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An Approach of Detecting Discontinuities in Images

Rekha Rani[1], Shailja Kumari[2]

[1]Research Fellow (M.Tech), Department of Computer Science, Ch. DeviLal University Sirsa, Haryana

[2]Assistant Professor, Department of Computer Science, Ch. DeviLal University Sirsa, Haryana

Abstract: ***Edge detection is the procedure of identifying and tracing sharp discontinuities in an image. The discontinuities are sudden changes in pixel intensity which describe boundaries of objects in a scene. The reason for that is that edges form the outline of an object. A benefit could be the linking a thing and the backdrop and shows the boundary between overlying objects. Image edge detection also decreases the amount of data and filters out inadequate information, while maintaining the important structural properties in an image. Edge detection is found in various fields like image analysis and pattern recognition. This paper describes the various edge detection techniques along with discussing their advantages and limitations. The techniques discussed here are Roberts operator, Sobel operator, Prewitt's cross operator, Laplacian, Laplacian of Guassian and Canny's edge detection. In this paper, The Experiments shows the completed edge information with the accuracy and reduced the errors, increasing the PSNR values which predict the signal are better rather than error and also the comparison of these techniques is carried out with an experiment by using MATLAB software.***

Keywords: Roberts operator, Sobel operator, Prewitt's cross operator, Laplacian, Laplacian of Guassian and Canny's edge detection, MATLAB

1. Introduction

Digital image is composed of a finite number of components, each of which has a special place or position and value. These components are cited to as picture elements, image elements, and pixels. Image processing is any form of signal processing for which image is the input, such as a photograph and the image processing output may be whether an image or, a set of characteristics or parameters associated to the image.Edge can also be defined as in binary images as the black pixels with one nearest white neighbour. Edges include large amount of important information about the image. The changes in pixel intensity describe the boundaries of objects in a picture.

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. Edge detection refers to the process of extracting edges from the image where there are sudden changes or discontinuities. These extracted edge points from an image provides an insight into the important details in the field of image analysis and machine vision. It acts as a preprocessing step for feature extraction and object recognition. Various techniques are reported in the literature like Sobel, Prewitt, Roberts, and Log and Canny detection techniques. However, most of the existing detection techniques use a huge search space for the image edge detection. Therefore, without optimization the edge detection task is memory and time consuming.

Edge detection is used mainly to extract the information about the image e.g. image sharpening and enhancement, location of object present in the image, their shape, size. Depending upon variation of intensity / grey level various types of edges are shown in in Figure 1:-

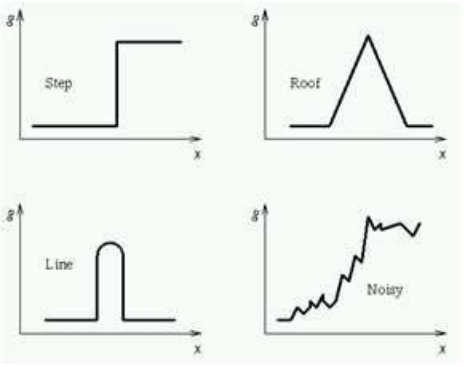


Figure 1: Typical edge profiles

2. Literature Review

Raman Maini et. al [1] " Study and Comparison of Various Image Edge Detection Techniques", International Journal of Image Processing (IJIP) Study and Compression of Image edge detection techniques. In this paper the analysis of various Image Edge Detection techniques is presented. The software is developed using MATLAB 7.0. It has been shown that the Canny's edge detection algorithm performs better than all these operators under almost all scenarios. Evaluation of the images showed that under noisy conditions Canny, LoG (Laplacian of Gaussian), Robert, Prewitt, Sobel exhibit better performance, respectively.

Muthukrishnan.R and M.Radha et.al[2] ", EDGE DETECTION TECHNIQUES FOR IMAGE SEGMENTATION" International Journal of Computer Science & Information Technology (IJCSIT), 2011. Analysis of image contents is one of the purpose in computer sight specifically in image processing.Here , edge detection is a fundamental tool for image segmentation. In this paper we study the performance of most commonly used edge detection techniques for image segmentation and also the comparison of these techniques is find out by using MATLAB software.

Lingli Mu, Jianjun Liu, Chunlai Li et.al[3], " Impact crater detection based on regional segmentation using Chang'E-1 CCD data", 2011,IEEE. A regional segmentation based methodology aimed at automatic recognition of impact craters on lunar surfaces is presented, and this method performs better result using Chang'E-1 CCD image. The initial and execution phase focus on regional segmentation to generate the candidate region, we process the data though, firstly, nonlocal means(NL-means) filtering for image noising when gain more edge information, secondly, edge detection with canny operator, and third, morphological processing to extract the individual region with attribute information.

Prashant Kumar Mohanty et.al[4]," On Edge Detection of Images Using Ant Colony Optimization and Fisher Ratio"2012. Study Edge detection Using ACO and FR. Edge detection is one of the important parts of image processing. It is essentially involved in the pre-processing stage of image analysis and computer sight. It generally detects the shape of an image and thus provides important details about an image. So, it reduces the content to process like object recognition and image segmentation. The very important step in the edge detection, on which the success of generation of true edge map depends, lies on the determination of threshold. For the determination of threshold calculation, new technique Fisher ratio (F-ratio) is used. The success of the work done is tested visually and empirically De-noising is the process of extracting the important features present in an image, by keeping the unimportant information present in the form of noise out as much as possible.

Parwinder Kaur Dhillon et.al [5],"A Novel framework to Image Edge Detection using Cellular Automata ", Special Issue of International Journal of Computer Applications, 2012. Edge detection is one of the most commonly used operations in image analysis and digital image processing. Edges of an image are considered a type of vital information that can be extracted by applying detectors. Gradient based edge detection methods, such as Roberts, Sobel and Prewitts have used two 2-D or 3-D linear filters to process vertical edges and horizontal edges separately to approximate first-order derivative of pixel values of the image. The Laplacian edge detection method has used a 3-D linear filter to approximate second-order derivative of pixel values of the image. Major drawback of second-order derivative approach is that the response at and around the isolated pixel is much stronger.

Om Prakash Verma et. al [6] "An Optimal Edge Detection Using Gravitational Search Algorithm", 2013. Edge detection is a fundamental tool used in image processing applications to obtain information from the image . Gravitational search algorithm (GSA) is a new population-based search algorithm activated by Newtonian gravity. Algorithm uses the theory of Newtonian gravity and its agents are the collection of masses. Masses attract each other by way of gravity force, and this force causes a global movement of objects towards the objects with heavier masses.The proposed approach is able to detect the edge pixel in an image up to a certain extent. The technique extended for finding more edge pixels by modifying the gravitational search algorithm.

Elif AYBAR et .al [7],"SOBEL EDGE DETECTION METHOD FOR MATLAB". Sobel which is a popular edge detection method is used in this work. There exists a function, edge. which is in the image toolbox. the Sobel method uses the derivative approximation to find edges. Therefore, it returns edges at those points where the gradient of the selected image is maximum. In this work, a function is advanced to find edges using the matrices whose dimensions are 5×5 in matlab.

P.Thukaram, S.J.Saritha et.al[8],"Image Edge Detection Using Improved Ant Colony Optimization Algorithm" International Journal of Research in Computer and Communication Technology, 2013 Image processing is a method to convert an image into digital form and perform some operations on it, so that we get an enhanced image. Image edge detection is the one of the method in the image processing. Edges are significant changes of intensity in an image. Edges typically occur on the boundary between two different regions in an image. In this paper, Ant Colony Optimization Algorithm is introduced to tackle the Image edge detection problem. The suggested ACO-based edge detection approach is able to establish a pheromone matrix that represents the edge information presented at each pixel of the image, according to the movements of a number of ants.

Rekha Dua, Deepika Garg, Girish Garg et.al[9], "Strength Based Ranking of Edges in Segment Blurred Digital Images", International Journal of Scientific and Research Publications, 2013.
Edge Detection is a part of various image processing operations. Thus an approach which keeps inferior edges but still divide them from the other prominent edges is needed. Their approach involves a color scheme for visual ranking of edges, a marking procedure for edge probability checking is used, The approach used is influenced by behavior of ants in real world, thus will involve different ant-bots in different steps for marking of pixels and later on benchmarking them.

Sunanda Gupta, Charu Gupta, S.K. Chakarvarti et.al[10]," Image Edge Detection: A Review "International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), 2013. Edge detection is important part of image handling for object detection. So it becomes extremely important to have a good knowldge of edge detection algorithms. An edge is the real or imagined line that marks the limit and divides of plane, object or appearance from other places or things. This means that if the edges in an image can be identified accurately, all of the objects can be located and basic properties can be measured. This paper brings out a sorting of most important and commonly used edge detection algorithms, namely Sobel, Robert, Prewitt, Laplacian of Gaussian, Canny, Ant colony Optimization.

Yu Xiong et.al[11] "Research on an Edge Detection Algorithm of Remote Sensing Image Based on Wavelet Enhancement and Morphology", JOURNAL OF COMPUTERS, 2014. In this paper, a new edge detection

algorithm based on wavelet enhancement and mathematical morphology is suggested. First, the remote sensing image is break down by a wavelet transform to get the low frequency part and high frequency part. Then a Laplacian sharpening operation is doing on the low frequency part to enhance the edge information. At the same time, the edge information of high frequency part is enhanced by means of with threshold method. Last, the edge of image which has been enhanced is detected by using mathematical morphology. Experimental results indicate that our method can achieves better image processing effect than traditional method, has strong ability of eliminating noise and keeping clear image edge.

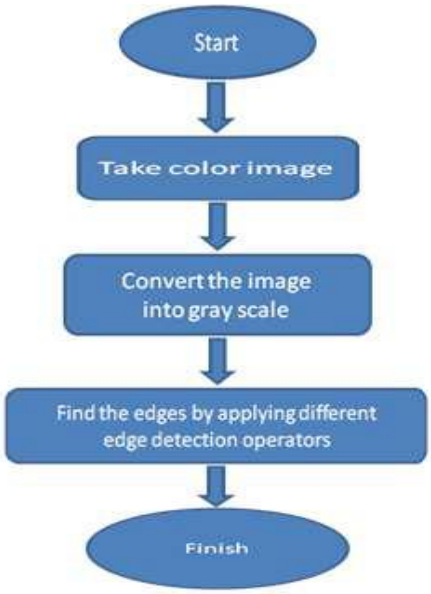
Chhabra, A et.al[12], "A hybrid approach for color based image edge detection,.", 2014, IEEE.
Edge detection is an essential step used in various image processing applications. The main problems in existing edge detection algorithms are poor edge localization, less noise removal capacity, unable to detect edges in complex background images and inability to accurately detect the color edges in images. here a sequential hybrid approach is suggested to overcome all the limitations of existing edge detection algorithms.The comparison among sequential and parallel edge detection will be show based upon different parallel metrics. The experimental results have shown that parallel strategy achieves a performance gain of 68% as compared to sequential approach.

Lixiong Gong, Xiangsheng Kong, Yong Liu, Min Huang4 et.al[13] " Subpixel edge extraction of part ant colony optimization-based and dimensional measurement ", 2014. Here a method combined improved ant colony and Zernike moment to detect image subpixel edge set aim at traditional ant colony algorithm's drawback of long time consumption and easily to be affected by noise. The methods improved parameters from clustering centre , clustering operator and pheromone updating, then clipping subpixel image edge based on Zerinke moments. Therefore, the output of image edge extraction is good and effective. Lastly, least square fitting is used to locate coordination of image edge and dimensions such as inner and outer diameters were measured.

3. Steps of Edge Detection

- Smoothing: suppress as much noise as possible, without destroying the true edges.
- Enhancement: apply a filter to enhance the quality of the edges in the image
- Detection: determine which edge pixels should be discarded as noise and which should be retained
- Localization: determine the exact location of an edge.

Flow chart for edge detection-



Algorithm for edge detection:-
Step 1-Take a color image.
Step 2-**Smoothing:** Annihilate as adequate noise as accessible, without wrecking genuine edges.
Step 3- **Enhancement:** the quality of edges is enhanced by applying differentiation.
Step 4- **Threshold**: Apply edge magnitude threshold to determine which edge pixels should be retained and which should be discarded as noise.
Step 5- **Localization**: Ascertain the postulate edge bearings.
Step 6- Evaluation with the algorithms.
Step 7- Get the image after edge disclosure.

3.1 Goal of Edge Detection

- Produce a line drawing of a scene from an image of that scene.
- Important features can be extracted from the edges of an image (e.g., corners, lines, curves).
- These features are used by higher-level computer vision algorithms (e.g., recognition)

3.2 Criteria for Edge Detection

The quality of edge detection can be measured from several criteria objectively. Some criteria are proposed in terms of mathematical measurement [13], some of them are based on application and implementation requirements. In all cases a quantitative evaluation of performance requires use of images where the true edges are known.

a) **Good detection**: There should be a minimum number of false edges or maximum Signal Noise Ratio (SNR). Usually, edges are detected after a threshold operation. The high threshold will lead to less false edges, but it also reduces the number of true edges detected.
b) **Noise sensitivity:** The robust algorithm can detect edges in certain acceptable noise (Gaussian, Uniform and impulsive noise) environments. Actually, an edge detector detects the edges and also amplifies the noise simultaneously. Strategic filtering, consistency checking and post processing can be used to reduce noise sensitivity.
c) **Good localization**: The edge location must be reported

as close as possible to the correct position, i.e. edge localization accuracy.

d) **Orientation sensitivity**: The operator not only detects edge magnitude, but it also detects edge orientation correctly. Orientation can be used in post processing to connect edge segments, reject noise and suppress non-maximum edge magnitude.

e) **Speed and efficiency:** The algorithm should be fast enough to be usable in an image processing system. An algorithm that allows recursive implementation or separable processing can greatly improve efficiency.

4. Methods for Edge Detection

4.1 Gradient based Edge Detection

It detects the edges by looking for the maximum and minimum in the first derivative of the image. Sharpening an image results in the detection of fine details as well as enhancing blurred ones. The magnitude of the gradient is the most powerful technique that forms the basis for various approaches to sharpening. The gradient vector points in the direction of maximum rate of change. The gradient method detects the edges by looking for the maximum and minimum in the first derivative of the image.

4.2 Laplacian based Edge Detection

The Laplacian method searches for zero crossings in the second derivative of the image to find edges. An edge has the one-dimensional shape of a ramp and calculating the derivative of the image can highlight its location. The Laplacian method searches for zero crossings in the second derivative of the image to find edges. An edge has the one-dimensional shape of a ramp and calculating the derivative of the image can highlight its location. Suppose we have the following signal, with an edge shown by the jump in intensity below

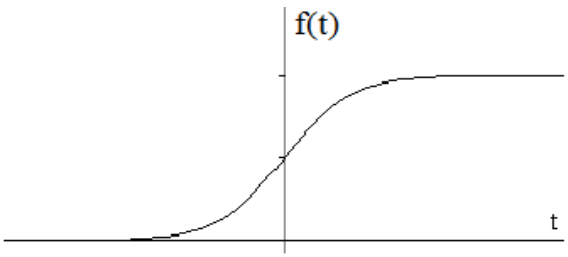


Figure 1: Signal showing edge

If we take the gradient of this signal (which, in one dimension, is just the first derivative with respect to t) we get the following

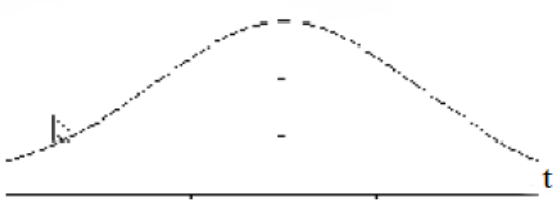


Figure 2: Gradient of Signal

Clearly, the derivative shows a maximum located at the centre of the edge in the original signal. This method of locating an edge is characteristic of the "gradient filter" family of edge detection filters and includes the Sobel method. A pixel location is declared an edge location if the value of the gradient exceeds some threshold. As mentioned before, edges will have higher pixel intensity values than those surrounding it. So once a threshold is set, you can compare the gradient value to the threshold value and detect an edge whenever the threshold is exceeded .Furthermore, when the first derivative is at a maximum, the second derivative is zero. As a result, another alternative to finding the location of an edge is to locate the zeros in the second derivative. This method is known as the Laplacian and the second derivative of the signal is shown below:

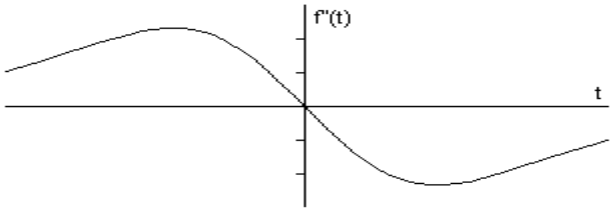


Figure 3: Second Derivative of signal

4.3 Optimal Edge Detector

The quality metric for edge detection is application dependent and based on the subjective requirements, few applications may require fine edges and others may require coarse edges at the output. It is hard for a semantically meaningful edge from a nuisance edge. Similarly there exists no generic threshold for edge detector and vary from applications to applications, however following are desirable for an elegant edge detector. Robustness to noise. The operator must respond well to true Localization. The edge map of the huge must precisely indicate true locations of the edges. Single response. The operator must give single response to each the optimality of the detector depends upon number of adjustable parameters that depend upon image SNR and relevancy of the edges as per user's requirements.

5. Edge Detection Techniques

The edge representation of an image significantly reduces the quantity of data to be processed, yet it retains essential information regarding the shapes of objects in the scene. This explanation of an image is easy to incorporate into a large amount of object recognition algorithms used in computer vision along with other image processing applications. The major property of the edge detection technique is its ability to extract the exact edge line with good orientation as well as more literature about edge detection has been available in the past three decades. On the other hand, there is not yet any common performance directory to judge the performance of the edge detection techniques. There are many edge detection techniques in the literature for image processing. The most Commonly used discontinuity based edge detection techniques are :-

5.1 Roberts Edge Detection

The Roberts edge detection is introduced by Lawrence

Roberts (1965). It performs a simple, quick to compute, 2-D spatial gradient measurement on an image. This method emphasizes regions of high spatial frequency which often correspond to edges. The input to the operator is a greyscale image the same as to the output is the most common usage for this technique.

5.2 Sobel Edge Detection

The Sobel edge detection method is introduced by Sobel in 1970 The Sobel method of edge detection for image segmentation finds edges using the Sobel approximation to the derivative. It precedes the edges at those points where the gradient is highest. The Sobel technique 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 gray scale image.

5.3 Kirsch Edge detection

Kirsch edge detection is introduced by Kirsch (1971). The masks of this Kirsch technique are defined by considering a single mask and rotating it to eight main compass directions: North, Northwest, West, Southwest, South, Southeast, East and Northeast The edge magnitude is defined as the maximum value found by convolution of each mask with the image. The direction is defined by mask that produces the maximum magnitude.

5.4 Robinson Edge detection

The Robinson method (Robinson 1977) is similar to Kirsch masks but is easier to implement because they rely only on coefficients of 0, 1 and 2. The masks are symmetrical about their bidirectional axis, the axis with the zeros.

5.5 Marr-Hildreth Edge Detection

The Marr-Hildreth (1980) technique is a method of detecting edges in digital images that is continuous curves wherever there are well-built and fast variations in image brightness. It is a easy and it operates by convolving the image with the LoG function, or, as a quick approximation by LoGs. Subsequently the zero-crossings are discovered in the filtered result to find the edges. The LoG method is sometimes as well referred to as the Mexican hat wavelet due to its image shape while turned up-side-down.

5.6 Canny Edge Detection

In industry, the canny edge 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, and still outperforms many of the newer algorithms that have been developed. To find edges by separating noise from the image before find edges of image the Canny is a very important method. Canny method is a better method without disturbing the features of the edges in the image afterwards it applying the tendency to find the edges and the serious value for threshold.

5.7 Detection of Ideal Edge

The expectation from an ideal edge detector is that any true edge point present in the image should not be messed and also the erroneously detection of any other edge point as edge should be reduced as much as possible. These two requirements are often having a trade off each other. The selection of a proper optimum threshold point is a minimum requirement of any edge detector. The threshold value should not be low as it can lead to the detection of noise as edges and also the threshold value as high causes some true edge points undetected. The SNR is improved when true edges are detected and false edges are avoided. The removal of false responses reduces the corrupted edge happened due to noise. The performance measure of edge detection operations are as follow ˆThe results can be compared visually as the eyes are behaving and acting like some sort of edge detection. ˆAlso the edge detection rate can be evaluated.

5.8 ACO-based Image Edge Detection

In the proposed method, ants move on a two dimensional image – stepping from one pixel to another – to construct a pheromone matrix, from which the edge information is determined to extract the edges of the image. The movement of the ants is steered by the local variation of the image's pixel intensity values.In the model used, each pixel in the image represents both a node and an edge in the graph. A pixel represents a node because locations in the graph are associated with pixel locations – ants move from one pixel to another. At the same time, it also represents an edge because the heuristic information is determined from the local variation of the image's intensity values and hence, is associated with a pixel location in the image. The components of the pheromone and transition matrices are associated with pixels in the image. The algorithm consists of three main steps. The first is the initialization process. The second is the iterative construction-and-update process, where the goal is to construct the final pheromone matrix. The construction and update process is performed several times, once per iteration. The final step is the decision process, where the edges are identified based on the final pheromone values.

(i) Initialization process
In this process for an image I of size M ×N is taken as input which works as a solution space for the artificial ants. The K numbers of ants are randomly moved over the whole image such that the every pixel of the image is viewed as a node. The constant is assigned to each, which is the initial value of every component of the pheromone matrix.

(ii) Construction Process
In the nth step of construction, one ant being randomly selected from K total ants and this ant will move over the image for L steps. This ant will move from the (l,m) node to (i, j) node which is its neighboring node or pixel, is specified by the transition probability.

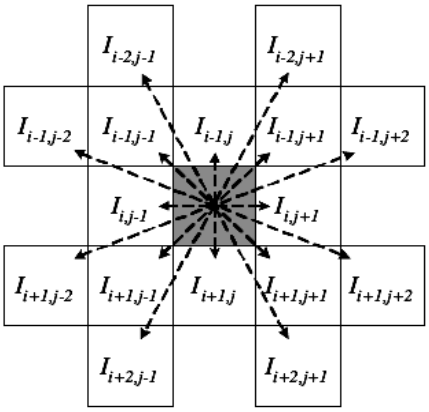


Figure 4: Clique matrix

(iii) Update Process

The pheromone matrix is updated in the update process after the two update operations. The first update is accomplished after the movement of each ant in each construction-step. Each building block of pheromone matrix is modified as given in equation.

(iv) Decision process

The solution is based on the values in the final pheromone matrix. The literature applies a threshold technique, also known as the Otsu threshold technique or by the method developed to reduce the resulting grey scale image to a binary image with only two possible values for each pixel. This is done to be able to classify each pixel as either an edge or a non-edge. Though, when it comes to analyzing the work carried out by the ant collective in image edge detection, a result showing various degrees in intensity values is just as good as a black and white declaration. Hence, in an ant's image edge detection, the solution is a direct result of the values in the final pheromone matrix In this step, a binary decision is made at each pixel location to determine whether it is edge or not. The decision is made by applying a threshold τ on the final pheromone matrix. Here the threshold value τ chosen to be adaptively computed.

(v)Visualize Process

In this step, different values of the Si (ψ) parameter are applied to the above algorithm. Smaller the value of the phi parameter more edges the algorithm detects in the image. As we go on decreasing the value of the phi parameter, output of the given image becomes clearer but it should not be zero.

The proposed algorithm is as follows:

a. Start Construction Process (Equation: 1)
b. Compute mean intensity of image from histogram, set T=mean (I).
c. Step 2: compute Mean above T and Mean below T using T from step a.
d. Adjusted the Parameters
e. Update Process (Equation 2)
f. Repeat step 2 if T(i)~=T(i-1)
g. Normalize the threshold to the range [i, 1].
h. Created Edged Output.

The Input images have been taken and edges will be improved. This image has been improved by the algorithm and shown in figure below. The different edges have been detected and can be identified directly. For accuracy measurements, the PSNR, RMSE values calculations has been measured.

The Histogram has been generated using the Code and has been explained below:

```
input = imread ('EdgeOutput.bmp');
imhist(input);
```

The root-mean-square deviation (RMSD) or root-mean-square error (RMSE) is a frequently used measure of the differences between values (sample and population values) predicted by a model or an estimator and the values actually observed.

6. Research Methodology

The Methodology provides the step by step explanation of proposed work and work flow. These following steps need to be point up for develop the algorithm and improve the steps. These points are described as:

a) To Study the Edge Detection or Discontinuities techniques.
b) To analyze the existing problems in the related ACO algorithm.
c) To study the different point or steps can be followed to improve the algorithm.
d) To implement the proposed improved approach of ACO probabilistic for solving computational problems technique practically using simulation tool.
e) To work on the performance parameters RMS, PSNR and generate results.

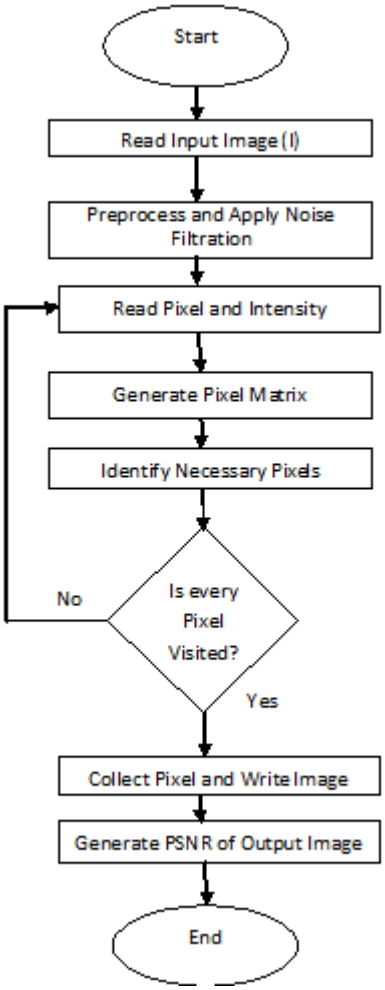


Figure 5: Flow Chart

7. Results and PSNR

The research work has been carried out on the input images and work has been simulated on the MATLAB Simulation Tool. The Intensity based work has been performed and pixel intensity MATRIX has been generated and unnecessary pixels has been removed from the memory and other pixels are considered in the memory. The Noise Filtration concept has been used to remove the noise from the input images and then processed the pixels on the filtered image. This preprocessing of noise filtration shows the better accuracy in terms onf PSNR values.

Figure 6: Example 1

Figure 7: Output 1

Figure 8: Output 2

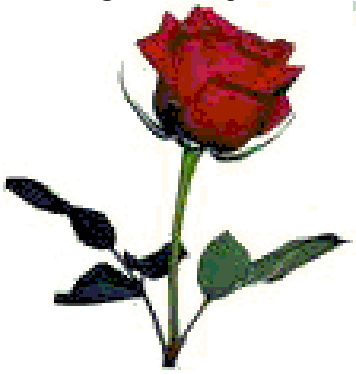


Figure 9: Example 3

Figure 10: Output 3

As the images shows the more edges and less distortion. The complete edges have been detected and show much accuracy.

Table 1: Peak Signal to Noise Ratio

Input	PSNR
1	36.44
2	36.014
3	36.87

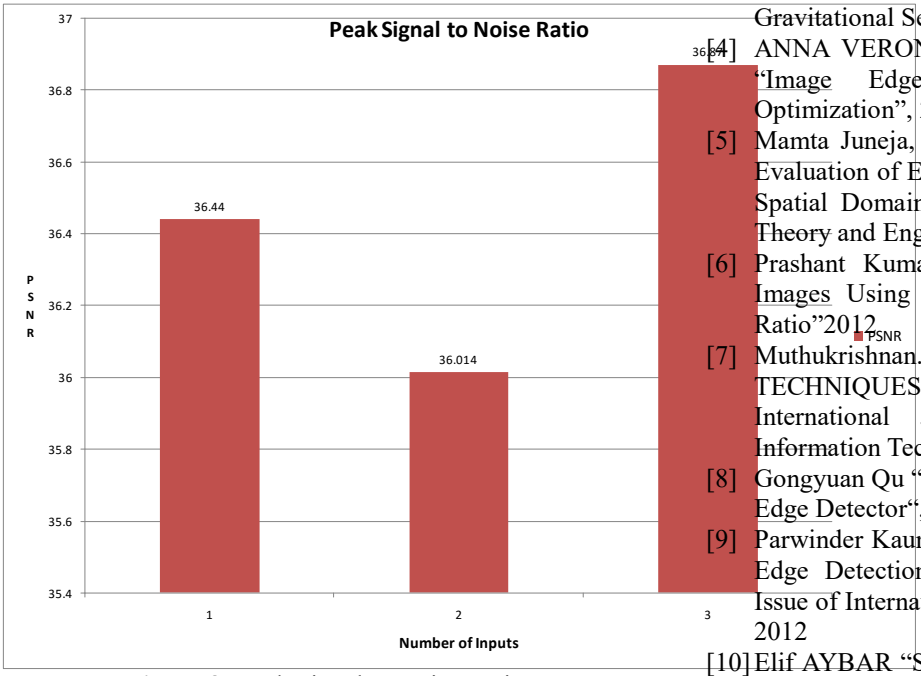


Figure 8: Peak Signal to Noise Ratio

8. Conclusion

Edge Detection is the process of detecting the discontinuities in the images. Edge Detection is the application of the image segmentation. As an example, the fingerprint, human facial look and also the body form of associate object square measure outlined by edges in pictures. Edges in a picture offer an illustration of object boundaries at intervals that image. In analysis work associate improved edge detection rule is style for detection of edges in an exceedingly grayscale image that has established to be a helpful. The Noise Filtration concept has been widely used on the proposed work along with the algorithm and Edges has been detected of the filtered image. The Experiments shows the completed edge information with the accuracy and reduced the errors, increasing the PSNR values which predict the signal are better rather than error.

9. Future Scope

The proposed algorithm obtains a relatively complete edge profile as compared to the traditional methods but also leaves some of the true edges as dim which should have been highlighted otherwise. So, the future scope will be to study the reasons for this in detail and improve this ACO method so that it combines the advantages of all of these methods without affecting the highlighting of true edges.

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Author Profile

Er. Rekha Rani is pursuing M. Tech. from Ch. DeviLal University (CDLU), Sirsa. She has received B. Tech. degree in Computer Science & Engg. from Ch. DeviLal Memorial Govt. Engg. College Panniwala Mota,Sirsa in 2013. She published paper on "A Review on Edge Detection using Different Techniques" in International Journal of Science and Research (IJSR).