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RESEARCH NOTE

Document Image Dewarping Based on Text Line Detection and Surface Modeling

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ABSTRACT

Document images produced by scanner or digital camera, usually suffer from geometric and photometric distortions. Both of them deteriorate the performance of OCR systems. In this paper, we present a novel method to compensate for undesirable geometric distortions aiming to improve OCR results. Our methodology is based on finding text lines by dynamic local connectivity map and then applying a low cost transformation to project curved area to 2-D rectangular area. We evaluate the performance of the proposed methods in combination with four participating methods on the public DFKI-I dataset (CBDAR 2007 dewarping contest), which contains camera-captured document images. Experimental results indicate the effectiveness and superiority of the proposed method.

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1. INTRODUCTION

Currently, OCR systems are part of our digital world, making document images searchable, editable and reproducible. A typical OCR system, consists of several parts including pre-processing [1], layout analysis [2], segmentation and recognition [3, 4].

Each part must be continuously improved to produce better results. One major part of pre-processing is document rectification or dewarping. Document images taken from scanners or digital cameras, often have non-linear distortions, especially in near-border parts. For example, when we scan a bound book or capture it by digital camera, the middle part and borders will be warped (Figure 1). This problem, even when it appears negligible to the human eyes, can cause problems for subsequent analysis, understanding and recognition of the document.

Over the last decade, many different techniques have been proposed for document image restoration. In the following, we will review some important methods. Existing restoration methods can be classified into two categories:

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1. 1. Approaches Based on 3D Document Shape Discovery In this category, document images are restored based on discovering the 3D shape that is estimated by various 3D models such as applicable surface, depth map, cylindrical model, and so on. Yamashita et al. [5] proposed shape reconstruction and image restoration method for documents with curved surfaces or fold line using a stereo vision system. Cao et al. [6] introduced a general cylindrical model to rectify warping of bound documents captured by camera; this model needs the geometry of the camera used in image formation. They also have a limitation on the pose that requires the image plane to be parallel to the directrix of the page cylinder. Zhang et al. [7] used a shape-from-shading formulation to reconstruct the 3D document surface. These techniques require some knowledge about the camera and lighting, which in most cases, these are not inaccessible. Ghods et al. [8] present a novel approach for document de-warping using Microsoft Kinect camera sensor.

1. 2. Approaches Based on 2D Document Image Processing Another approach is based on image processing techniques such as binarization, connected component analysis, linear and nonlinear interpolation, and so on, without attention to the document shape information. Lavialle et al. [9] introduced a new text line straightening method based on cubic B-spline. This method is computationally expensive. Zhang and Tan [10] represented the text lines using natural cubic. They assumed that the book spline is found along iso-parametric lines. Bukhari et al. [11] mapped characters over each curled baseline pair (upper and lower) to its corresponding straight baseline pair. This method is sensitive to large and various distortions. Y. Zhang et al. [12] took a rough text line and character segmentation to estimate the warping direction. In this method, text line and character segmentation using projections at the original warped document can cause many segmentation errors. Gatos et al. [13] proposed a method based on text line and word detection. They recovered document images word by word. Brown and Tsoi [14] used document boundary interpolation to correct geometric distortion. They used a physical pattern to guide the uniform parameterization, so it is limited to some specific document distortions. Masalovitch and Mestetskiy [15] approximated deformation of interlinear spaces in an image based on elements of image's skeleton that lie between the text lines. This method is sensitive to the approximation of vertical borders' deformation in text block, which diminishes the accuracy. Shamgholi and Khosravi [16] projected curved lines to 2-D rectangular area. This algorithm is sensitive to large number of text lines and it is not able to deal with the skew of text lines. Stamatopoulos et al. [17] proposed coarse-to-fine rectification methodology, which needs to find all words of text line. Bukhari et al. [18] proposed image based methodology for the performance evaluation of dewarping algorithms using SIFT features. They tested performance evaluation methodology on the participating methods of CBDAR 2007 document.

In this paper, we propose a rectification methodology to compensate for undesirable distortions of document image captured by flatbed scanner or digital camera. Our methodology is based on low cost transformation which addresses the projection of the curved line to 2-D rectangular area without needing of external equipment. In section 2, we detect text lines with dynamic local connectivity map and then the required transformation to convert the curved shape to 2-D rectangular area will be found. Experiments applying this performance evaluation methodology are presented in Section 3. Finally, conclusions are drawn in Section 4.

2. PROPOSED METHOD

The most important part of each document is text lines. If we dewarp text blocks carefully, the subsequent OCR system will produce better results. We detect text lines of the document and then transform curved surface to a proportional rectangle area. The proposed algorithm is illustrated in Figure 2 and fully is described in this section.

2. 1. Text Line Detection To detect text lines of a curved image, the document is divided into three vertical parts to avoid merging of adjacent lines. Then, we apply a Horizontal Run-Length [19] for each row of the binary image from left to right and save the results to a new matrix I (see Figure 3b). Once matrix I have been created, we apply DLCM algorithm [20] to matrix I. In this way, all non-zero values smaller than T, will converted to 1 and the others to 0. T is a threshold selected as the average distance between succesive words [13]. This process applies to each three parts of the input document. After this phase, all horizontally neighboring connected components, are consecutively linked (Figure 3c and Figure 3e). The pseudo code of the proposed algorithm is shown in Figure 4.

2. 2. Curved Surface Estimation After detecting lines, we must find the top and bottom lines to construct the curved surface map (Figure 5). For this, we need to eliminate small lines that may confuse the algorithm. This is explained in the following section. Next, we estimate AD and BC by finding dominant lines and finally in next stage, AB and DC curved lines are detected using 3rd polynomial estimation. Flowchart of this stage is shown in Figure 6.

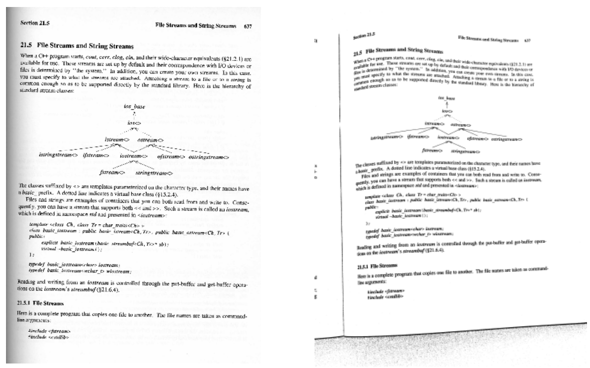


Figure 1. Example of captured image, left) by flatbed scanner, right) by digital camera [21].

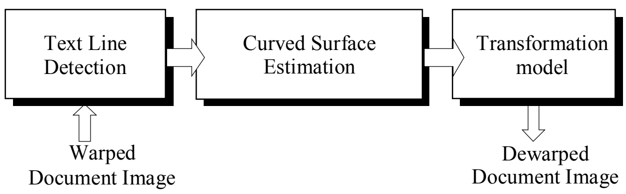


Figure 2. Flowchart of the proposed method.

2. 2. 1. Removing Non-Ideal Lines Length of each text line related to the major axis of the ellipse that has the same normalized second central moments as the text line. Then, all lines that their lengths are smaller than the 0.8 of the average length of all text lines, will be ignored. Now, more reliable text lines are retained.

2. 2. 2. Finding Start and End Point of Each Text Line Left and Right points of each text line are important to determine the transformation. These are simply calculated by the following equations. Figure 7 shows these points for a typical line.

$$\text{Right}_{point}(line(i)) = \frac{RT(i)+RB(i)}{2} \quad (1)$$

$$\text{Left}_{point}(line(i)) = \frac{LT(i)+LB(i)}{2} \quad (2)$$

2. 2. 3. Left and Right Straight Line Segment Estimation To construct the curved surface, at first, we must find the left and right boundaries of the surface. In the case of distorted documents, these boundaries are not perfect vertical and have some rotation.

In this stage, the straight lines corresponding to the left and right boundaries are estimated. If the length of a dominant line is larger than T_1, its left and right points are assumed to be on the boundary lines (AD and BC), otherwise it will be excluded from boundary estimation. T_1 is 0.9 of maximum length of the text lines. In this way, short text lines such as titles, marginal text and equations, and so on are eliminated and the most representative text lines are retained. Finally, we interpolate a straight line from left and right points to construct AD and BC, respectively.

1	1	0	0	1	0	1	0	0	1	0	1	0
1	0	0	0	1	1	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	0	0	1	0	1	1	0	1	0	1	0
0	1	0	0	0	0	1	0	0	0	1	0	1

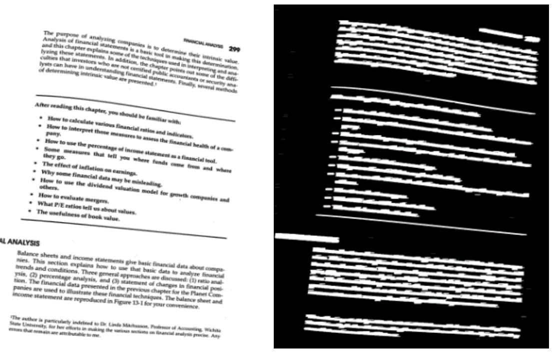
(a)

1	1	2	1	1	1	1	2	1	1	1	1	0
1	3	2	1	1	1	2	1	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	2	1	1	1	1	1	1	1	1	1	0
1	1	4	3	2	1	1	3	2	1	1	1	1

(b)

1	1	1	1	1	1	1	1	1	1	1	1	0
1	0	1	1	1	1	1	1	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	0	0	1	1	1	0	1	1	1	1	1

(c)



(d) (e)

Figure 3. Applying DLCM algorithm, **a** sample binary image, **b** matrix I, **c** DLCM algorithm, **d** a sample image from DFKI-I, **e** detecting lines by DLCM algorithm.

Begin **initialize** Binary image, T
Apply Hirozontal Run-Length for each Row from left to right
    Do check value of each pixel
if pixel is black
find nearest white pixel of the black pixel
DLCM= x_{white} - x_{black}
else
    DLCM=1
End
if *DLCM*(pixel)<T & *DLCM*(pixel)≠0
    DLCM(pixel)=1
    End
    Until all points of the image are scanned
Return *DLCM*
End

Figure 4. DLCM algorithm.

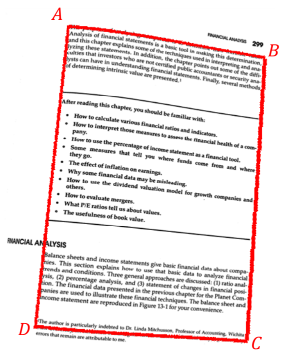


Figure 5. Schematics of warped surface of document images.

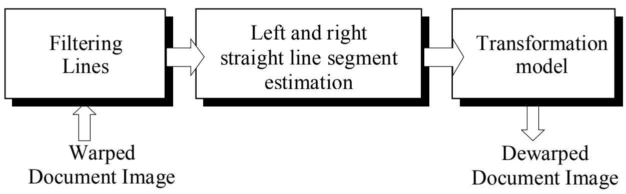


Figure 6. Flowchart of detecting curved surface

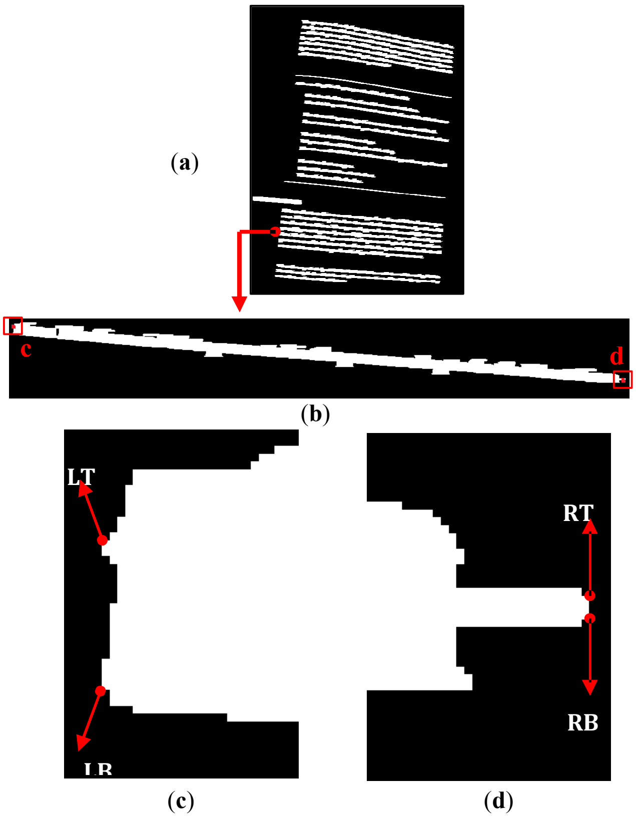


Figure 7. Start and end point of each text, **a** image with detected lines, **b** one separated line, **c** left top point (LT) and left bottom point (LB), **d** right top point (RT) and right bottom point (RB).

2. 2. 4. Top and Bottom Curved Line Estimation

Having the left (AD) and right (BC) boundaries detected, we need to determine AB and CD curved lines to complete the curved surface model. For this, central points of each connected component of AB and DC text lines is determined. Then, coefficients of 3rd degree polynomial of central point are calculated using a Least Squares Estimation method. As you see in Figure 8, the blue rectangles and red points indicate connected components and their central points, and green curved lines represent the interpolated curved lines. Figure 9 shows the complete surface model. Green point represent remained lines that are extracted from section 2. 2. 3.

2. 3. Transformation Model

To dewarp the document we must generate a transformation model that map the curved surface to a 2-D rectangular area as shown in Figure 10. Flowchart of this stage is shown in Figure 11.

2. 3. 1. Transformation Function

Let A', B', C', D' denote the corner points of the rectangular area (see Figure 10). One of them coincides with one of the dominant corner points of the projection of the curved surface (A ≡A) and the rest of them are calculated by taking into account the width W and the height H of the rectangular area. For calculating W and H, assume that A=(x_a,y_a), B=(x_b,y_b), C=(x_c,y_c), and D=(x_d,y_d). Since AD and BC are straight lines, lengths of them are simply calculated by |AD| and |BC| use Euclidean distance:

$$|AD| = d(A,D) = \sqrt{(x_a - x_d)^2 - (y_a - y_d)^2} \quad (3)$$

$$|BC| = d(B,C) = \sqrt{(x_b - x_c)^2 - (y_b - y_c)^2} \quad (4)$$

However, AB and DC are not straight lines, so to calculate their lengths, we calculate the sum of Euclidean distances between each successive components:

$$|\widehat{AB}| = \sum_N d(p_i, p_{i+1}) = \quad (5)$$

$$\sum_N \sqrt{(x_{i+1} - x_i)^2 - (y_{i+1} - y_i)^2}$$

where, p_i is the centre point of i th component of the line and N is the number of components on that line. $|\widehat{DC}|$ is calculated similarly. Width W and height H of the rectangular area are calculated as follows:

$$H = \min(|AD|, |BC|) \quad (6)$$

$$W = \min(|\widehat{AB}|, |\widehat{DC}|) \quad (7)$$

Now, that rectangular area has been defined, each point *O(x,y)* located on the curved surface must be mapped to the corresponding point O *(x ,y)* on the rectangular area. At first we define a correspondence between all points of AC and BD; two points E and G are correspondent if they satisfy Equation (8):

$$\frac{|\widehat{AE}|}{|\widehat{AB}|} = \frac{|\widehat{DG}|}{|\widehat{DC}|} \quad (8)$$

The corresponding point *O (x ,y)* in rectangular area is calculated by finding two points *E(x ,y)* and *h(x ,y)* using following equations. These equations preserve the ratio between projection of the curved surface and the rectangular area in the x direction Equation (9) as well as in the y direction Equation (10):

$$\frac{|\widehat{AE}|}{|\widehat{AB}|} = \frac{|A'E'|}{W} \Rightarrow |A'E'| = \frac{W}{|\widehat{AB}|}|\widehat{AE}| \quad (9)$$

$$\frac{|EG|}{|EO|} = \frac{H}{|A'h|} \Rightarrow |A'h| = \frac{H}{|EG|}|EO| \quad (10)$$

2. 3. 2. Transformation of Defined Points To find point *O* (*x* ,*y*), corresponding point of *O(x,y)*, in the rectangular area, we divide the curved surface into four parts as shown in Figure 12. For each part, a specific transformation model is defined:

1- Points on the top of AB and to the right of AD

$$x' = x_a + |A'Z| \qquad y' = y_a - |A'h| \tag{11}$$

2- Points at the bottom of AB and to the right of AD

$$x' = x_a + |A'Z| \qquad y' = y_a + |A'h| \tag{12}$$

3- Points on the top of AB and to the left of AD

$$x' = x_a - |A'Z| \qquad y' = y_a + |A'h| \tag{13}$$

4- Points at the bottom of AB and to the left of AD

$$x' = x_a - |A'Z| \qquad y' = y_a - |A'h| \tag{14}$$

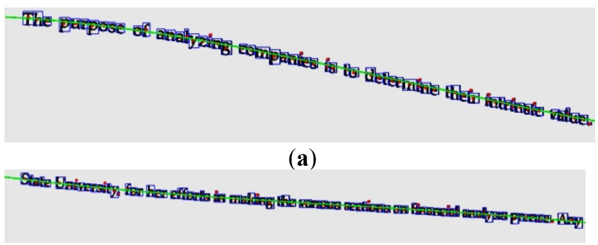


Figure 8. Top and bottom curved line estimation, (a) top curve line, (b) bottom curve line.

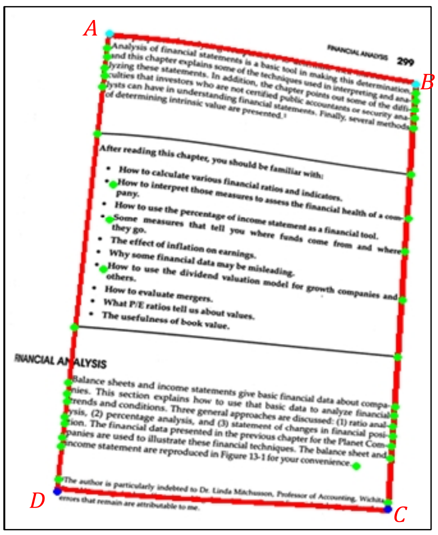


Figure 9. A sample of estimation of curved surface.

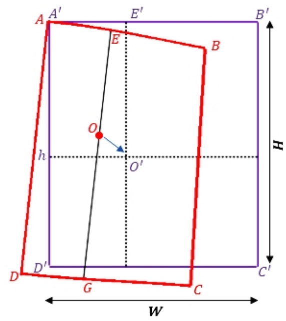


Figure 10. Transformation model.

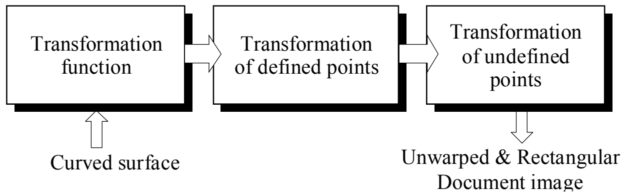


Figure 11. Flowchart of Transformation model.

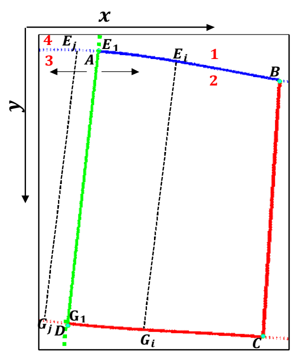


Figure 12. Dividing curved surface into 4 areas according to Equation (11)– Equation (14)

2. 3. 3. Transformation of Undefined Points All points which are not included at the projection area of the curved surface, inherit the transformation of the nearest point. As you see in Figure 13, these points are some columns that are not located on any line like E_iG_i. To solve this problem, run-length method is applied on columns with all-zero values. Value of a point will change if values of its left and right neighbors equal to one. Figure 14 illustrates this procedure on a sample from DFKI-I database.

3. EXPERIMENTAL RESULT

To evaluate the proposed method, we randomly selected 50 document images from DFKI-I dataset [21]. DFKI-I dataset contains 102 both grayscale and binarized document images of pages from several technical books captured by an off-the-shelf handheld digital camera in a normal office environment. Document images in this dataset consist of warped text-lines. Also, DFKI-I contains both non-graphical and graphical regions beside text lines. This dataset is binarized with Bukhari binarization method [22] and extra margins ,The dark border and noisy text regions from neighboring page, removed by the method proposed in [23].

One widely-used figure of merit for dewarping algorithms is the improvements of the OCR results. We sent dewarped documents with different algorithms to Omnipage 18.0[1], a commercial OCR system. Surely, it does not measure how well the dewarping algorithm works on non-text parts, like math or graphic regions. However, it is still better than visual evaluation.

To verify the validity and effectiveness of the proposed method, we carried out OCR testing on original and rectified document images using the word accuracy measure [24]. Word accuracy is defined as the number of corrected words to the total number of words in the correct document transcription.

$$Word\ \text{Accuracy}=\frac{\#Words - \#\,Misrecognized\ \text{words}}{\#Words} \tag{15}$$

A word in the result is considered correct if all of its characters are correct.

Our method has two parameters that may be changed: minimum operator in Equation (7) is used for finding the width of rectangular area, but it may be changed to Maximum operator. Furthermore, center of each word in top and bottom text lines is replaced by center of connected components for interpolation of top and bottom curved lines. These alternatives are also used in the following to compare the results. Table 1 shows the results.

Also, we compared the proposed method with SEG [13], Snake [11], and SKEL [15] methods as well as the commercial package Limb processig unit[2]. Table 2 illustrates the comparative results of all five dewarping methods with respect to the word accuracy results. A representive result is shown in Figure 15.

As you see in this Figure, the proposed method can also deal with non-text content but SEG and Snake didn't have good result. SKEL method is sensitive to the approximation of vertical borders' deformation in text blocks. it diminishes the accuracy and the warping lines could be seen. Finally, Limb cannot handle all distortions of the original document and several text lines are not straightened.

TABLE 1. word accuracy result of proposed methods.

Rectification methods	#words	#Misrecognized words	Word Accuracy
Without Rectification	15681	1421	90.9380%
Max w & center of connected components	15681	328	97.9082%
Min w & center of words	15681	272	98.2654%
Max w & center of words	15681	221	98.5906%
Min w & center of connected components (finally proposed method)	15681	101	99.3622%

TABLE 2. word accuracy result of proposed method vs. different rectification methods.

Rectification methods	#words	#Misrecognized words	Word Accuracy
Without Rectification	15681	1421	90.9380%
SEG method [13]	15681	787	94.9811%
Snake method [11]	15681	590	96.2374%
Limb [2]	15681	232	98.5205%
SKEL method [15]	15681	217	98.6324%
Proposed method	**15681**	**101**	**99.3622%**

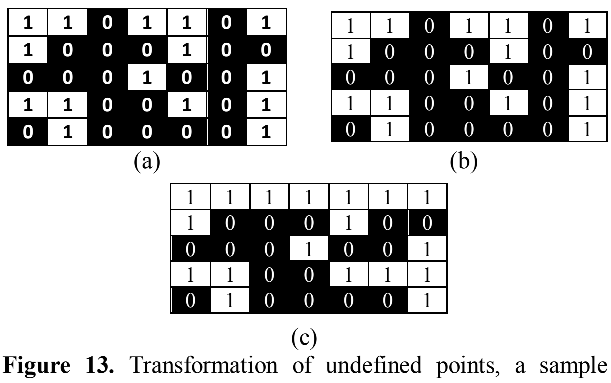


Figure 13. Transformation of undefined points, a sample binary image, b columns with zero values in red, c changing undefined point to one.

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[1] OmniPage 18 (2011). http://www. nuance.com/, visited at 09/20/2013.

[2] Limb (2013). http://www.i2s-digibook.com/, visited at 06/07/2014.

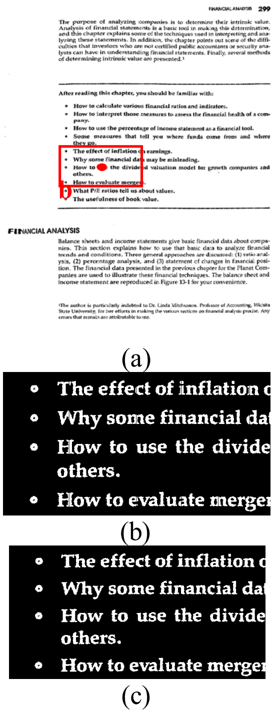

Figure 14. Transformation of undefined points, a result of image of section 2.3.3, b magnification of specifying by rectangle, c detecting all-zero columns and correcting undefined points.

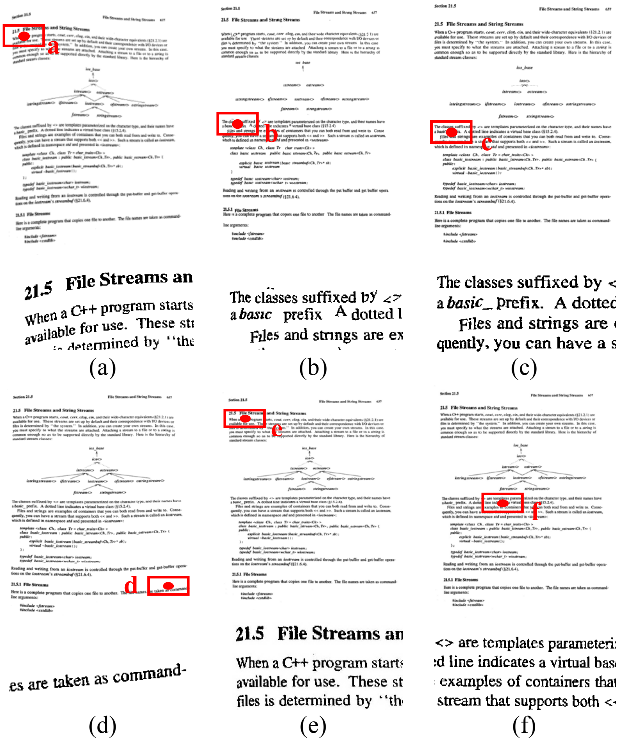

Figure 15. Comparing result of different rectification methods, a warped image from DFKI-I, b SEG method, c Snake method, d SKEL method, e Limb, f Proposed method.

4. CONCLUDING REMARKS

The proposed transformation model has been described in order to remove undesirable distortions from English document images. Our method doesn't need to find all words in text line. The proposed methodology increases the confidence of the OCR engine as it further reduces the suspect characters produced by OCR Engine. Our method and three groups participated in the competition with their methods, the result showed that proposed methods performed better than the other three methods.

5. REFERENCES

1. Hassanpour, H. and Ghadi, A.R., "Image enhancement via reducing impairment effects on image components", ***International Journal of Engineering-Transactions B: Applications***, Vol. 26, No. 11, (2013), 1267-1274.

2. Ashourian, M., Daneshmandpour, N., Tehrani, O.S. and Moallem, P., "Real time implementation of a license plate location recognition system based on adaptive morphology", ***International Journal of Engineering-Transactions B: Applications***, Vol. 26, No. 11, (2013), 1347-1356.

3. Khosravi, H. and Kabir, E" ,.A blackboard approach towards integrated farsi ocr system", ***International Journal of Document Analysis and Recognition (IJDAR)***, Vol. 12, No. 1, (2009), 21-32.

4. Keyvanpour, M., Tavoli, R. and Mozafari, S., "Document image retrieval based on keyword spotting using relevance feedback", ***International Journal of Engineering-Transactions A: Basics***, Vol. 27, No. 1, (2013), 7-14.

5. Yamashita, A., Kawarago, A., Kaneko, T. and Miura, K.T., "Shape reconstruction and image restoration for non-flat surfaces of documents with a stereo vision system", ***In Proceeding of 17th IEEE Intentional Conference on Pattern Recognition***. Vol. 1, (2004), 482-485.

6. Cao, H., Ding, X. and Liu, C., "Rectifying the bound document image captured by the camera: A model based approach", ***In Proceeding of IEEE Intentional Conference on Document Analysis and Recognition***, (2003), 71-75.

7. Zhang, L., Yip, A.M., Brown, M.S. and Tan, C.L., "A unified framework for document restoration using inpainting and shape-from-shading", ***Pattern Recognition***, Vol. 42, No. 11, (2009), 2961-2978.

8. Ghods, A.R., Mozaffari, S. and Ahmadpanahi, F., "Document image dewarping using kinect depth sensor", ***In 21st Iranian Conference on Electrical Engineering***, (2013), 1-6.

9. Lavialle, O., Molines, X., Angella, F. and Baylou, P., "Active contours network to straighten distorted text lines", ***In Processing of IEEE International Conference on Image Proceedings*** Vol. 3, (2001), 748-751.

10. Zhang, L. and Tan, C.L., "Warped image restoration with applications to digital libraries", ***In Proceedings of IEEE International Conference on Document Analysis and Recognition***, (2005), 192-196.

11. Bukhari, S.S., Shafait, F. and Breuel, T.M., "Dewarping of document images using coupled-snakes", ***in Proceedings of Third International Workshop on Camera-Based Document Analysis and Recognition***, Barcelona, Spain. , (2009), 34-41

12. Zhang, Y., Liu, C., Ding, X. and Zou, Y., "Arbitrary warped document image restoration based on segmentation and thin-

plate splines", In IEEE International Conference on Pattern Recognition., (2008), 1-4.

13. Gatos, B., Pratikakis, I. and Ntirogiannis, K., "Segmentation based recovery of arbitrarily warped document images", In IEEE International Conference on Document Analysis and Recognition Vol. 2, (2007), 989-993
14. Brown, M.S. and Tsoi, Y.-C., "Geometric and shading correction for images of printed materials using boundary", ***IEEE Transactions on Image Processing***, Vol. 15, No. 6, (2006), 1544-1554.
15. Masalovitch, A. and Mestetskiy, L., "Usage of continuous skeletal image representation for document images de-warping", in Proceedings of International Workshop on Camera-Based Document Analysis and Recognition, Curitiba., (2007), 45-53.
16. Shamqoli, M. and Khosravi, H., "Warped document restoration by recovering shape of the surface", **In *8th Iranian Conference on Machine Vision***., (2013), 262-265.
17. Stamatopoulos, N., Gatos, B., Pratikakis, I. and Perantonis, S.J., "Goal-oriented rectification of camera-based document images", ***IEEE Transactions on Image Processing***, Vol. 20, No. 4, (2011), 910-920.
18. Bukhari, S.S., Shafait, F. and Breuel, T.M., An image based performance evaluation method for page dewarping algorithms using sift features, ***in Camera-based Document Analysis and Recognition***. (2012), Springer. 138-149.
19. Stamatopoulos, N., Gatos, B. and Pratikakis, I., "A methodology for document image dewarping techniques performance evaluation", In IEEE International Conference on Document Analysis and Recognition., (2009), 956-960.
20. Shi, Z. and Govindaraju, V., "Multi-scale techniques for document page segmentation", In Proceedings of 8th International Conference on Document Analysis and Recognition., (2005), 1020-1024.
21. Shafait, F. and Breuel, T.M., "Document image dewarping contest", ***In International Workshop on Camera-Based Document Analysis and Recognition,*** Curitiba, Brazil., (2007), 181-188.
22. Bukhari, S.S., Shafait, F. and Breuel, T.M., "Foreground-background regions guided binarization of camera-captured document images", in Proceedings of the International Workshop on Camera Based Document Analysis and Recognition. Vol. 7, (2009)
23. Shamqoli, M. and Khosravi, H., "Border detection of document images scanned from large books", in Machine Vision and Image Processing (MVIP), 8th Iranian Conference on, IEEE, (2013), 84-88.
24. Kanai, J., Nartker, T.A ,.Rice, S. and Nagy, G., "Performance metrics for document understanding systems", in Document Analysis and Recognition, Proceedings of the Second International Conference on, IEEE., (1993), 424-427.

Document Image Dewarping Based on Text Line Detection and Surface Modeling

RESEARCH NOTE

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چکیده

وقتی سند توسط اسکنر و یا دوربین دیجیتال تهیه شده باشد، همواره با دو نوع مشکل یکی تخریب فتومتریک و دیگری تخریب هندسی مواجه است که در بیشتر موارد باعث تخریب عملکرد سیستم‌های نویسه‌خوان نوری (OCR) می‌شوند. در این مقاله، روشی برای برطرف کردن تخریب هندسی برای منظور افزایش خوانایی تصاویر سند در نرم‌افزارهای OCR معرفی شده است. روش پیشنهادی بر اساس یافتن خطوط نوشتاری تصویر با استفاده از الگوریتم DLCM و سپس اعمال یک تابع انتقال کم هزینه برای تصویر کردن سطح خمیده اسناد به یک سطح دو بعدی مستطیل شکل می‌باشد. برای ارزیابی عملکرد روش پیشنهادی، از پایگاه داده‌ی DFKI-I، که شامل اسناد تولید شده به وسیله‌ی دوربین دیجیتال با اعوجاج‌های متنوع است، استفاده کرده و این روش را با چهار روش مشهور مقایسه می‌کنیم. نتایج حاصله بیانگر اثر بخشی و برتری روش پیشنهادی می‌باشد.

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