dots Detection: Extracts recto dots from single-sided Braille documents and recto/verso dots from double-sided Braille documents and places them in images. The detected recto/verso dots are thus used to define Braille cells. The paper is organized as follows; in Section 2, we explain the stability thresholding method for Braille image segmentation. The original Braille image has small rotation that will make the processing of dots and cells detection more difficult. In section 3, we apply a method to correct the rotation. Section 4 presents the grid formation based on recto and verso dots detection. This grid will be used for cell Braille recognition. Section 5 shows experimental results. Section 6 concludes this work.

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II. BRAILLE IMAGE SEGMENTATION

The three modes of a histogram of a Braille image represent the following three classes of pixels: (i) Mode 1: represents the dark region of a recto and verso dot. (ii) Mode 2: represents the background. (iii) Mode 3: represents the light region of a recto and verso dot (See figure 1b). The problem of segmentation is the estimation of thresholds T1 and T2 for separating the three classes. We assume that a histogram of a Braille image is a combination of three Beta distributions. The Beta distribution is a continuous probability distribution with the probability density function (pdf) defined on the interval [0, 1] [5]:

$$\mathrm{f}(x,\alpha,\beta) = \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\,\Gamma(\beta)}\, x^{\alpha-1}\,(1-x)^{\beta-1} \tag{1}$$

Where α and β are the shape parameters of the distribution and must be greater than zero, x is a random variable, and it must be between 0 and 1. The Beta distribution can take different shapes depending on the values of its two parameters α and β. The histogram *h(x)* of a Braille image can be written as follows:

$$h(x) = p_1 f(x,\alpha_1,\beta_1) + p_2 f(x,\alpha_2,\beta_2) + p_3 f(x,\alpha_3,\beta_3) \tag{2}$$

Thresholds T_i^{new}, i=1, 2 are estimated using the following formula [3]:

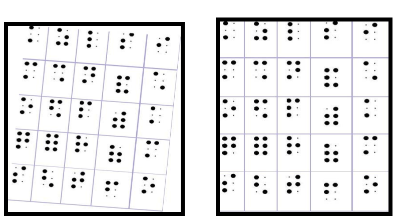
$$T_i^{new} = 1 - e^{\frac{-A - B\log(T_i^0)}{C}} \tag{3}$$

Where: $A = \log((p_i K_i)/(p_{i+1}K_{i+1}))$, $B = \alpha_i - \alpha_{i+1}$ and $C = \beta_i - \beta_{i+1}$ $K_r = \Gamma(\alpha_r - \beta_r)/\Gamma(\alpha_{r+1} - \beta_{r+1}), r = i, i+1$

The statistical parameters of the histogram (p_i, α_i, β_i), i=1, 2, 3 are estimated using the stability of thresholding algorithm [5].

III. BRAILLE IMAGE ROTATION

The cells in Braille document are arranged in horizontal and vertical directions. So, the dots in Braille document are also arranged in horizontal and vertical directions. Due to some reasons of copying Braille document, there are many Braille documents where cells (dots) are not arranged in horizontal and vertical directions (See Figure 2a). That will make the processing of dots and cells detection more difficult. To solve this problem, we rotated the Braille image for arranging the cells (dots) in right directions using the information in segmented image [1]. In Figure 2b, the original Braille Image is rotated where all dots are arranged in horizontal and vertical redirections.



(a) (b)

Figure 2: (a) Original Braille image where cells are rotated. (b) Original Braille Image where all dots are arranged in horizontal and vertical redirections.

IV. GRID FORMATION FOR CELLS RECOGNITION

The procedure presented in this section is used for detecting recto dots from double-sided Braille documents. In order to accomplish this task, a grid is first formed using the segmented image and then detection of dots takes place. The grid is formed by, first selecting a starting dot and then generating horizontal lines with regular intervals and vertical lines. Horizontal lines generation is straightforward being compared with vertical lines generation. This is due to the regular horizontal arrangement of Braille cells opposed to the irregular vertical arrangements of cells. Therefore, we cannot predict the spaces between cells in the same line and draw vertical lines accordingly. After a gird with each of the recto dots contained within a box has been formed, recto dots detection should then take place. Starting from the first horizontal block in the resulting grid; only boxes are checked with certain size range. For each box in the grid, a test is carried out to decide whether it holds a recto dot or not. If a recto dot is found then it will be drawn on the output image in the same location. The output of this step is a text file that contains the coordinates of the center of each found recto dot. Verso dots are detected in a similar way. Having identified all possible valid dots, the system defines the region containing all the dots such that no dots exist outside this region. We know that there are standard distances between dots inside a cell (See Figure 1). Also there are standard distances between cells in Braille image. Based on these distances, the Braille cells can be easily recognized.

V. EXPERIMENTAL RESULTS

We applied the proposed algorithm on several Braille images, the results were excellent. In the following, we will show the result of applying our algorithm on a Braille image. Figure 3 shows an image of double-sided Braille document before rotation.

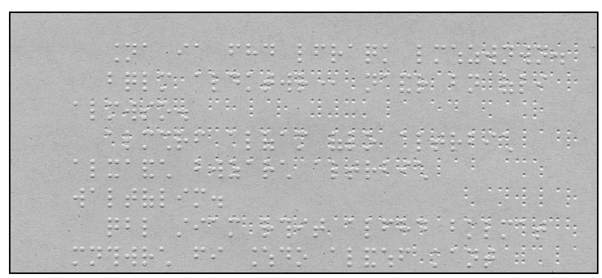


Figure3: A part of original double-sided Braille image.

Figure 4 shows the rotated image. Figure 5 shows segmented image where there are three classes of pixels. Figure 6 shows the same image after drawing the grid for recto dots. Figure 7 shows the detected recto dots from the image. Figure 8 shows recognized cells for recto dots. We remark that the percentage of recognized cells is 100%. The same results for verso cells recognition.

Figure 9 shows the rotated single-sided image. Figure 10 shows the detected recto dots from the single-sided image. Figure 11 shows recognized cells for recto dots. We remark that the percentage recognized cells in single-sided Braille image is 100%.

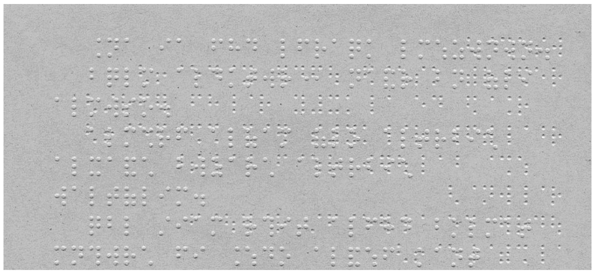


Figure 4: Double-sided Braille image after rotation.

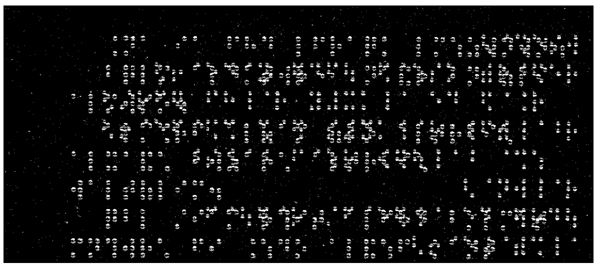


Figure 5: Double-sided segmented image.

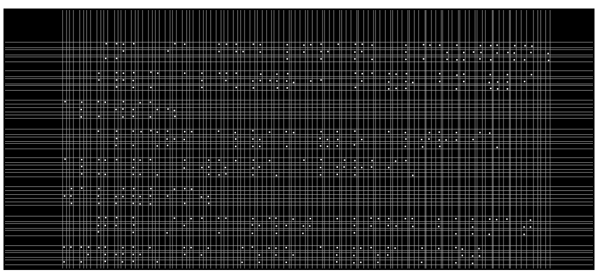


Figure 6: Double-sided grid of recto dots.

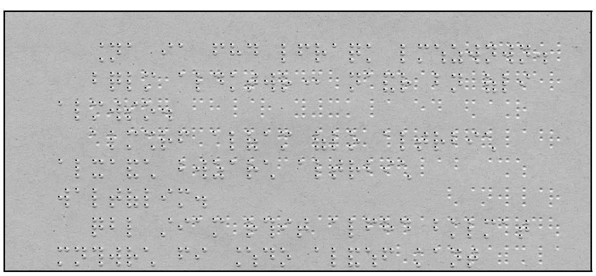


Figure 7: Double–sided recto dots detection.

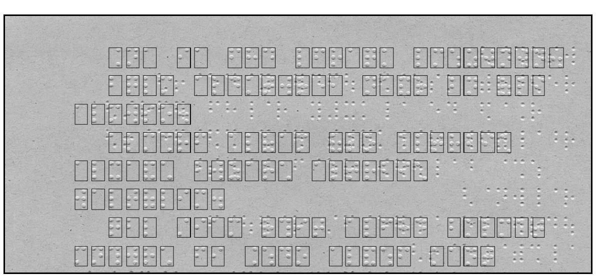


Figure 8: Double-sided cells Braille recognized.

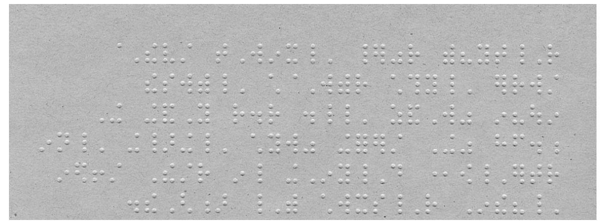


Figure 9: Single-sided Braille image after rotation.

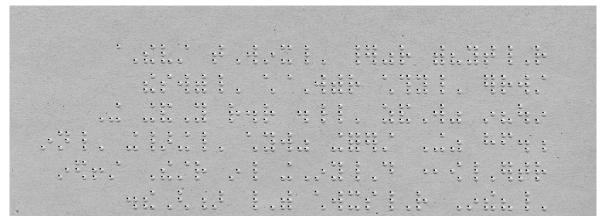


Figure 10: Single–sided recto dots detection.

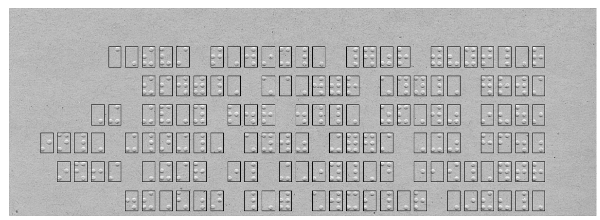


Figure 11: Single-sided cells Braille recognized.

VI. CONCLUSION

This paper described an algorithm to recognize the Braille cells. We applied a segmentation method based on the Beta distribution to estimate thresholds. To ensure correct detection of dots composing Braille characters, a grid is formed. By using a grid, many detection problems were eliminated; most importantly is the problem caused by the merging of light or dark regions between dots. After identifying all possible valid dots, Braille cells are then recognized based on standard distances between dots and cells. The proposed method showed excellent identification of Braille cells.

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