Arabic Braille scripts recognition and translation using image processing techniques

. Zainab I. Authman

Collage of science-university of basrah

Zamen F. Jebr

searcher

Abstract:

Braille is one of the important means of written informational communication between visually-impaired and sight people, so it gains the research interest. This paper describes a new technique for recognizing Braille cells in Arabic single side Braille document. The mean challenge in (OBR) system -which is resolved here- is how to binaries Braille image So we suggested two algorithms two binaries Braille sheets based on morphological operations. We apply morphological tophat filter on green Braille documents and morphological bothat filter in yellow Braille documents.

Optical Arabic Braille Recognition system has two main tasks, first is to recognize printed Braille cells, and second is to convert them to regular text. We introduce in this search, automatic system which converts printed Braille Arabic to binary digital format to perform the first task from recognition system then we convert character result into binary string and used template matching to recognize this character after that the character translate into text based on ASCII code which map for each Arabic letter. The recognition rates for green Braille documents were between (98.04% - 100%) and (97.08% - 99.65%) for yellow Braille documents while execution time was between (8-38 s.) .

Keywords: image processing, morphological operation, Braille, optical recognition.

1.Introduction:

Visually impaired people are part of the society, and can play an integral role in its prosperity. Therefore, it has been a must to provide those people with means and systems through which they may communicate with the world. These systems should depend on the sense of hearing or touching. Many systems have been developed to achieve this purpose; the most famous system that is based on touching is Braille system. Braille is a writing system that enables visually people to read and write through touch using a series of raised dots to be read with their fingers.

The Braille is a system of touch reading and writing in which raised dots represent the letters of alphabet. Braille also contain equivalents for punctuation marks and provides symbols to show letter groupings. Braille is read by moving the hand or hands from left to right along each line. Both hands are usually involved in the reading process, and reading is generally done with the index fingers [1].

Braille was first introduced in 1825 by French scientist Louis Braille. He took a secret code devised for the military and saw in the basis for written communication for blind individuals. The original military code was called night writing and was used by soldiers to communicate after dark. It was based on a twelve-dot cell, two dots wide by six dots high. Each dot or combination of dots within the cell stood for a letter or a phonetic sound. The problem with the military code was that the human fingertip could not feel all the dots with one touch [2].

Louis Braille created a reading method based on a cell of six dots. This crucial improvement meant that a fingertip could encompass the entire cell unit with one impression and move rapidly from one cell to the next. The system of embossed writing invented by Louis Braille gradually came to be accepted throughout the world as fundamental form of written communication for blind individuals, and it remains basically invented it [1].

A Braille character (or Braille cell), is a rectangular array of six points arranged in two columns of three row as can be seen in Figure 1. Each of the points in a cell can be either raised (a bump) or flat. A raised point will be referred to here as a dot. On the document, the Braille characters are embossed from left to right and from top to bottom, much like characters in ordinary documents[3].

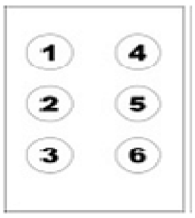


Figure 1, Braille cell

An obvious, perhaps, but significant characteristic of Braille documents is the absence of any information visible in a color contrasting the background. The only information recorded on a Braille page is in terms of the protrusions created by embossing the card. The fact that Braille documents are not intended to convey any visual information also has repercussions on the quality of card used to produce them. It is not uncommon for the card to be of low (visual) quality, with visible grain and imperfections (dark and light regions). This fact can affect the recognition of Braille documents by visual means [4].

Every Braille cell dot's can be set or cleared, giving 64 possible combination in six-dot and 256 combinations in eight-dot Braille. Each of the 64 different Braille characters can correspond to an ordinary character (grade1 Braille) or to a group of characters (grade2 Braille)[3,5].

The Braille code system has become widely used by several communities because of its simplicity, comfortable for blinds to use it when read and write. Braille was applied or translated into several languages including Arabic language[6] .

2.Interest of optical Braille recognition

Nowadays, lack or problem of vision has been an important obstacle to access to printed contents and to the information society. For this reason, some people have tried to achieve that blind people are able to access to the printed culture for example Louis Braille understood importance of a communication code. Globally, an estimated 40 to 45 million people are blind and 135 million have low vision according to the World Health Organization (WHO) [7] and this number grows every year.

A Braille Optical Character Recognizer is interesting due to the following reasons [8]:

- It is an excellent communication tool for sight people (who do not know Braille) with the blind writing.
- It is a cheap alternative Braille to Braille copy machine instead of the current complex devices which use a combination of heat and vacuum to form Braille impressions.
- Braille writing is read using finger so is necessary touch the document, for this reason the book after many readings is possible has been deteriorated.
- It is interesting to store a lot of document of blind authors which were written in Braille and were never converted to digital information.
- Braille recognition system offers a better integration of blind people to the "information society".

The structure of this paper is the next In section 3 we describe the characteristic of data base created. After that section 4 is a chart explain system overview in section 5 we explain methodology and techniques that we are used it in recognition system. The last section 6 include results and conclusion.

3-Database

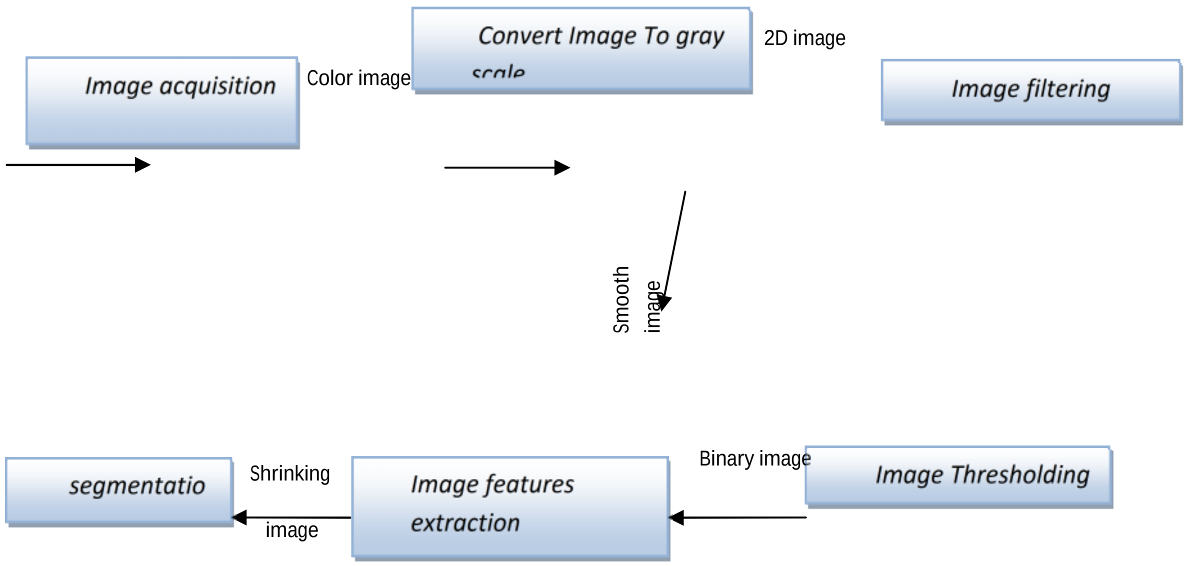
A big database has been created in order to check the global system with as many characters as we could. This database provides single side Braille documents with color green and yellow which have dots in one side of sheet. The next table (see Table 1) give a full explanation of this database.

Braille sheets	25 green sheets, 25 yellow sheets
Digital format	Color
Resolution	100 dpi(horizontal and vertical)
Image size	(274 kb)in yellow sheets & (336) in green sheets
Image format	Jpg
Braille type	Single side –grade 1

Document size	29.5 cm. (horizon tal)×30.5cm(vertical)

4-System Overview

The Braille recognition system consist of seven operations as illustrate in figure 2:



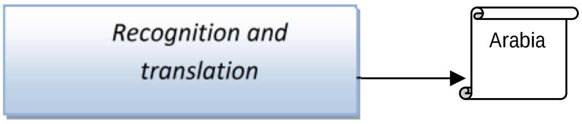
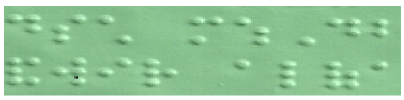


Figure 2 system
overview

5.1 Image Acquisition

The test image has scanned by using HP Scan Deskjet F2400 scanner with horizontal and vertical resolution 100 dpi, bit depth 24, and the image store in JPEG format. Figure 3 illustrate sub-image of Braille sheets with colors green and yellow.



a

b

Figure3 a) yellow Braille sheet b) green Braille sheet

5.2 Convert image to grayscale

Inside a computer system, colored images are stored in 3-D arrays while gray level images are stored in 2-D.arrays. Dealing with 2-D arrays is much easier and faster. Therefore, the second step in the proposed system converts colored scanned images to gray level so that any pixel value in the image falls within the range 0- 255 as could be seen in Figure4.

a

T

Figure4 a) yellow Braille sheet after
b) green Braille sheet after

convert to gray scale
convert to gray scale

h
ere is
difference

in gray levels of two Braille sheets images is clearly (green and yellow) because difference in distribution of lighting level in two image where yellow sheet appear more light from green sheet so this will effect on threshold for this image so we use two threshold algorithms for binaries it.

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5.3 Noise filtering

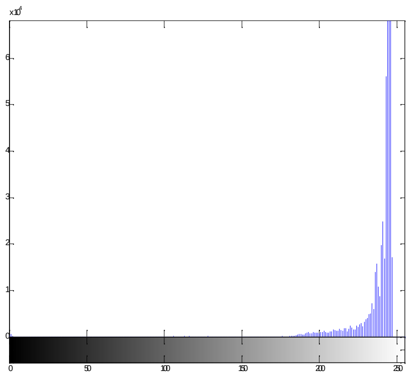
During image acquisition, impulse noise was introduced in the image. These noises generally manifest themselves as random fluctuation in gray-level values superimposed upon the "ideal" gray-level value, and it usually has a high spatial frequency. Therefore, a low-pass spatial Gaussian filter is applied to the image to attenuate the high spatial frequency noise from the image while at the same time preserving the detailed edge information of the Braille dots [9].

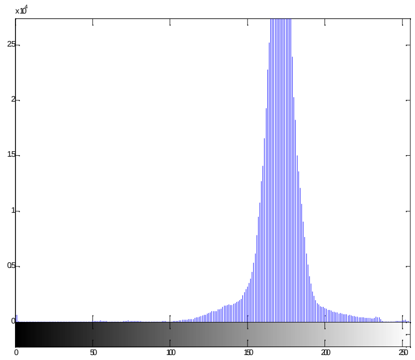
5.4 Image Thresholding

Since Braille pages contains dots (foreground) and page (background) only, analysis a binaries image is much simpler than that of gray-scale images. For a simple global threshold where the image histogram is bimodal or has easily identifiable peaks and valleys, the selection of the threshold value is straightforward. However, the digitized Braille page images are noisy, and there are considerable spread in gray level values, the selection of threshold value problematic as it illustrate in the histogram of Braille images in figure5 [10].

To cope with significant variation in lightness across the whole image, we proposed to use

the following two algorithm (algorithm1 and algorithm2) to threshold green and yellow Braille pages images.





b

b

llow Braille image b) histogram green Braille image

Algorthim1

We suggest to use local thresholding method on green Braille page because global thresholding methods fail when the background illumination is uneven, as was noticed in figure4 (b). A common practice in such situations is to preprocess the image to compensate for the illumination problems and then apply a global threshold to the preprocessed image. Apply tophat filter (opening , images subtraction) operation on image help us to compensate for non uniform illumination. Opening operation are use to remove small bright details while leaving the overall gray levels and larger bright features relatively undisturbed. Because opening suppresses bright details smaller than the structural element it is used for image smoothing and noise removal [11].

Algorithm 1 threshold green Braille images pages

Input: gray image of green Braille document(f);

Output: binary image of Braille document;

Method:

Step1: smooth image using tophat filter (opening, subtract images)

- Apply opening

1. create flat structural element (z) and must be disk shape and size=4 ;
2. Translate the structural element to all location in the image(f), starting from the pixel in the top left corner of image(f) where the origin point of structural element place on this pixel.
3. At each translated location the structural element values are subtracted from the image(f) pixel value and the minimum is computed result in R1 image.

   $R1(x,y)=\min\{f(x+x',y+y') \mid (x',y') \square D_z\}$
4. Translate the structural element to all location in the image R1, starting from the pixel in the top left corner of image (R1) where the origin point of structural element place on this pixel.
5. At each translated location, the structural element values are added to the image(R1) pixel value and the maximum is computed result in R2 image:

   $R2(x,y)=\max\{R1(x-x',y-y') \mid (x',y') \square D_z\}$

- Subtract the last result image from the original

  $R=(f-R2)$

Step2: using iterative procedure to threshold result image from step 1

1. Select T as it midpoint between minimum and maximum intensity values in the R image.
2. Segment the image using T to produce two group of pixels G1>T and G2<=T.
3. Compute the average intensity values μ_1 and μ_2 for pixels in regions G1 and G2 respectively.
4. Compute new threshold value :

   $T=1/2(\mu_{1+}\ \mu_2)$
5. Repeat step2 through 4 until the difference in T in successive iterations is smaller than predefined parameter T_o.

Method end.

<u>Algorthim2</u>

We suggest to use local adaptive thresholding method on yellow Braille pag.. Apply morphological bothat filter (closing, images subtraction) operation on image help us to compensate for non uniform illumination, closing operation are use to suppresses dark details small than the structuring element. Because closing suppresses bright details smaller than the structural element it is used for image smoothing and noise removal [11]. local adaptive method works by dividing the image into 32×32 pixel region (the size of window is experimentally derived) and assesses whether region contains whole dots or just background. This assessment equivalent comparison of sets of ranges of gray levels observed in that region [12].

Algorithm 2 threshold yellow Braille images pages

Input: gray image of yellow Braille document(f);

Output: Binary image of Braille document;

Method:

Step1: smooth image using bothat filter (closing, subtract image)

- Apply closing

1. create flat structural element (z)and must be disk shape and size=4;
2. Translate the structural element to all location in the image (f), starting from the pixel in the top left corner of image (f) where the origin point of structural element place on this pixel.
3. At each translated location, the structural element values are added to the image(f) pixel value and the

maximum is computed result in R1 image:

$$R1(x,y)=\max\{f(x-x',y-y') \mid (x',y') \in D_z\}$$

4. Translate the structural element to all location in the image R1, starting from the pixel in the top left corner of image (R1) where the origin point of structural element place on this pixel.
5. At each translated location, the structural element values are subtracted from the image(R1) pixel value and the minimum is computed result in R2 image:

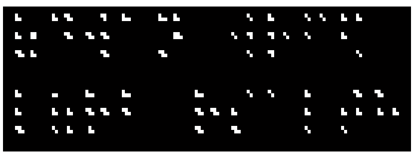
$$R2(x,y)=\min\{R1(x+x',y+y') \mid (x',y') \in D_z\}$$

- Subtract the last result image from the original

$$R=(f-R2)$$

Step2:threshold resulted image using local adaptive method

```
%%segment the image R into(32*32 pixel regions);

[NumRow , NumCol ]=size (R) ;

p=1; m =32; A=false;

While  A

    n=32; q=1;T=false;

  while  T

    Threshold=0.5*(max (R(p to m , q to n))+min(R(p to m , q to n)));

      if  n> NumCol

        T=true;

          break;

      end

        For   i = p to m

          For  j = q to n

      if   R(i,j)>= T

      hreshold

            R_bin(i,j)=1;

            Else

              R_bin(i,j)=0;

            End {if};

      End {for}

   End {for}

 update q with value (n+1);

 update n with value (n+32);

End{while}

    update P with value (m+1);

 update m with value (m+32);

     iF  m> NumRow

       A=True;

       Break;

     End {if}

End{while}

              Method end.
```



a

b

Figure 6 a) yellow Braille image after apply algorithm 2 b) green Braille image after apply algorthim1

Now, we ended the first task of (OBR) system and Braille sheet image became officinal to the second task of Braille Recognition system (translate Braille cells in to equivalent text).

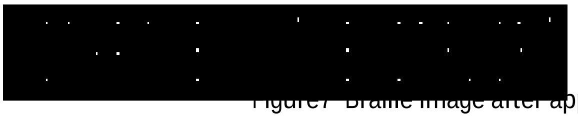


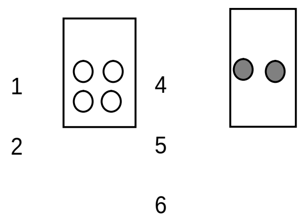
Figure7 Braille image after apply shrinking mechanism

5-5 Segmentation

In this stage the shrinking binary Braille document will segment into lines using horizontal projection (HP) by search about lines which Hp=0 if this lines increase from the value of empty space which separate two lines in Braille page this represent the beginning of new lines and determine this region of document image as line and so on of remaining image. After that the lines segment into word firstly then into character using vertical projection (VP) and in same manner in line segmentation but search from empty column which VP=0 rather than empty row.

5-6 translation

When character recognized this character convert into binary string consist of six bit the value of this bit depend on presence or absence of dots in this character when dot found the value of this bit which map this dot assign 1 else assign to 0. For example :



5.4 Feature extraction and dots centres's detection

The main function of this phase is to extract the Braille dots from the binarised image. This includes following steps:

1- we search from coordinates that busy by Braille dots using 8-connected search then we assign label for every object in this image using recurrent connected component labeling algorithm.
2- Find maximum row, minimum row and maximum column ,minimum column for this dot and determine the center of it according to following equations.

cenX=(maxX-minX)/2+minx

cenY=(maxY-minY)/2+minY

3- After that we apply shrinking mechanism, where each object in Braille cell will be represent in one pixel and it is placed in center location of dot in last cell in Braille image and so on for each cell dot's in binary image as in figure7. This procedure gave us two benefits:
   - Make dots of Braille cell in more regular shapes.
   - Reduce search time of dot in second task from (OBR) system.

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In this example the character on the figure in right side represent character "م" in Arabic alphabetic which its binary string is [1 1 1 1 0 0] based on presence or absence of dots in this character. When translate this character we must convert this string into ASCII code which map the character "م" then print this character in text file.

6. Results and Conclusion

In this paper we have explained the development of an automatic system for recognizing and translation printed Braille cells. It has been divided in different modules for each part of the image processing. For achieving this system, local and adaptive thresholding has been used ,and shrinking mechanism is added to the system for make Braille cells shape's more regular after that the document segment into lines then into words and character, this character convert into binary string which is convert into ASCCII code in order to translate it into correct Arabic letter the system gave recognition rate of correct letters between (%98.04 - %100) for green Braille document and (%97.08 - %99.65) for yellow Braille document. Whether the time consume in running this system depend on number of character in document which is range between (8-32) sec. for document with number of character between (230-645) character.

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تمييز و ترجمة مخطوطات برايل العربي باستخدام تقنيات معالجة الصور

نظام برايل هو احد الوسائل المهمة للاتصال معرفياً بين الأشخاص المكفوفين والأشخاص المبصرين ولذلك عُنيَ هذا الموضوع باهتمام الباحثين. هذا البحث يصف تقنية جديدة لتمييز خلايا مخطوطات برايل العربي ذات الوجه الواحد. الصعوبة في أنظمة تمييز برايل – والتي عولجت في هذا البحث- هو كيفية تحويل صورة مخطوطة برايل إلى صيغة الصورة الثنائية لذا قمنا باقتراح خوارزميتين لتحويل وثائق برايل إلى الصيغة الثنائية بالاعتماد على العمليات التركيبية للصورة حيث تم تطبيق tophat filter على وثائق برايل ذات اللون الأخضر والذي بدوره يتكون من تنعيم الصورة باستخدام morphological opening ثم طرح الصورة الناتجة من مرحلة التنعيم من الصورة الأصلية (الرمادية)، وكذلك تم تطبيق bothat filter على وثائق برايل ذات اللون الأصفر والذي يتكون من تنعيم الصورة باستخدام morphological closing ثم طرح الصورة الناتجة من مرحلة التنعيم من الصورة الأصلية (الرمادية) .

نظام التمييز الضوئي لمخطوطات برايل يتضمن مهمتين أساسيتين، المهمة الأولى هي تمييز خلايا مخطوطات برايل والمهمة الثانية تحويل هذه الخلايا إلى نص. وقد عرضنا في هذا البحث تقنيات آلية لتحويل مخطوطات برايل العربية إلى صيغة رقمية ومن ثم جرى تقطيع الصورة الرقمية الناتجة من عملية التقليص إلى سطور ومن ثم إلى كلمات وحروف بعدها يتم مطابقة هذه الحروف مع ASCII المقابل لها لكي تتم عملية الترجمة. التقنيات قدمت نتائج سريعة ودقيقة في تمييز خلايا مخطوطات برايل العربي حيث تراوحت هذه النسب بين (100% - 98.04%) بالنسبة لوثائق برايل ذات اللون الأخضر و (99.65% - 97.08%) بالنسبة لوثائق برايل ذات اللون الأصفر أما بالنسبة لوقت التنفيذ فقد تراوح لبين (8-38) ثانية.