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A SURVEY ON RELEVANT EDGE DETECTION TECHNIQUE FOR MEDICAL IMAGE PROCESSING

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ABSTRACT
Medical image edge detection is an important work for object recognition of human organs and it is an important pre-processing step in medical image segmentation and 3D reconstruction. With the increasing research on better algorithms for segmentation and feature extraction of medical image, it is important to categorize the already known techniques, their conceptual basis and their overview. This paper is a review of the approaches adopted by several authors for edge detection in medical image processing as well as various traditional approaches which are of two types namely Gradient and Gaussian based techniques. Gaussian edge detection can be further divided into Laplacian of Gaussian (LoG) edge detection and Canny Edge Detection. These approaches are reviewed with an importance placed on enlightening the advantages and drawbacks of these methods for medical edge detection.

KEYWORDS: Medical Edge Detection, Active Contour, Texture Discrimination, Multi-scale Edge Detection, Threshold, Hopfield Neural Network, Generic Algorithm, Bayesian Edge Detection, Low Contrast Lesions.

1. INTRODUCTION

Interpretation of image contents is one of the main objectives in computer vision. The purpose of Image segmentation is to partition an image into meaningful regions with respect to a particular application. There are mainly four techniques of image segmentation viz. threshold techniques, edge techniques, region based techniques and connectivity preserving relaxation techniques. Most widely and important technique of Image Segmentation is "edge detection". For accurate segmentation of medical image an effective edge detection algorithm is required. Edge is a basic and an important feature of an image. Image is a combination of edges. Detecting edges is one of the most important aspects in image segmentation. It is an important step in digital image processing and is mainly used in the application of feature extraction.

Edge detection is an interdisciplinary subject originated from Artificial Intelligence and Image Processing. It is a fundamental tool in image processing, machine vision and computer vision, particularly in the areas of feature detection and feature extraction. Image processing is defined as the processing of images using mathematical operations by using any form of signal processing for which the input is an image, a series of images, or a video, such as a photograph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it. Whereas Artificial Intelligence is a branch of computer science dealing with the simulation of intelligent behavior in computers. Edge detection is in the forefront of image processing for object detection. It is thus an important part of image preprocessing aimed to their segmentation and automatic recognition of their contents.

1.1. Edge Detection

Edge detection is the name for a set of mathematical methods which aim at identifying points in a digital image at which the image intensity changes sharply or, more formally, has discontinuities. Edge detection techniques are generally used for finding discontinuities in gray level images. There are three different types of discontinuities in the gray level namely like point, line and edges. The points at which image intensity changes sharply are typically organized into a set of curved line segments termed as edges.

In general, Edge detection is a fundamental tool for image segmentation. Edge detection methods transform original images into edge images benefits from the changes of grey tones in the image. It is principally a high-pass filter that can be applied to extract the edge points in an image. It has been a major concerning issue in image segmentation and for the researchers. The purpose of image segmentation is to partition an image into meaningful regions with respect to a particular application where edges in digital images are areas with strong intensity contrasts and a jump in intensity from one pixel to the next can create major variation in the picture quality and image segmentation.

(a)

(b)

Fig 1: Figure showing result of Edge detection (a) Original Lena Image and (b) Image after edge detection.[1]

1.2. Medical Edge Detection

Edge detection is an important terminology in medical science as well. Medical edge detection is implemented in medical image analysis is critical innumerous biomedical applications such as detection of abnormalities, tissue measurement, surgical planning and simulation and many more. Medical images obtained from devices such as Ultrasonography, X-Ray, CT and MRI exhibit diverse image characteristics but are essentially collection of intensity variations from which specific abnormalities are needed to be isolated. Homogeneity enhancement, followed by edge detection and resulting segmentation is essential prerequisite for all histopathological image analysis system. The term Histopathology comes from Greek words: histos "tissue", pathos "suffering", and logia "study of". It refers to the microscopic examination of tissue in order to study the manifestations of disease. Specifically, in clinical medicine, histopathology refers to the examination of a biopsy or surgical specimen by a pathologist, after the specimen has been processed and histological sections have been placed onto glass slides. Before the feature extraction, the medical image undergoes pre-processing i.e. first the RGB colored image is converted to grey scale to reduce the image complexity followed by image segmentation and feature extraction. Edge detection is usually preceded by De-noising or image smoothing to increase the accuracy and reliability of edge detection. The simplest flowchart of the edge detection technique is shown.

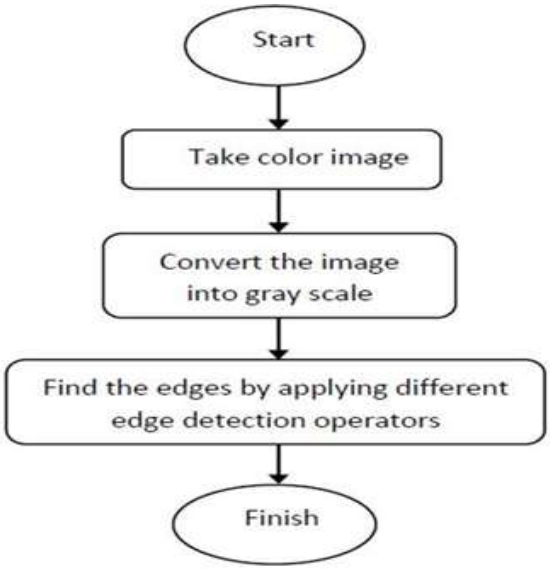
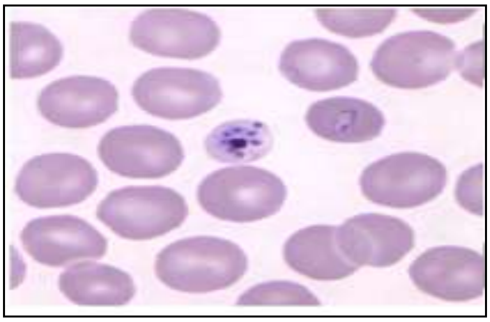
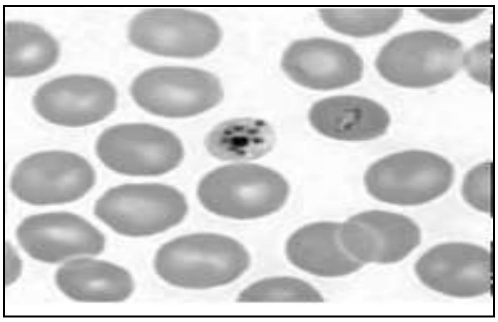


Fig 2: Flowchart of Edge Detection Technique[2]



(a)



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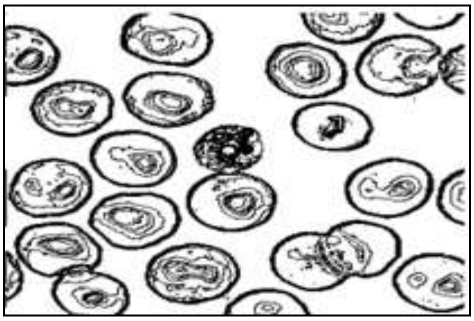


(c)

Fig 3: Image showing Medical Edge Detection: (a) Original Colour Medical Image, (b) Gray-scaled Image and (c) Image after Edge detection.

Since we have not found a comprehensive literature review of edge detection, in the latter part of this paper, in section two we are going to discuss about the prior and the recent techniques of edge detection. This sub-section contains the various filter based edge detection techniques discussed briefly. Further in this section the most commonly used methods proposed by different authors are cited whereas the penultimate section represents the discussion. The final section contains the conclusion of our citation.

2. METHODS

Edge detection of an image is one of the most fundamental features in image processing as well as in video processing. It refers to the process of identifying, locating and indicating the discontinuities in image. Edge detection of the medical image is a very useful task for object recognition of human organs. There are several research papers where we find a detailed review on various traditional edge detection techniques, their purpose, advantages and disadvantages. Some of them are discussed here. Efforts has been made to review[3] the different techniques for edge detection based on FPGA and focus has been made on comparing different edge detection methods using Remote Sensing images.[4] The FPGA based architecture reduces time for edge detection and give the real-time edge detection of image. However the complexity in the canny edge detector is high compared to other detectors. Further review has been made on Image Enhancement using Canny detection method.[5] Different Filter based[6] [7] methods like Sobel, Prewitt, Laplacian of Gaussian (LOG) and Canny are discussed here. In the Survey on Edge detection we find review over the published articles on edge detection.[8] At first, it provides theoretical background, and then reviews wide range of methods of edge detection in different categorizes. The review also studies the relationship between categories and presents evaluations regarding to their application, performance, and implementation. Another paper presents a review on different color based edge detection techniques.[9] It has been found that the most of the existing techniques has neglected the use of colors while detecting the edges but in many applications a region can be categorized based upon the color. This paper has shown that the most of the existing techniques fails in case of images with complex background.

2.1. Filter Based Methods

There are many edge detection techniques in the literature for image segmentation. The most commonly used discontinuity based edge detection techniques are reviewed in this section. Those techniques are basically of 2 types namely: Gradient (Roberts, Sobel and Prewitt) and Gaussian. Gaussian based edge detection are of two types LoG edge detection and Canny Edge Detection. The gradient method detects the edges by looking for the maximum and minimum in the first derivative of the image while the Laplacian method searches for zero crossings in the second order derivative of the image to find edges.

Roberts Edge Detection

The Roberts edge detection[10] is introduced by Lawrence Roberts in 1965. It requires a simple and quick to compute 2-D spatial gradient measurement on an image. This method emphasizes regions of high spatial frequency which often correspond to edges. Pixel values in every point in the output represent the estimated complete magnitude of the spatial gradient of the input grayscale image at that point. In Robert edge detection, the vertical and horizontal edges bring out individually and then put together for resulting edge detection.

Sobel Edge Detection

The Sobel edge detection[10] method is introduced by Sobel in 1970 (Rafael C. Gonzalez (2004). This method for image segmentation finds edges using the Sobel approximation to the derivative. It precedes the edges at those points where the gradient is highest and performs a 2-D spatial gradient quantity on an image and so highlights regions of high spatial frequency that correspond to edges. In general it is used to find the estimated absolute gradient magnitude at each point in n input grayscale image. In conjecture at least the operator consists[11] of a pair of 3x3 complication kernels as given away in under table. One kernel is simply the other rotated by 90degree. This is very alike to the Roberts Cross operator.

Prewitt Edge Detection

The Prewitt edge detection[10] is proposed by Prewitt in 1970 (Rafael C. Gonzalez). Prewitt operator edge detection masks are one of the oldest and best understood methods of detecting edges in images. This edge detector uses the masks to approximate digitally the first derivatives Gx and Gy. The 3X3 total convolution mask is used to detect gradient in the X, Y directions.[1]

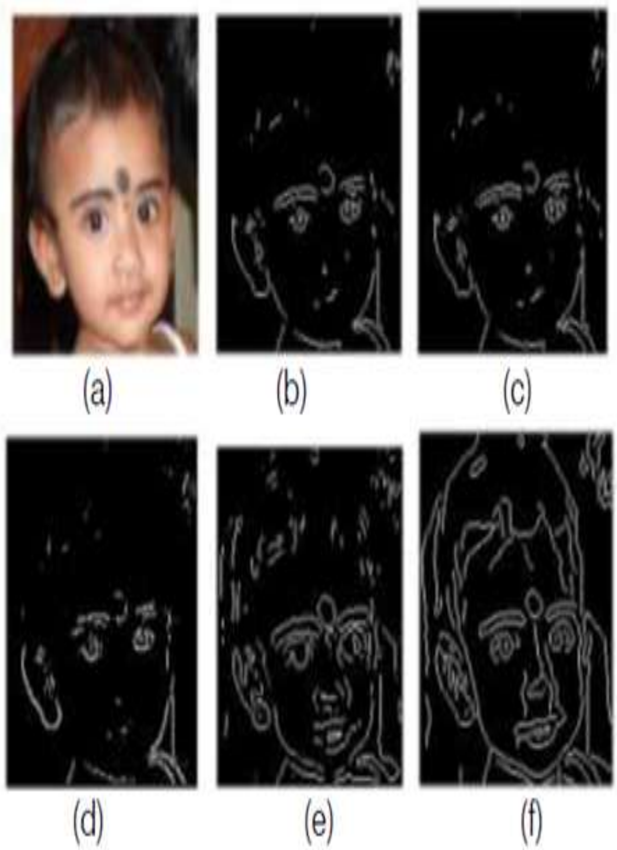


Fig 4: Image showing the various Filter based edge detection techniques (a) Diya (original image), (b) Sobel, (c) Prewitt, (d) Roberts, (e) Laplacian of Gaussian and (f) canny.[2]

LoG edge detection

The Laplacian of Gaussian (LoG)[10] detection technique was proposed by Marr in 1982. The LoG of an image f(x,y) is a second order derivative defined as,

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

The Laplacian of an image highlights regions of rapid intensity change and is therefore often used for edge detection. It has two effects, it smoothens the image and computes the Laplacian, which yields a double edge image. Locating edges then consists of finding the zero crossings[2] between the double edges. It is generally used to find whether a pixel is on the dark or light side of an edge. The Laplacian operator normally takes a single grey level image as input and produces another grey level image as output.

Canny Edge Detection

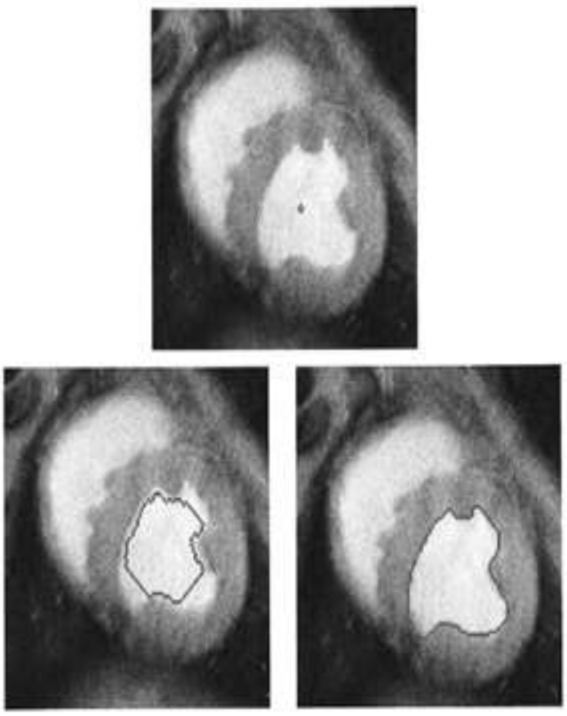
In industry, the Canny edge[10] detection technique is one of the standard edge detection techniques. It was first created by John Canny for his Master's thesis at MIT in 1983. Canny edge detection is a multistage algorithm to detect a wide range of edges in images. This detector finds edges by looking for local maxima of the gradient of f(x, y). The gradient is calculated using the derivative of a Gaussian filter. The method uses two thresholds to detect strong and weak edges and includes the weak edges in the output only if they are connected to strong edges.[2]

2.2. Other Contemporary Methods

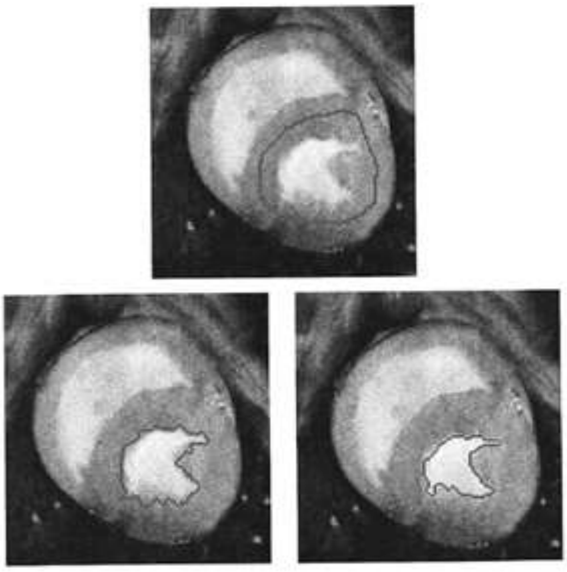
In spite of the mathematical sophistication of these filter based techniques, the problem of finding true edges that correspond to physical boundaries of an object in an image is still a very difficult one. Thus several contemporary techniques are developed with new ideas of medical edge detection. Here we have reviewed some of the published articles on edge detection. The recent developed algorithms include Active contour or snake model, Texture discrimination based edge detection, Multi-scale edge detection, Contextual based Hopfield Neural Network, Generic Algorithm based, Bayesian Edge Detection, Fuzzy set based, linking to Boundaries of Low Contrast Lesions and Adaptive Thresholding based approach.

Active contour or Snake Model

A snake[12] is an energy minimizing spline guided by external constraint forces and influenced by image forces that pull it towards features such as lines and edges. Snakes are active contour models: they lock into nearby edges, localizing them accurately. Scale-space continuation can be used to enlarge the captured region surrounding the feature. This methodology is based upon the utilization of deformable contours which conform to various object shapes and motions. Snakes have been used for edge and curve detection in medical imaging, segmentation, shape modeling and visual tracking.[13]



(a)



(b)

Fig 5: Comparative edge detection results with (a)Bubble and (b)Snake edge detector for MRI heart images

Based on Texture Discrimination

As medical images are fuzzy, edge detection based on texture characteristics is comparatively effective than intensity based techniques. A generic methodology[14] has been described for texture edge detection using multi-resolution and multi-scale filters on some modalities of medical images for discriminating, segmenting different texture regions and capturing texture edge information. First texture edge information is defined and an experimental work bench is presented for finding efficient range of values for Gabor function parameters to capture it. Then step by step approach is delineated to achieve the texture edge map.

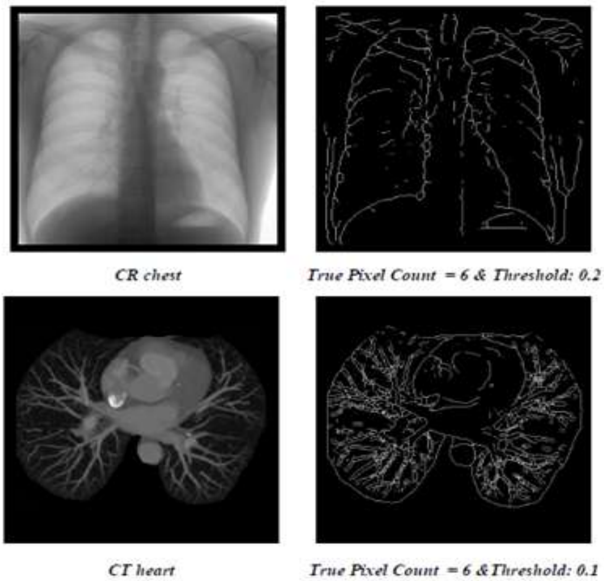


Fig 6: Edge detection results of Texture Discrimination for images from CR and CT modalities.

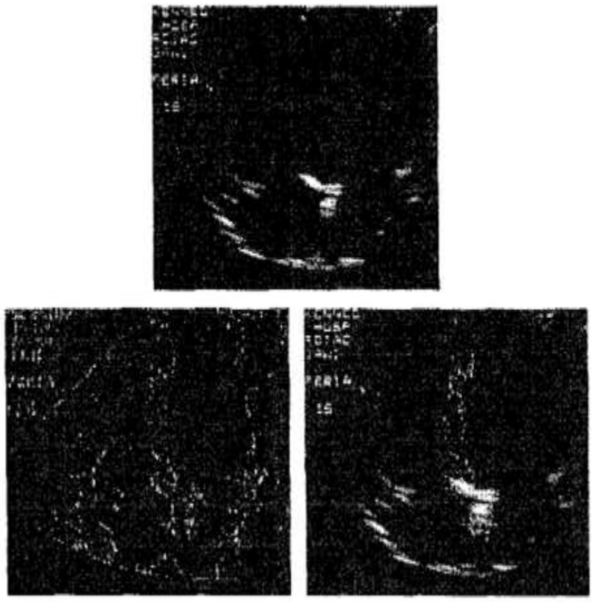


Fig 7: Multi-scale edge detection: (top) Original image, (bottom left) edges found, and (bottom right) original image with enhanced wall where the edges along the wall are emphasized to monitor the ventricular performance.

Multi-scale edge detection for medical image enhancement

This method is based on multi-scale analysis[15] using filter banks and is adaptive to a large number of features. Initially, an optimal one-scale filter is designed for the required detection and then it is further extended to a set of multi-scale filters, which in turn are used in designing the filter bank that would provide the desired multi-scale responses. Subsequently, the scale space information is optimally combined in a maximum-a-posteriori (MAP) classifier, whose design depends on the desired feature and the resulting filter bank.

Contextual based Hopfield Neural Network (CHNN)

In this technique[16], a special design Hopfield neural network called Contextual Hopfield Neural Network (CHNN) is presented for finding the edges of CT and MRl images. Different from the conventional 2-D Hopfield neural networks, the CHNN maps the two-dimensional Hopfield network at the original image plane. With the direct mapping, the network is capable of incorporating pixels' contextual information into a pixels' labeling procedure. As a result, the effect of tiny details or noises will be effectively removed by the CHNN and the drawback of disconnected fractions can be overcome.

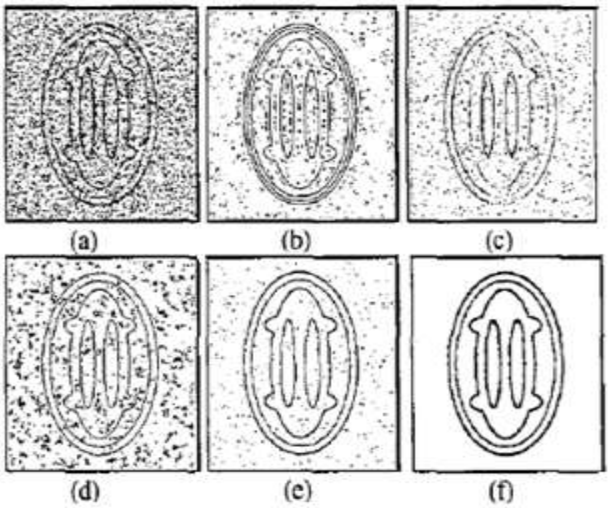


Fig 8: The edge detection results of phantom image with added noise (K=30), (a) result by the Laplacian based method, (b) result by the Man-Hildreth's method, (c) result by the wavelet-based method, (d) result by the Canny's method, (e) result by the CHEF and (f) result by the CHNN

Using Generic Algorithm

An algorithm[17] is developed that detects well-localized, un-fragmented, thin edges in medical images based on optimization of edge configurations using a genetic algorithm (GA). Several enhancements were added to improve the performance of the algorithm over a traditional GA. The edge map is split into connected sub regions to reduce the solution space and simplify the problem. The edge-map is then optimized in parallel using incorporated genetic operators that perform transforms on edge structures. Adaptation is used to control operator probabilities based on their participation.

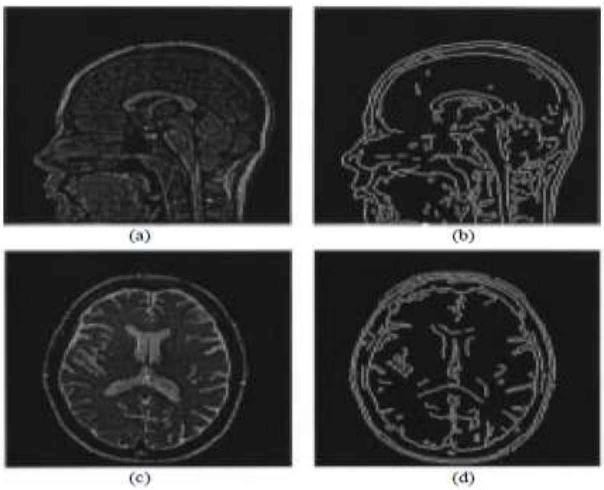


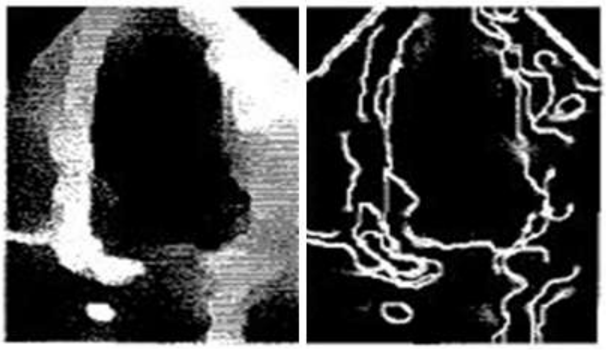
Fig 9: Edge detection of MRI brain images using Genetic Algorithm. (a) A sagittal T1-weighted MRI brain image and (b) its edge image, after 300 generations. (c) An axial T1-weighted MRI brain image and (d) its edge image after 300 generations.

Using Morphological filters

Morphological operations[18] can be used for edge detection, segmentation and image enhancement. The basic set operations are dilation, erosion, opening, and closing. Morphological opening and closing operations perform similar nonlinear noise removal with litter or no loss of edge feature. The edge structure can be estimated by subtracting the morphological erosion. This morphological edge detector obey threshold-linear superposition which means a complex gray-scale edge detector that can be formulated by implementing simple binary edge detector subsections and summing their output binary edges.

Bayesian Edge Detection

In this work, a discrete linear imaging model appropriate for clinical ultrasound B-scans is derived. Based on this model[19], a Bayesian restoration approach is developed that is currently designed for the generation of correct edges of medical ultrasound images. In this method, a priori information is incorporated in part by the use of line sites, which have numerical values between 0 and 1, as a way of evaluating the probability of the presence of edges between two neighboring pixels. This auxiliary information is utilized to avoid smoothing across true edges and thus perform speckle reduction, edge detection and region segmentation at the same time.

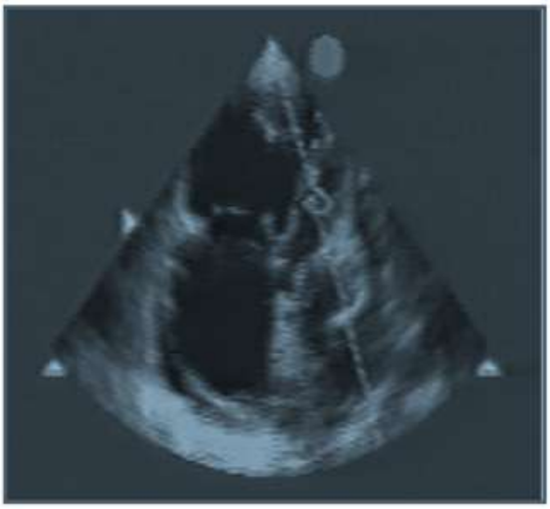


(a) (b)

Fig 10: (a)Restored cardiac image and (b)its edge map obtained by the Bayesian Edge Detection technique.

Fuzzy set based

A fast edge detection method[20] basing on the combination of fuzzy subsets is developed which involves partitioning the image into two portions: the edge portion and the non-edge portion. The latter one, as the main constituent of an image, consists of the object and its background. Removing the non-edge portion from an image, the remainder is nothing but the edge of this image. In this technique, the gray level histogram is partitioned into several sub-regions, and some operations are performed with the associated fuzzy subsets corresponding to those sub-edges in the sub-regions on the gray-level-square-difference histogram and the edge of this image is finally obtained.



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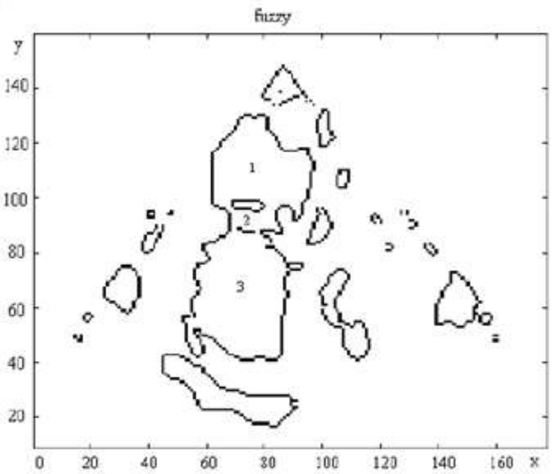
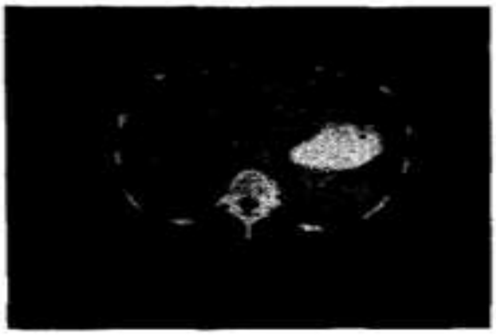


(b)

Fig 11: (a) An ultrasonic heart image and (b)Edge picture of the image of heart obtained by means of fuzzy operators

Sequential Edge Detection and Linking to Boundaries of Low Contrast Lesions

This technique describes an algorithm[21] for the optimal edge contour estimation in medical images without a priori shape models. An optimal and robust contour estimator is derived by minimization of a risk function R, which measures the error from both inappropriate choice of edge contour and the noise model in the image. The result includes Huber's function. If a parametric statistical noise model and the Neyman-Pemon criterion are used, the result is an extension of maximum likelihood function. A recursive formula can be implemented by assuming independent random field and a Markov path model. The assumption of independent statistics can be satisfied by use of an autoregressive moving-average (ARMA) preprocessor. The problem of varying edge strength is lessened using an adaptive trimmed mean. The robust algorithm is implemented using a priority-tree (stack) structure. The system's performance is illustrated by estimation of lesion boundaries in medical images.



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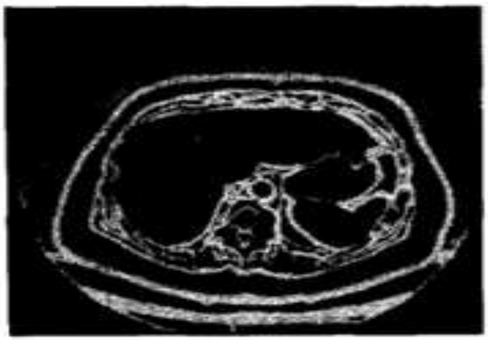

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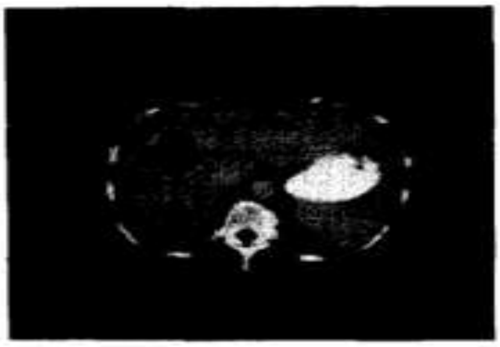
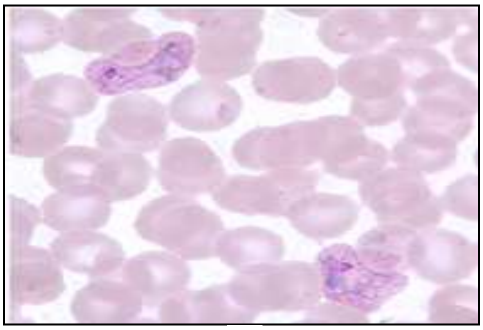


(c)

Fig 12: (a) Original CT image, (b) Edge enhanced image, (c) Algorithm result obtained by Sequential Edge Detection and Linking to Boundaries of Low Contrast Lesions.

Adaptive Thresholding Based Approach

Tree based approach toward edge detection of Histopathological Images is implemented using Maximum Difference Threshold (MDT). For the image segmentation to be accurate it must be preceded by a robust edge detecting algorithm. In this paper a method is professed where with the tree based approach and with the help of statistical analysis and distance thresholding an improved image enhancement and edge detection algorithm providing excellent results have been developed.[11][22]



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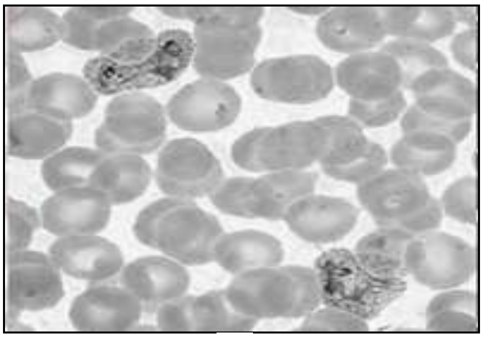

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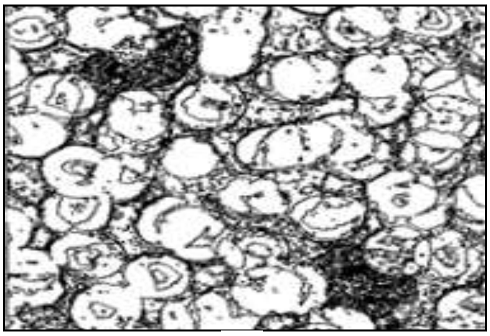

(c)

Fig 13: (a) Original Colour Image, (b) Gray-scaled Image, (c) Edge Map Image using Adaptive Thresholding based method

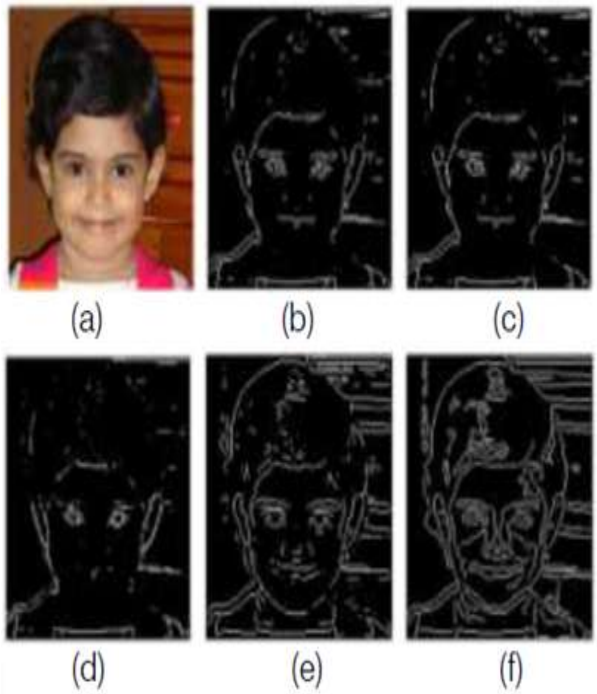

Fig 14: (a) Trisha (original image), (b) Sobel, (c) Prewitt, (d) Roberts, (e) Laplacian of Gaussian, (f) canny.[2]

Table: Statistical Measurement[2]

IMAGE	ENTROPY	PSNR	MSE	EXECUTION TIME
Trisha with Sobel	1.2820	11.4067	4.7034e+003	1.052911 seconds
Trisha with Prewitt	1.2792	11.3928	4.7185e+003	0.878266 seconds
Trisha with Roberts	1.2306	17.1396	1.2564e+003	0.831094 seconds
Trisha with LoG	1.4354	11.2313	4.8973e+003	0.978503 seconds
Trisha with Canny	1.5701	10.9043	5.2803e+003	1.014961 seconds

***Table:* Comparison of the classical methods with the Adaptive Thresholding based approach on important parameter.**

Edge Operators	Convolution	Sensitivity to Noise	Single Pixel edge	Edge continuity	Algo	Running Time
Sobel	Yes	Yes	No	No	Simple	Slow
Roberts	Yes	Yes	No	No	Simple	Slow
Kirsch	Yes	Yes	No	No	Simple	Slow
Prewitt	Yes	Yes	No	No	Simple	Slow
LoG	Yes	No	No	No	Complex	Slow
Adaptive Thresholding based Approach	No	No	Yes	Yes	Simple	Fast

3. DISCUSSION

This section presents the relative performance of various edge detectors. Five edge detection operators have been chosen to carry out for edge detection and image segmentation. They are namely, Sobel, Prewitt, Roberts, LoG and Canny. The original image is shown in figure 16 (a) and the segmented images have been shown in figure 16 (b) to figure 16 (f). The entropy, PSNR, MSE and execution times of the segmented images have been calculated and are shown in the table. Peak signal to noise ratio (PSNR) is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. It is the logarithmic function of the peak value of the image and the mean square error. Its value must be high. It have been observed that that the Canny edge detector produces higher accuracy in detection of object edges with higher entropy, PSNR, MSE and execution time compared with Sobel, Roberts, Prewitt, Zero crossing and LOG. On the other hand Robert's edge detector has the minimum entropy with PSNR, MSE and execution time compared with others. The statistical analyses for all the edge detectors are shown in table.[2]

Derivative methods are the most efficient allowing to detect local intensity variations. Edges can be obtained by extraction of the local maxima's of the first derivative or well by extracting the zero cross of either the directional second derivative, or the Laplacian. The gradient method include many matrix multiplications thus the complexity increases to a great extent. So a better approach, Laplacian method is introduced. It searches for zero crossings in the second order derivative of the image to find edges. It is better in terms of Entropy, PSNR, MSE, but the time and calculation complexity is more compared to the first order derivative.

In spite of the mathematical sophistication of these techniques, the problem of finding true edges that correspond to physical boundaries of an object in an image is still a very difficult one. Thus several contemporary techniques are developed with new ideas of medical edge detection. The technique of Robust Sequential Edge Detection and Linking to Boundaries of Low Contrast Lesions[21] derived the optimization equations used for edge contour estimation by sequential linking. The algorithm proposed in this paper does not assume a model for the shape of the object boundaries, and its input is an edge enhanced image. Compared with many other intermediate-level algorithms that use the set of edge points as input, this algorithm preserves more information about the object and can be more efficient. Compared with Canny's operator, the performance by sequential estimation is computationally more efficient, and yields fewer isolated segments. Unlike this method, a discrete linear imaging model appropriate for clinical ultrasound B-scans is derived in Bayesian edge detection technique.[19] Based on this model, a Bayesian restoration approach is developed that is currently designed for the generation of correct edges of medical ultrasound images. The proposed Bayesian approach is very flexible and has the potential of being extended to perform speckle reduction, edge detection, and region segmentation at the same time.

Owing to the better performance of the edge detectors, classical snake edge detection is modified to geometrical edge or active contours.[12] In this technique, new geometric active contour models are formulated for edge detection and segmentation of magnetic resonance imaging (MRI), computed tomography (CT), and ultrasound medical imagery. Though this method is fast and reliable, it does not respond well in noisy image. This disadvantage is resolved by another proposed method of edge detection using Multi-scale analysis.[15] Multi-scale edge detection is based on multi-scale analysis using filter banks and is adaptive to a large number of features. Multi-scale analysis provide means to localize the features at low scales, and minimize noise at higher scales. The method is successfully tested on echocardiographic images and can be applied to images suffering from severe noise degradation. It is thus robust to noisy conditions which are common to medical images in angiography, echocardiography, blood vessels, and others based on ultrasonic imaging, X-ray, arid tomography.

As medical images are fuzzy, edge detection based on texture characteristics is comparatively effective than intensity based techniques.[14] A new methodology is described for texture edge detection which uses a multi-scale filter to capture texture edge information. Implementing a multi-scale filtering method of texture edge detection for medical images across modalities requires, configuring the function parameters to capture maximum edge information across the range of intensity resolution and developing a generic methodology for edge detection. Further it is shown that morphological operators can significantly reduce noise, and offer greater flexibility than median filtering. This can be achieved by using Morphological edge detector[18] which obey threshold-linear superposition which means a complex gray-scale edge detector that can be formulated by implementing simple binary edge detector subsections and summing their output binary edges. Since local variance of many medical images are relatively small, morphological edge detection provides better performance than linear edge detection.

To improve the quality of edge detection, an algorithm is developed that detects well-localized, unfragmented, thin edges in medical images based on optimization of edge configurations using a genetic algorithm (GA).[17] Several enhancements were added to improve the performance of the algorithm over a traditional GA. While the simulated annealing (SA)-based method uses fixed probabilities for the transformation strategies, the GA takes advantage of dynamic operator probabilities. This has the advantage that the participation of the transformation strategies is adaptive; each operator or strategy participates relatively according to its effectiveness. The detected edges were thin, continuous, and well localized. Most of the basic edge features were detected. Contextual based Hopfield Neural Network (CHNN) is proved to design more appropriate, more continued edge points than Laplacian-based, Marr-Hildreth's, Canny's, and wavelet based methods. Inspired by the concept of Competitive Hopfield Edge Finding Neural Network (CHEFNN), a reduced two dimensional Hopfield-based neural network is obtained by including pixel's surrounding contextual information into image edge detection, known as Contextual Hopfield Neural Network (CHNN).[16] The CHNN consist of NxN neurons, the input is the original two-dimensional image and the output is an edge-based feature map. Consequently, the CHNN saved a half of neurons than CHEFNN resulting the networks evolution fast. The network is capable of taking into account each pixel's feature and its surrounding contextual information. As a result, the effect of tiny details or noises will be effectively removed by the CHNN and the drawback of disconnected fractions can be overcome. Fuzzy-set Based Fast Edge Detection of Medical image is quite simple and effective to achieve the edge picture of a medical image for the diagnostic purpose, e.g. it is possible to accurately determine the sizes of atria cordis, mitral valve and ventricles of heart, etc. so as to judge the status of his/her heart (be normal or not) and the degree of disease. A comparison among three methods shows that, the fuzzy operator is preferable to other two operators namely Sobel and Prewitt for detecting the edge of a medical image.[20]

Whereas in the tree based technique we find that most of the problems related to edge detection can be overcome. Experimentation results showed almost cent percent accuracy with almost negligible values of over or under segmentation regions. The added advantage of this edge detection process is that it separated the main object i.e. breasts, knee, brain etc. from the exterior non object region. The dynamicity of the algorithm helps it to adapt to any kind of medical image and intensity nature as it adapts to different image conditions. With this edge detection method, the image segmentation process becomes simple and efficient as it does not require convolution. It is also robust, highly accurate and can be very useful for diverse medical imaging technologies. The comparative study of this method compared to the traditional methods with respect to some statistical parameter is shown in the table.

4. CONCLUSION

This paper is a review over the published articles on edge detection. At first, it provides the theoretical background, and then reviews wide range of methods of edge detection in different categories. The existing filter based techniques are discussed briefly and then compared with one another based on several statistical parameters including their advantages and short comings. Here we have also discussed about the various innovative approaches of medical edge detection adopted by several authors. The review also studies the relationship between categories and presents evaluation regarding to their application, performance, and implementation. The objective of the paper is to showcase different edge detection techniques comprehensively with the pros and cons to enhance the knowledge.

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