Handwritten Characters Segmentation using Projection Approach

Thi Thi Zin, Shin Thant, Ye Htet
Graduate School of Engineering
University of Miyazaki
Miyazaki, Japan
thithi@cc.miyazaki-u.ac.jp

Pyke Tin
International Relation Center
University of Miyazaki
Miyazaki, Japan

***Abstract*— In the area of optical character recognition, handwritten character segmentation is still an ongoing process. Having good segmentation result can provide the better recognition accuracy. In the proposed system, segmentation is carried out mainly on labelling and projection concepts. The input word is firstly labelled. Then, the modified word is segmented with projection approach. The experiments are performed on local dataset with 1600 words approximately and the system gets segmentation accuracy around 85.75 percentage.**

Keywords—optical character recognition, handwritten character, character segmentation, projection

I. INTRODUCTION

The handwritten character recognition is more complex than document character recognition in optical character recognition area. The accuracy of recognition result relays much on segmentation process. Segmentation is carried out in multiple approaches such as zoning, neural network, histogram, projection, background analysis and so on. Most segmentation approaches longer in performance time since they applied multilayer perceptron. In some approaches, there are limitations like containing more than one object in a segment that are fixed in the proposed system.

In the proposed system, the handwritten character is simply segmented using projection profile approach. The system can segment cursive words either. The handwritten word is firstly preprocessed and labelled. However, there can be some miss-written or original characters that contains more than one label. So, three constraints are applied to combine respective labels. Then, individual character is segmented using projection and the segment points are filtered with closed character detection and pixel count detection concept.

In this paper, we proposed segmentation of handwritten characters using labelling and projection approach. The rest of the paper is organized as followed. In section 2, we describe our proposed method. Some experimental results are shown in section 3 and conclusion and future work are described in section 4.

II. PROPOSED MEHTOD

The proposed system is mainly composed with four parts: preprocessing, labelling, segmentation and removing over-segmented points. The input to the system is an image written on tablet. Firstly, the input image is preprocessed and labelled. Then, the labels of preprocessed image are rearranged with specific space. The rearranged image is then passed the modification step of connecting small disjoint parts and segmented using projection concept. Finally, the segmented points are obtained by removing some over-segmented points.

A. Preprocessing

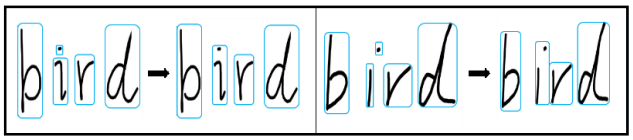
The original image is in RGB format. The image is binarized and inverted. Since word segmentation is performed mainly on vertical projection in this proposed system, the image is thinned. For faster performance, the extra parts of the image are cropped.

B. Labelling

The preprocessed image is performed labelling with three minor steps. Firstly, the connected components in the image are labelled. Secondly, since some characters in English alphabets such as ‘i’ and ‘j’, have two connected components, the labelled objects have to be combined. The process of label combination is considered in three ways; completely covered objects, partially covered objects and uncovered objects.

As the first way, if one object is completely covered by another object and its total pixel count is less than possible maximum pixel count of ascender of i or j, then the two objects are combined as one label object. For the second way, if two objects are overlapped more than 50 percent of each other, the two labels are combined.

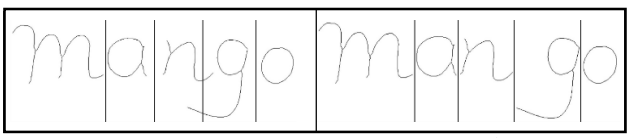
As the third way, if one object is not covered at all but its total pixel count is less than possible maximum pixel count of ascender of ‘i’ or ‘j’, then the two labels need to be combine with left or right neighbor object. The distances between center of selected object and center of left and right neighbor objects are compared. The neighbor object with smaller distance is combined with the selected object. All three ways of label combination are illustrated in figure 1.



(a) (b)

Fig. 1. Ways of label combination (a) completely covered and (b) uncovered labelled image

In the final step of labelling approach, each labelled object is rearranged with specific space between them to solve characters overlapping problem. The half point of the space is taken as predefined segment points. The result is shown in figure 2.

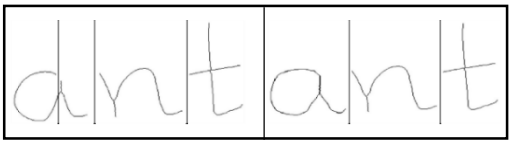


(a) (b)

Fig. 2. Label separation (a) original and (b) label separated images

C. Segmentation

The segment points are determined based on vertical projection. The image is modified with four modification steps; small disjoint connection, core zone detection, slant correction [2] and skew correction before taking segment points. Since vertical projection is applied as main segmentation approach, tinny gap can cause over-segmented points. So, the small disjoint part is connected using simple morphological operation as in figure 3.



(a) (b)

Fig. 3. Small disjoint connection (a) original and (b) disjoint connected images

For each segment object obtained from rearranged labels in label combination step,

- Find the sum of row pixel values for each column of the entire segmented partial image.
- Take the pixel location where the sum is '0' or '1'.
- Reduce taken points by averaging the adjacent points where distance between two points need to be at least 7 that there cannot be a character within the two points.
- Then, discard the averaged points whose taken point is edge of the partial image.

Then, all the individual label segment points are combined with the label segment points obtained from the label combination step.

D. Removing over-segmented points

Over-segmented points are removed based on two constraints; closed character detection and pixel count detection. Closed character detection is performed because an over-segmented line cannot have loop or semi-loop in its nearest neighbor. Close character is a character with loop or semi-loop such as a, e, c, d and so on [1]. The concept of whether a character is closed or not is depend on four pairs of foreground pixel points. Two pairs of points need to have same vertical position for each pair with specific distance between points such as a1 and a2 or b1 and b2 in figure 4. And the other two pairs of points also need to have same horizontal position as c1 and c2 or d1 and d2 in figure 4.

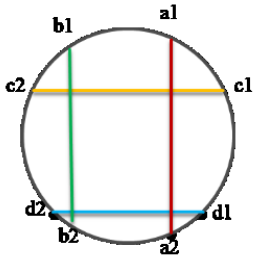
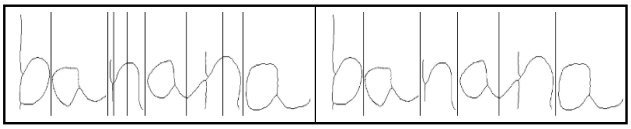


Fig. 4. Closed character detection

After removing over-segmented lines by closed character detection constraint, the segmented lines between open characters such as l, r, v, etc., would be disappeared in some cursive words like bell, hill and so on. So, the segment line between two upper zone adjacent segment parts with higher peak than a threshold (general peak of character 'l') should be preserved. The before and after stages of closed character detection constraint is compared in figure 5 [1].



(a) (b)

Fig. 5. Closed character detection (a) original image and (b) over-segment removed image

If a segment contains only one object and is not first part, then divide it into two equal parts vertically. The divided left part must contain two objects and space between these two objects must be greater than half high of the part. A vertical line is added to rightmost of the divided left part. If the line added part contains no holes, then that segment part is assumed as left open data. Since left open data is absence in English alphabets, that data should be combine with its left neighbor. If the pixel count is less than a number that is too small to be a character, then the segment is combined with neighbor joint segment as shown in figure 6 [3].

(a) (b)

Fig. 6. Pixel count detection (a) original and (b) over-segment removed images

III. EXPERIMENTAL RESULTS

The proposed method is applied to 1607 words of '139' numbers (0 - 9) and '1468' characters (a - z) such as ant, banana, candy, eye, fish, hill, grapes, juice and so on . The total number of correctly segmented words is '1378' images. So, the overall accuracy of the proposed segmentation method is around 85.75 percent.

The characters touching each other too much cannot be segmented into individual characters. And the disjoint character would be separated into multiple segments. Some incorrectly segmented words are shown in figure 7.

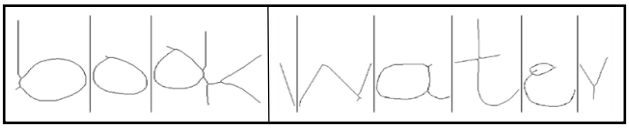


Fig. 7. Incorrectly segmented words

IV. CONCLUSION AND FUTURE WORK

In this paper, we proposed the character segmentation of cursive handwritten words. The projection approach is mainly applied for segmentation. The proposed method can segment correctly most of the cursive words. The modification will be made to improve segmentation result.

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