

# An adaptive threshold algorithm for offline Uyghur handwritten text line segmentation

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Published online: 2 January 2020 © Springer Science+Business Media, LLC, part of Springer Nature 2020

#### Abstract

This paper presents an effective text-line segmentation algorithm and evaluates its performance on Uyghur handwritten text document images. Projection based adaptive threshold selection mechanism is implemented to detect and segment the text lines with different valued thresholds. The robustness of the proposed algorithm is admirable that experiments on 210 Uyghur handwritten document image including 2570 text lines got correct segmentation by 97.70% precision and 99.01% recall rate and outperformed the compared classic text-line segmentation algorithm on same evaluation set. Additionally, the proposed algorithm is tested on the public handwriting dataset and get 98.05% correct segmentation rate which is robust and promising.

Keywords Text line segmentation · Adaptive thresholding · Offline Uyghur handwritten documents

# 1 Introduction

With the prevalence of computers and scanners, tremendous books and handwritings of its copies are being digitally available. In order to make these document can be accessed easily, various techniques is utilized and some of it are already playing major role in commercial application. Text line segmentation is significant stage of offline handwritten document recognition and analysis [1]. Correctness of segmented text lines would influence the process and result of subsequent stages directly [2]. Text-line segmentation on document images of printed texts is easily handled by using simple projection method and a statistically estimated threshold. However, it is not a promising way to segment handwritten document images [3–5]. Unlike machine printed documents [6], due to high diversity in writing habits of different writers, distances within text lines are irregular and existence of touching and overlapping text lines makes this work challenging.

Modern Uyghur script is an alphabetic script which has 32 basic characters and it is written from right to left [7]. Almost each letter has several special ascenders or descenders which distinguish them from similar letter forms. Due to the cursive nature of Uyghur script, the special symbol may appear connected, overlapped not only in a word and text-line, but also between neighboring textlines, as well. This makes text line segmentation more difficult than printed texts or other scripts of isolated styles.

Traditional projection-based text-line segmentation method uses a confirmed constant threshold to separate different and neighboring text lines [7]. It is suitable for machine printed text images due to equal or regular spatial distance between neighboring text lines. Yet, its effectiveness is not acceptable for handwritten documents.

In this paper, we propose a novel approach for text line segmentation based on projection and adaptive thresholding mechanism. The proposed method has proven its effectiveness and robustness during the experiments on handwritten text images of text-lines with different styles, lengths, skewing and touching degrees. Rest of the paper is organized as follows: some previous works are recalled in Sect. 2. In Sect. 3, the proposed method is described in detail. Discussion on the conducted experiments and evaluation methods are given in Sect. 4. Section 5 draws brief conclusion then.

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# 2 Related work

In 2006, Li Et Al proposed an approach based on smearing [8]. They first convert a binary image to gray scale image using a Gaussian window. Then, text lines are extracted by evolving an initial estimate using level set method [2]. The algorithm correctly detected 85.6% of 2691 ground-truth text lines. The segmentation error caused by adjacent text lines and over-lapping text line makes this algorithm less compatible.

In 2009, Vassilis Papavassiliou Et Al proposed an algorithm based on the piece-wise projection [9]. The algorithm is tested on the benchmarking datasets of IDCAR07 handwriting segmentation contest, correct rate of the segmentation reached 95.67%. Although the segmentation is mostly correct, over-segmentation is occurred.

In Bal and Saha [10] proposed a text line segmentation algorithm based on projection. All Rising section in the projection is measured and the average value of rising section is treated as threshold. The algorithm is tested on the IAM database which contains more than 550 text images which has different writer. This approach correctly segmented 95.65% text lines. Due to the chosen threshold is constant, it is not adaptable for various handwritten document and it is not able to segment severely sloped text line.

In Ptak et al. [11] proposes an algorithm based on projection with a variable threshold. This method can segment handwritten text lines which text lines are in similar length. However, performance of segmentation declines when text lines are short or touched. The author tested the algorithm on their own collected Polish document images, which contains similar length text lines document and random length text lines.

In this paper, a projection based adaptive threshold algorithm for text line segmentation is proposed.

# 3 Methodology

#### 3.1 Framework

The first-hand collected Uyghur handwritten text samples are preprocessed using common preprocessing techniques including turning the original image to the gray scale image, dilation, binarization and noise removal [12]. After the document image is preprocessed, horizontal projection of preprocessed image is calculated, and thresholding is performed according to projection peaks and its locations. After measuring threshold, each text line is segmented according to each previously determined threshold and the line separators are drawn at the valley point, which is determined according to horizontal projection profile, of each neighbor text lines in the original image. The major steps of proposed algorithm are shown in Fig. 1.

## 3.2 Preprocessing

Preprocessing technique aims to eliminate and minimize harmful or insignificant content and enhance useful features in images, especially for document images [13]. Thus, it improves generality of sample representation and performance of subsequent works. Before the proposed textline segmentation method is applied, preprocessing is performed using turning the original image (color image) to the gray scale image, dilation, noise removal and binarization which is used twice.

### 3.2.1 Gray scaling

In order to calculate a projection profile, original document image should be turned to binary image, thus, gray scaling is performed before binarization. Therefore weighted sum method is used to conduct gray scaling. Commonly, a color image contains three channels, each channel stores the 2dimentional array which represents red, green and blue [14]. The gray scale image is determined by calculating a weighted sum of three channels components for every pixel of color image. Therefore, three dimensional tensor became two dimensional array that stores the result of calculation which is the final gray scale image.

$$S = 0.2989 \times R + 0.587 \times G + 0.1140 \times B \tag{1}$$

#### 3.2.2 Dilation

Dilation is one of the basic operations in mathematical morphology [15]. The dilation operation usually uses a structuring element for probing and expanding the shapes contained in the input image [16]. The dilation of A by B is defined by:

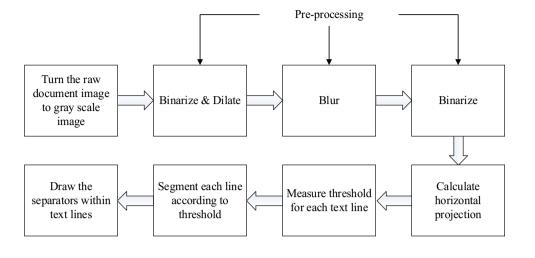
$$A \oplus B = \bigcup_{b \in B} A_b \tag{2}$$

where  $A_b$  is the translation of A by B.

The dilation process is highly dependent on its structuring element [17]. If it is not suitable for particular situation in image, dilation process may cause unpromising result which is different from expectations [18]. Thus, the structuring element must be defined properly. The dilation kernel used in this work is shown in Fig. 2. By using the kernel shown below, representation of text in document image became conspicuous.

In this paper, dilation is used to thicken the texture of text in document image and keep the main area of the text,

Fig. 1 Major steps of proposed algorithm



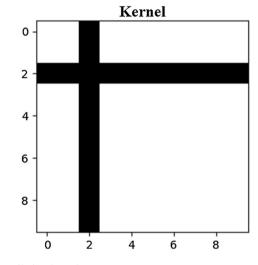


Fig. 2 Dilation kernel

Fig. 3 Before and after dilation

which allows the proposed algorithm easier to extract vital information like peak points and valley points, and distinguish each text line. Fig 3 compares binary image of a text document and its dilation effect.

# 3.2.3 Noise removal

Noise removal is important to any kind of image processing task [19], especially for handwritten document images [20]. Generally, scanned handwritten document image contains some kind of noisy points which caused by dirt or during the scanning process. These points are harmful for the entire process of algorithm. Since binarized image is dilated, consequently, noisy points are also became bigger that could affect subsequent work. Filtering is a prevalent way to minimize or remove the noise in images. Each filter commonly contains a corresponding window. With the expansion of window size, result of filter would be vaguer

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(b) Dilated image
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                    تودرنده توبيه مونه تقطع خال نوزلۇن بار .
                              بر بىرىن الرغير تاكيز مقولتىق.
                                        او بغلبام وري متر.
                                  الواندر بغ الزاروشيقا والشلحان ا
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(a) Original image

[21]. This means window size must be chosen appropriately; otherwise, the document image will lose important information in the process of filtering. In this paper, we use mean filter to perform noise removal. Mean filtering is a simple, intuitive and easy to implement method of smoothing images i.e. reducing the amount of intensity variation between one pixel and the next [22]. Thus, noisy points in blank area in document image can be weakened or eliminated. For every pixel in image, the filter would calculate average value of corresponding window and replace the original value to the calculated one.

$$O(x,y) = \frac{1}{mn} \sum_{(s,t)\in S} I(s,t)$$
(3)

Besides, we also used mean filter to minimize the local extrema (minima and maxima points) in projection profile which is calculated after whole preprocessing technique is done. Some different blurring parameters are tested to observe their blurring effects, setting window size to 30 by

Fig. 4 Differently blurred images

30 pixels gave the best blurring effect and is selected as blurring parameter in later experiments. Handwritten document image after smoothing by different window sizes parameters are compared in Fig. 4.

# 3.2.4 Binarization

Document image binarization is a crucial phase which is able to segment the text and the background by eliminating remaining unimportant information [23]. The histogram of original gray image and image blurred by 30\*30 window is shown in Fig. 5. As the second histogram shows, after the document image is blurred, gray level in each black pixel is reduced [24]. Moreover, the gray level of pixels, which is near to black ones, are increased. This means that threshold of binarization should be chose correctly.

Thus, Otsu thresholding method is used for image binarization [25].

(b) blurred by 20\*20 window

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(c) blurred by 30\*30 window

(d) blurred by 40\*40 window

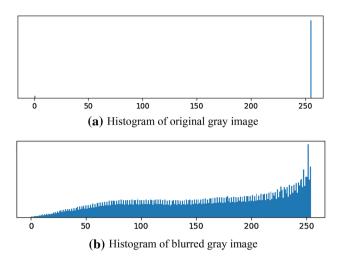


Fig. 5 Histogram of document image

$$\sigma_{\omega}^2(t) = \omega_0(t)\sigma_0^2(t) + \omega_1(t)\sigma_1^2(t) \tag{4}$$

Weights  $\omega_0$  and  $\omega_1$  are probabilities of two classes, which refers text lines and the background or black pixel and white pixel, separated by a threshold *t*, and  $\sigma_0^2$  and  $\sigma_1^2$  and variance of these two classes [26].

Fig. 6 Binarization effect

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(a) Binarization of image blurred by 10\*10 window

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(c) Binarization of image blurred by 30\*30 window

In this work, binarization also enhances the generality of the text lines in our document image. Four images, which are differently blurred, after binarization effect are shown in Fig. 6.

As the binary image shows, some noisy points are removed, text area in document image became smoother than original image. This is very conducive to compute a smooth projection profile. The projection after binarization on each differently blurred images are shown in Fig. 7.

# 3.3 Text line segmentation

Widely acknowledged text line segmentation method based on projection calculates the average gap between successive text lines, then define a constant threshold to separate these text lines [27, 28]. However, when threshold is constant, touched or near text lines might be omitted. Therefore, the process of defining threshold must be adaptive to different gaps between each neighbor text line couples.

In this work, after calculating horizontal projection profile H from the preprocessed image, significant peaks' location which might represent each potential text lines are

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(**b**) Binarization of image blurred by 20\*20 window

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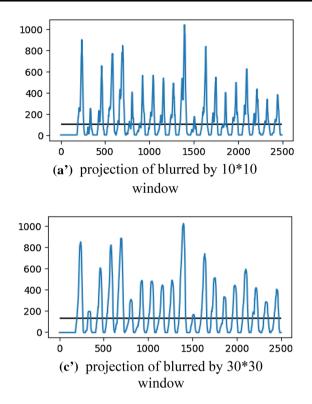
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(d) Binarization of image blurred by 40\*40 window



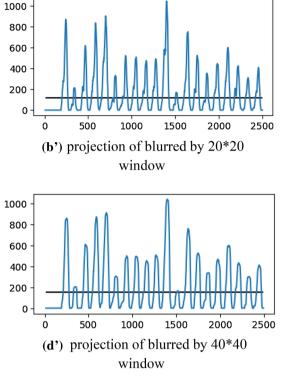


Fig. 7 Projections after binarization

extracted to set *P* and *P'*. Next, thresholding is performed as follows: visit each element P(i) in set *P*; for given P(i), take the half of the peak value and give it to threshold *T*. In general, visit each peak's location, then get its value and take the half of it and treat it as threshold.

$$T_p = P(i) \cdot \frac{1}{2} \tag{5}$$

Since each threshold is differently measured form peaks of horizontal projection values, the threshold will have different values for each neighbor text lines. After measuring each threshold, the projection values are visited reversely from the current peak location. If the currently visited projection value is less than threshold, then the location of this projection value is assumed as starting point of a text line and added to set S and break the loop. Then, the ending points are determined same way using forward visiting of projection values and the ending point is added to set E, correspondingly. However, these intervals, which composed by starting points and ending points, are not totally reliable for determine each potential text line. Therefore, interval inspection is performed to remove the intervals that do not represent text line. The pre-estimated text-line intervals and tip points (starting, ending) are checked to confirm their validity and correctness by the following algorithm.

First, visit each element in set S and set E, for given start point S(i) and end point E(i), to calculate midpoint  $M_i$  of each interval using equation below;

$$M_i = \frac{S(i) + E(i)}{2} \tag{6}$$

Second, get next interval's start point S(i + 1), if it is greater or equal to  $M_i$ , the algorithm see these two intervals as true intervals, which means they are not overlapped with each other, then accept it as a true interval, otherwise it is seen as false interval (7) and it will be added to the previous interval, which is the process of combination of two intervals. This process makes the performance of interval selection more acceptable.

$$\begin{cases} S(i+1) \ge M_i & true \\ S(i+1) < M_i & false \end{cases}$$
(7)

After modifying set S and E straight lines are drawn to separate the text-lines in the document image. The separator lines are drawn horizontally at valley points, which is in the horizontal projection profile, between two adjacent estimated text-line positions.

In the respect of computation complexity, firstly, the projection calculation is depend on the height and width (rows and columns) of document image. Then, due to every peak is extracted by a projection vector (one dimensional array), thus, peak extraction stage is linear. Moreover, line drawing is also linear. Thus, final equation of time complexity is:

$$O(n) = rc(w * h) \tag{8}$$

where r and c refers to row and column of binarized document image, where w and h refers to the width and height of the filter.

# 3.4 Algorithm

The pseudo code of proposed algorithm is shown in Table 1.

**Step 1**: Read a handwritten document image as a multidimensional array;

**Step 2**: Convert the raw image to gray scale image and binarize the gray image;

Step 3: Dilate the binarized image;

**Step 4**: Blur the dilated image;

**Step 5**: Binarize the blurred image;

**Step 6**: Calculate the horizontal projection profile of binarized image;

**Step 7**: Add peaks, which is above the mean value of projection, to set P and their locations are stored into set P'.

**Step 8**: For each element in set P, calculate the threshold by taking half of the peak value. Visit the elements of projection vector from currently visiting peak's location forwardly and reversely to determine ending point and starting point, respectively. Where projection value is less than threshold is measured as starting point or ending point and the location of these are added to set S and set E.

**Step 9**: For each interval, calculate the mid point  $M_i$ . Compare it with next interval's start point. If it is greater or equal to  $M_i$ , accept it as a true interval. Otherwise it is seen as false interval and it will be added to the previous interval

**Step 10**: Draw a straight line at the valley point between two adjacent intervals according to HPP.

Step 11: End.

Table 1 Pseudo code of algorithm	Text line Segmentation Algorithm
	1. Count the horizontal projection profile $H$ preprocessed image $I_p$
	2. $M \leftarrow \frac{1}{H.length()} \sum_{n=1}^{H.length()} H(n)$
	<b>3.</b> $P \leftarrow \emptyset, S \leftarrow \emptyset, E \leftarrow \emptyset, i \leftarrow 1, j \leftarrow 1, k \leftarrow 1, entrance \leftarrow false, t_r \leftarrow 0, b \leftarrow 0, mid \leftarrow 0$
	4. for each row in H
	5. if $H(i) > M$ and <i>entrance</i> is <i>false</i> then
	6. entrance $\leftarrow$ falce
	7. if $H(i) > b$ then
	8. $b \leftarrow H(i)$
	9. if $H(i) < M$ and entrance is true then
	10. $P \leftarrow P \cup b$
	11. entrance $\leftarrow$ false
	12. while $P.length()$ is not 0 do
	13. $t_r \leftarrow \frac{P(1)}{2}$
	14. for each corresponding row of $P(1)$ to first row do
	<b>15.</b> if $H(j) < t_r$ then
	16. $S \leftarrow S \cup$ corresponding row of $H(j)$ , break
	17. for each corresponding row of $P(1)$ to first row do
	18. if $H(j) > t_r$ then
	19. $E \leftarrow E \cup$ corresponding row of $H(j)$ , break
	<b>20.</b> Delete $P(1)$ from $P$
	<b>21.</b> while $k \neq S.length()$ do
	22. $mid \leftarrow \frac{S(k)+E(k)}{2}$
	<b>23.</b> if $mid > S(k+1)$ then
	24. Delete $S(k)$ from S and $E(k+1)$ from E

# **4 Experimental result**

#### 4.1 Database

To verify the proposed algorithm, we collected 210 Uyghur handwritten document images including 2570 text lines. The collected handwritten documents are written by different writers that each document varies in length and handwriting styles. The handwriting styles in the established database are broadly categorized into three types: (1) neatly written text-lines with random lengths; (2) similar length of text-lines in casual style that contain many overlapping and ligatures; (3) skewed normal handwriting. Fig 8 shows some typical examples of the mentioned handwriting styles in the database. Each document image is separately stored in TIF format. The pixel intensity of the samples also varies between  $1477 \times 944$  to  $2175 \times 2277$ .

Additionally, we also collected the Polish handwritten document images from website that is given by Ptak et al. [11]. Dataset include 29 pairs of Polish document image which has 58 images in total. They generally put these document images into two different classes which are documents that contains short length of text lines and documents that almost has equal length of text lines. In the database, each document is stored as pair. Each pair has random length text line version and mostly identical length text line version. In the document, writing style is divergent from image to image. Some are very neatly written, but severely sloped, which is multidirectional. Some are not sloped but written in extremely casual style. Thus, running test on this data set is also able to evaluate the performance of proposed algorithm due to the dataset's challenging feature.

Finally, the proposed algorithm is also tested on the public offline handwriting dataset, the IAM dataset [29], to

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Fig. 9 Sample of IAM English handwriting dataset

evaluate its performance. It includes unconstrained handwritten text, which were scanned at a resolution of 300 dpi and saved as PNG images with 256 gray levels. The sample of IAM database is illustrated in Fig. 9.

## 4.2 Evaluation method

In this paper, we calculated precision, recall and the Fmeasure to evaluate the performance of proposed algorithm [30]. Precision is based on manually counting the total segmented text lines and correctly segmented text lines, recall is based on counting the total text lines and the correctly segmented text lines. Then, the F-measure is calculated according to precision and recall.

```
Fig. 8 Three samples of
                                                                                                                                                                                      تويغد نوه بكسر قلتد بالفرق مرملد برابلان سرمن ورفتور.
                                                                                      تۇيغى ىى بېلىر تىلى جەندىت ئاھايتى ساغار بى مۇرىكەب بولغان
                                                                                                                                                                                                                  بوكتاب هاياتنا ماراروت فوه تلهام بمردق
database
                                                                                                                                                   ېد مالوشتون .
                                                                                                                                                                                 نو تا کمالکر بالنور بدایتی تورینی تسمیس، محمد توجدی کوکر قکد
مایا تکود بای بوجه ی تو توز کامکانت مراد
می از مراد بای بوجه ای تو کوز کامکانت مراد
                                                                                                         بې تشاب ماياتىغا مارلرەت ۋە ئىلمام بىرىدۇ .
                                                                             الإ تمكاندر بالغرز بركس كوجزن تحسس، صمعمر تومون كومك متكم،
                                                                                                                                                                                                                                  المحكمنز بامد دوست بولوك .
                                                                           ىلىياتىدىدا باي بلۇش ۋ. كۆز ۋالىنىكىرىتمى بۇرسىتلىنى مۇھ ئۆتۈشتىرا كو.،
                                                                                                                                                                                                                  تلماتى بولالى تشارئى تسوال قبال،
تىوتى بولالى تعارفي تسوال قبال،
تىرتولك هالدا تىرىسالى ۋە تىك رولانى
                                                                                                                                 تَشْلُرْ بالمن روست بولۇلى ,
                                                                                                                   قاماهى بولغان الشَّلْرَبِي تەلىلىل قىلىكى .
                                                                                                                                                                                                            بتكركدى بى خوالىدى.
تونشى قارىد قدىنات باب قىلدىك لمف شچى
بىرى بر غابىرىد ز كور مى استا مى بود.
                                                                                                                             تەرىلىز بلەن ھەققالىنى ئىلاھ .
                                                                                                                     ترتبله مالدا تدرب لماله في تتكوروله .
                                                                                                                                                                                                                       الخصرج فالمستعاى فتؤاستدي وحددتند
                                                                                                                                                   با-ئ بارلۋ. ر .
                                                                                            الوَ تُسْنَى الدهده ملح تعزينات بالمان تعليمان لبغت تستحسه .
                                                                                                                                                                                                     دار تراردا 42 بولاس مى تور ئالدلىرى بىدرىمالى بدرىمالى مى م تۇنىللىز كىروك .
                                                                                                                  بوردخ بر فابوتك كاز مالماشكا شاريش
                                                                                                                                                                                                                                                   لتُكْثر بلدى دولت يولؤكى
                                                                                                                       الْوُ صبى زاراد لماي الوَّلْسَدْ ، الوَقْسَدِ )
                                                                                                                                                                                                           قلما قصى بولواى أنتكمتر تدهلل قلافى، تدرُّلز رابى وقف لمرئ مُلاك
                                                                                                                                                                                    ملما علی بوعاه منطر، منه .
هوتیله هاما توریدای هو ترکسنوروناع .
درهمرگه میزارمای ترین المسر هو نشبی گاوهده قرصلاه بله 6 قلدهاه لعمت تشعیسی .
                                                                                                        الۇلتىرنىڭ ئۆيىدە ئۈنىرە دىتىدەلە خار خۇرلۇق بار .
                                                                                                                        ېر يىردىن تمر ئىر ئاۋىز مېھۇانىر،
                                                                                                                                      انۇ بىغىلىداب كۇلۇپ كەتتى .
                                                                                                                                                                            بوت بر فابركول كار ما كان ثل بوز.
مؤتري اوقوسترد. او مانك الديره تواه مؤروك مان موزلون الرز المربون كوكور كالاز جتوارق
الا المانيان المانيان المانيان المانيان المانيان المانيان المانيان المربون كوكور كالاز جتوارق ا
                                                                                                                               كۈلار بىغ ئۆرۈشىغا باشلىرى
```

تى يىغلدان كۈلى كەنتى ، ئۇللىر بىخ ئۇرۇنىق بايتلى .

$$P = \frac{L_c}{L_s} \tag{9}$$

$$R = \frac{L_c}{L_t} \tag{10}$$

$$F = \frac{2PR}{P+R} \tag{11}$$

where  $L_c$  and  $L_s$  denote the correctly segmented text lines and total segmented text lines, respectively. Where  $L_t$ refers to the total lines in document image.

## 4.3 Result and analysis

Several algorithms including projection based are tested on introduced datasets to compare with proposed algorithm. Brief introduction of algorithms and its segmentation mechanism is depicted below.

There are three parameters is taken to the participant algorithm which is the input image, windows size of filter and the relative threshold. The optimum values of parameters are given that the window size takes 9 and the relative threshold takes 0.5. The experimental results of text-line segmentation on our dataset are shown in Fig. 10 and Table 2. For comparison, we evaluated the participant algorithm on our database.

In the participant algorithm [11], the Polish document image is preprocessed including turning the original image to gray scale image, binarization and noise reduction. Then

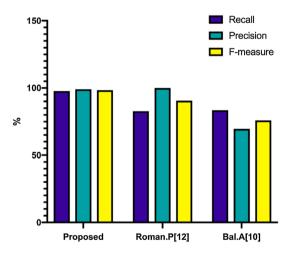


Fig. 10 Comparison of algorithms

#### Table 2 Result of experiments

	Proposed (%)	Roman [11] (%)	Bal [10] (%)
Recall	97.70	82.75	83.54
Precision	99.01	99.99	69.53
F-measure	98.35	90.56	75.92

count the projection profile of preprocessed image and sort it with descending order. Then visit each value of sorted projection to determine the threshold. Each time the algorithm chooses a threshold, text lines would be segmented afterward. If the text lines are already segmented, the algorithm would continue to the next iteration. The algorithm stops when the current value of projection is less than 1/10 of maximum value of projection.

In contrast, our algorithm's preprocessing stage has one more step which is dilation. This guarantees the important features of text in document image not to be removed by the noise reduction process. In the respect of threshold measuring, we extract each location corresponding to the significant peaks to determine the threshold rather than sorting the entire projection profile. In text line extraction stage, our algorithm starts visiting from the location of a significant peak, terminates when algorithm find a starting point or an ending point of one interval, rather than visiting all values of projection. In the respect of checking extracted text lines whether it is correctly segmented, we conducted checking mechanism that is totally different from the participant algorithm. The participant algorithm simply just omits if the currently segmented text lines overlaps with intervals which is segmented previously, even it is not severely overlapped. In our checking mechanism, we consider each two adjacent intervals and observe the current interval's start point that whether it is greater than the next interval's midpoint.

According to results of the two segmentation algorithms in Table 2, proposed algorithm outperformed the participant algorithm in recall and F-measure. Although the precision of the participant algorithm is higher than the proposed algorithm, its recall rate is much lower than proposed algorithm. This means method [11] is not strong as the proposed algorithm in the respect of text-line detection. Segmentation precision of the participant algorithm is high for neatly styled text-lines, but it is observed not strong enough to detect sufficient text lines. Some textline segmentation effects of two compared algorithm are illustrated in Fig. 11. In sample (a), which is neatly written handwriting sample, the participant algorithm is unable to detect and segment short text lines. Although the text lines in sample (b) is mostly similar in the respect of length, the casual writing style and skewed text lines affected the participant algorithm's accuracy. Even the participant algorithm detected one of the skewed text lines, the segmentation is incorrect. But our algorithm segments the all text lines in both sample properly.

Proposed algorithm and the algorithm [11] are also tested on the polish handwriting documents. In this experiment, proposed segmentation method still outperformed the compared method. However, the result of both algorithm is not promising due to testing dataset's feature

ىد مىلۇقتۇر .

2 كتاب

 تۇخۇ 3. ئۆر خىش جەست ئامايتى ئىلى ۋ. مۇرتقىپ بېلىنى

 بد مەنەۋىتۈر.

 بې مەنەۋىتۈر . ئۇرى بولى ئەرەت ۋ. ئىلمام بېرىش.

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 بۇ ئىلى بولى ئەرەت ۋ. ئىلمام بېرىش.

 بۇ ئىلى بولى ئەرەت ۋ. ئۇز ئالىتكى ئۈچۈن ئۆلى ئىلى .

 ئىلى بولى .

 ئىلى بولى .

 ئۇر بىل بى بولى .

 ئۇر بىل بىنى .

 ئۇر بىل بى بولى .

 ئۇر بىل بى بىل .

 ئۇر بىل بى بى بىل .

 ئۇر بى .

 ئۇر بىل .

 ئۇر بى .

_ الج أمكا للدر باللحار المركسي الوجان المسمى المسممر الوجان الواكم المكر ،	الج تمكاندر بالغزز بركس كوجن المسه ، مسمن المجن المراجم .
_ ىلايتىڭىزىك باي بىلانىش ۋە تۆز ئالىنىكىزىكى بىلىرسەتلەنى مېڭە ئۆتۈنىتىگىز كو، ھ	ماما تَكْرُكْ مَا عَالَمُوْسَ فِي تَوْزَ الْمُنْكَامُ الْمُسْمَالِينُ مَا لَمُ تَوْرَدَكُ مَا يُو
تشر بال روست بولۇلى ,	الشور باين بورت بوايل ب
_ قاماهی بولغان اشکری توسلس علق	قلعاهم، وبلغان 22 في تسعيل مالي
_ تەرىلىن بىلەن ھىقىتىكىنى ئىلاھ .	تورشني بامني متعظماني تراك
ــــــــــــــــــــــــــــــــــــــ	توتېلىك مالول تروبىيدامالى فى تتك كۈزانى .
با-ئ باراۋەر .	با-ئە بارۋەر .
- ثَرْ نُسْمَ قَالَدُهُ هَ مَرْعَنَهُ مِدْنُ مَدْهُ مَانَ تَدْهُمُ لِعُتْ مُحْمِسِهُ .	الح الله الم
<ul> <li>بورد بر خابور ما المحال المحا محال محال محال محال محال محال المحال المحال المحال المحال محال</li></ul>	بحاثي بد خابيتك المراج الا التحالي المحالي الم
- نو سه زارد مای نواند ، نوشنو م	الفراسج المرادنياي التأشف المقارح
كو قىچە رارد ئاغ لولىدى ، لومىدو م – ئۇلارنىڭ ئۆيىدە ئۇد.دە بۇكىدە ھار خۇرلۇق بار .	المخادر أما الأنبية الأنبية وأسعاه خاز غراواني الور
ا تولارت اونده توده دندهای عار موژانوی بار . — بر بیردس اثر څکر کاکاز میتواندن ،	ېد يېرمن غر غار داون بېټولتېر.
	الا بىلداب كۈلۈپ كەتتى .
انۇ بىخلىراب كۈلۈپ كەتتى . ئارالىر بىغ تۇترۇرشىقا باشلىرى _	الوالىر بغ الوروشتا باشلەي
	d handwritten sample
سا معدودان مؤدرة 17 . ج 19 84 مؤمون ، مرك مكر	ما چینودان مؤد وی مرکز کی از می والا 19 رفیمیزاند. کراچ مکو ک
ما معدران خزمرت ۲۲ ۲۰ ۲۶ او او بلویزن. شاه عدن منابعین فره مهکر عکش موند شنن ناهایش نالطار فره مؤره کد مو	ىلى مىلىن تىلى تى بى بى بى 19 مىل ئىلىنان كى غان
الما عمدران خوروت ۲۱ ج ۱۹۶۰ طوفون، کولا عکو میزمینو فره میکر مکش هود تنشن ناهایش نگاهای اور میزولکه م مولها ش به صفایی کی .	عدمدران توسرت ۲۰ ۲۵ ۹۶ بلوزان کاه کار <u>وانیز مر</u> بر مار طرح مواکن نامایی نامار زر موزیکا م بران مر معالمی ۵ 
ما معدران خودرت ۲۰ ج ۹۶ ۹۶ الموخان. تولا علان مذیخ وه بیکر عکم جد تشن ناهایش تلفار او مؤدولکرم مولها د بر مشکری . به ترین های عما قدارد خو تکماهام مردو.	عدمدران توسرت ۲۰ ۲۵ ۹۶ بلوزان کاه کار <u>وانیز مر</u> بر مار طرح مواکن نامایی نامار زر موزیکا م بران مر معالمی ۵ 
ما معددان خودرت ۲۲ ۲۰ ۲۰ ۱۹ ۱۹ فوعوّن. مولا عوّ موّن مخابعة فره مهلر علم جد شن ناهايتن نلطار فره مؤرولكرم مولعات مر معلوكم . مود تشاير هايا شعا قاردن نوه تلمام مرددو. مود شمالاغار با نظار مر كمش خوانيون نامس. هدمسر مؤجوز لوتيكر تلكم.	المعمودان توريص من مع 19 19 . المعتزان خلام على من المعتزان خلام على مع 19 19 . المعتزان خلام على من مع 10 10 م والعات المرار عاش عبد محتنا المعالية في مناطان في مواجلاً م ولعات المرار معتلية من مو المعتالين ما تعان مراكز الأميان المعام الموالية مو المعتالين ما تعان مراكز الأميان المعام المحالية المحق المحق المحق المح
ما معددان خود روت ۲۲ . ۲۰ . ۲۶ . ۱۹ و مؤمون . ماد ماد می مواسان در ماش طش جد شن ناها بین ناطار او مؤرونکر م مواسان در مایک ما عسا هاراد ما نو شامام مردو. مرد شما باعدا ماد موز مرد شر مؤمون نامه می موسو . مایا شری باین میکون او قان کاد شود و بر معمن مجال مونو شرم .	ما معدود توريم من مره من به مر ۲۵ مرا موند من
ما معدران خدرت ۲۲ جو ۹۶ ۲۹ لوخان. تولا على مذيخة فوه بيكر علم جومتن نامايتن تلطار اوه مؤدالكرم مولعات مير مشلوكات مير ممتلوكات مر ممتليكار بالغزارين تو تلماعام مردور. ما تشري الميتليكر المي وتلاكار تلكر تلكمس. هامسر نفجز تؤتيكر للم. ما تشريل ميتلكر بلدن دوست ميرادي. خاملمي مولغان متعطر بن تدملل تلك (	ما معدران توری ۲۰ م ۵۵ ۲۹ م ۲۹ م ۲۹ میزان کاد ۲۵ کاری در معلق معتقد نامایین مالمار از مزوماکم براما د اس معلق تم مو معال تا مو معال مال مالیام مورد مو معال مالی مالیام مورد مو معال مالیام مورد مالیام مورد مو میزد و قان عامل در می معله دور مار ایروستامین معله دور مرد ایروستامین معله دور مرد ایروستامین معله دور مرد
ما معدران خدرت ۲۲ جو ۹۶ ۲۹ لوخان. تولا عرق مذیعة فوه بیکر علی موستین ناهایتن تللغار او مؤدولگ ب مولعات سر معلی که . مرد معلی که . مرد معلی ما یا مواد بر کم خذید نام هامسر نفیجو کو ترک ملی . ما یا شرق این مولا کر این شده هامسر نفیجو کو ترک ملی . ما یا شرق این مولا کر این تواد ما یا شرق مای مولا کر این مالیل میکران ما معلی مولوان معلی میکران مرک مرد با ممالیل میکران	معدمدران ترسیم محکما نامایین مالمار از مزود کرد کرد کاری در معلی محکما نامایین مالمار از مزود کرد بولها ت در معلی کا مولها ت در معلی کارداده در محکما نامایی محکما معاد شده مالی کرد تر محکم در محکمان محکما اور در محکم مای شده مالی کرد تر محکمان در محکمان محکمان محکمان در محکم محکما تری مولها در محکم در محکمان محکمان محکمان محکمان در محکم محکما تری مولها در محکم در محکمان
ما معدران خذرت ۲۲ جو ۱۹۶ م طون بنا علی ۲۰ بولعات میر صفایت تن طعات ناهایتن تلخار او مؤدلگر مولعات میر صفایت تن مولیات میر صفایت اولات تو تلخام مرددو. مور شما لمان بر کا طفیق نامس، همسز طفیق کوتر تلم. مور شما لمان بر کر طفیق نامس، همسز طفیق کوتر تلم. موران عسطر میدن دوست میروان. موران مسطر بان معالم کارلی . تر میریک طالم کوسال کارلی .	معدوران توسرت بي ه 19 مين مال على المعالي معالي المعالي المعالي معالي المعالي معالي المعالي معالي المعالي ممالي المعالي معالي المعالي معالي معالي معالي معالي معالي معالي المعالي ممالي المعالي معالي معالي ممالي معالي ممالي معالي معالي ممالي ممالي
ما معدران خذرت ۲۲ جو ۱۹۶ م طون بنا علی ۲۰ بولعات میر صفایت تن طعات ناهایتن تلخار او مؤدلگر مولعات میر صفایت تن مولیات میر صفایت اولات تو تلخام مرددو. مور شما لمان بر کا طفیق نامس، همسز طفیق کوتر تلم. مور شما لمان بر کر طفیق نامس، همسز طفیق کوتر تلم. موران عسطر میدن دوست میروان. موران مسطر بان معالم کارلی . تر میریک طالم کوسال کارلی .	عدمدران توسرت بي ه 19 م مون كر تاريخ وم دار على صفت ناهايين ملامار او مزودكم بولات در معلى تل من تربي ها مناهادون تو علامام مورو من تربي ها مناهادون تركم و تاريخ من تربي عدار موان دوست مياده التربي عدار باس دوست مياده التربي عدار باس دوست مياده التربي عدار باس دوست مياده التربي عدار ماد تربيل التربي عدار ماد تربيل التربي التربي ماد تربيل الماد تربيل التربي التربي مياد مربيل التربيل التربي التربيل هاد كرديل التربي التربيل الماد كرديل التربيل
ما معدران خدرت ۲۲ جو ۹۶ ۲۹ لوخان. تولا عرق مذیعة فوه بیکر علی موستین ناهایتن تللغار او مؤدولگ ب مولعات سر معلی که . مرد معلی که . مرد معلی ما یا مواد بر کم خذید نام هامسر نفیجو کو ترک ملی . ما یا شرق این مولا کر این شده هامسر نفیجو کو ترک ملی . ما یا شرق این مولا کر این تواد ما یا شرق مای مولا کر این مالیل میکران ما معلی مولوان معلی میکران مرک مرد با ممالیل میکران	معدوران توسرت بي ه 19 مين مال على المعالي معالي المعالي المعالي معالي المعالي معالي المعالي معالي المعالي ممالي المعالي معالي المعالي معالي معالي معالي معالي معالي معالي المعالي ممالي المعالي معالي معالي ممالي معالي ممالي معالي معالي ممالي ممالي

(b) Skewed handwritten sample

is very challenging and segmentation condition is extreme. The result shows that the proposed algorithm detected and segmented most text lines in this Polish document image. However, in proposed algorithm, same error occurred because text lines are skewed. Although our algorithm detected every text line in the image, the segmentation is not correct. Since skewed text lines affected the extraction of significant peaks of projection profile. Algorithm [11] is not sensitive to short text line and when it exist in document, the algorithm is not able to segment these text lines. Finally, the recall rate of proposed algorithm and algorithm [11] are 63.23% and 38.06%, respectively.

We tested several algorithm on our Uyghur documents and Table 3 is the result of each algorithm. It can be seen Table 4 Comparison of algorithms on IAM dataset

	Proposed (%)	Bal [10] (%)	
Accuracy	98.05	95.65	
Over	0.00	1.45	
Under	1.95	2.9	

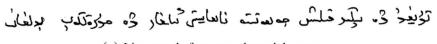
from the result that the proposed algorithm is alsobetter than other compared algorithms.

In addition, proposed algorithm is also tested on IAM public handwriting dataset. The experimental result shows that out method is also promising on public handwriting-dataset. As the Table 4 shows that proposed algorithm's

Algorithm	Accuracy (Correctly segmented text lines) (%)
Simple projection	76.58
Projection with variable threshold	82.75
Piece-wise projection	88.74
Smearing-based	94.84
Coloring-based	96.33
Proposed	97.70

**Table 3** Comparison ofalgorithms on Uyghur dataset

Fig. 12 result of two different algorithms



(a) Line sample from non-skewed document

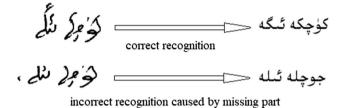


Fig. 13 result of two different algorithms

performance is also betterthan other recent approach using same dataset.

In the final stage of segmentation process, detected text lines will be separated from original image. At the same time, every separated text line will stored as individual line image. Some of segmented line images are shown in Fig. 12

As it can be seen from the separation results, sample A, which is written neatly and has significant gap between each text line, is separated easily with all of its contents and did not miss any significant information during the separation process. Thus, in the recognition stage [31], this will enhance the recognition accuracy by providing a whole text line. In contrast, due to skewness of some text lines in other type of document images, the separated line image lost some important information which includes part of words or characters even the line is accurately detected. In this scenario, handwriting recognizers would be affected directly and cause incorrect recognition. Consequence of this kind of segmentation is illustrated in Fig. 13.

# 5 Conclusion

This paper proposed a novel approach, which is not effected by the length of text lines in handwritten document, for off-line Uyghur handwritten text line segmentation using projection based adaptive threshold selection. The proposed algorithm is verified on 210 different Uyghur handwritten document images and 27 pairs of Polish document image, which is 58 images in total, including 1474 text lines. The experimental results shows robustness of the proposed text line segmentation algorithm. In our dataset, (**b**) Line sample from skewed document

Recall rate of the proposed text-line segmentation algorithm is observed as 97.70% which is much higher than 82.35% recall of the compared algorithm. In Polish document dataset, the final recall rate of proposed algorithm is 63.23% which is twice as accurate as algorithm [11]. Finally, in the IAM public handwriting dataset, proposed algorithm is also better than the recent approach. The increase of segmentation rate means that the subsequent stages will be done in more reliable way. However, there are some disadvantages in proposed algorithm due to its simple projection-based mechanism. If the written direction of document is severely skewed, the performance of the proposed algorithm would decline or even unable to segment skewing text lines. Another factor that makes the performance of the algorithm decline is incorrect peak extraction from calculated projection profile, since the existence of overlapping text lines and nearly written neighboring text lines. To develop more comprehensive and general text-line segmentation algorithm, that is able to segment skewed text lines, is the main content of our next work.

Acknowledgements This work has been supported by the National Natural Science Foundation of China (under Grant of 61462080 and 61662076) and Ph.D. Scientific Research Startup Project of Xinjiang University.

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