A Hybrid Approach using Sobel and Canny operator for Digital Image Edge Detection

Anchal Kalra
Department of CSE, ASET
Amity University Uttar Pradesh
Noida, UP, India
kalra.anchal@gmail.com

Roshan Lal Chhokar
Department of CSE, ASET
Amity University Uttar Pradesh
Noida, UP, India
rchhokar@amity.edu

***Abstract*— Edge Detection is a very essential part in digital image processing. In case of applications which require object information or feature extraction in an image, edge detection can play a vital role. Edge occurs where there is discontinuity or a sharp change in the intensity function. Now there are many operators for edge detection, but the challenge is to get better results from the existing system. This paper represents a hybrid approach which combines the Sobel and Canny edge detectors. It also uses a median filter to remove the salt and pepper noise from the image which consequently smoothen the image and edges can be detected easily. A comparison has also been shown between the hybrid approach with median filter and without median filter. The comparative study shows that using median filter shows enhanced result. As it filters the noise from the image, the accuracy of edge detection improved and achieved ideal effect.**

Keywords*— Canny operator, Edge detection, Hybrid, Median Filter, Sobel operator.

I. INTRODUCTION

Digital image Processing is a method to carry out image processing on digital images using various algorithms. Pattern recognition and feature extraction come under the uses. For this identification of edges is very important. Edge Detection is a process to identify an edge in an image. To understand the image features, edge detection is a very significant approach. Edges comprise of useful information and features. It decreases the size of image and filter out the information which is less useful. Hence only significant structure of the image is maintained. Edge detection also reduces the storage space consumed by an image. Detection of edges identifies boundaries and objects; therefore it is widely used for image segmentation. Edge detection also helps to extract important features in an image for pattern recognition.

The edge detection techniques are Differential operators which include Robert's, Sobel and Prewitt operators. There are also Log operator and Canny operator.

This paper represents a hybrid approach which combines Sobel edge detector and Canny edge detector, keeping their respective advantages. Although Sobel operator is computationally slow but its large convolution kernel smoothens out the image to a larger extent. This makes the operator less sensitive to noise. The canny edge detection algorithm first blurs the image and then applies the operator. This helps in making the edges one pixel thin.

The main objective of this paper is to improve the accuracy of edge detection of an image.

Section II in this paper discusses the related work which has been done till now. Section III & IV explains the two edge detecting operators and their hybrid approach which have been used in the proposed algorithm. Section V shows the results of the proposed algorithm with section VI finally concluding the results.

II. RELATED WORK

Amer et al. [1] compared all the edge detection algorithms to study their performances. The results showed that Sobel and Canny edge detectors are less sensitive to random noise in an image as compared to Robert's and Prewitt operators.

Cui et al. [2] discussed the advantages and disadvantages of edge detection algorithms and compared them. The comparison shows that binary morphology operator obtains better results. A method namely bordering close has also been used so as to obtain clear and integral image profile. [3] Deng et al. developed an algorithm in which fusion technology is used. In this an improved Sobel operator is introduced which is combined with wavelet transform, canny and prewitt operators. The algorithm effectively improved the results of edge detection.

Chinu et al.[4] discuss a hybrid strategy for color based image edge detection. This approach has been mainly implemented for overcoming poor edge localization, high sensitivity to noise, edge detection of images with complex background and detecting color edges. Both sequential and parallel approaches have been used and compared which depicted that parallel strategy shows a performance gain of 68%. To measure the accuracy of edge detection various metrics are used like PSNR, speed up, efficiency etc.

[5] An algorithm is developed in which improved canny operator is used. In this improved operator, morphological filter replaces the Gaussian filter. The morphological filtering pre treats the noise of image, keeps the edge strength and details, thus achieving better accuracy. Gao et al.[6] proposed a method in which Sobel edge detection is combined with

978-1-5090-3411-6/16 $31.00 © 2016 IEEE
DOI 10.1109/ICMETE.2016.49

soft-threshold wavelet de-noising on images which have White Gaussian noises. Firstly, soft-threshold wavelet de-noising is used to remove the noises from the image and then Sobel operator is applied to it. The results show an improvement in the accuracy of edge detection.

Biswas et al.[7] discussed an algorithm which uses type-2 fuzzy sets that contend with uncertainties that automatically selects threshold value required to segment gradient image using canny edge detector. In the existing system where we select threshold randomly, this method can come into play by selecting effective threshold values for canny edge detection algorithm. Apparently, this method yielded effective results.

[8] A Hybrid approach is proposed in which modified Percentile thresholding method is combined with edge detection techniques. The edge detection technique used is canny edge detection. The P-tile method used works as a global thresholding method that helps in retrieving shape information. Thus this algorithm is useful for applications that require preserving shape of the objects. The results depict that the proposed algorithm shows better results than Otsu and P-tile method.

In [9], Pavithra et al. used a Canny edge detection algorithm to find the accurate edges. Using this edge detection algorithm the amount of data in the image reduced. This edge detection algorithm refined the visual perception of the image. The proposed method was used to convert 2D image into 3D images. In [10], Sidhu discussed a double threshold technique. Using this technique, the results of canny operator are analyzed with different color spaces like RGB and HSV. Improved canny operator is presented which comprises of a new double threshold technique. This technique is implemented with three color spaces: HSV, RGB and L*a*b*. This provides optimized results of edge detection with nominal computational cost. The new technique has better results than traditional canny edge detector.

[11] He et al. use linear interpolation which resulted in much efficient edge detection and hexagonal structure leaded to more precise and less noisy edge maps as compared to the state-of-the art Canny edge detector.

[12] A new algorithm is presented in which improved Sobel operator and genetic algorithms are used which optimizes the segmentation threshold. The demerits of classical Sobel operator have been overcome.

In [13], K B et al. implemented an effective sobel edge detection algorithm on FPGA (Field Programmable Gate Array). The proposed method has modified gradient calculation unit in order to improve the speed and reduce the FPGA resources required for the implementation. Due to this the propagation delay and area has reduced to 51% and 40% respectively.

[14] A method which convolves canny operator with wavelet lift has been developed in this paper. Using wavelet lift, the algorithm lessens the requirement of memory and complexity. The extracted edges become visually clear and precise, the column and row wavelet transformations reduce the consumption of memory and the amount of computation also reduces.

III. Sobel And Canny Edge Detection

A. Sobel Edge Detector

Sobel operator is based on first order differential. This operator convolves the image with a integer valued, small, separable filter in horizontal and vertical direction. It is computationally inexpensive. It is a type of orthogonal gradient operator which is partial derivative in x and y direction calculated using 3×3 neighborhood of $f(x, y)$, [8] that is

$$Sx = \{f(x+1,y-1) + 2f(x+1,y) + f(x+1,y+1)\} - \{f(x-1,y-1) + 2f(x-1,y) + f(x-1,y+1)\} \quad (1)$$

$$Sy = \{f(x-1,y+1) + 2f(x,y+1) + f(x+1,y+1)\} - \{f(x-1,y-1) + 2f(x,y-1) + f(x+1,y-1)\} \quad (2)$$

The gradient in oblique direction is

$$g(x,y) = \sqrt{S_x^2 + S_y^2} \quad (3)$$

For a digital image, the above formula can be reduced to as follows

$$g(x,y) = |Sx| + |Sy| \quad (4)$$

Its convolution operator is

$$\begin{bmatrix} -1 & 0 & -1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \quad \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$$

There are two main advantages of Sobel edge detection: (a) It has some smoothing effect on the unwanted noise in an image. (b) As a differential of 2 rows or 2 columns have been used, it enhances the elements of the edge thus edge becomes thick and bright.

B. Canny Edge Detector

Canny edge detector is a multi stage algorithm which is used to identify a wide range of edges in an image. Its performance is quiet good so it is also known as optimal edge detector. The basic principle of Canny operator is to find the first order derivative of Gaussian function in any direction as a noise filter [5]. Using this filter the local gradient maximum value can be determined. Thus the edges of image can be detected [5]. The steps are as follows.

- Noise removal:
  This step involves the smoothening of image for noise removal. Gaussian filter is widely used for noise removal, in which signals are smoothed out by convolving the image with a Gaussian kernel [8].

- Differentiation:

It involves finding the gradient of image so that the regions with high spatial derivatives can be highlighted [8].

- Non-maximum suppression:
  The highlighted regions are tracked down and the pixels which are not at the maximum are suppressed.
- Double thresholding:
  Two thresholds are used by a canny operator to identify strong edge and weak edge respectively. Only when a strong edge is connected to a weak edge, the output will contain weak edge.
- Edge tracking by Hysteresis:
  It is used to check on the remaining pixels which have not been suppressed by non-maximum suppression. Two thresholds T_1 and T_2 are used to classify the gradients in three parts [7]:
  - Gradients > T_2 are definitely an edge point
  - Gradients <T_1 are definitely not a non-edge point
  - Otherwise, decision will be made depending upon the direction of point and the existing edge paths.

C. Median Filter

This paper shows a combination of median filter along with Sobel and Canny edge detectors. Median filter is a non linear filter which is used to remove impulsive or salt-and-pepper noise. While removing noise it also preserves the edges of image. Basically in median filtering a window is used, which slides along the image. The median intensity value of pixels that are within the window becomes the output intensity of the pixels that are being processed.

IV. Proposed Algorithm

This paper concentrates on accuracy of edge detection and effective noise removal. For better removal of noise a median filter has been used which filters out the salt and pepper noise efficiently. The hybrid approach in this algorithm combines the advantages of all the methods used.

The goal of the proposed method is to overcome the shortcomings of existing edge detecting algorithms: Sobel and Canny edge detection algorithm.

Step 1: Add some salt-and-pepper noise to the input image $f_1(x, y)$.

Step 2: Use median filter on the image to remove the noise. The out image is $f_2(x, y)$

Step 3: First apply Sobel edge detection operator to the image $f_2(x, y)$ and take the output as BW1.

Step 4: Then apply the Canny edge detector to the image $f_2(x, y)$ and take the output as BW2

Step 5: Make a hybrid of both the results

$$\text{Hybrid\_image} = BW1 + BW2 \quad (5)$$

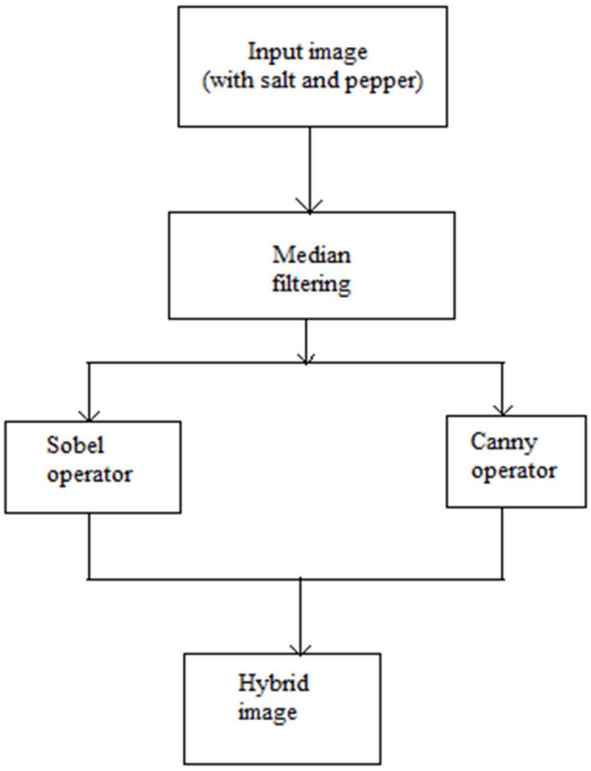


Fig. 1 Proposed Algorithm

V. Experimental Results

Fig. 2 (a) shows the original image and (b) shows the input image with salt and pepper noise. When the median filter is applied upon this image, it filters out the noise and smoothes the image. Fig. 2 (c) shows the smoothened image after filtering. After filtering, edge detection becomes more effective.

Now Sobel operator and canny operator is applied to this image. Fig. 2 (d) shows the image on applying Sobel operator. It can be seen that some details have been lost in the edges of the image. It is known that there is still a part of detail information to get lost, and edge image is not quite well [3]. Fig. 2 (e) shows the result of applying Canny operator. It is seen that the edges are clearer as canny operator is less sensitive to noise than Sobel operator. But there are a few edges which are detected by Sobel operator and not Canny operator. This is where Hybrid approach helps in achieving efficient results.

Fig. 2(f) shows the final result of the algorithm. It combines the advantages of all the three components.

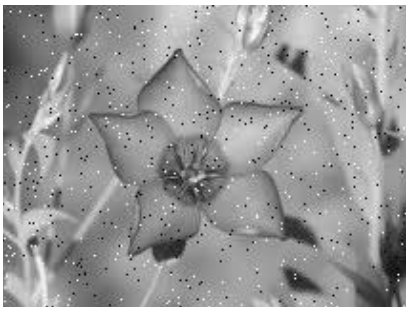
Fig. 3 shows the result of only using Sobel and Canny operator on the image. Median filter is not used therefore the image has some noise in it. The edges detected are a little discontinuous. Consequently it makes the information a little

abundant. Fig. 4 and Fig. 5 show some more outputs of the proposed algorithm.

Classical edge detection methods are sensitive to noise because of the introduction of various forms of differential operation. Noise is detected as edge points in edge detection instead of real edge with interference of noise. Therefore good noise immunity is required. The position of Sobel edge operator is accurate, but is sensitive to noise [3]. The canny method detects the weak edge easily and suppresses it down.

Thus using the hybrid approach improves the result by making the details of image visually richer and complete, there are no false edges and it gets an ideal effect.

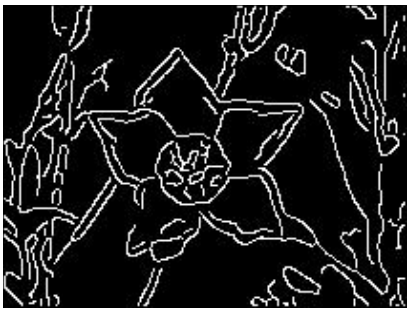
(a) Original image



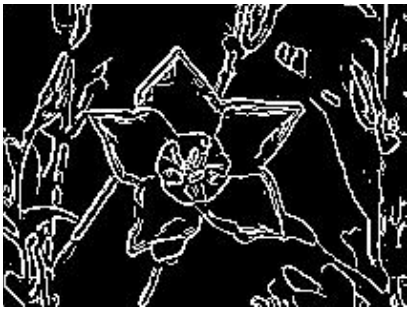
(b) Image with salt and pepper noise

(c) Image after applying Median Filter

(d) Sobel edge detection



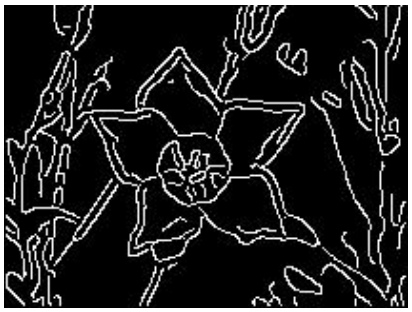
(e) Canny Edge Detection



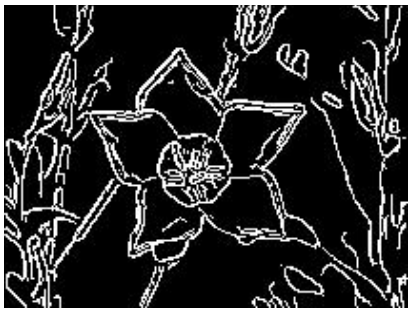
(f) Hybrid image

Fig. 2 Results when Median Filter is applied

(a) Sobel Edge Detection



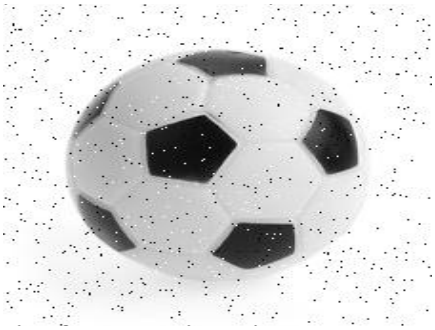
(b) Canny Edge Detection



(c) Hybrid image

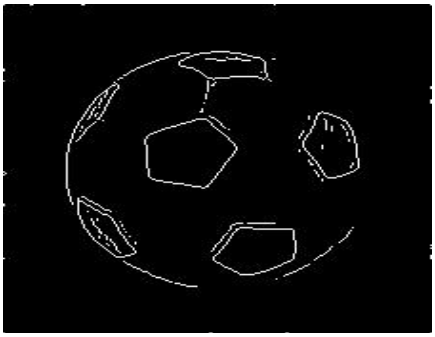
Fig. 3 Results when Median Filter is not applied

(a) Original image



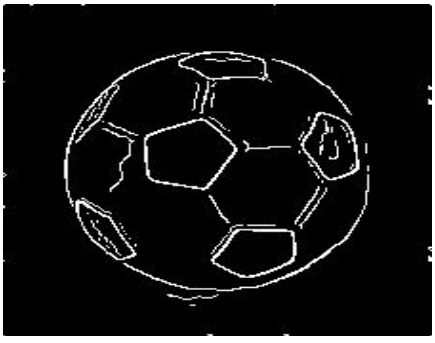
(b) Image with salt and pepper

(c) Image after applying Median Filter



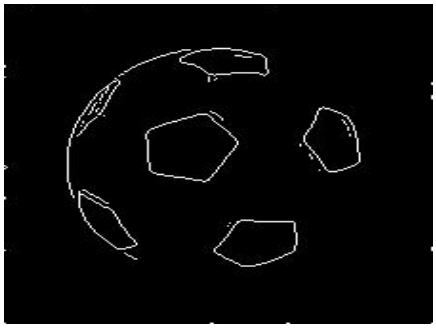
(d) Sobel Edge Detection

(e) Canny Edge Detection



(f) Hybrid image

Fig. 4 Results when Median Filter is applied



(a) Sobel Edge Detection

(b) Canny Edge Detection

(c) Hybrid Image

Fig. 5 Results when Median Filter is not applied

VI. CONCLUSION

Edge detection is an important step for object extraction. Edge detection reduces the storage space consumed by an image. Detection of edges identifies boundaries and objects; therefore it is widely used for image segmentation. Edge detection also helps to extract important features in an image for pattern recognition. Therefore it is important to get good results from edge detection techniques. Individually the operators do not detect all the edges; therefore this paper presented a hybrid approach which can group together the advantages of Sobel and Canny edge detectors. The proposed algorithm also uses a median filter in order to remove any noise. This median filtering smoothes the input image and gives better output. In this way, the extraction image consists of relatively complete profile and rich detailed information. It effectively improves the accuracy of edge detection and gets quite an ideal edge detection effect.

ACKNOWLEDGMENTS

We would like to acknowledge the support of Amity University, NOIDA, Uttar Pradesh who gave us access to their resources. We would also like to express our gratitude to the Director, ASET and HOD, Computer Science and Engineering for their encouragement to pursue research work under this topic.

REFERENCES

[1] Ghassan Mahmoud husien Amer and Dr. Ahmed Mohamed Abushaala, "Edge Detection Methods", IEEE, 2015.

[2] Feng-ying Cui, Li-jun Zou and Bei Song, "Edge Feature Extraction Based on Digital Image Processing Techniques", International Conference on Automation and Logistics Qingdao, China, 2008, pp. 2320-2324.

[3] Caixia Deng, Weifeng Ma and Yin Yin, "An Edge Detection Approach of Image Fusion Based on Improved Sobel Operator", 4th International Congress on Image and Signal Processing, 2011, pp. 1189-1193.

[4] Chinu and Amit Chhabra, "A Hybrid Approach for Color based Image Edge Detection", International Conference on Advances in Computing, Communications and Informatics (ICACCI), 2014, pp. 2443-2448.

[5] Cai-Xia Deng, Gui-Bin Wang and Xin-Rui Yang, "Image Edge Detection algorithm based on Improved Canny Operator", International Conference on Wavelet Analysis and Pattern Recognition, 2013, pp. 168-172.

[6] Wenshuo Gao, Lei Yang, Xiaoguang Zhang and Huizhong Liu, "An Improved Sobel Edge Detection", IEEE, 2010, pp. 67-71.

[7] Ranita Biswas and Jaya Sil, "An Improved Canny Edge Detection Algorithm Based on Type-2 Fuzzy Sets", Procedia Technology 4, 2012, pp. 820 – 824.

[8] Moslem Taghizadeh and Mahboobeh Hajipoor, "A Hybrid Algorithm for Segmentation of MRI Images Based on Edge Detection", International Conference of Soft Computing and Pattern Recognition, 2011, pp. 107-111.

[9] C.Pavithra, M.Kavitha and E.Kannan, "An Efficient Edge Detection Algorithm for 2D-3D Conversion", International conference on computation of power, energy, information and communication, 2014, pp. 434-436.

[10] Ravneet Kaur Sidhu, "Improved Canny Edge Detector in Various Color Spaces", IEEE, 2014.

[11] Xiangjian He, Wenjing Jia and Qiang Wu, "An Approach of Canny Edge Detection with Virtual Hexagonal Image Structure", 10th Intl. Conf. on Control, Automation, Robotics and Vision Hanoi, Vietnam, 2008, pp. 879-882.

[12] Zhang Jin-Yu, Chen Yan and Huang Xian-Xiang, "Edge Detection of Images Based on Improved Sobel Operator and Genetic Algorithms", IEEE, 2009.

[13] Lavanya K B, K. V Ramana Reddy and Siva S Yellampalli, "Comparative analysis of different optimization technique for Sobel edge detection on FPGA", International Conference on Advances in Electronics, Computers and Communications (ICAECC), 2014.

[14] Xiaofeng Zhang, Yu Zhang and Ran Zheng, "Image edge detection method of combining wavelet lift with Canny operator", Procedia Engineering, 2011, pp.1335-1339.