Improving Visual Presentation Of Bas Relief Image From Historical Temple

by Karina Auliasari

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***Abstract*—Two stages are developed in this research namely optimal pre-processing and main-processing. The pre-processing to enhance the presentation of image relief by using contrast stretching, histogram equalization and adaptive histogram equalization. Here the presentation of image is vital for the input of main process. Three operations of image enhancement are employed to improve image contrast, including contrast stretching, histogram equalization and adaptive histogram equalization. Comparison between contrast stretching with α value 1.1 and histogram equalization show that the gray-level of histogram equalization result are distributed. Experiment of show that the adaptive histogram equalization has produced the best image enhancement. After doing image enhancement the next step is to do threshold and edge detection operations. This procedure enhances horizontal or vertical edge of the figure. The image enhancement operation is very useful to remove the illumination no uniformities. Threshold process using Otsu algorithm shows that both of LPF kernel 1 and 2 output image have a similar result rather than LPF kernel 3. Three of LPF kernels has produced two different threshold values. Kapur algorithm show that both of LPF kernel 2 dan 3 output image have a similar result of rather than LPF kernel 1 output image. The experiment also show that Sobel and Canny operators has enhanced edges and weaken weak textures.**

Keywords— relief image; image enhancement; image analysis

I. INTRODUCTION

A relief is a sculptured artwork carved on the surface of the stone or wood. There are three types of relief namely as high relief, bas reliefs and sunken relief [1]. High relief have standout from the surface of the field. Meanwhile high relief could be found in the monument [2]. In Bas relief only half have standout from the surface. However in sunken relief, the relief have carved on the surface. In Indonesia many temple have applied bas relief as ornament style. A skillfull handcrafter is needed to restore of the temple because the works involve manual crafting of complicated figures and symbols found in every area of the temple. A relief have various meaning or stories and purpose. A symbols or figures in relief contains but human figures, animals and plants shape which are symbolic not naturalists. The animals and plants have a tendency to fill relief field beside the human figure. Each relief is observed to obtained the description or stories about the figure. This process produce the description of every icons from the relief. Most of the temples on Java island experience some damage due to their age that have been exicted on earth for hundreds years. The damages involve obsolescent, flaking, perforated and changes color [2]. These damages affect the shape of the figures or symbols of relief. Therefore to restore them, complicated works are required that involve the works of archeologists or other related reseacher to analyze the meaning of relief.

A number of research papers related to the use of image processing methods in the relief image are studied. A report of the literature review is presented here. Belhumeur *et. al* [3] developed some algorithm to reconstruct surface of bas relief. Their works require a structure of transformation from a shape to a corresponding bas relief. The technique employs shading and shadowing that are identical if the viewer's perspective changes slightly around an orthogonal view. However, if an optimum angle of view is exceeded, it produce distortion and unnatural results. This approach therefore ultimately relies on human perception. Weyrich *et. al* [4] demonstrated a technique to produce seamless reliefs that stitches figures with multiple heights. The example of this work is to generate a collage or a cubism-like piece of art. This approach lead to a noticeable reduction of user defined parameters. The result show that this approach is much simpler and faster without sacrificing the quality of the output. Kerber *et. al* [5] employed a single scale approach for unsharp masking in a bilateral filter. This approach is to smooth the gradient signal. A bilateral filter is known for its edge preserving nature. When being applied to a set of figures with different height, the algorithm ensures the sharpness of curvature extrema as they appear at ridges and valleys. Alexa and Matusik [6] created reliefs that present different appearance when the reliefs were illuminated from different direction of light sources. Instead of exposing relief to one constant lighting, they are capable of producing bas reliefs that contain information about a pair of input images. Their method was the first attempt to exploit the nature of reliefs. The complexity to retrieve edges from natural image object is high and indeed become an open research issue [7]. This study aims to automate the process of understanding temple relief, despite the difficulties to analyze the contents of natural images. This research also proposes several methods of image enhancement and image analysis to improve image visual quality of bas relief. The purpose is to restore the shape of the figures or symbols on the relief.

II. METHOD

The objective of the research is to improve visual presentation of relief images found in historical temples. Each fragment from the collection of relief images consists of several figures, in which the conditions of some of them experiences damage condition. The damage is due to obsolescent, flaking, perforated and changes color. Some stones are also experience eroded and mossy as shown in Fig. 1. Before processing the relief images, the size of image is set to 448 x 336 pixels in order to conserve memory usage and limiting the iteration.

Fig. 1. Relief image acquisition

The research aim to produce better relief image that involves image enhancement and segmentation process. Two main stages are included for visual analysis and object segmentation as shown in Fig. 2.

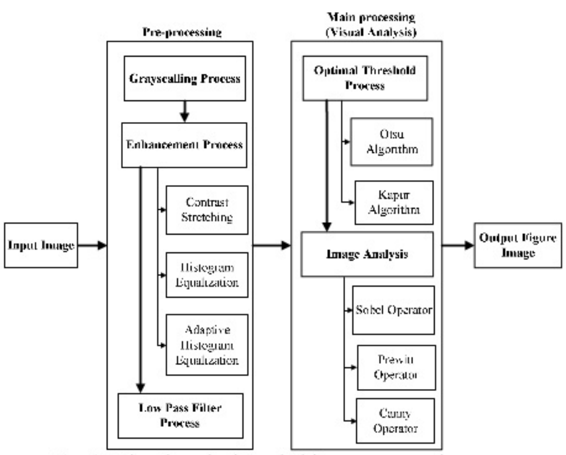

Fig. 2. Visual analysis and object segmentation stage

Several operations of image enhancement are employed to improve image contrast and spatial characteristics of image appearances such as reducing noise on distorted images, eliminating some form of focal and blur errors, modifying or correcting image geometry in order to combine many images. The digital image enhancement is to improve the visual quality from degraded image. The visual analysis stage is conducted on the result of three different image enhancement that include contrast stretching, histogram equalization and adaptive histogram equalization. Image enhancement using pixel point process to change the gray-level of each pixel in the input image to a new value. The general equation of point process follows formula 1, with M is an operation function with I as input pixel and O is the output. The brightness of an output pixel residing at coordinates (x,y) is equal to the brightness of input pixel at the same coordinate after being converted by the function M.

$$O(x,y) = M[I(x,y)] \quad (1)$$

One-by-one change the gray-level in the input image is modified to a new value and placed in the output image at the same spatial location. Using this operation, all pixels are modified individually in which the pixel at coordinates I(x,y) in the input image has been changed and returned to the output image at coordinate O(x,y) as shown in Fig. 3.

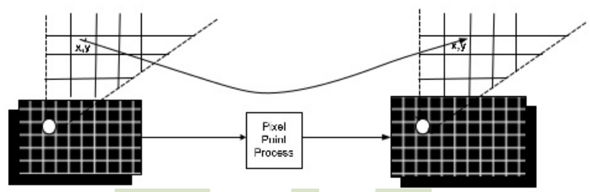

Fig. 3. Each pixel value in the input image is changed

Relief images with low-contrast and high-contrast are improved by pixel point process to change the intensity value of . The change of intensity value by contrast stretching operation is illustrated in mathematical equations as shown in Equation 2. Based on Equation 2 the contrast value is increased if the value of > 1 and decreased if the value <1.

$$O(x,y) = \alpha\, I(x,y) \quad (2)$$

Histogram equalization process is done by modifying the gray-level distribution into uniformity. The purpose of the histogram equalization is to obtain an even distribution of the histogram, so each degree of gray-level has a relatively equal number of pixels. Each degree of gray-level image is expressed by hist [k+ 1] where k is 0, 1, 2 to L-1, where L is the number of pixels of the gray-level. Histogram accumulation for all the pixels having k is represented by Equation 3. The next step the value of k replaced by the value of α according to the function as shown in equation 4 where N is the number of pixels in the image.

$$c[k+1] = \sum_{i=1}^{k} hist[k+1],\ k = 0,1,2,\ldots,L-1 \quad (3)$$

$$\alpha_k = round\left((L-1)\frac{c[k+1]}{N}\right),\ k = 0,1,2,\ldots,L-1 \quad (4)$$

The result of the developed algorithms for image enhancement would be compared to its others based on the visual appearance of original image. The best approach of image enhancement is selected based on visual analysis and would be passed to the filtering stage. The filtering stage employ low-pass kernel in order to reduce the noise. This process employs convolution operation that modify the value of a pixel with a number of neighboring areas of pixels based on predetermined kernel. The kernel is operated by shifting in the input image. The kernel is multiplied by the pixel area of the input image to obtain a new value of the output pixel as shown in Fig. 4. Low-pass filter (LPF) is used to eliminate the noise of a relief image. The low-pass kernel of this experiment process is [1/9 1/9 1/9; 1/9 1/9 1/9; 1/9 1/9 1/9], [1/16 1/8 1/16; 1/8 1/4 1/8; 1/16 1/8 1/16] and [1/10 1/10 1/10; 1/10 1/5 1/10; 1/10 1/10 1/10].

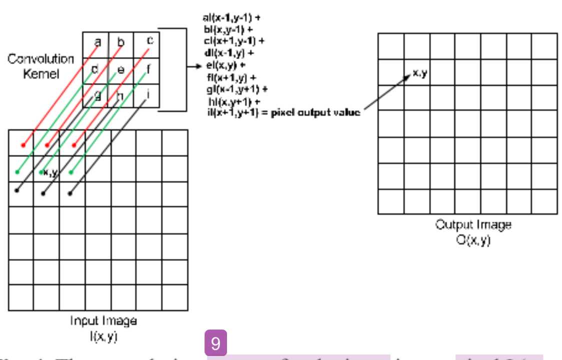

Fig. 4. The convolution process for the input image pixel I (x, y) modified on the output image pixel O (x, y)

Next stages is to employ thresholding and edge detection in order to localize image object. The threshold consist of Otsu [8] and Kapur algorithm [9]. Here Otsu method help to determine threshold value by clustering foreground and background histogram, while Kapur method is operated based on entropy value.

III. Experiment and Discussion

The data of relief images are obtained from several temple, located near Malang City, namely Candi Jago, Candi Kidal and Candi Singosari. Not all figures of reliefs have a complete shape. Some content of the relief image suffer from deterioration due to the condition of the temple. This condition show the complexity to deal with actual relief image obtained directly from the temple spot. Relief image prepared as input image has a dimensions of 340 x 648 pixels. The beginning of all processes is to do image enhancement of the input image. Prior to the image repair process, the input image is converted into grayscale first. Contrast enhancement is applied for the input image that after from high contrast. The results show a gray-level composition on image histogram indicating that the pixel value is dominated by a low gray-level value. Contrast stretching operations has improved a low-contrast image, with three different α values. The values is below 1 (0.8) and two values is more than 1 (1.1 and 1.4). The results of each α value are presented in Fig. 5. The result show that the α value 1.1 has a wide range of values. The output image with α value of 1.1 has no gray-level values dominating by dark or light color. The histogram of this result indicates a relatively uniform gray-level value. The comparison between contrast stretching with α value 1.1 and histogram equalization indicate that the gray-level of histogram equalization result are distributed. The output image from this comparison show that histogram equalization has more clear presentation than contrast stretching, that makes the relief object is more visible. A comparison result between histogram equalization and adaptive histogram equalization is shown in Fig. 6. The histogram equalization show good result but the gray-level change unnaturally and not significantly. The adaptive histogram equalization is capable of presenting a sharp object shape. Fig. 6 shows that the adaptive histogram equalization produces the best image enhancement.

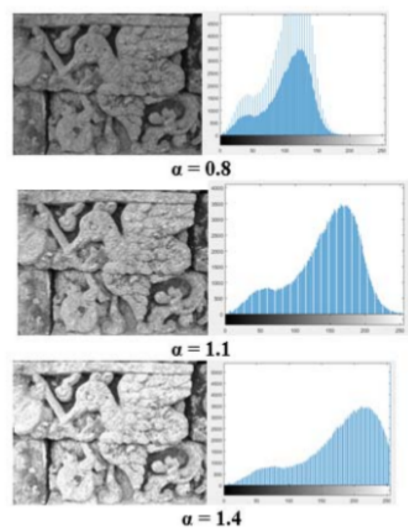

Fig. 5. Result of stretching contrast operation

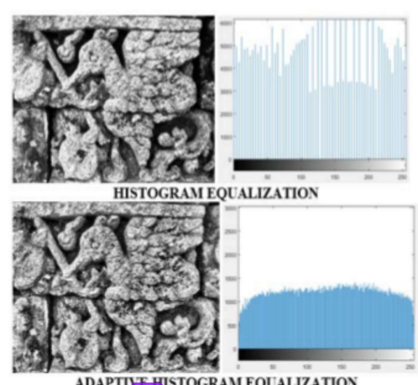

Fig. 6. Result histogram equalization and adaptive histogram equalization

The validity of the enhancement also be evaluated by image analysis process that employ threshold process and edge detection in order to localize image object. The threshold process using Otsu and Kapur algorithm [8], [9] are shown in Fig. 7. Before Otsu and Kapur algorithm is applied low-pass filter is used to pass smooth areas by considering both global and local information in the image. Three different kernel of LPF are employed. The results are shows in Fig. 7.

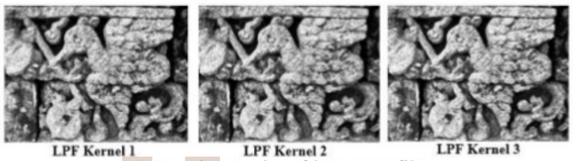

Fig. 7. The results of low-pass filter

Threshold process using Otsu algorithm deliver two different threshold values. Low-pass filter with kernel 1 and kernel 2 have the same threshold values (0.4784) using Otsu algorithm. Different value has produced by low-pass filter with kernel 3 where threshold value is 0.475. Otsu algorithm shows that both of LPF kernel 1 and 2 output image have a similar result rather than LPF kernel 3. This result is because of three LPF kernels have produced two different threshold values. Kapur algorithm with LPF kernel 2 and kernel 3 have the same threshold values (124). Different threshold value has produced by LPF kernel 1 where threshold value is 125. Kapur algorithm shown that both of LPF kernel 2 dan 3 have a similar result rather than LPF kernel 1. Both output image of Otsu and Kapur threshold process are shown in Fig. 8. Edge detection results using Sobel, Prewitt and Canny operators are shown in Fig. 8. The result show that both (Sobel and Canny) operators have enhanced edges and weaken weak textures. Fig. 9 also shows the effect of using Prewitt operator that smooth areas of an image, but some edge of the object is gone.

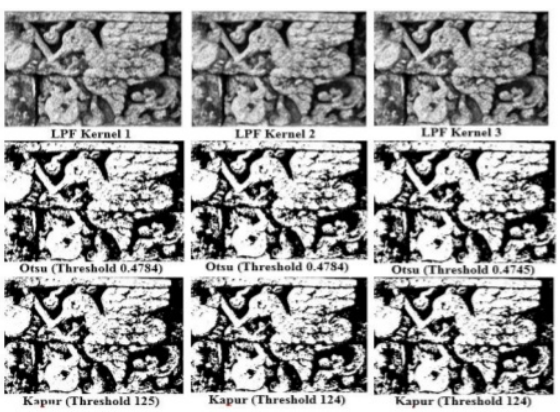

Fig. 8. The results of Otsu and Kapur algorithm

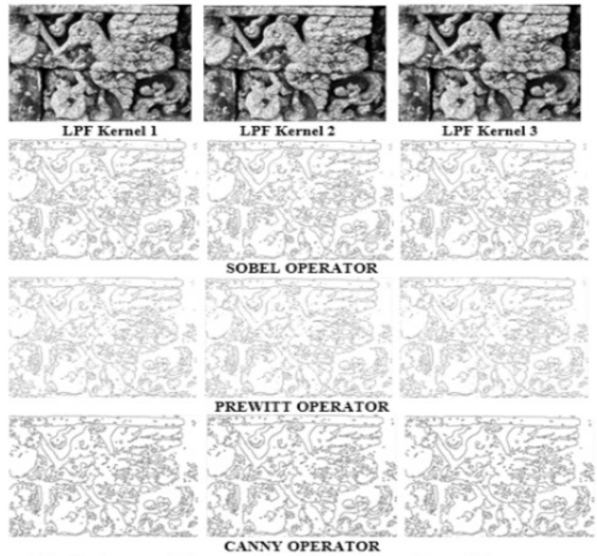

Fig. 9. Segmentation results of Sobel, Prewitt and Canny

IV. CONCLUSION

The experimental result shows a gray-level composition on image histogram that indicates the domination of low grayscale value. Contrast stretching operations improves a low-contrast image, with three different α values. The values is below 1 (0.8) and two values is more than 1 (1.1 and 1.4). The α value 1.1 has a wide range of values with no gray-level values dominating by dark or light colors, the histogram of this result indicates a relatively uniform gray-level value. The comparison between contrast stretching with α value 1.1 and histogram equalization indicate that the gray-level of histogram equalization result are distributed. The output image from this comparison show that histogram equalization has more clear presentation than contrast stretching, that makes the relief object is more visible. Adaptive histogram equalization has produced the best image enhancement based on the analysis of experimental result. The validity of the enhancement is also evaluated by image analysis that employs threshold and edge detection in order to localize image object. Threshold process using Otsu algorithm deliver two different threshold values. Low-pass filter with kernel 1 and kernel 2 have same threshold values (0.4784) using Otsu algorithm. Different value has produced by low-pass filter with kernel 3 where threshold value is 0.475. Otsu algorithm shows that both of LPF kernel 1 and 2 output image have a similar result rather than LPF kernel 3. This result is because of three LPF kernels that produce two different threshold values. Kapur algorithm with LPF kernel 2 and kernel 3 have the same threshold values (124). Different threshold value is produced by LPF kernel 1 where threshold value is 125. Kapur algorithm shows that both of LPF kernel 2 dan 3 output image have a similar result of threshold value rather than LPF kernel 1. Sobel and Canny operators is shown to be significantly better than Prewitt operator. Because the edges of Sobel and Canny operators contains more edge pixels than Prewitt operator.

ACKNOWLEDGMENT

This work is supported by the Research Grant 2017, Research on Beginner Lecturer Scheme from Directorate General of Higher Education, Ministry of Research and Technology and Higher Education Republic of Indonesia.

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