A Braille Recognition System by the Mobile Phone with Embedded Camera

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Abstract

It has been suggested that blind and visually impaired people may have difficulty reading Braille that is widely set in the public place according to barrier free policy of the government. This paper describes a new system that recognizes Braille characters from a photo taken by a mobile phone with embedded camera. The photo is dealt with by a Java program developed by "DoJa I-appli tool kit " to supply a real time reply.

1. Introduction

Since the inception of Braille in 1829, significant developments have taken place in the production of Braille and Braille media as a helpful tool for the blind and visually impaired people. Nowadays, Braille characters can be found as the instructions at the railway stations, door labels in the elevators, and the direction signs on the information boards at the public places. However, great rates of the visually impaired people, especially those who lost their visual abilities in adult, may have difficulty reading Braille. It is reported that less than 10% of the legally blind people can really read Braille. This situation makes a waste of the public resources. By the end of January 2007, more than 100 million mobile phones (PHS) are used in Japan. The coverage reaches 78.5% of the population of Japan. At the mean time, many new functions are attached in the mobile phone, and the new type mobile phones are equipped with more powerful CUP and programmable environments as while as camera and GPS.

In this paper, we describe a mobile Braille recognition system by running a Java programmed application installed in a camera-phone. The aim of the research is to provide a portable and helpful tool to improve the independence of the visually impaired users.

2. About the Braille used in Japan

Braille is a particular system of representing information in tactile form. Basic characters of hiragana, katakana, alphabets, digits, and various special symbols are represented by groups of protruding "dots". Each Braille character is a set of dots arranged in two columns of three on a 3 by 2 grid. The meaning of each Braille character (the Braille cell) depends on the type of Braille encoding used.

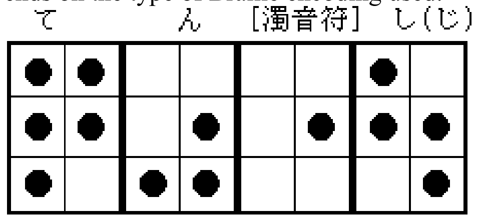

Figure 1. Example of Braille used in Japan

Fig. 1 shows an example of the Braille used in Japan.

When Braille is read by running the fingertip over the characters, the vertical axis can be seen as providing spatial information and the horizontal axis as providing temporal information.

3. The System

The system is designed for visually impaired users with a camera embedded mobile phone at hand. We assume the user can touch the Braille characters. He (or She) can then use his (her) mobile phone to take a photo of the Braille, and then a java program will automatically obtain the image. The image is thresholded to pick up the candidate dots of the Braille. Then the candidates are processed to remove noise according to the features of Braille cells. After that, a flexible grid of possible dot location is constructed and is transferred into a vector. Braille Characters are subsequently recognized and translated into the equivalent printed text or voice through the speaker of the mobile phone. The process can be repeated by pushing the button again. The flow chart is shown in Fig. 2.These programs are friendly and intuitive to use. No computer knowledge is required.

The details are described below.

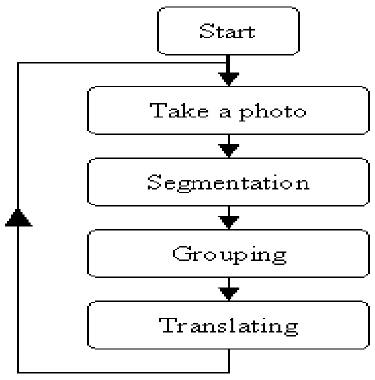

Figure 2. Flow Chart

3.1. Getting a photo image

A 320x240 photo image is taken by pushing a button during the running of a java programmed application. Then a gray scale image can be got from the R, G, and B components.

3.2. Segmentation of the Braille dots

The basic features of Braille dots are as follows.

(1) They are protrusive dots.
(2) They are circle-like shapes.
(3) They are dots collection with similar types.

Because of the refection of the protrusive parts of Braille dots, they appear to be brighter than the surrounding parts. We use a dynamic threshold method to segment the image into two parts to obtain the dots candidates. Then the single pixels are removed. If three of the four neighborhoods of a candidate pixel are not candidates, the pixel of the candidate will be removed. This is effective to speed up the labeling processing afterward. Then the connected candidates will be labeled. The pixel numbers, position and shape features of the labeled groups will be used to remove noise in the candidates, and thus obtain the final Braille dots.

3.2.1. Fast dynamic thresholding. A focus pixel will be remained as candidate, if its value minus value M is greater than the average of a moving N-by-N window. For a size of X by Y image, it would take $O(XYN^2)$ calculation. In the interest of efficiency for the not very powerful mobile phone's CPU, we take the next strategies to speed up the calculation. If the focused pixel shift in X direction, we minus the left side pixel and add the right side pixel of the filter window from the former result. Then the total calculation becomes $N(1+X+Y)+4XY$. The processing time will not change a lot for different filter sizes.

3.2.1. De-noising. After removing the isolated single pixels in the candidates, much noise still remains. We first label the connected pixels, and calculate the areas, the widths the heights of the blobs. Then we remove the too small or too big too narrow or too wide blobs. Then we repeatedly remove the blobs according to the similarities (that is the radius, the roundness) of the blobs. If there are no more than three similar blobs remain as Braille candidates, the blobs will be removed; if there are no similar blobs within a scope of the blob (say 8 times the radius of the blob), the blob will be removed. Fig. 3 shows an example so far. The left side is the original image taken by the phone camera. The yellow pixels are the first stage Braille dots candidates. The pixels enclosed by the red boxes are noise to be removed.

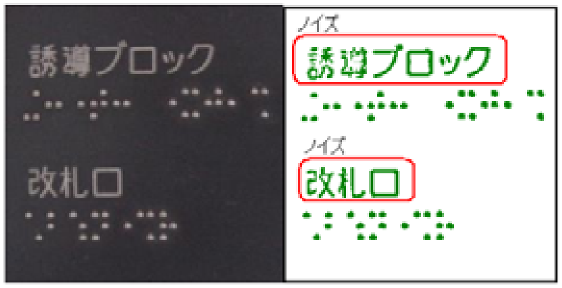

Figure 3. Example of the segmentation

3.3. Grouping of the Braille dots

By definition, the placement of dots within a Braille character is regular. The dots can be aligned into horizontal lines according to the vertical positions (y-coordinates) of the dots in the image. Then we can arrange the lines into groups according to the spaces between the lines. Each group should include three lines with similar features. If not so, the candidates should be removed. This forms the character lines of Braille. Fig.4 shows an example.

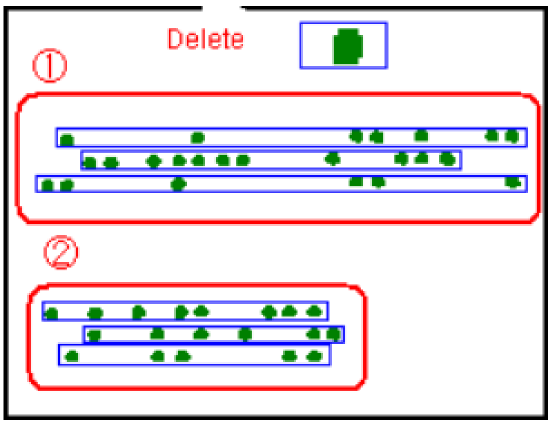

Figure 4. Example of Character line groupings.

In each character line group, the Braille dots will be assigned into vertical groups according to the horizontal positions (x-coordinates) of the dots. The space between the adjacent characters and that between the dots in the same Braille cells should be different although small distortions and skew may be present. The distances of the horizontal spaces can be divided into two groups. The average distances of the narrow spaces can calculated, and thus be used to index each vertical columns as show in Fig. 5.

By comparing the space between indices (0,1) and that between (1,2), we can assign the indexed X-groups into 3x2 Braille cell formation. If D(0,1) < D(1,2), then column '0' is the first column of the first Braille character; otherwise, column '0' is the second column of the first Braille character of the line. In the case of Fig.6, the Braille cells are (01), (2,3), (4,5), (6,7), (8,9), (10,11), (12,13).

3.3. Braille Character Translating

According to the position of the dots in the 3x2 Braille cell, each Braille character is corresponded to a binary digital. A set of lookup tables is designed for the translating of Braille characters. As show in Fig.7, digital two is represented as 110100. In Japanese Braille code, Hiragana, katakana, digits, alphabet, and other special codes can be translated into their textual equivalent.

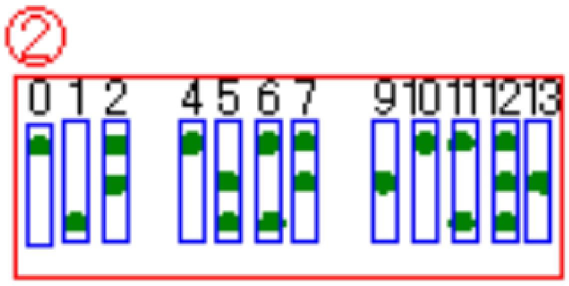

Figure 5. Index of X-groups

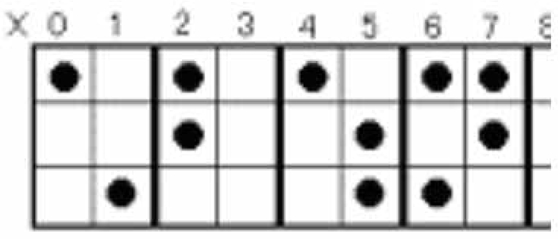

Figure 6. Braille cell formation

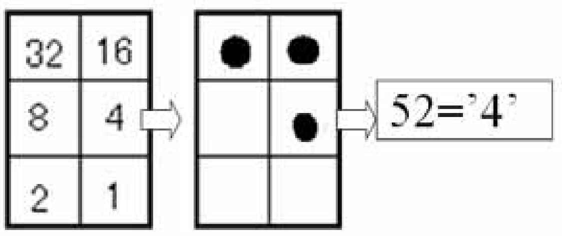

Figure 7. Looking up table

4. Experimental Results

The system is first implemented on a JAVA development emulator named as "iappli for DoJa-4.1". After the confirmation of the algorithm, it is implemented on a DOCOMO mobile phone "N902i". The running time depends on the quality of the image. The more noise in the image, the longer time is required to finish the translating. Totally, it takes two seconds for the whole process on average.

Fig. 8-11 shows four experimental results. The photos are taken by the phone camera, and then the segmented Braille dots are displayed on the monitor. The pictures are cut into240x240 image. In Fig.8 and Fig. 9, Braille dots are properly extracted. The translating results are shown as red katakana on the monitor. In Fig.10, noise is not completely removed, and some Braille dots like points of the insert slot remained. In Fig.11, the skew dots are not properly recognized.

5. Conclusion

This paper presents a mobile Braille recognition system that allows visually impaired people to access the public information whenever they need them. The experiment results showed that the concept of the paper is sound, the further aim of ours is to put the system into real use.

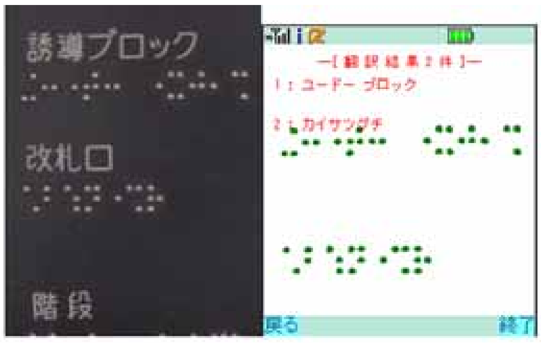

Figure 8. Experiment 1.

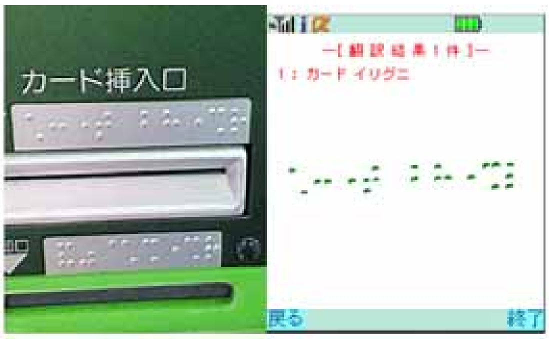

Figure 9. Experiment 2.

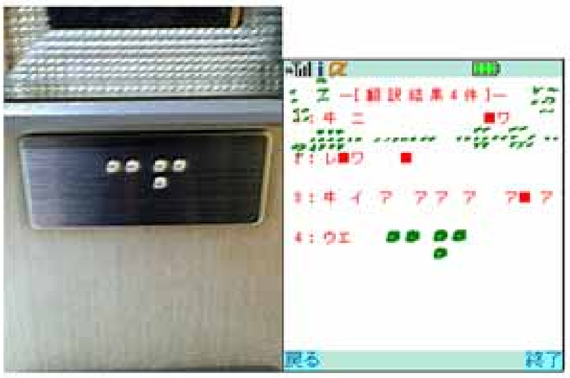

Figure 10. Experiment 3.

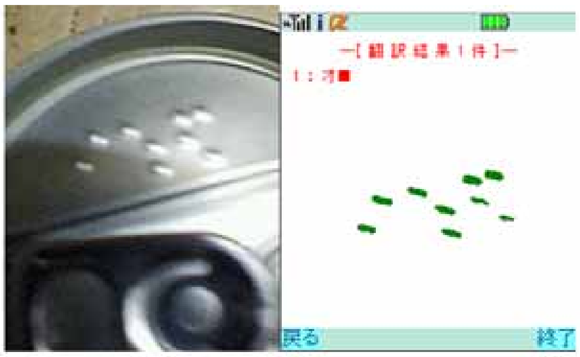

Figure 11. Experiment 4.

10. References

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