Comparison of Canny and Sobel Edge Detection in MRI Images

Zolqernine Othman
Faculty of Computer Science and Information System,
Universiti Teknologi Malaysia,
81310 UTM Skudai, Malaysia.
zolqernine@gmail.com

Habibollah Haron
Faculty of Computer Science and Information System,
Universiti Teknologi Malaysia,
81310 UTM Skudai, Malaysia.
habib@utm.my

Mohammed Rafiq Abdul Kadir
Biomechanics & Tissue Engineering Group,
Faculty of Biomedical Engineering and Health Science,
Universiti Teknologi Malaysia,
81310 UTM Skudai, Malaysia.
rafiq@fkm.utm.my

ABSTRACT
Feature extraction approach in medical magnetic resonance imaging (MRI) is very important in order to perform diagnostic image analysis [1]. Edge detection is one of the way to extract more information from magnetic resonance images. Edge detection reduces the amount of data and filters out useless information, while protecting the important structural properties in an image [2]. In this paper, we compare Sobel and Canny edge detection method. In order to compare between them, one slice of MRI image tested with both method. Both method of the edge detection operators are implemented with convolution masks. Sobel method with 3x3 masks while canny used adjustable mask. Those masks will determine the quality of the edge. Edges areas represent a strong intensity contrast which is darker or brighter.

Keyword: MRI, Edge detection, Canny method

1. INTRODUCTION
MRI can produce equally goods tissue slices in any orientation and superb three-dimensional images compared to others medical images [1]. MRI image can produce the best view of tissues in any part of human body, so the analysis of MRI images plays crucial role in medical field. Edge detection is one of method in medical analysis. An edge can be defined as the boundary between two regions separated by two relatively distinct gray-level properties [2]. Edge detection refers to the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene. Edges in images are areas with strong intensity contrasts. Edge detecting an image significantly reduces the amount of data and filters out useless information, while preserving the important structural properties in an image and one of the ways to extract more information from magnetic resonance images [4]. There are many methods to perform edge detection such as Sobel Method, Prewiit Method and Canny method. In this paper, we make a comparison between Sobel and Canny edge detection method of MRI image of knee, the most widely used edge detection algorithms [5]. The Sobel operator performs a 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial frequency that correspond to edges. Typically it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image. Canny edge detector uses a filter based on the first derivative of a Gaussian, it is susceptible to noise present on raw unprocessed image data, so to begin with, the raw image is convolved with a Gaussian filter. The two parameters that play with are the high and low thresholds that are used in the non-maximum suppression and the tracing part of the Canny algorithm. More edge pixels will appeared by decreasing the thresholds [2].

2. EDGE DETECTION
Preprocessing algorithms are important in MRI image analysis to extract information. An edge is defined by a discontinuity in gray-level values. The pixel's gray-level which value is similar to other around pixel's gray-level, there is probably not an edge at that point. However, if a pixel has neighbors with widely varying gray levels, it may represent an edge point. Many of the edge detection operators are implemented with convolution masks [7].

3. SOBEL EDGE DETECTION
Sobel method is applied to perform edge detection. The Sobel edge detector use two masks with 3x3 sizes, one estimating the gradient in the x-direction and the other estimating the gradient in the y-direction [7]. The mask is slid over the image, manipulating a square of pixels at a time. The algorithm calculates the gradient of the image intensity at each point, and then gives the direction to increase the image intensity at each point from light to dark. Edges areas represent strong intensity contrasts which are darker or brighter [2].

Sobel algorithms work using a mathematical procedure called convolution and commonly analyse derivatives or second derivatives of the digital numbers over space. We

implement the Sobel method for edges detection, which is based on a 3 by 3 array that is moved over the main image. This array is given by [7]:

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

Figure 1.0: Sobel convolution kernels

We move the Sobel kernels over a particular pixel in the MRI image. Then we calculate a new value. The sobel convolution kernels are designed to respond to edges vertically and horizontally. These masks are each convolved with the image. We calculate horizontal and vertical gradient (G*x* and G*y*), then we combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient. We use these numbers to compute the edge magnitude which given by:

$$|\mathbf{G}| = \sqrt{\mathbf{Gx^2} + \mathbf{Gy^2}}$$

4. CANNY EDGE DETECTION

In order to implement the canny edge detector algorithm, a series of steps must be followed. The Canny Edge Detection Algorithm has the following steps [8]. Firstly smooth the image with a Gaussian filters. Then compute the gradient magnitude and orientation using finite-difference approximations for the partial derivatives. After that apply nonmaxima suppression to the gradient magnitude. Then use the double threshold algorithm to detect and link edges.

The equation below used [2]:

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

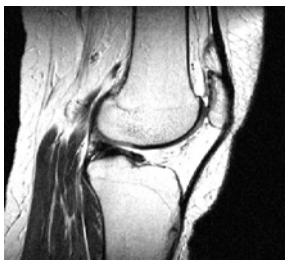
where *x* is the distance from the origin in the horizontal axis, *y* is the distance from the origin in the vertical axis, and σ is the spread of the Gaussian and controls the degree of smoothing. Then the gradient of the smoothed array *G(x, y)* is used to produce the x and y partial. Once we got the x and y partial, we combined the x and y directional derivatives to get the normal of the gradient.

After the edge directions are known, nonmaximum suppression now has to be applied. Two threshold values are applied to Nonmaxima Suppression. With these threshold values, two thresholded edge images $T_1[x, y]$ and $T_2[x, y]$ are produced. Nonmaximum suppression is used to trace along the edge in the edge direction and suppress any pixel value (sets it equal to 0) that is not considered to be an edge. This will give a thin line in the output image.

5. RESULT

We have implemented one slice of MRI sample images. Sobel and Canny edge detection operators have been implemented on that image and we can see the results in Figure 2.0. Using the Sobel method, the result shows from the image tested, the edges detected are too messy and the data almost lost the important structure. The pixel of the image is noisy and the edges are not smooth and thin. The edges are two or three thick of pixel. Result did not show the important information because most of them lost the important structure. But, the result still can show the shape of bone but totally cannot show the area of tissues.

For Canny edge detection, using σ equal to 4, we set threshold value (α) equal to 0.25. At this value, the edge smoothly detected on the image and almost no noise pixels detect on the image while protecting the important structural properties in an image. The important structure of the image almost lost when the value of α more then 0.25. The canny method produces smooth and thin edges. In Figure 2.0 (c), we can see good view of the bone structure. Less noise pixel detected compared to soble edge detection.



(a)

(b)

(c)

Figure 2.0: Sobel and Canny Edge Detection algorithms implemented on an MRI image (a). Result of Sobel Edge Detection (b) and Canny ed ge detection (c).

(a) (b)

Figure 3.0: The edge generated by Sobel (a) and Canny Edge (b) detection algorithms.

6. DISCUSSION

Edge detection method has become an important tool in medical image analysis. This method widely use as a part of pre-processing stage before segmentation or classification of medical images. In order to reduce time processing, MRI image converted from DICOM to GIF format. DICOM format is 16 byte of data size, so its produce up to 65536 gray levels. DICOM converted to GIF format because GIF format only has 8 byte of data size that produces only 255 gray levels.

Sobel edge detection cannot produce good edge detection with the thin and smooth edge (figure 3.0 a). It's meaningless information for further study in medical image analysis like segmentation and classification. The quality of the edge totally depends on quality of the picture, in other words the raw picture must be totally filtered from noisy pixels. Otherwise the small island of pixels will appear after the edge detection process.

For Canny edge detection, there are important adjustable parameters, which can affect the computation time and effectiveness of the algorithm, the size of the Gaussian filter and thresholds [2]. Smaller filters cause less blurring, and allow detection of small, sharp lines. A larger filter causes more blurring, smearing out the value of a given pixel over a larger area of the image. Larger blurring radii are more useful for detecting larger, smoother edges.

The use of two thresholds with hysteresis allows more flexibility than in a single-threshold approach, but general problems of threshold approaches still apply. A threshold set too high can miss important information. On the other hand, a threshold set too low will falsely identify irrelevant information (such as noise) as important. It is difficult to give a generic threshold that works well on all images. The Canny method uses a lot of memory during processing, so may not be appropriate if for very large raster, or if memory is low.

Canny edge detection can produce good detection of the edge with the thin and smooth (figure 3.0 b). It's very useful for further study in medical image analysis like segmentation and classification. The quality of the edge totally depends on quality of the picture, in other words the raw picture must be totally filtered from noisy pixels. Otherwise the small island of pixels will appear after the edge detection process. In terms of edge quality, Canny method is very useful to get optimum border on the image that can give meaningful information in medical image analysis.

7. CONCLUSION

From this study, we can see that Canny method can produce equally good edge with the smooth continiuos pixels and thin edge. Sobel edge detection method cannot produce smooth and thin edge compared to canny method. But same like other method, Sobel and Canny methods also very sensitive to the noise pixels. Sometime all the noisy image can not be filtered perfectly. Unremoved noisy pixels will effect the result of edge detection. From our analysis, we have shown that between Sobel and Canny edge detection algorithms, response given by Canny edge detection was better than result of Sobel detector used in these MRI images.

8. REFERENCE

[1] D. W. McRobbie, E. A. Moore, M. J. Graves, M. R. Prince, *MRI : From picture to proton*. 2nd. ed. New York: Cambridge University. 2007

[2] Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing. 3nd. ed. New Jersey: Pearson Prentice Hall. 2008

[3] Anna Fabijańska, Dominik Sankowski (2008), Edge Detection in Brain Images, MEMSTECH'2008, pp 60-62.

[4] Mark´us Gudmundsson, Essam A. El-Kwae, and Mansur R. Kabuka (1998), Edge Detection in Medical Images Using a Genetic Algorithm, IEEE Transactions on Medical Imaging, vol. 17, no. 3, pp 469 - 474.

[5] Somkait Udomhunsakul' and Pichet Wongsita (2004), Feature Extraction in Medical MRI Images, Proceedings of the 2004 IEEE Conference on Cybernetics and Intelligent Systems Singapore, pp 340-344.

[6] Robert P. Velthuizen, Lawrence 0. Hallt, Laurence P. Clarke (1996), MRI Feature Extraction Using Genetic Algorithms, 18th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Amsterdam, pp 1138-1139.

[7] Rezai-Rad, G. and M. Aghababaie (2006). *Comparison of SUSAN and Sobel Edge Detection in MRI Images for Feature Extraction*. in

Information and Communication Technologies. ICTTA '06. 2nd. pp 1103 - 1106.

[8] Mohamed Ali and David Clausi (2001), Using The Canny Edge Detector for Feature Extraction and Enhancement of Remote Sensing Images, IEEE, pp 2298-2300.

[9] Gang Liu and Robert M. Haralick (2000), Two practical issue in Canny edge Detector Implementation, IEEE, pp 676-678.

[10] Zhenyu Wu and Richard Leahy(1992), Image Segmentation via Edge Contour Finding: A Graph Theoretic Approach, IEEE, pp 631-619.

[11] J. Tendra Malik, S. Belongie, T. Leung and J. Shi(2001), Contour and Texture Analysis for Image Segmentation, International Journal of Computer Vision 43(1), pp 7–27.

[12] Ying-jie Zhang Li-ling Ge, Improving Image Segmentation Performance via Edge Preserving Regularization, International Journal of Computer Science Vo 1 No 3, pp 212-217.

[13] D. Marr and E. Hildreth (1980), Theory of edge detection, Proc. Royal Soc. of London, vol. 207,pp. 187-217