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HYBRID IMPLEMENTATION OF LEVEL SET AND SKELETONISATION FOR BATAK TOBA HANDWRITING

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ABSTRACT

Batak Toba handwriting is a family of Batak handwriting and became Indonesia's cultural heritage. Batak Toba handwriting was not used for everyday purposes, but one is used to write "pustaha" scripts which contain mostly shamanism and in 1852 began to be destroyed, so it needs to be preserved. Batak Toba script which contained in an obsoleted manuscript or other print media can be obtained using image processing techniques. This study implements a hybrid method of level sets and skeletonisation. Level set method is used to detect the contours of the Batak Toba script and the skeletonisation is used to process thinning, thus obtained from the Toba Batak alphabet characters that shaped the image of the manuscript. Through this research is expected to contribute in expansion of the implementation of method in image processing, thus Batak Toba script information can be preserved.

***Key word** : level set, skeletonisation, thinning, Batak Toba handwriting*

1. Introduction

Character Batak Toba letters or characters appearing on a document or manuscript that has obsolete can be obtained by using image processing techniques. By making the print media that contains characters Batak Toba characters into an image, then further image processing can be done. In image acquisition process, images sometimes contain noise due to the low quality of the document images, so this became one obstacle in image processing, especially if the object to be processed on the small image like this character Batak Toba script.

Image processing can be performed by numerical approach, for example by the level set method. Level sets can be used for image enhancement, image segmentation, irregularities surface reconstruction and others [1]. In [2] and [3] the level set is used as an operator to edit the surface in 3-dimensional image and in [4] summarize the algorithms for producing level set input models and for localizing/minimizing computation during the editing process. In [5] level set is used for reconstructing a smooth surface from a sparse set of parallel binary contours, e.g. those produced via histologic imaging. It creates a volume dataset by interpolating 2D filtered distance fields.

Level sets are also often used for segmentation, eg in medical image segmentation iliac bone structures from CT (Computed Tomography) [6]. Besides, segmentation with level sets are used to segment the tumour or the white matter of a brain from a given MRI image and in airport screening, one might wish to segment certain 'sensitive' shapes, such as weapons [7]. [8] combining level set to segment the boundary at points of maximal positive curvature and a distance map from each of the segments for determining the skeleton (medial axis transform) of an object.

In this research level set method is used as a segmentation to detect the contours of the Batak Toba characters in the image based on region-based models, then the thinning method result a framework called the skeleton, which is considered to represent the shape of the object or character in the form as one pixel of the image, by removing the points or the outermost layer of the image [9]. Thining method used in this research is the Zhang-

Suen method. Tests performed on an image that contain noise. Through this research is expected to contribute to the expansion of the implementation of the method in image processing, by combining the level set and thinning to get the skeleton of Batak Toba character. Thus Toba Batak script information can be preserved.

2. Batak Toba Script

Batak Toba script is classified as abugida, which is a combination between silabogram (writing system with the basic unit in the form of a consonant followed by a vowel) and the alphabet. Batak Toba script consists of two devices letter, call *ina ni surat* and *anak ni surat*. *Ina ni surat* consists of letters that ended silabik basic sound /a/ (except for the letters i and u), while the *anak ni surat* is the addition diaktrik to change sound /a/ in *ina ni surat* by adding phonetic value.

The order is known so far and is often used in ina ni letter is a-ha-na-ra-ta-ba-wa-i-ma-nga-la-pa-sa-da-ga-ja, used to be easy to remember in form of the phrase "aha na rata bawa i mangalapa sada gaja ", in Bahasa Indonesia which means "apa yang hijau lelaki itu memotong seekor gajah" [10] [11]. Sample letter to *ina ni surat* of Toba Batak script can be seen in Figure 1.

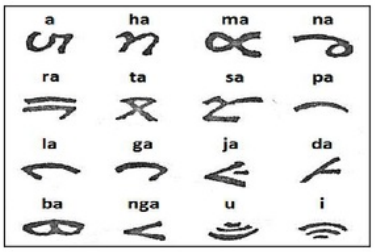

Figure 1. Characters of *ina ni surat*

3. Level Set

The level set method for capturing moving fronts was introduced in Osher and Sethian (1988) [7]. Level sets are used for approximating the dynamics of moving curves and surfaces using partial derivative equations (PDE). Level set methods are used for the evolution of the movement curve / interface that is due to a force [12][13]. Active contour models have been extensively applied to image segmentation. Existing active contour models can be categorized into two major classes: edge-based models and region-based models. (Li, Minimization).

The algorithm used for segmentation using the level set is as follows [12]:

Input : Feature Image *I*, Initial mask *m*, Treshold *T*, Iteration *N*, Reinitialize Every *RITS*

Output : Segmentation Result

Initialize ϕ_0 to Signed Euclidean Distance Trasnform (SEDT) from mask *m*

Calculate Data Speed Term *D(I)* = $-|I - T|$ ... (1)

forall *N* Iterations do

Calculate First Order Derivatives $D_x^{(\pm)}, D_y^{(\pm)}, D_z^{(\pm)}$

Calculate Second Order Derivatives $D_x^{(\pm y,z)}, D_y^{(\pm x,z)}, D_z^{(\pm x,y)}$ #

Calculate Curvature Terms $\mathbf{n}^+, \mathbf{n}^-$

Calculate Gradient ∇_ϕ

Calculate Speed Term

$$F = \alpha D_{\vec{x}} + (1-\alpha)\nabla.\frac{\nabla_\phi}{|\nabla_\phi|} \quad \ldots (2)$$

Update Level Set Function

$$\phi(t + \Delta t) = \phi(t) + \Delta t F|\nabla_\phi| \ldots (3)$$

if Iterations % *RITS* == *0* **then**

Reinitialize to SEDT

end

end

Partial Differential Equation (PDE) :

$$\frac{\partial f}{\partial t} + \vec{S}.\nabla f + V_N|\nabla f| = b\kappa|\nabla f| \ldots (4)$$

Vector Field Based | In Normal Direction | Curvature Based

Interface translation :

$$\frac{\partial f}{\partial t} + \vec{S}.\nabla f = 0 \ldots (5)$$

$$\frac{\partial f}{\partial t} + \frac{\partial f}{\partial x} + \frac{\partial f}{\partial y} = 0 \ldots (6)$$

Force in normal direction

$$\frac{\partial f}{\partial t} + V_N|\nabla f| = 0 \ldots (7)$$

Vn = 1 : Interface expansion

Vn = -1 ; Interface shrinkage

f(x,y) = *(x,y)* = pixel intensity curve/edge

Curvature term $\nabla.(\nabla_\phi/|\nabla_\phi|)$ keeps the level set function smooth. The data function *D(I)* acts as the principal 'force' that drives the segmentation. *T* describes the central intensity value. describes the intensity deviation around T. The derivatives required for the level set equation update. $\mathbf{n}^+$, $\mathbf{n}^-$ are the two normal used to compute divergence, allowing for mean curvature to be compute.

4. Thinning

Thinning is an image pre-processing technique that is important in a number of applications like pattern recognition, data compression and data storage [14]. It reduces a large amount of memory usage for structural information storage [15]. Thinning operation is used to take the order as thick as one pixel of the image, by removing the points or the outermost layer of the image. The resulting framework is called the skeleton, which is considered to represent the shape of the object. In the line-shaped image, skeleton shows all the information from the original object. The components of the skeleton, namely position, orientation, and length of line segments representing the skeleton lines memberntuk image. These components facilitate the characterization of the components of the image. For example, the length of a form can be estimated by calculating the ends and the farthest point on the skeleton [9].

An effective thinning algorithm is one that can ideally compress the data, eliminate local noise without introducing distortions of it own. But the key goal is to retain the significant features of the pattern. In a search for a pixel side is checked by several criteria to determine whether a pixel side is removed or not. A large number of searches that occur are calculated based on the number of loops (loop) that occurs [16]. There are two types of thinning algorithms[17]:

a. Sequential thinning algorithms : result of n^{th} iteration depends on result of(n-lt iteration as well as pixels already processed in the nth iteration.
b. Parallel thinning algorithms : deletion ofpixels in of nlb iteration depends only on the result that remains after $(n-1)^{th}$ iteration.

4.1. Zhang-Suen Algorithm

Zhang-Suen algorithm was advanced first by Zhang T Y in 1984 [18]. This algorithm is one of some popular thinning algorithm. It's usually used as a basic to compare thinning algorithm. This algorithm is fast and easy to be implemented [19]. In applying these algorithms, we assume that background region pixels (white pixels) have the value "0" and the object regions (black pixels) have the value "1". Contour points are defined as points that have value "1" and they have at least one 8-neighbor pixel value equal to "0". Zhang-Suen thinning algorithm performs sub-iterations step wise[15].

- The first step

1. $2 \leq N(Pi) \leq 6$
2. $S(Pi) = 1$
3. $P2 * P4 * P6 = 0$
4. $P4 * P6 * P8 = 0$

Condition 3 and 4 represent value P4=0, or P6=0, or (P2=0 and P8=0) [20]

- The second step

Conditions 3 and 4 in the first step are replaced with the following conditions.

3. $P2 * P4 * P8 = 0$
4. $P2 * P6 * P8 = 0$

Condition 3 and 4 represent value P2=0, or P8=0, or (P4=0 and P6=0)

5. Experiment Result

In this study, the implementation is done using MATLAB 2010a. Implementation level set

method using a source code developed by Li [21] by changing sigma and iteration value, then performed thinning algorithm after the segmentation contour Toba Batak script in the image is found. Test image used an image of letter 'A' of Batak Toba script size of 56 x 42 pixels containing noise.

Level set is implemented for active contour models with region-based models. Segmentation begins with the initial contour (Figure 2). Segmentation by region-based models find the contours of the object based on the homogeneity of the Batak Toba characters, but if there inhomogeneity the object that is segmented, the algorithm is also able to handle it. Level sets continue to evolve to find the contours of the object so that the results obtained by the contour of the letter 'A' Batak Toba script (Figure 3). Iteration is used only 100 iterations, the number of iterations has been effective enough to find the contours of characters on the test image. In this implementation uses the sigma 5 (sigma values are quite high). With a high sigma value can increase robustness of the algorithm.

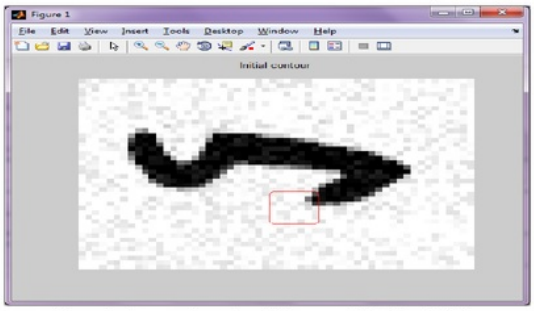

Figure 2. Countur detection of character 'A' of Batak Toba

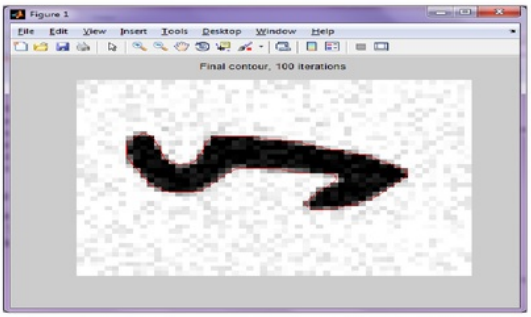

Figure 3. Countur detection of character 'A' of Batak Toba

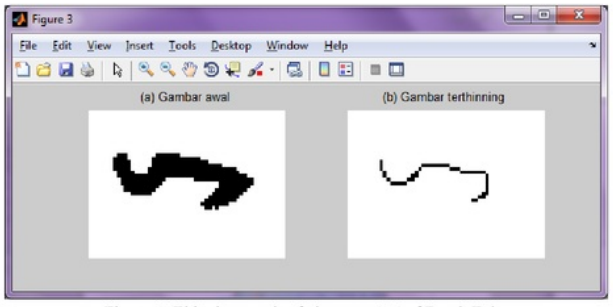

Figure 4. Thinning result of character 'A' of Batak Toba

Thinning algorithm that is used can also find the skeleton of the characters without being distracted by noise around the object contained in the image (Figure 4).

6. Conclusion

In this research, the level set segmentation is successfully implemented for Batak Toba characters on a small image and contains noise. This proves that the level set is also effectively used for segmentation in small-sized objects such as Batak Toba script, other than that iteration is used also do not need large quantities. Thinning process managed to get a skeleton of the Batak Toba script without being distracted by the noise contained around the object. Image segmentation results and thinning process that has been obtained can be useful to prepare digital documents for further computer aided analysis and to enable the use of simplified analysis techniques, e.g. feature extraction or Optical Character Recognition (OCR).

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