European Journal of Research Development and Sustainability (EJRDS)
Available Online at: https://www.scholarzest.com
Vol. 3 No. 2 February 2022
ISSN: 2660-5570

A MORPHOLOGY-BASED METHODS OF CORRECTING PRINTED AND HANDWRITTEN GEORGIAN TEXT IMAGES

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Article history:

Received: 7th December 2021
Accepted: 6th January 2022
Published: 13th February 2022

Abstract:

This paper discusses issues of correction of printed and handwritten texts using mathematical morphological methods, word and letter skew correction, segmentation, localization and filtering of gradient backgrounds of images resulting from uneven illumination. Through the use of developed algorithms, we are able to significantly improve the quality of the original image

Keywords: Image processing, mathematical morphology, marketing, video surveillance, drones, security, barcodes, car plate numbers, human faces, mining, OCR.

Image processing and analysis are important applications of mathematical morphology. This applies to both binary and achromatic and multichannel images. Currently, it is hard to find a field that does not require image processing and analysis. These are medicine, marketing, video surveillance, drones, security, barcodes, car plate numbers, human faces, mining, OCR.

In terms of detection and recognition problems in OCR field is the restoration exercises of printed and handwritten images.

One of the first steps in processing of the printed and handwritten images is to filter out the images from different sources for unwanted noise and distortion effects. The images obtained from the scanner are one of the most important sources of textual imagery, since the uneven lighting creates a gradient background effect on the image. Further image analysis and transformation require the removal of this background effect as much as possible.

The morphological top-hat operation can be used to reduce the gradient effect caused by uneaven illumination, since top hats with wide isotropic structural elements act as high-frequency filters on images. [1]

Considering the fact that intensity of text objects inside the text documents is higher than the intensity variation of the gradient background [3] using morphological opening and closing operations all objects smaller than the structural element will be removed, and regions bigger then structural element will remain. Hence, using top-hat we can achieve evenly illuminated image. However, we need take into consideration that by increasing the size of the structural element we will face fake edges caused by so called block effect [2].

The noise generated by the block effect can be reduced by modifying morphological top-hats with opening and closing by reconstuction algorithms.

Opening by reconstruction operation allows us to easily detect the background of the image.

As a result, by substituting the base opening operator with an opening by reconstruction, we can obtain a modified top-hat with properties better suited to the given problem.

$$\tilde{g}^{w}(f) = f - \tilde{\gamma}_R(f) \qquad (1)$$

In spite of the fact that the modified white top hat perfectly equalizes light in the image, resulting in a background with balanced illumination without blocking, this operation introduces a new problem - part of the text is perceived as background due to over-illumination [4].

Our solution is to use the dual operation of opening by reconstruction - reconstruction by closing, which removes incorrectly perceived textual information from the background, obtaining only the background of the image.

$$\tilde{\phi}_{\gamma}(f) = \tilde{\phi}_R[\tilde{\gamma}_R(f)] \qquad (2)$$

As a result, the modified top hat looks as follows:

$$\tilde{g}(f) = f - \phi_{\gamma}(f) = f - \tilde{\phi}_R[\tilde{\gamma}_R(f)] \qquad (3)$$

An example of a gradient background filtered with white top-hats is shown in Figure 1.

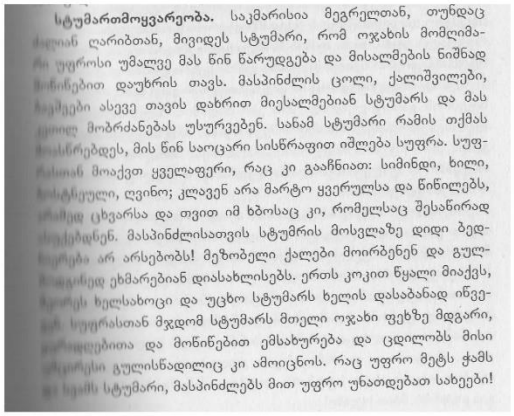


Figure 1.a - Initial gray tone image with uneven lighting and gradient background

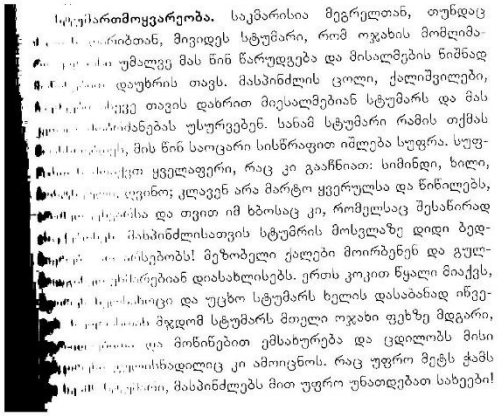


Figure 1.b - Binary image converted by threshold operation

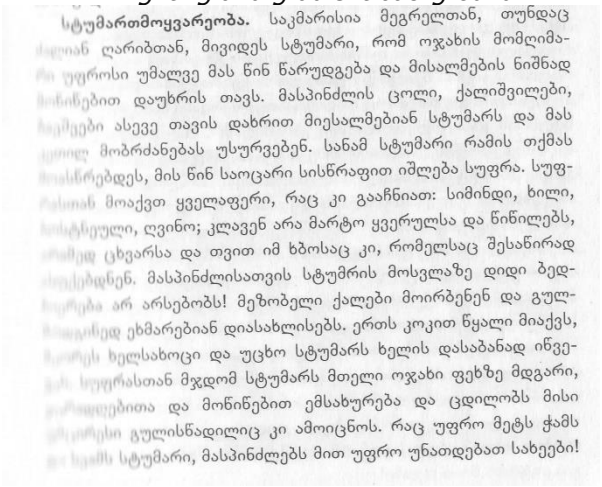


Figure 1.c - Image processed with a morphological top hat, using square structural element of 40 pixels.

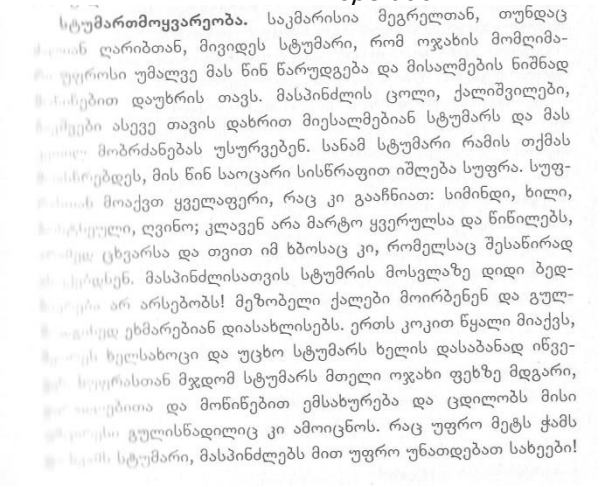


Figure 1.d – Image processed with a modified top hat, where the morphological opening is replaced with opening by reconstruction.

Besides the gradient background, one of the difficulties in analyzing handwritten texts is that the letters and words tend to be skewed, which makes the process of analyzing and recognizing them complicated. The inclination of the letter is the angle formed between the initial level of the word (Baseline) and to its horizontal direction. This inclination can be removed by turning the entire text in the direction of the horizon, while specific skewed letters can be corrected by adjusting the angle of connected pixels of letter relative to the baseline. [1].

Tilt correction of printed handwritten text examples are shown on Fig.2 [4]. We use CV2 and Skimage libraries for image correction.

As a first step in shown example, we recreate the images tilted at different angles, on the recreated images where the text is tilted at different angles, we perform deslanting operation, as a result of which we get the image aligned to the horizontal line (Fig. 2c, d).

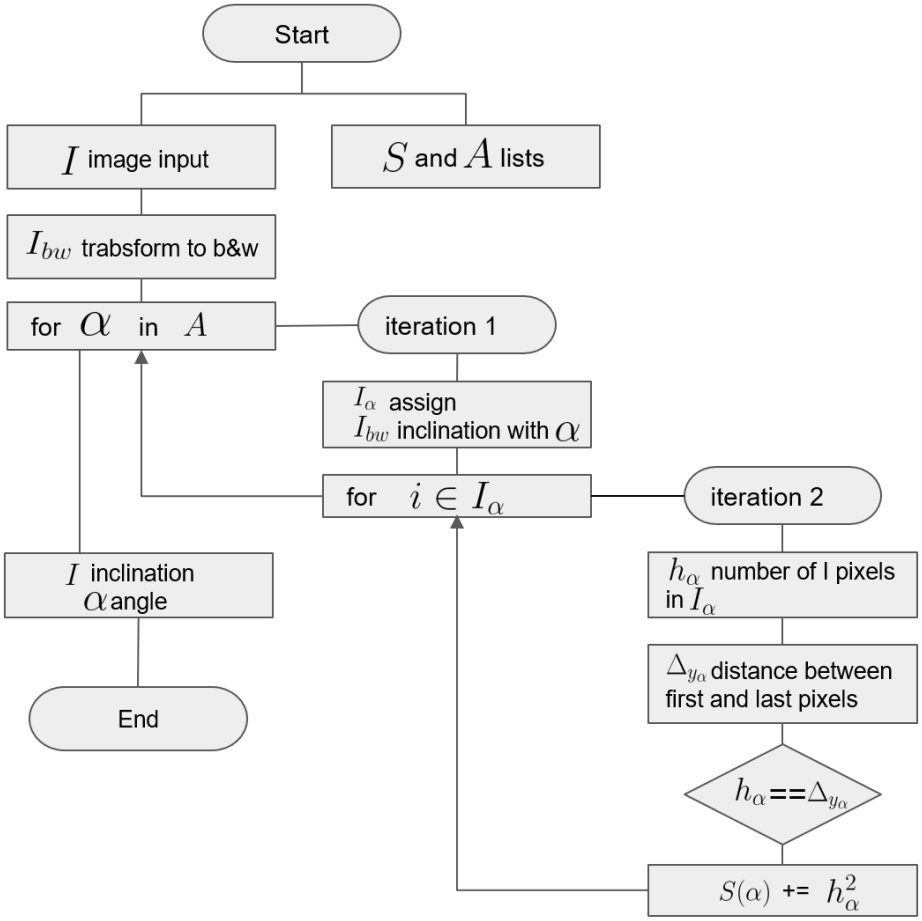
a) Image inclined by -15 degrees

b) Image inclined by +30 degrees

c) Corrected Image

d) Corrected Image

An deslanting operation (Fig.3) has been used to convert skewed printed and handwritten texts and lines (words, letters) into a normal initial state, which allows us to adjust texts of different orientations and inclinations. [5]

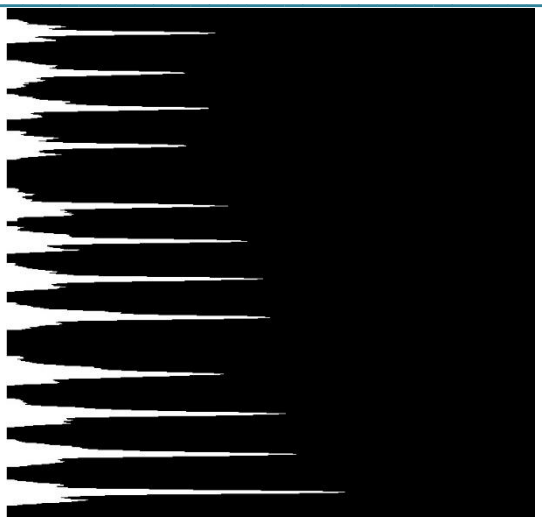


In order to extract the text lines from already binarized image we use histogram projections, which is one of the simplest and fast way of text segmentation.

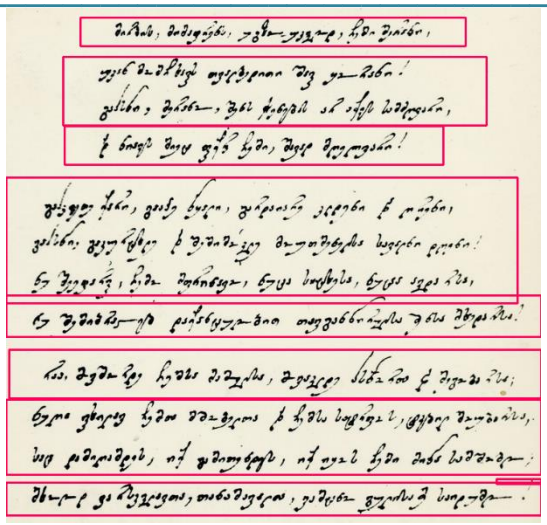
To separate the lines of text on a banarized image, we use the histogram projection operation, which is a simple and fast method for segmenting handwritten texts.[6]

As texts usually lay from 0-90 degrees in direction (except for some Asian scripts), we need to project the histogram on Y axis, so that the histogram peaks correspond to the text direction, while regions with low histogram height indicate potential spaces between text lines. Thus, we can segment the text lines based on the minima and maxima in the histogram.

Fig.4 shows an example of a histogram projection of a handwritten text.



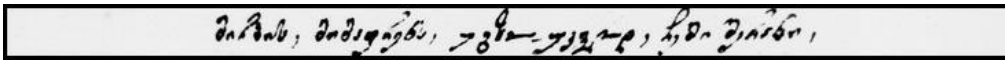
Histogram projection of text lines



Segmented text using normal segmentation algorithms

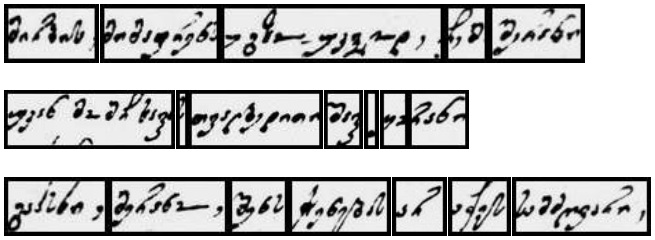
Fig. 5 shows an example of segmentation of manuscript text lines obtained by projection of histograms on the Y axis.

1

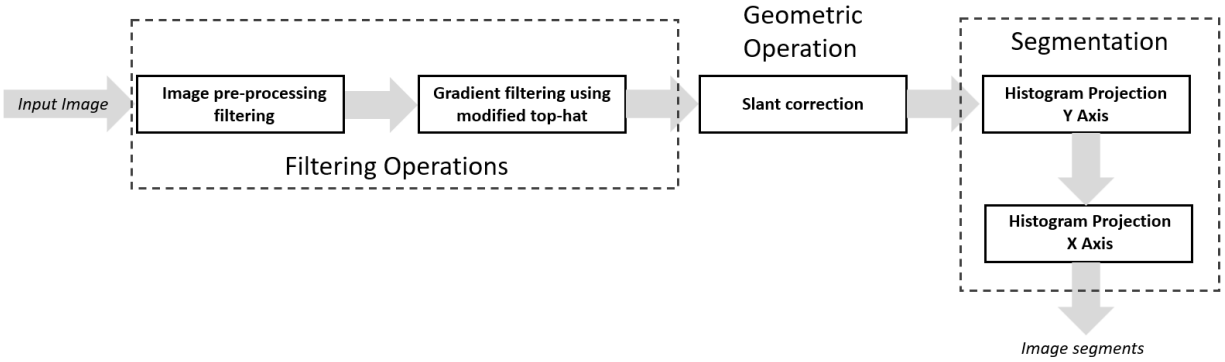


2

Once we have segmented the lines of text, and separated them from each other, it is possible to perform segmentation of the histogram projection for each segment this time with respect to the X axis resulting in segmentation into words.[7] An example of segmenting lines into words is shown in Fig 6.



The processing steps and the methods used by the algorithm from the initial image to the segmented image into lines and words are shown in Fig 7.



CONCLUSION

Those, we have used morphological top-hat algorithm to remove background gradient caused mostly by uneven illumination, which as a result gave us image without gradient background however, this operation introduced undesirable blocking effect, which was eliminated by modification of top-hat algorithm with morphological reconstruction operations.

The image filtered from background gradient using top-hat operation was further processed for text line de-slanting and adjustment for horizontal direction. This was further processed for line segmentation using the histogram projection algorithm on Y axis and word segmentation using the histogram on X axis. Finally, we received a segmented document that is easier to process for the recognition exercises.

The results and algorithms obtained in the paper can be used for automatic and semi-automatic scanning and digitization of archival documents, when the skewed images with background gradient obtained from the scanning device are corrected horizontal position and filtered from unwanted illumination effects and noises.

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