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InTEC: Integration of Enhanced Entropy – Canny Technique for Edge Detection in Digital X-Ray Images

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Edge detection is one of the fundamental techniques in image processing. The technique consists of several processing procedures to identify and validate abrupt changes in pixels intensity for greyscale images; namely segmentation, registration, feature extraction and object recognition. In digital x-ray images enhancement, the extraction of the foreground region from its surrounding background region is a challenging issue due to overlapping pixels intensity range in image. This paper constructed an improve technique that can smartly identify the discontinuity pixel to detect edge between background and foreground of an object. The edge will be identified sharp and clear by integrating the enhanced entropy technique and Canny technique (InTEC) respectively. Based on the quality performance test, the mean square error (MSE) of InTEC technique recorded lower value (range of 633.88 – 3345.40 dB) than conventional techniques.

Keywords: Image processing, Segmentation, Edge detection, Digital image, InTEC

I. INTRODUCTION

Interpretation of image contents is a significant objective in computer vision and image processing. It has received much attention from researchers during the last three decades. An image contains different information of scene such as objects, shape, size, colour and orientation (Maini, 2011). Discrimination of the objects from their background is the first essential task that should be performed before any interpretation (Sarage, 2012; Sa'dah *et al.*, 2013). In order to extract the contour of an object, we must detect the edges forming that object. The early stages of vision processing identify features in image that are relevant to estimating the structure and properties of objects in a scene. Edges are one such feature. Edges are significant local changes in the image and are important features for analyzing images (Kumar *et al.*, 2014; Rashmi *et al.*, 2013). Edges typically occur on the boundary between two different regions in an image. Edge detection is frequently the first step in recovering information from images. Due to its importance, edge detection continues to be an active research area.

Gradient based classical operator like

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Robert, Prewitt, Sobel were initially constructed edge detection technique by researchers but they did not give sharp edge and most sensitive to noise condition (Makandar, 2015). Laplacian operators also suffers from two limitations; high probability of detecting false edges and the localization error may be severe at curved edges (Rashmi *et al.*, 2013). An algorithm has been proposed by John F.Canny in 1986 is considered as the ideal edge detection algorithm for images that are corrupted with noise (Canny, 1986). Canny's technique discovered the optimal edge detection steps that reduces the probability of detecting false edges and gives sharp edges.

II. RELATED WORK

An edge in an image is a significant local change in the image intensity, usually associated with a discontinuity in either the image intensity or the first derivative of the image intensity (Kumar *et al.*, 2014; Crisan & Holban, 2013). Discontinuities in the image intensity can be either step discontinuities, where the image intensity changes from one value on one side of the discontinuity to a different value on the opposite side or line discontinuities. The image intensity abruptly changes value but then returns to the starting value within some short distance (Rashmi *et al.*, 2013; Kumar *et al.*, 2014). Step edges become ramp edges and line edges become roof edges, where intensity changes are not instantaneous but occur over a finite distance. Illustrations of these edge profiles are shown in Figure 1:

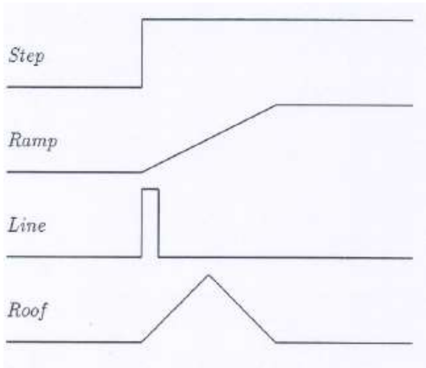


Figure 1. One dimensional edge profiles (Rashmi *et al.,* 2013)

1. Steps in Edge Detection

Edge detection is a process that detects the presence and location of edges constituted by sharp changes in pixel intensity (brightness) of an image. Since, it can be proven that the discontinuities in image brightness are likely to correspond to; discontinuities in depth, discontinuities in surface orientation, changes in material properties and variations in scene illumination (El-Owny & Hassan, 2013; El-Sayed, 2013). Algorithms for edge detection contain three steps (as refer to Figure 2; filtering, enhancement and localization). Since gradient computation based on intensity values of only two points are susceptible to noise and other vagaries in discrete computations, filtering is commonly used to improve the performance of an edge detector with respect to noise. However, there is a trade-off between edge strength and noise reduction. More filtering to reduce noise results in a loss of edge strength. In order to facilitate the detection of edges, it is essential to determine changes in intensity in the neighborhood of a point. Enhancement emphasizes pixels where there is a significant change in local intensity values and is usually performed by computing the gradient magnitude. Figure 2 shown the steps for edge detection process.

Figure 2. Steps for edge detection (El-Sayed, 2013)

2. Entropy Computation & Constructing

The entropy value represents the measure of randomness associated with pixel values belonging to each gray level. Following Shannon's definition of entropy and Pun's representation of image entropy, for an image with gray level, and probability of k^{th} gray level P_k, the image entropy can be represented as:

$$E = \sum_{k=0}^{G-1} P_k \log_2 \left(\frac{1}{P_k}\right) \quad (1)$$

Then, $$E = -\sum_{k=0}^{G-1} P_k \log_2 (P_k) \quad (2)$$

where, $P_k = \frac{n_k}{M\,x\,N}$, n_k is the number of pixels with grayscale k, and $M\,x\,N$ is the size of the image.

Local entropy represents the discrepancy between two probability distributions on the same event space. It is related to the variance of grayscales in the neighborhood of a pixel (Bandyopadhyay *et al.*, 2016; El-Zaart, 2010). Local entropy divides the image into separate regions and then analyzes each region as a separate information source. If a small neighborhood window Ω_k of size M_k x N_k is defined within the image, then entropy of Ω_k can be represented as:

$$E(\Omega_k) = -\sum_{j=0}^{G-1} P_j \log_2 P_j \quad (3)$$

where $P_j = \frac{n_j}{M_k\,x\,N_k}$, P_j denotes the probability of gray scale j, in the neighborhood Ω_k, n_j is the number pixels with gray scale j in Ω_k, and $E(\Omega_k)$ is the local entropy of Ω_k.

3. Canny Technique

It was proposed by John F. Canny in 1986. The aim of the technique is to construct an algorithm for edge detection which fulfills following criteria:

a) Good detection: Maximum probability of detecting real edge point and minimum of false edges points. This result into the maximized signal to noise ratio.

b) Good localization: There should be maximum possibility of detected edge closeness to real edges.

c) Minimal responses: One real image should result into only one detected image.

Noise contained in image is smoothed by convolving the input image *I(i,j)* with Gaussian filter. The smooth resultant image is given by,

$$F(i,j) = G * I(i,j) \quad (4)$$

Assuming the 2D Gaussian function as,

$$G(i,j) = \frac{1}{\sqrt{2\pi\sigma^2}} exp - \left(\frac{i^2+j^2}{2\sigma^2}\right) \quad (5)$$

Second step, finding gradients to detect edges where the change in greyscale intensity is maximum. The mask is used to determine the gradient at each pixel and given as:

$$D_i = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \text{ and } D_j = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

Therefore, the gradient magnitude direction of a pixel is given by:

$$G = \sqrt{G_i^2 + G_j^2} \text{ and } \theta = arctan\left(\frac{G_j}{G_i}\right) \quad (6)$$

Non-maximum suppression carried out to preserve all local maxima in the gradient image and delete everything else in thin edges. The output of non-maxima suppression still contains the local maxima created by noise. Double thresholding technique is used to avoid streaking edges problem.

$$if\ G < t_{low} - discard\ the\ edge;$$

$$if\ G > t_{high} - keep\ the\ edge$$

$if\ t_{low} <$ G $< t_{high}$ - any of its neighbor in 3x3 region around it have gradient magnitude greater than t_{high}, keep the edge. Else, discard the edge.

III. METHODOLOGY

This section explains on the architecture of InTEC technique. Firstly, this paper explained on the architecture of the whole system in general. Then, we will discuss the enhancement of the entropy and Canny technique in order to detect the edge efficiently. These both techniques, enhanced entropy and enhanced Canny technique will be integrated and will be further discussed. The general overview of the InTEC is shown in Figure 3:

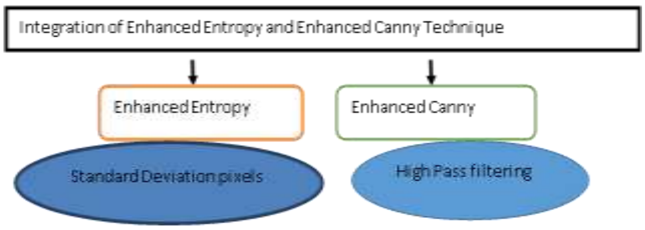


Figure 3. Overview of the InTEC Technique

1. *Enhanced Entropy Technique*

The entropy technique is focusing more on represents the variation of grayscale in the neighborhood of a pixel. A x-ray image usually have much higher resolution. Therefore, the flesh to bone transition regions tend to appear with higher sharpness. The entropy image fails to identify the flesh to bone transition region correctly as the uncertainty is less. The transitions between the background and flesh regions are falsely marked as bone boundaries. To overcome this problem, we have calculated local standard deviation at each pixel and multiplied with local entropy to generate an intermediate product image.

2. Enhanced Canny Technique

The conventional canny is suffered from the following negative points; the use of Gaussian filtering, smoothed the important edges while removing the noise. This weakened the edges and increases false edge detection. Furthermore, double thresholding algorithm is used which require to set high and low threshold values manually in order to get appropriate threshold values for an image several experiments are required. High pass filter used convolution kernel whereas the minus sign for the adjacent pixels. If one pixel is brighter than neighbors, it get boosted.

3. Integration of Enhanced Entropy- Canny Technique

The enhancement of entropy and canny technique which explained previously are integrated to achieve the desired edge detection accurately. We show the detailed version of the InTEC technique in the following pseudocode:

The Psuedocode of the InTEC Technique

Input

- Load grayscale image

Process

- Enhanced contrast using histogram equalization
- Compute entropy value for image
- Compute standard deviation pixel for 3x3 kernel size
- Multiply entropy value with standard deviation for pixel
- Compute gradient pixel
- Obtain non-maxima suppression step
- Set double threshold value
- Enhanced high pass filtering

Output

- Edge object

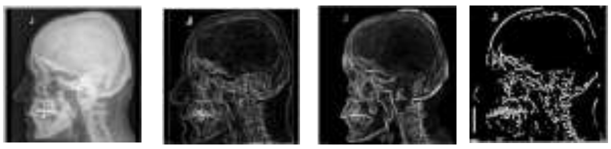
Figure 4. Pseudcode for InTEC Technique

The first step consists of entropy process which is including enhancing the contrast image using histogram equalization. The entropy value for image is computed and the standard deviation for each pixel in 3x3 kernel size is determined. Then, the entropy and standard deviation are multiplied to separate the segmented region. After the enhancement entropy step completed in order to find the transition flesh to bone region, the resulted of the image will be enhanced using Canny technique. The Canny technique enhanced by high pass filter approach to make the edge clearer and sharper.

IV. RESULT AND DISCUSSION

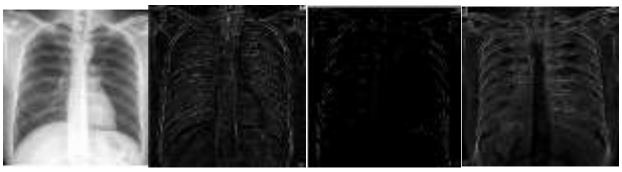
Based on previous literature, in this section, we compare our InTEC with outstanding technique known as Entropy technique and Canny technique. The experiments are carried out on a Dell Precision T1650 CPU Intel Inside

Xeon with Windows 10 using Matlab R2015a software. Three samples medical x-ray images were used. We evaluate the performance of the InTEC technique with conventional Entropy and Canny technique. Three sample images are selectd to conduct the mean square error (MSE) test. Figure 5,6 and 7 show the output images of Entropy, Canny and InTEC respectively. As compared with the result of Entropy and Canny technique, InTEC able to detect edge.



(a) (b) (c) (d)

Figure 5. Sample 1 (a) Original image (b) Entropy (c) Canny (d) InTEC technique



(a) (b) (c) (d)

Figure 6. Sample 2 (a) Original image (b) Entropy (c) Canny (d) InTEC technique

(a) (b) (c) (d)

Figure 7. Sample 3 (a) Original image (b) Entropy (c) Canny (d) InTEC technique

Based on Fig.4,5 and 6 (Sample 1,2 and 3), all techniques were able to manage outstanding edge detection with different technique respectively. From our observation, the InTEC technique produced bright edge for each pixel. While, entropy and Canny technique produced more blur edge.

Table.1. MSE Test

SAMPLE	Entropy	Canny	InTEC
1	1934.29	3262.90	1834.33
2	3474.64	4613.37	3345.44
3	784.93	968.08	633.88

Based on the MSE test, the quality output image disable to manage good detection if the MSE value computed is higher value. From sample 1 result, InTEC technique indicates the lowest MSE value than entropy and Canny technique. This indicates the edge image produced by InTEC is more accurate. The InTEC output image also recovered sharp image rather than other technique.

V. CONCLUSION

As conclusion, the proposed technique was able to manage the edge detection of the object efficiently. The MSE values for the proposed technique was lower value than outstanding technique. For future studies, we are looking into enhancing the proposed technique with other processing methods, such as morphological methods, to improve further the detection rate accuracy.

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