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A Review and study paper on Edge Detection algorithms and techniques

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***Abstract*- The edge detection is very important function which used in a majority of image processing applications in order to collect data from the frames as a precondition for feature extraction and object segmentation. This technique distinguishes between an object's outline and the background of the image. An edge is a boundary separating two regions that are close in proximity. Edge detection is a necessary pre-processing step in every image processing application, including object recognition and object identification. In this review paper, I am going to review various edge detection algorithm and do the literature review. According to the literature review, there have been many studies produced in the area of edge detection. Numerous studies by researchers compare different edge detection methods, picture segmentation methods, enhanced edge detectors, etc.**

Keyword: Edge detection, extraction, Image Processing, edge detector

1. INTRODUCTION: -

The edge can be created of change in a color, light, shades and texture and this change can be utilised to determines an image's depth, size, direction, and surface characteristics. Digital image analysis, which removes extraneous features from the image, aids in edge point selection [1]. Noise may prevent the detection of slight changes, depending on the pixel threshold of change that identifies an edge. Finding these limits requires a lot of time and effort, especially when noise has warped the image. The core image processing disciplines, such as feature identification and feature extraction, use edge detection as a fundamental and crucial tool. Edge detection, a branch of image processing, is essential. In an image, edge detection locates the borders between objects and their surroundings as well as the contour of an object. A line dividing two similar places is referred to as an edge. "The process of finding and locating sharp discontinuities in an image is called edge detection". In specific circumstances, various edge detectors operate more effectively. In order to choose the optimum technique, we must first comprehend which edge detectors work best in specific situations. In this paper, I am going to review various edge detection algorithm and techniques.

2. Edge Detection

The edge detection is process of identifying boundaries and boundaries that separate an image's look from other areas or objects in a digital image. The edge display of the image reduces the quantity of the information that must be processed, including essential information regarding an object's shape in a photograph. Edges are characterised as minute changes in an image's brightness. At the point where two zones converge, the edge forms. One can mine the edge for the important data. A technique for locating edges that are correctly oriented is

edge detection. It is a crucial tool for image segmentation. Using operators, the edge detection method converts the original image into the edge image. Finding intensity value discontinuities is a typical practice. The image is input and turned into a grayscale image before edge detection. Then, using the output of the image, use the edge detector to find and extract any edges that might be present.

3. *Edge Detection Algorithm and Technique*

***3.1 Hough Transformation and Bee Colony Optimization*: -**

This purposed technique [2] is based on a hybrid bio inspired technique in which they use Hough Transformation and Bee Colony Optimization. They use Hough transformation for edge detection in an image. The upgraded Hough transformation methodology outperforms previous Hough transformation algorithms in the comparison research because it allows for user-defined threshold pixel intensities for edge identification. In this study, the threshold intensity of the pixels will be defined by using the bee colony technique.

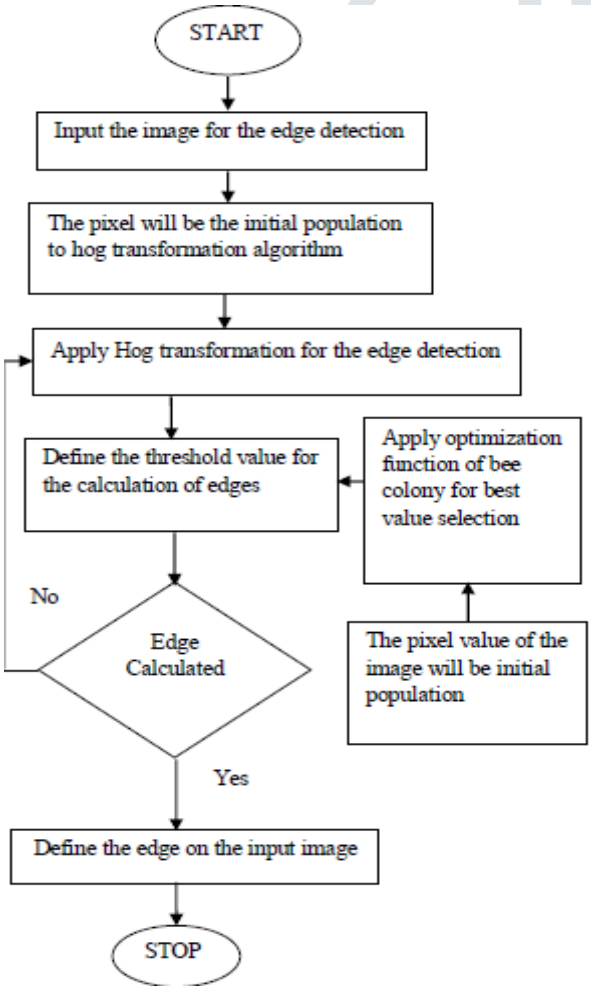


Fig. 1 Proposed Flow Chart

The purposed technique [3] is ant colony edge detection technique for edge detection. This algorithm is part of bee colony algorithm. An ant acts as a simple computational agent in an ant colony optimization algorithm, which produces a solution to the arising problem. Iteration programmes are continuing initiatives that consistently tackle issues. The solution states, which are the outcomes, are put into effect when the algorithm runs. After each step is finished, the entire intermediate solution is reached. Potential expansions are transferred from the existing state to the probabilistically attainable states. The first is the move's heuristic indicator previous, which will demonstrate its allure, and the second is the move's level as a trial, which demonstrates how advantageous it has been to to employ that move in the past. These two factors determine the likelihood of ant migration from one state to another. Only the order of the trials' use, which raises or lowers the level of trials depending on their success or failure, will be influenced by the trial level. At the conclusion, all trials are updated. When all of the ants' executions are complete, all of the trails are updated.

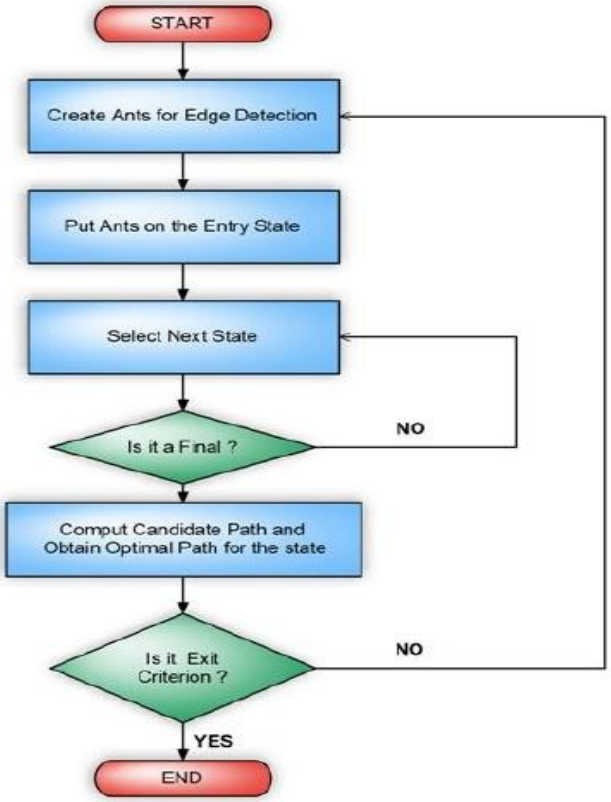


Fig. 2 Flowchart for Ant Colony Optimization

3.2 ***Ant Colony Optimization Technique for Edge Detection*: -**

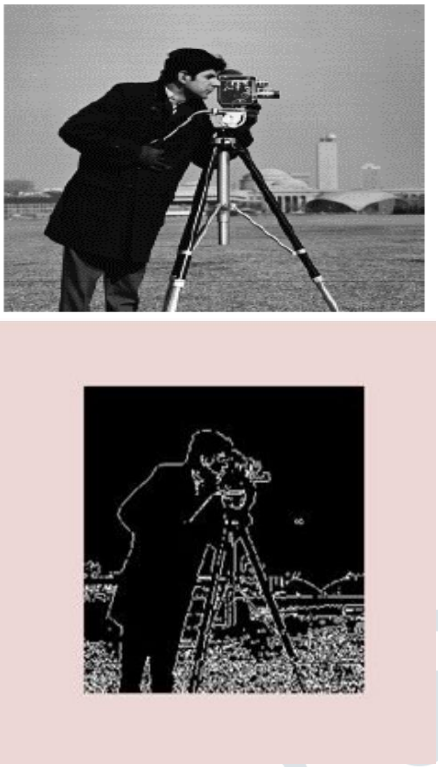


Fig.3 Edge detected by proposed methodology

3.3 *Canny Edge detection*: -

The Canny edge detection algorithm is frequently regarded as the best edge detector. Canny Edge Detector seems to be close to the operator that maximises the product of signal-to-noise ratio and localization [4]. Typically, it is a Gaussian first derivative.

The steps of the Canny Edge Detection Algorithm are as follow: -

Step1: - Applying a Gaussian filter will smooth the image.

Step2: - Finite-difference approximations of partial derivatives are used to determine the gradient's size and direction.

Step3: - The gradient magnitude should be nonmaxima suppression, and the double thresholding approach should be used to find and connect edges.

The magnitude image array is used to test the Nonmaxima Suppression. This method can be applied to the thresholding step of the gradient-based method to create edge pixel ridges. Canny, however, employs a more sophisticated solution to the problem. This approach defines an edge point as a site where the gradient's strength is locally greatest. This constraint, which is more challenging to satisfy, thins the ridges found by thresholding. Nonmaxima suppression is the process that produces ridges that are one pixel wide.

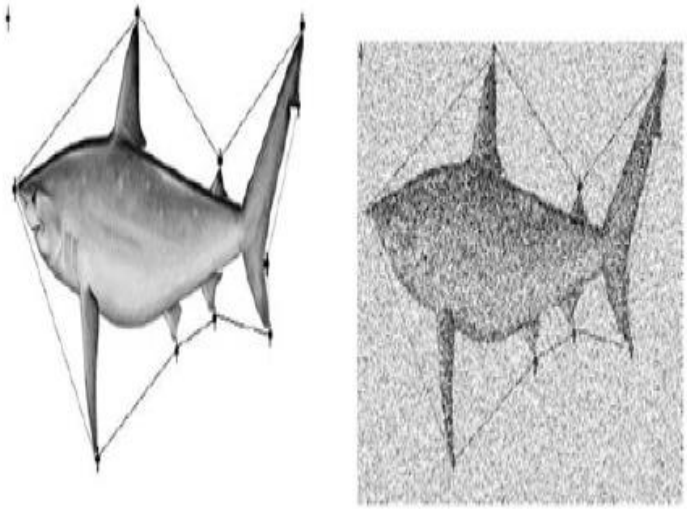


Fig.4 Edge detection using Canny edge detector

3.4 *Sobel Edge Detection Technique*: -

The Sobel edge detection method was initially presented by Irwin Sobel in 1970. Because the Sobel kernel depends on the centre difference, it provides the central pixel priority while averaging. The higher noise reduction abilities of the Sobel kernel over the Prewit kernel are one of its advantages. The pair of 3x3 convolution masks are a component of the Sobel edge detection algorithm. The two masks are only separated by a 90-degree turn. With this mask, it is possible to handle edges that are 45 degrees away from the pixel grid. This mask can be used to obtain gradient components in each orientation for the input image [5].

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

G_x

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

G_y

Fig.5 Mask use by Sobel Operator

The gradient magnitude is given by:

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

An approximate magnitude is given by:

$$|G|=|G_x|+|G_y|$$

Fig.6 Output image

3.5 *The Morphological Gradient Technique and Generalized Type-2 Fuzzy Logic*: -

This algorithm [6] uses the two-technique morphological gradient technique and generalizes type-2 fuzzy logic. Using alpha plane theory, generalised type-2 fuzzy logic is implemented for edge detection. Defuzzification employs the heights and approximation approaches. The results of an edge detection simulation employing a type-1 fuzzy inference system, an interval type-2 fuzzy inference system, and a generalised type-2 fuzzy inference system (GT2FIS) are presented. "The proposed generalised type-2 fuzzy edge detection method was evaluated using benchmark images and synthetic images". We demonstrated the benefits of using generalised type-2 fuzzy logic using the Pratt merit measure.

a. **Edge detection using the morphological gradient technique: -**

   The morphological gradient of a grey scale image is the difference between the intensity levels of two adjacent pixels that are a part of a particular structural element. Of course, gradient edge detection revolves around the gradient operator.

b. **Edge detection using a Generalized Type-2 Fuzzy Logic: -**

In this technique there are six steps: input images, obtaining the image gradient, fuzzification (input linguistic variables), interference (define the fuzzy rules, performing interference with alpha planes, firing strengths, the outputs in a multiple input single output of fired rules), type reduction (heights method, approximation method, alpha plane integration), defuzzification. It uses the edge detection metrices. There are several ways to assess an image's edge detection, and each one typically uses a different set of standards in order to evaluate the sudden shift in pixel color. The Pratt figure of merit is one of the tactics that is most frequently applied. The difference between the calculated and actual edge points is shown by this metric. The fuzzy rule basis will be used in the future to identify edges because it has a flexible structure and is less complicated. In this below figure: MG is morphological gradient, T1FIS is type-1 fuzzy interface system, IT2FIS is interval type-2 fuzzy interface systems, GT2FIS is gradient type-2 fuzzy interface systems.

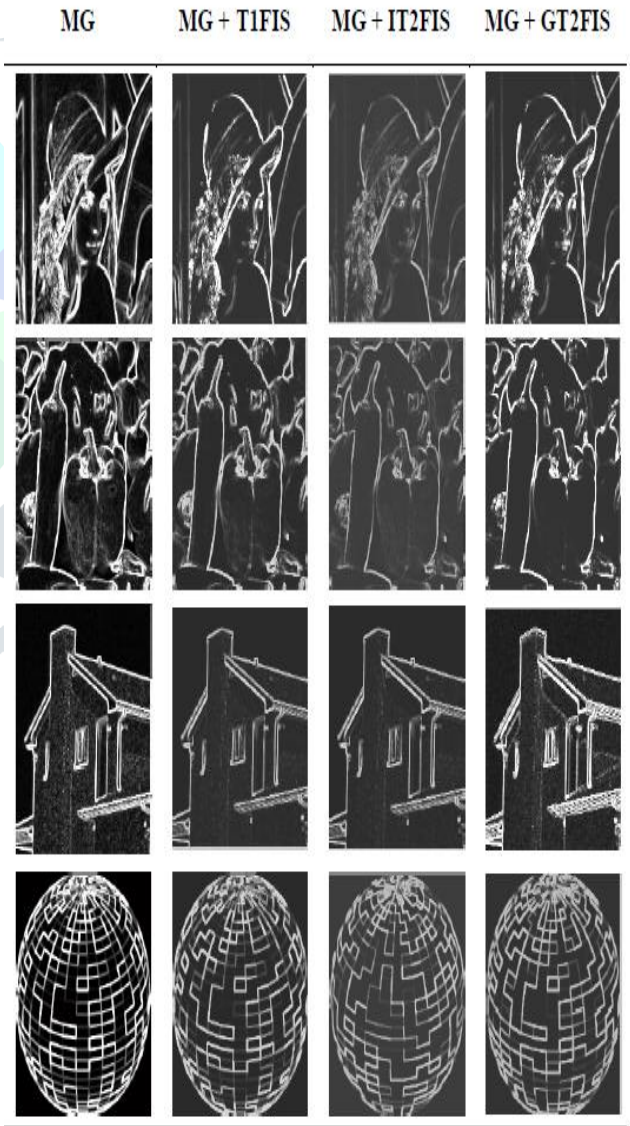


Fig.7 Simulation result using morphological gradient type-1, interval type-2 and generalized fuzzy system.

3.6 *Edge detection using AlexNet Deep Convolutional Neural Network*: -

Using a set of annotated, for instance, labelled, images for training, a deep Convolutional Neural Network calculates the learning parameters in the learning layers between the input and output layers through hundreds to millions of repetitions. In the last five years, the classification and object recognition processes for autonomous images have been completely altered by deep convolutional neural networks, a kind of feedforward artificial neural network. When evaluated on fresh datasets obtained under more difficult conditions like dim illumination, low-quality cameras and the presence of shadows, etc., these algorithms might not be as reliable. Second, image processing algorithms frequently incorporate human judgement in their design to help the inspector with crack detection. In this approach it uses to detect the cracks in the building.

In fully trained mode, it took 6200s to process 14 epochs (17934 iterations) before the validation requirement was met. As a result, the accuracy of the validation was 97.5%. After 7 epochs (8967 iterations) in transfer learning mode, which required 4100 s of processing time to reach 98.1% validation accuracy, the validation conditions were satisfied. The classifier took 299 seconds to build in classifier mode and had a 93.2% accuracy rate on the validation dataset[7].

The below figure (8) illustrates the DCNN result for 0.08 mm width of crack.

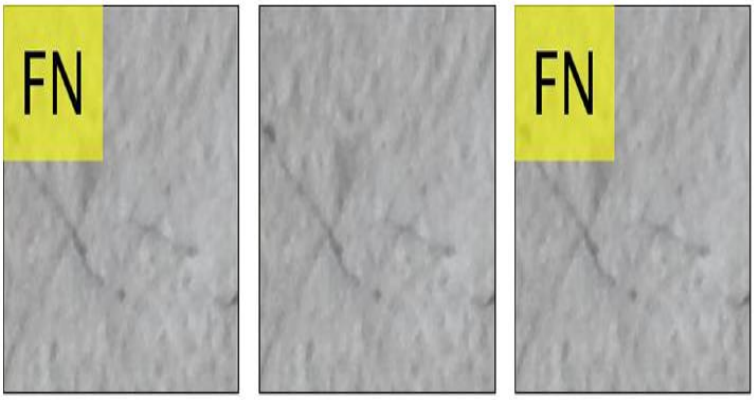


Fig.8

3.7 *Edge Detection using the Canny Edge Detection Method and Ant Colony Optimization*: -

This proposed technique [8] is combined the Canny edge detection method and Ant Colony Optimization. This method begins by extracting the image's edge using the conventional Canny operator. The ant's initial position is used to calculate the edge's terminus. The grey value in the neighbourhood introduces the fuzzy triangle membership function. The heuristic matrix of the ant colony determines the fuzzy membership value of each pixel between the edge endpoints. Ants are incentivized by the heuristic matrix to probe along the actual edge to find continuous and complete edge lines. The experiments' findings indicate that the suggested technique significantly increases the precision of target object contour extraction in photos and provides clearer edge information.

Original Image

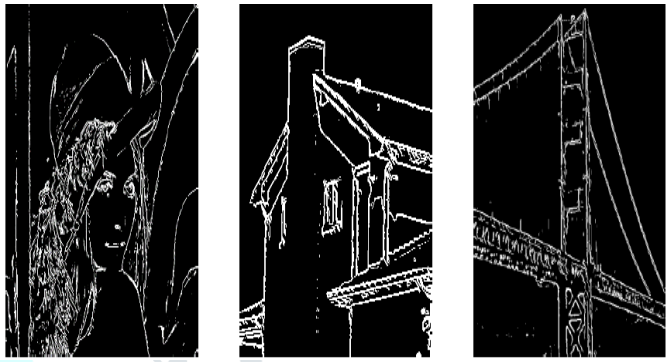


Fig.9 Edge Detection using the proposed algorithm

3.8 *Semantic segmentation and edge detection in Satellite images*: -

This method aim to combining these 2 methods to enhance road detection and results road edges are produced using segmented masks using sharp-pixel segmentation maps. This section provides a detailed description of the suggested methodology. require three things before creating a network to demarcate a road from incredibly detailed images. First, the network needs to have a receiving region large enough to gather the required a statement in context. Second, split pixels need to be accurate and predictable. Edges and segmentation masks demand a high spatial resolution. The third problem is how to efficiently manage the extremely imbalanced dataset [9].

The proposed technique is divided into three parts: -

1. Utilizing attention maps, the encoder encodes the features in full resolution.
2. Segmentation masks are then generated using the encoded characteristics.
3. The encoded characteristics and previously created segmentation masks are
   used to forecast the margins of the road.

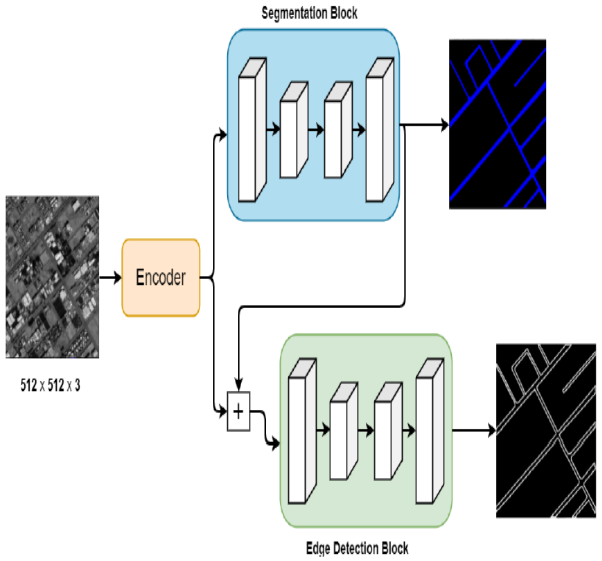


Fig.10 Proposed algorithm architecture

Fig.11 Input images

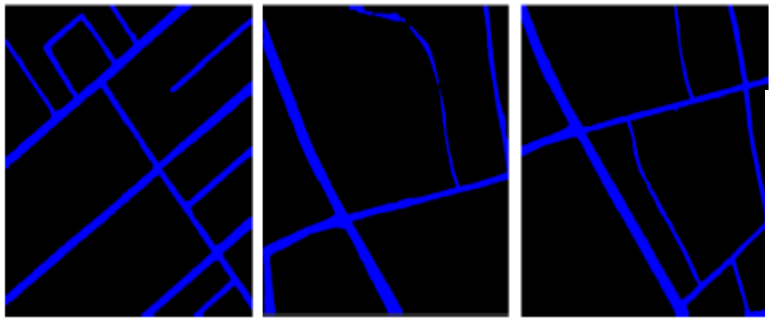


Fig.12 After applying the proposed technique

3.9 *Quantum Image Edge Detection using Improved Sobel Mask based NEQR*: -

This proposed algorithm [10] uses the improved Sobel mask based on NEQR (A Novel Enhanced Quantum Representation). Since Quantum image processing has reduced circuit complexity and storage capacity, it is becoming more and more popular for image edge detection. Due of limitations in the vertical and horizontal axes, the Sobel operator's edge extraction method generates less edge data. They provide a novel enhanced quantum representation methodology in this paper that combines a double threshold method, a non-maximum suppression technique, and a quantum-enhanced Sobel edge detection algorithm. We have studied the complexity of the quantum circuit, the number of edge pixel, and the implementation of the edge detection method. Then, we compared a few recent techniques for both classical and quantum edge detection. In terms of edge information and circuit complexity, the suggested approach has significant room for improvement.

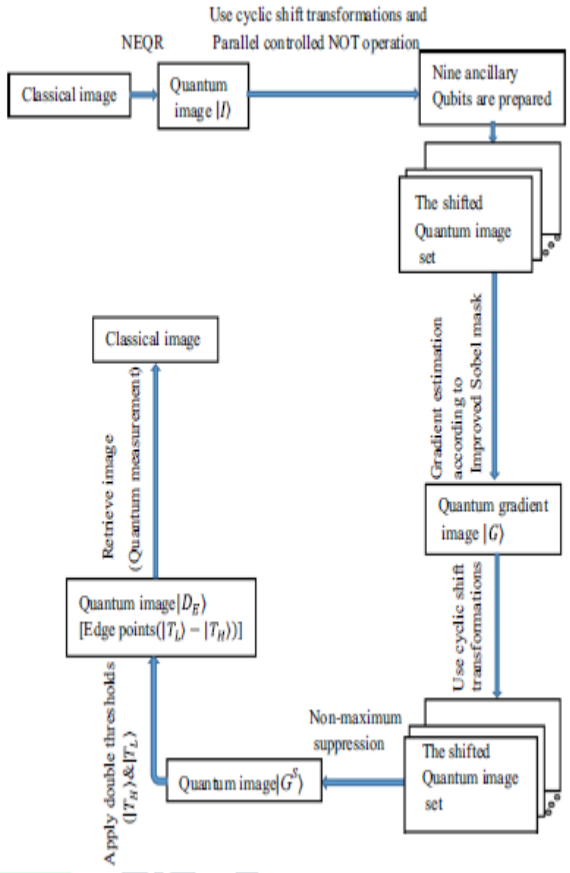
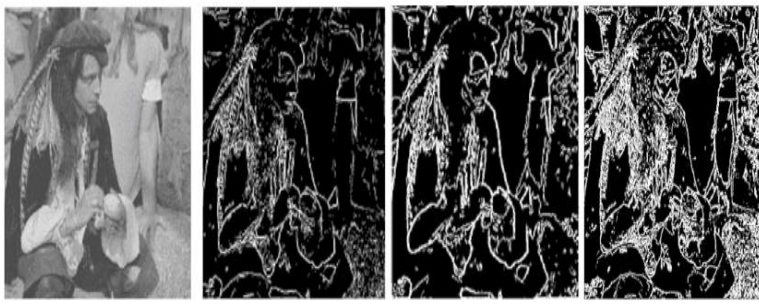


Fig.13 Proposed Algorithm Flow Chart



(a) Input image (b) Sobel image (c) Quantum Sobel (d) Proposed algo.

Fig.14

3.9 *Edge detection using CNN*: -

The edge detection challenge is accomplished using the CNN methodology, which benefits from the extraction of momentum characteristics and can handle any input image regardless of size without additional training. When compared to both traditional methods and other ANN-based methods, the results are very positive.

CNN biologically inspired MLP variants. Early research on the cat's visual cortex by Hubel and Wiesel taught us that the visual cortex has a sophisticated cell organization. The receptive fields of these cells, which are tiled to cover the whole visual fields, are responsive to specific subregions of

the input space. These filters are better equipped to benefit from the significant spatially local correlation seen in real-world photographs because they are local in input space. Additionally, simple cells (S) and complicated cells have been identified as the two main cell types. Simple cells (S) respond most strongly to specific edge-like input patterns within their receptive field. Larger receptive fields and local invariance to the precise location of the stimulus are characteristics of complex cells (C). There are three steps in this method. They are: sparse connectivity, shared weight neural network, max pooling [11]. PSNR (Peal Signal to Noise Ratio).

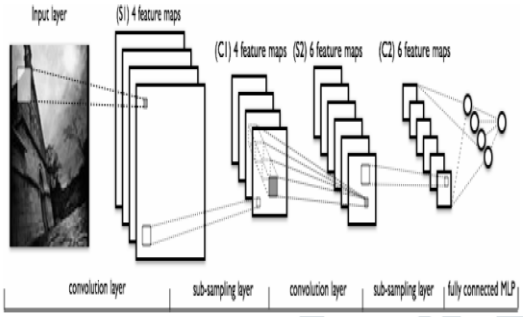


Fig.15 Model of CNN

Original Image

epochs=500

PSNR= + 5.72db

Epochs=1000

PSNR= + 5.70db

epochs=10000
PSNR= + 5.70db

Fig. 16 Proposed algorithm result

Table1: ***Advantage and Disadvantage of different Edge Detection Algorithm and Techniques***

Algorithms	Advantage	Disadvantage
Hough Transformation and Bee Colony Optimization	The Hugh Transform's tolerance for holes in the boundary line and resilience to noise in the image in comparison to other methods.	It uses the brute force method so; it is very complex in computation. It slow and required large amount of memory.
Ant Colony Optimization	Premature convergence is avoided through distributed computing	Time of convergence is not fixed.
Canny Algorithm	It uses the thresholding method to detect the edges in noisy state. Better detection specially in noisy state.	The biggest disadvantage of using the Canny edge detector is that it takes a long time because of its complex processing.
Sobel Algorithm	Good noise suppression qualities. Good in discovering better outer lines.	Give moderate result.
The Morphological Gradient Technique and Generalized Type-2 Fuzzy Logic	It is possible to use inexpensive sensors, which encourages us to keep the complexity and cost of the overall framework to a minimum.	A fuzzy information-based framework requires extensive testing with equipment in order to be approved and verified.
AlexNet Deep convolutional neural network	It uses the more hidden layer to give the accurate result.	Lack of spatial invariance with respect to the supplied data
Canny edge detection method and ant colony optimization	It uses simple local methods to complete complex jobs.	Time consuming.
Semantic Segmentaion	Different types of land images can be recognized and segmented using semantic segmentation.	Could not be useful in those images which have many edges**.**
Improved Sobel mask based NEQR	It uses the NEQR so this algorithm removes the drawback of Sobel algorithm.	It uses the so much mathematical computation.
Convolutional neural network	CNN automatically finds essential features that are not required human intervention.	Lots of training data is needed for CNN implementation.

4. *Conclusion*: -

This study reviews and studies several edge detection algorithms and techniques. Edge detection is the initial step in detecting an image object, thus it's important to be aware of the advantages and disadvantages of any edge detection filter. In this paper, Hough transformation and Bee colony Optimizer, Ant colony Optimizer, Canny Edge detection, Sobel Edge detector, CNN, AlexNet DCNN, Canny and Ant Colony, Improved Sobel mask based on NEQR, morphological and gradient and fuzz logic, and semantic segmentation technique are reviewed and studied in which DCNN gives the best result. Fuzzy logic, improved sobel mask, fuzzy logic, canny and ant colony, also give the good result but these are time consuming. All are having some advantages and disadvantages which were described in above table.

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