Volume 5, Issue 6, June 2015 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Comparative Analysis of Edge Detection Techniques based on MSR & PSNR

[1]Nishant Kush, [2]Ankush Kansal
[1]Student, [2]Assistant Professor
[1, 2] ECED, Thapar University, Patiala, Punjab, India

Abstract-Edge is the boundaries of an object in image. An edge is the, rapid change in image intensity. Edge detection is applied to reduce the data and identify the edges of image and useless information is filtered out, during this process important structural features of image are preserved. In this paper, study of basic concepts of edge detection algorithms and comparative analysis of Sobel and Compass edge detection algorithms is presented with MATLAB tool. After comparing we can see that, compass edge detector performs better than sobel edge detector in terms of PSNR value, and provide sharp and less false edges. The minimum PSNR value obtained from compass edge detector is 7.0816 and that of sobel operator is 7.1236

Keywords- Edge Detection, Sobel operator, Compass Edge, MSE & PSNR

I. INTRODUCTION

Edge detection is the process of locating and identifying sharp discontinuities in image. Abrupt changes in pixel intensity are termed as discontinuities in an image. Generally in edge detection techniques, an image is convolved with an operator which is constructed so that it can be sensitive to the large gradients of image [1-2]. Various types of edge detection techniques use different operators, and depending on the applications each are sensitive to different type of edges. Selection criteria of edge operators include edge structure, edge orientation and noise environment [3-4]. For detecting the diagonal, vertical or horizontal edges operators are optimized [5]. In noisy images it is difficult to detect the edges, because edges and noise both have high frequency content. Reducing the noise from an image, results in distorted or blurred edges. In noisy images if edge operators are applied then probability of accurately localizing of detected edges becomes less [8]. Edge operator must be responsive to gradual change in the images such as poor focus and refraction. Edge detection generally has problems of high computational time, missing true edges, false edge detection, edge localization and problems due to noise. Therefore the motive is the comparative analysis of different type of edge detection techniques and performance of these in different conditions [9].

II. EDGE DETECTION TECHNIQUES

Edge detection techniques are grouped in two categories; one is gradient based edge detection, other one is laplacian based edge detection. Gradient based techniques looks for the minimum and maximum in 1st derivative of image to detect edges. Zero crossing is the criteria in 2nd derivative of image for detecting edges [13-15]. In this paper we did visual comparative analysis of compass edge detection technique and edge detection technique having sobel operator.

2.1 Sobel operator

Sobel operator has two 3×3convolution kernels. By rotating one kernel to$90°$, other kernel is obtained.

$$S_a = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix}; S_b = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

These masks are designed such that they respond to edges of the image running horizontally or vertically relative to pixel grid [6-7]. One kernel is for horizontal and other kernel for vertical orientation [16]. These kernels are applied on input image separately, gradient magnitude and orientation can be calculated by:

$$|S_G| = \sqrt{S_a^2 + S_b^2}\ ; \tag{1}$$

Typically, $|S_G| = |S_a| + |S_b|$

In this operator, a RGB image is first converted into grayscale image. Then at each point magnitude of absolute gradient is calculated. Generally approximated value of gradient magnitude is calculated. That can be helpful for the faster calculations. Angle of orientation is given by:

$$\theta_g = \arctan(S_b/S_a) \tag{2}$$

2.2 Compass Edge

Compass edge uses a set of kernels which is convolved with image and these have different orientations. If N_h is the standard kernel then rotating it by 45 degree provides new kernel i.e. W_t. Similarly by rotating our standard kernel in the range from 0 degree to 360 degree, rest of the kernels i.e.S_h,E_t,N_hW_t,S_hW_t, S_hE_t and N_hE_t are obtained[11-12].In this paper we use 8 different orientations of these kernel in compass edge detection technique. In comparison to the local edge gradient the Differential gradient is time consuming [14].

$N_h = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$; $W_t = \begin{bmatrix} 0 & 1 & 2 \\ -1 & 0 & 1 \\ -2 & -1 & 0 \end{bmatrix}$;$S_h = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$;$E_t = \begin{bmatrix} 2 & 1 & 0 \\ 1 & 0 & -1 \\ 0 & -1 & -2 \end{bmatrix}$;

$N_hW_t = \begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix}$; $S_hW_t = \begin{bmatrix} 0 & -1 & -2 \\ 1 & 0 & -1 \\ 2 & 1 & 0 \end{bmatrix}$;$S_hE_t = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$; $N_hE_t = \begin{bmatrix} -2 & -1 & 0 \\ -1 & 0 & 1 \\ 0 & 1 & 2 \end{bmatrix}$Local edge gradient magnitude is the maximum response of all kernels. Local edge gradient magnitude is given by:

$|C| = max\ (|C_i|;\ i\ = 1\ to\ n)$ (3)

Other masks that can be used as standard kernels are Kirsch and Robinson, these are as follows:

$K_i = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$; $R_n = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$

2.3 MSE & PSNR

MSE stands for Mean Square Error and PSNR stands For Peak Signal to Noise Ratio. MSE is avg. pixel difference and performance of noise removal is measured using PSNR[10], MSE &PSNR calculated as:

$MSE = \frac{1}{N}\sum_d \sum_q (S_{dq} - T_{dq})^2$

(4)$PSNR = 10\ log\ (255^2/MSE)$ (5)

N is image size, T is original image, and S is processed image

III. ANALYTICAL ANALYSIS

*Sobel Operator:*From section 2.1 we know that kernels used in this operator are:

$S_a(d,q) = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix}$; $S_b(d,q) = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$

For source image$A(d,q)$, first of all, source image $A\ (d,q)$ is to be converted into grayscale image,

$A(d,q)_{Grayscale}\ = N\ (d,q)$ (6)

Kernel$S_a(d,q)$ is convolved with the source image $A(d,q)$ which results $B\ (d,q)$; and then second kernel which is obtained by rotating the first kernel by 90 degree i.e. $S_b(d,q)$ is convolved with source image which results in $C\ (d,q)$

$B\ (d,q) = S_a(d,q) * A\ (d,q)$ (7)

$C\ (d,q) = S_b(d,q) * A\ (d,q)$ (8)

From equation (1) we know that by combining $B\ (d,q)$& $C\ (d,q)$; at any point the absolute magnitude of Gradient can be calculated. For faster calculation, an approx. magnitude is calculated. From equation (7) and (8), Gradient Magnitude is given by:

$D\ (d,q) = \sqrt{[B\ (d,q)]^2 + [C\ (d,q)]^2}$ (9)

Orientation angle of edge, generally give rise to spatial gradient. The angle of orientation is given by:

$$\theta = tan^{-}\left[\frac{C\ (d,q)}{B\ (d,q)}\right]$$

Compass edge: First of all source image $A\ (d,q)$ is convolved with a standard kernelN_h giving out a function $E\ (d,q)$, similarly after that, this standard kernel is rotated by $45°, 90°, 135°, 180°, 225°, 270°, 315°$ and then convolution of each of them is done with source image. Convolution of$A\ (d,q)$&$W_t$is given by $F\ (d,q)$, and that of $A\ (d,q)$&S_h, $A\ (d,q)$&E_t, $A\ (d,q)$&N_hW_t, $A\ (d,q)$&S_hW_t, $A\ (d,q)$&S_hE_t and $A\ (d,q)$&N_hE_t is given by $G\ (d,q)$,$H\ (d,q)$, $I\ (d,q)$, $J\ (d,q)$, $K\ (d,q)$, and$L\ (d,q)$

$E\ (d,q) = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} * A\ (d,q);$ $F\ (d,q) = \begin{bmatrix} 0 & 1 & 2 \\ -1 & 0 & 1 \\ -2 & -1 & 0 \end{bmatrix} * A\ (d,q);$

$G\ (d,q) = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} * A\ (d,q);$ $H\ (d,q) = \begin{bmatrix} 2 & 1 & 0 \\ 1 & 0 & -1 \\ 0 & -1 & -2 \end{bmatrix} * A\ (d,q);$

$I\ (d,q) = \begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix} * A\ (d,q);$ $J\ (d,q) = \begin{bmatrix} 0 & -1 & -2 \\ 1 & 0 & -1 \\ 2 & 1 & 0 \end{bmatrix} * A\ (d,q);$

$K\ (d,q) = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} * A\ (d,q);$ $L\ (d,q) = \begin{bmatrix} -2 & -1 & 0 \\ -1 & 0 & 1 \\ 0 & 1 & 2 \end{bmatrix} * A\ (d,q);$

Maximum response of all these kernels after convoluting with source image is calculated and it is magnitude of our absolute edge gradient. From equation (3) the absolute edge gradient magnitude can be calculated.

$M_{max}\ (d,q) = \max[E(d,q), F(d,q), G(d,q), H(d,q), I(d,q), J(d,q), K(d,q), L(d,q)]$(10)

*MSE & PSNR Calculations:*from equation (4); (6) & (9)mean square error of images $D(d,q)$ and $N(d,q)$ is given by

$MSE = \frac{1}{N}\sum_d \sum_q (D_{dq} - N_{dq})^2$ (11)

From equation (5) & (11)

$$PSNR1 = 10\, log\, (255^2/MSE) \quad (12)$$

Similarly, from equation (4); (6) & (10) mean square error of images $M_{max}\,(d,q)$&$N(d,q)$ is given by:

$$MSE = \frac{1}{N}\sum_d \sum_q (M_{dq} - N_{dq})^2 \quad (13)$$

From equation (5) & (13)

$$PSNR2 = 10\, log\, (255^2/MSE) \quad (14)$$

IV. RESULT

4.1 ImageA (d,q)4.2 Image N (d,q)


Fig.1Source Image   Fig.2 Grayscale image of source image $A\,(d,q)$

4.3 Image D (d,q)4.4 Image$M_{max}(d,q)$

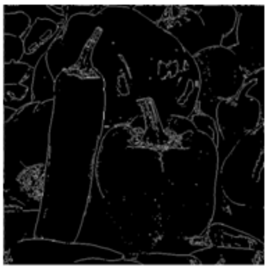


Fig.3 Output image of Sobel operator   Fig.4 Output image of Compass operator

Source image $A\,(d,q)$ is converted into the grayscale image i.e.$N\,(d,q)$, Image $D\,(d,q)$ which is sobel output image has shown more edges as compared to the image obtained after compass edge detection i.e. $M_{max}\,(d,q)$

Table. 1 MSE & PSNR of images with sobel and compass edge detection

Edge detection operator	MSE of Image	PSNR of Image
Sobel Operator	1.2610e+04	7.1236
Compass operator	1.2733e+04	7.0816

In table 1, MSE & PSNR of grayscale image$N\,(d,q)$ and Image after applying sobel operator i.e. $D\,(d,q)$ is calculated. Similarly MSE & PSNR of $N\,(d,q)$ and Image after applying compass operator i.e. $M_{max}\,(d,q)$ is calculated.

V. CONCLUSION

Sobel operator is simple to use for detecting the edges and their corresponding orientations because it uses only two kernels, but the disadvantage of using sobel operator is that, it is very sensitive to noise and sometimes inaccurate. While on the other hand compass edge uses 8 different kernels and provides sharp edges with very less probability of detecting false edges. In terms of PSNR value compass edge performs better then sobel operator. Image $D\,(d,q)$is obtained by applying sobel operator on source image$A\,(d,q)$. Grayscale image of source image $A\,(d,q)$is image $N\,(d,q)$, from equation (11) & (12), MSE of $D\,(d,q)$& $N\,(d,q)$ is 1.2610e+04, and corresponding PSNR value 7.1236 is calculated, similarly $M_{max}\,(d,q)$ is obtained by applying compass edge operator on source image$A\,(d,q)$. From equation (13) (14) the MSE of $M_{max}\,(d,q)$& $N\,(d,q)$ is 1.2733e+04 and corresponding PSNR value is 7.0816

REFERENCES

[1] Marivi Tello Alonso, Carlos Lopez-Martinez, Jordi J. Mallorqui and Philippe Salembier, "Edge Enhancement Algorithm Based on the Wavelet Transform for Automatic Edge Detection in SAR Images", *IEEE Transactions On Geoscience And Remote Sensing*, vol. 49, no. 1, pp.222-235 2011

[2] Yu Jing, Jubai An, and Zhaoxia Liu, "A Novel Edge Detection Algorithm Based on Global Minimization Active Contour Model for Oil Slick Infrared Aerial Image", *IEEE Transactions On Geoscience And Remote Sensing*, vol. 49, no. 6,pp.2005-2013, 2011

[3] S. Klonus, D. Tomowski, Manfred Ehlers, Peter Reinartz, and Ulrich Michel, "Combined Edge Segment Texture Analysis for the Detection of Damaged Buildings in Crisis Areas", *IEEE Journal Of Selected Topics In Applied Earth Observations And Remote Sensing*, vol. 5, no. 4, pp.1118-1128, 2012

[4] Fabio Baselice, and Giampaolo Ferraioli, "Statistical Edge Detection in Urban Areas Exploiting SAR Complex Data", *IEEE Geoscience And Remote Sensing Letters*, vol. 9, no. 2, pp.185-189, 2012

[5] Tian Qiu, Yong Yan, and Gang Lu,"An Autoadaptive Edge-Detection Algorithm for Flame and Fire Image Processing", *IEEE Transactions On Instrumentation And Measurement*, vol. 61, no. 5,pp.1486-1493, 2012

[6] Palaiahnakote Shivakumara, Rushi Padhuman Sreedhar, Trung Quy Phan, Shijian Lu, and Chew Lim Tan, "Multioriented Video Scene Text Detection Through Bayesian Classification and Boundary Growing", *IEEE Transactions On Circuits And Systems For Video Technology*, vol. 22, no. 8,pp.1227-1235, 2012

[7] Miodrag Jovic, Sanja Maravic Cisar and Petar Cisar, "Delphi Application for Face Detection Using the Sobel Operator", *IEEE International Symposium on Computational Intelligence and Informatics*,pp.371-376, 2012

[8] Bin Zhang, Kuizhi Mei,and Nanning Zheng, "Reconfigurable Processor for Binary Image Processing", *IEEE Transactions On Circuits And Systems For Video Technology*, vol. 23, no. 5, pp.823-831, 2013

[9] Abbas M. Al-Ghaili, Syamsiah Mashohor, Abdul Rahman Ramli, and Alyani Ismail, "Vertical-Edge-Based Car-License-Plate Detection Method", *IEEE Transactions On Vehicular Technology*, vol. 62, no. 1,pp.26-38, 2013

[10] K. Shri Sarika and P. Sudha, "An Analysis of Edge Extraction for MRI Medical Images through Mathematical Morphological Operators Approaches", International Journal of Computer Applications, pp.0975-8887, 2013

[11] Petar Cisar, Sanja Maravic Cisar and Branko Markoski, "Kernel Sets in Compass Edge Detection", *IEEE International Symposium on Computational Intelligence and Informatics*, pp.239-242, 2013

[12] Mohammad Reza Faraji and Xiaojun Qi, "Face recognition under illumination variations based on eight local directional patterns", *IET Biommetrics*, vol. 4, no. 1, pp. 10–17, 2014

[13] Patricia Melin, Claudia I. Gonzalez, Juan R. Castro, Olivia Mendoza, and Oscar Castillo, "Edge-Detection Method For Image Processing Based On Generalized Type-2 Fuzzy Logic", *IEEE Transactions On Fuzzy Systems*, vol. 22, no. 6,pp.1515-1525, 2014

[14] Mohammad Reza Faraji and Xiaojun Qi, "Face recognition under varying illumination based on adaptive homomorphic eight local directional patterns", *IET Computer Visual*, vol. 9, no. 3, pp. 390–399, 2014

[15] Kiichi Niitsu, Yusuke Osawa, Naohiro Harigai, Daiki Hirabayashi, Osamu Kobayashi,Takahiro J. Yamaguchi, and Haruo Kobayashi, "A CMOS PWM Transceiver Using Self-Referenced Edge Detection", *IEEE Transactions On Very Large Scale Integration Systems*, vol. 23, no. 6, pp. 1145-1149, 2015

[16] Jaewoong Kimand Sukhan Lee, "Extracting Major Lines by Recruiting Zero-Threshold Canny Edge Links along Sobel Highlights", IEEE Signal Processing Letters, vol. 22, no. 10, pp.1689-1692, 2015

