Reviewing Soft Computing Approaches for Edge Detection: Hybrid and Non-hybrid

Manisha Kaushal
UIET, Panjab University Chandigarh
Er.manishakaushal@gmail.com

Akashdeep
UIET, Panjab University Chandigarh
akashdeep@pu.ac.in

***Abstract*—Soft Computing is a multifaceted technique comprising of Fuzzy Logic, Neural Network, Genetic algorithms and other Evolutionary computation. These paradigms have found wide variety of applications in the field of image processing. One of the most vital applications of image segmentation is edge detection where edge refers to the boundary between two consistent regions and edge detection is the process of detecting and finding abrupt discontinuities in an image. This paper summarizes hybrid and non-hybrid approaches for edge detection. The objective of this paper is to survey the core issues for soft computing based approaches for edge detection.**

***Index Terms*—Soft computing, Neural Networks, Genetic Algorithm, Fuzzy logic, Hybrid**

I. Introduction

A classical problem in the field of computer vision and image processing is edge detection. This paper covers various edge detection techniques based on soft computing approaches such as Neural network, Fuzzy logic and Genetic Algorithm. Some of the hybrid approaches are also discussed. At first, Artificial Neural network based edge detection approach are presented which are inspired by the working of nervous system. Neural networks have the ability to learn about solution from input data. The Second approach, fuzzy logic based edge detection takes into account vides variety of uncertainties in logical reasoning. The third approach, Genetic algorithm which is basically derived from evolution theory. GA can be applied to various areas related to image processing. Hybrid approaches using combination of two or more of the above mentioned techniques are presented next which is followed by the conclusion and future directions.

II Soft Computing Approaches

Soft computing refers to a bank of techniques that are stretching many fields that come under various categories in Computational Intelligence. They are implanted on field within computer science to surmount problems such as NP-complete problems for which there is no known algorithm that can compute an exact solution in polynomial time. Soft computing varys from conventional (hard) computing based on the concept of precise modeling and analyzing to yield accurate results, human mind is the role model of soft computing [23]. Image segmentation is implemented using following approaches of soft computing (1) Neural Network based (2) Fuzzy Logic based and (3) Genetic Algorithm based.

A. Neural Network Based Approaches

Neural network is the emerging technology which can be used in many applications such as digital image processing. An artificial neuron is the center point in working of neural network. A simple model of neural networks consists of multiple inputs and a single output. Weights are assigned to inputs [17] and different neurons combine these weighted inputs and help the neuron to fire. A neuron fires ie produces a positive input if its combined value is greater than threshold. AN activation function is applied to combined input to calculate its output [16]. Various activation function employed includes binary sigmoid, bipolar etc. The edge detection approaches based on neural network provides better results than the classical edge detection approaches.

Multi-layer feed forward neural network framework with one hidden layer was used by W.E. Blanz et al.[1] for segmentation in gray scale images. Their framework consists of three layers: an input layer, a single hidden layer, and an output layer. The input and output layers are not directly linked and all units of a layer is completely connected with the units in the layer above but there are no links among units within a layer. The Back propagation learning algorithm was applied to convert the image segmentation problem into a pixel classification problem. The input vector for the ANN included vector of features extracted from every pixel, and the output vector was the vector of classes desired for segmentation. They executed image segmentation on two real world applications:

Armando J. Pinho et al. [2] explored another approach to edge detection based on neural network classifiers which uses some properties of the data in order to simplify the design of the disseminate functions. They used feed-forward neural networks, trained with back-

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propagation comprising of nine inputs, one output and from two to six hidden units.
They compared their approach with the well known derivate of a Gaussian edge detection filter and found that the neural networks generates less thick and less missing detections compared to the DG Linear filters.

Yasar Becerikli et al. [3] demonstrated that edge detection can be implemented using artificial neural network (ANN) by taking any raw image for edge detection using Laplacian method to produce the edges of the image and neural network in turn applied to learn edges of all images. The proposed artificial neural network architecture consists of 22 cells i.e. nine for input layer, twelve for hidden layer and one for output layer Each node uses a sigmoid function, $f(x) = 1/(1+e^{-x})$ as the activation function. In order to train neural network the Back Propagation method with momentum factor was applied and comparison was made with the laplacian edge detectors.

Leila Fallah Araghi et al. [4] put forward two methods for edge detection. The first method used Neural Network and the second method is Sobel methods based on Wavelet function. The proposed method applied the multi layer perceptron neural network with two layers for edge detection and modified levenberg marquart for learning. Each pixel of image is taken as input and edges are output of neural network. The comparison of the proposed approach with classical edge detection methods such as Canny edge detection method found that results of neural based edge detection approach was very promising.

Jesal Vasavada et al.[5] come up with an algorithm based on Feed forward Neural Network (FNN) technique to detect edges in gray scale images and applied the back propagation learning algorithm in order to decrease the error rate. The training patterns applied by them are Standard deviation and gradient values of the image to be processed which are calculated using Sobel operators. The network is tested for a wide variety of grayscale images. The proposed approach is analyzed against the classical operators such as Prewitt, Roberts, Sobel, LoG and other neural network based method in which binary training patterns are applied and on the basis of visual perception and edge pixels counts.

Sabeur Abid[6] have successfully developed multilayer perceptron (MLP) image edge detection method. The author has applied Back propagation algorithm is in the learning stage in order to determine all learning patterns. The proposed algorithm works well for gray-scale images and can be extended to color images.

Nikša Antišić etal. [7] introduced a novel approach to edge detection based on back propagation for noisy images. This approach basically applied feed-forward multilayer back propagation neural network for detecting edges and comparisons are drawn at the end with classical edge detector such as Sobel operator to show the performance of the technique.

B. Fuzzy Logic Based Approaches

The fuzzy technique has always been put forward as one of the modern methods in variety of processes as an operator to simulate at a mathematical level the compensatory behavior in process of decision making or subjective analysis. Fuzzy image processing is basically assembling of all techniques that understand, represent and process the images, their segments and features as fuzzy sets. Fuzzy image processing has three major steps during processing of an image: image fuzzification, changing of membership values, and, if required, image defuzzification. Images are migrated from intensity level plane to fuzzy level plane known as fuzzification to modify their membership values. A rule based, clustering or fuzzy integration approach might be employed for this purpose. 15]. There are wide varieties of methods for illustrating the advancement in the field of fuzzy logic based edge detections techniques. .

One of the most promising methods by Noor Elaiza et al. [8] is based on the Gaussian shaped membership function to the Rule Based Fuzzy (RBF) image detection. The introduced algorithm improves the detection of periosteal and endosteal edges of hand phantom radiographs. The Mean and median filters are used for preprocessing tools. Both subjectively and statistically they concluded that GRBF i.e Gaussian shaped Rule Based Fuzzy produces better results than the RBF i.e. Rule Based Fuzzy(RBF) image detection.

Sulimani et al. [9] put forward a approach based on the use of a fuzzy classifiers for detecting edges in grayscale images. The primary distinction between proposed method and other identical method is the morphological operation which is applied in order to obtain the accurate i.e. thin edges in images. They concluded that the applied approach has brought out far better results as compared to the other methods. One enhancement of the proposed scheme was obtainment of continuous edges and use of Chord-to-Point Accumulation Technique to perform corner extraction.

Methos of Aborisade et al.[10] classifies edges into three categories based on their strength which were later on fuzzified using Gaussian membership functions. Membership was changed to low, medium or high using Fuzzy if-then rules. Defuzzification used to calculate final output was Mamdani Inference. The efficiency of the introduced method is demonstrated through computer simulation against

TABLE 1 :
SUMMARIZATION OF NEURAL BASED APPROACHES

Author	Network Structure	Training & learning	Types of images	Comparison Drawn	Analysis of given results	Findings
W.E. Blanz et al. 1]	multi-layer Feed forward perceptron	Standard back-propagation (BP) learning algorithm	Gray scale images	---	Better for complex real world applications.	Justification of result is required.

Armando J. Pinho et al. [2]	Feed-forward neural networks,	Back-propagation (BP) learning algorithm	Gray scale images	Gaussian edge detection filter	Less thick and less missing detections compared to the DG Linear filters.	Under adverse conditions the performance degrades gracefully.
Yasar Becerikli et al. [3]	MLP structure, using forward propagation neural network	Supervised learning method with momentum	Gray scale images With Noise	Laplacian based edge detection method.	Provides more desirable results than Laplacian method.	Works only with noise less images
Leila Fallah Araghi et al. [4]	Multi layer perceptron neural network	Modified levenberg marquart used for learning	Gray scale images	Classical methods such as canny and sobel method for edge detection	The proposed approach provides better results than classical methods.	Only Lena image taken for results.
Jesal Vasavada et al. 5]	Feedforward Neural Network (FNN)	Back propagation learning algorithm	Gray scale images	Classical methods such as canny, sobel, prewitt, method for edge detection	The method detects highest edge pixels and performs well in case of noisy images also.	Less Training rules are used.
Sabeur Abid[6]	Multi layer perceptron neural network	Back propagation algorithm	Gray scale images	Classical methods such as canny, sobel, Robert, prewitt, method for edge detection	More detailed edges are found than classical operators.	Can be extended to color images
Nikša Antišić etal. [7]	feed-forward multilayer Neural Network	Back propagation algorithm	Gray scale images With Noise	Compared with the Sobel operator only	Provides more promising results than classical edge detector.	Can be compared with other edge detection operater.

existing classical edge detector such as Sobel and Krisch edge detection operators.

Aijaz Ur Rahman khan et al. [11] explored fuzzy rule base algorithm which provides a method for detecting edges efficiently from the gray scale images. In the proposed approach, Mandani method is employed for defuzzification and Triangular Membership functions is used as membership function. At last the method is compared with the classical edge detector such as prewitt and sobel. In future proposed method can be applied on higher dimension window.

Wafa barkhoda et al. [12] introduced two different methods based on calculation of gradient and standard deviation of pixels to form two set of edges used as inputs for fuzzy system. The fuzzy system includes appropriately defined fuzzy rules and fuzzy membership functions to decide about pixel classification as edge or non-edge. The proposed method demonstrated that the extracted edges when analyzed against classical edge detection methods such as Sobel, Robert, and Prewitt provides better results.

Koushik Mondal etal.[13] formulate a new edge detection technique that is based on fuzzy rules. The main focus of their study is to imply fuzzy set theory for image segmentation technique and quality of the present approach is measured both subjectively and objectively. The proposed approach is capable to produce promising results as compared to their counterparts addressed in literature. RanitaBiswas et al. [14] put forward a novel approach to edge detection that selects effective threshold values using type-2 fuzzy logic to be applied in Canny's edge detector. Experimental
results suggest that the proposed approach is capable one in comparision to the Canny's edge detector.

C. Genetic Algorithm Based Approaches

Genetic algorithm can be used to optimize the functioning of the classical edge detection algorithms. They are the simulation of natural biological progression mechanisms which are used to develop highly adaptive search algorithm Basically, a genetic algorithm are adaptive heuristic search algorithms which consists of three major operations: selection, crossover, and mutation. The selection used to improve average quality of the population by keeping only the fittest ones in the population [18]. The quality of the individual is measured by the fitness function. The crossover operator is a genetic operator that combines two chromosomes to produce a new chromosome. They are classified as One Point, Two Point, uniform, arithmetic and heuristic crossover oprators. The mutation operator changes one or more gene values in a chromosome from its initial state. It helps in maintaining diversity of the population[19].

Mutation is done with small probability and helps to avoid local minima/maxima.

Zhang Jin-Yu et al. [20] put forward an approach to edge detection that automatically determines an optimal threshold. They proposed automatic threshold algorithm for images processing based on

TABLE2:
SUMMARIZATION OF FUZZY BASED APPROACHES

Author	Approach	Types of images	Comparison Drawn	Analysis of given Results	Findings
Noor Elaiza et al. [8]	Gaussian shaped membership function to the Rule Based Fuzzy(RBF) image detection	Hand Phantom Radiograph Images	Rule Based Fuzzy (RBF) image detection.	GRBF provides better results than RBF	The proposed algorithm is far more computationally expensive.
SULIMAN1, et al. [9]	Fuzzy classifiers	Grayscale images	----	Provides thick edges.	The Chord-to-Point Accumulation Technique can be used along with this algorithm to perform corner extraction.
Aborisade, D.O[10],	Gaussian membership functions	Grayscale images	Sobel and Krisch edge detection operator	Better than the classical edge detectors	Better refining algorithm using different membership functions can be developed.
Aijaz Ur Rahman khan and Dr. Kavita Thakur[11]	Fuzzy rule base algorithm	Grayscale images	Sobel and Prewitt edge detection operator	Better than the classical edge detectors	The proposed algorithm avoids detection of spurious edges corresponding to nois.
Wafa barkhoda et al. [12]	Fuzzy Edge Detection Based on Pixel's Gradient and Standard Deviation Values	Grayscale images	classical edge detection methods such as Sobel, Robert, and Prewitt	Better than the classical edge detectors	Compared only with traditional operators.
Koushik Mondal etal.[13]	Mamdani rule base.	Gray scale image with noise	Compared with different threshold methods.	efficient as compared to the other techniques	Only lena image used for drawing comparison
Ranita Biswas etal. [14]	single threshold selection technique from image histogram using type-2 fuzzy logic	Medical images of hand radiography	Compared with the canny edge detector.	minimizes uncertainty involved in thresholding procedure.	Can be extended to colored image domain.

genetic algorithms and improved Sobel operator. It is observed that although the proposed algorithm overcame many shortcomings of classical Sobel edge detection algorithm but detected edges are not fine enough and better algorithm can be developed in future. The advantage of using Genetic algorithm is that it is capable of global search on the data space and the biggest disadvantage of using it is that it cannot use local information effectively.

Zhang Jing et al. [21] introduced evolutionary approach for edge detection which combines the local search capability of the classical edge detection operators with global space capability of the emerging genetic based edge detection approach. The approach can be applied to extract the edges efficiently in wield images. The study concluded that proposed algorithm cannot restrain the noise but can protect edge information effectively.

Wenlong Fu et al. [22] approach takes as input an entire image and pixels are classified as edges or non classical edge detector operator such as Laplacian and Sobel edge detectors and the results suggest that the detectors evolved by GP provides better results than the classical edge detectors.

Wenlong Fu et al.[23] presented a rising genetic programming approach in order to develop detectors with new fitness functions. Fitness function was trained with accuracy of training images. The experimental approach points that fitness functions was able to balance the accuracies across results of detection and joining accuracy of overall pixels along with the accuracy of training images. Results show that proposed method outperforms the previously available classical edge detectors. In future, this approach can be applied using a multi-objective approach for the training images.

Huili Zhao et al. [24] proposed algorithm for the enhancement of Canny operator in pavement image detection. The method works on the principle of Mallat wavelet transform to detect the weak edges and quadratic optimization of genetic algorithm for proper thresholding. But in order to make the edge much more accurate, they are still some problems such as payment crack detection, etc to be improved.

III HYBRID SOFT COMPUTING APPROACHES

Hybrid soft computing approaches are the ones who combine features of multiple approaches to overcome each other shortcomings and look for optimized solutions.

The studies discussed in this section are based on combination of neuro-fuzzy and fuzzy- genetic techniques

TABLE3:
SUMMARIZATION OF GENETIC ALGORITHM BASED APPROACHES

Author	Approach	Operators	Comparison Drawn	Analysis of given Results	Findings
Zhang Jin-Yu et al. [20]	Improved Sobel Operator and Genetic Algorithms	Population Initialization : Produce N individuals randomly with equal probability between 0 to 255. Fitness Function: is the summation of ratio of original gradient and individual's gradient.	Classical operator such as sobel	Better than the classical edge detectors	No crossover and mutation operator is specified and very few images taken.
Zhang Jing et al. [21]	Gradient calculation based on genetic algorithm	Population initialization: Randomly generates 40 chromosomes as the initial population. Fitness function Refers to the maximum classes variance. Crossover operator: Use single-point crossover method with 0.9 probability	----	Edge detection accuracy and noise immunity.	If the mutation probability isachieved much, genetic algorithm will degrade as random search.
Wenlong Fu et al. [22]	Genetic Algorithm and Canny Edge Detector	Mutation operator: inverse mutation operator is used. Fitness function: inverse of Hamilton ring length Crossover operator: Partially mapped crossover operator.	Classical edge detector operator such as Laplacian and Sobel edge detectors	Better than the classical edge detectors	proposed algorithm is very complex.
Wenlong Fu et al.[23]	Genetic Programming via Balancing Individual Training Images	Fitness function: the mean square error or the accuracies for different indicators are employed. Population size:500 Mutation Probability: 0.15 Crossover Probability: 0.80	Compared with various fitness functions	Better results	Can be applied using a multi-objective approach for the training images in future.
Huili Zhao et al. [24]	Mallat wavelet transform	Quadric optimization genetics algorithm is applied	----		Fails at detecting thin edges
A. Saenthon et al.[25]	Edge detection based on the soldier detection	crossover, mutation, and reproduction operators are applied	Classical edge detector operator such as Sobel, Prewitt, and Canny filters.	The accuracy of proposed technique is better than Sobel, Prewitt, and Canny filters.	Computationally Complex Technique

TABLE4:
SUMMARIZATION OF FUZZY- NEURAL BASED APPROACHES

Author	Network Structure	Training & learning	Types of images	Analysis of given results	Findings
M. EminYuksel [26]	Each NF subdetector is a first-order Sugeno type fuzzy inference system with 3-inputs and 1-output.	Training by using simple artificial training images	Gray scale images with impulse noise	Promising results as compared to ones classical operator.	Thick edges
Mohammed Madiafi et al. [27]	Kohonen neural network (ANN)	Unsupervised fuzzy competitive learning	Gray scale images	Better results as compared to traditional ones.	Need to compare with existing approaches
Victor Boskovitz et al. [28]	Multi-layer Feed-forward neural networks and Fuzzy entropy for detecting edge pixels	Unsupervised Learning	Gray scale noisy images	Better than other approach such as histogram clustering : median cut, FCM, etc.	Less Training rules used
H. Farahanirad et al. [29]	neuro-fuzzy network (nf), an adaptive median filter and four identical neural networks (nn).	Back propagation learning algorithm	Gray scale images with salt and pepper Noise	Provides more desired results than the classical edge detector such as canny, sobel and performs well in case of noisy image	Limited test images including Boats and Cameraman
Siwei Lu et al. [30]	three-layer feed-forward fuzzy neural network	Back propagation learning algorithm	Gray scale images	The method detects the highest edge pixels and performs well in case of noisy images	Complex algorithm

A .Neuro-Fuzzy Algorithms

The approach of artificial intelligence founded on fuzzy logic and neural networks are put together to amalgamate these two soft computing techniques in order to reduce the limitations and difficulties of each isolated technique. Usually, when they are applied in a combined way, they are known as Neuro-Fuzzy Systems.

Fuzzy systems are suitable for industrial application but the problem of determining the membership function and appropriate rules is generally exhausting process of attempt and error. This provides to the direction of exercising learning algorithms to the Fuzzy System. The neural network presents computational characteristics of learning algorithms that act as substitute to support the advancement of fuzzy systems. This type of arrangement is characterised by a fuzzy system where fuzzy sets and fuzzy rules area arranged using input output patterns. Therefore, the limitations of the fuzzy systems are removed by the capacities of the neural networks.They combine techniques of both areas so these approaches are complementary, which justifies its use together.

M. EminYuksel [26] put forward a recent neural fuzzy operator that was employed for extraction of edges in impulse noise images. A number of NF sub detectors were combined with a post processor to develop the implemented operator. The comparison of the proposed approach with classical edge detection methods such as Sobel and Canny edge detection method found that results of fuzzy neural based edge detection approach was very promising.

M. Madiafi et al. [27] has presented a neuro fuzzy approach for automatic recognition of facial images. This approach is build on a Kohonen neural network (ANN), which was trained in unsupervised way, using a fuzzy competitive learning algorithm previously developed, applied and well tried on real images. The experimental approach points the effectiveness of the techniques by demonstrating through examples using a test dataset used by other researchers.

V. Boskovitz et al. [28] has proposed architecture comprising of a multilayer perceptron (MLP) like network that carry out image segmentation by adaptive thresholding of the input image using labels. A fuzzy clustering technique was used to automatically pre-select these labels. A feed-forward neural network with unsupervised learning is used whose output is described as a fuzzy set. Segmentation errors and likely edge pixels were measured by fuzzy entropy. The results presented indicate that study is good when tested on noisy images.

H. Farahanirad et al. [29] come up with a neuro-fuzzy edge detection algorithm in situations where the image is corrupted by Salt and Pepper noise. The presented approach is very simple and combination of a neuro-fuzzy network (nf), an adaptive median filter and four identical neural networks (nn). The improvement of the proposed work is that it provides better results than the several edge detection methods such as Roberts,Prewitt, Sobel, Zero-crossing, Canny, etc under the noisy conditions.

Fuzzy-neuro system presented by Siwei Lu et al.[30] was employed for both edge detection and enhancement. A three-layer feed-forward fuzzy neural network was used for edge detection and a modified Hopfield network was used for enhancement. Sample patterns were first fuzzified and used to train proposed fuzzy neural network and trained network was able to determine the edge elements. The authors had also compared their approach with standard edge detection operators.

B. Fuzzy-Genetic Edge Detection Algorithm

Fuzzy Logic has turned out to be a very efficient tool for describing human knowledge with the help of mathematical expressions. The advantage of fuzzy system is that they are rule based systems which can easily represent the imprecise information. So, prototyping can be made very effortlessly but most of the time involved in changing the involved parameters and that can turn out to be worse with growing difficulty of the system. Thus in order to optimize the fuzzy rule set based on the training data, genetic algorithms (GA) is proposed which is also known as fuzzy-genetic algorithm. The fuzzy-genetic algorithm belongs to a newly developed class of hybrid knowledge which combines the main features of the fuzzy and genetic paradigms and these approaches are very promising for noisy images. FGA works considerably better than other well-known conventional edge detection methods in the literature.

A. JUBAI et.al [31] put forward a novel algorithm which integrates uncertainty principles of fuzzy with evolutionary concepts of genetic algorithms for detection of oil spilled on sea. Authors have tried to improve Pal-king fuzzy edge detection method with the help of genetic algorithms. The method has a problem as the calculations were complex and thresholds value was fixed which was not useful for problems like oil in sea. The proposed algorithm presents the hybrid approach which consists of improved version of fuzzy enhancement algorithm to simply the Pal-king fuzzy edge detection method and a genetic algorithm with which threshold value can be easily determined for image processing. The presented approach have been put up in a complemtary fashion to adjust some of the undesirable features.The processing results are compared with Pal-King algorithm for the purpose of experimental evaluation.

Somya Jain [32] presented a novel approach for the edge detection which combines fuzzy logic derivatives and evolutionary learning techniques such as genetic algorithm. The combinations of both the approaches will lead to simplify the edge detection process. In the introduced approach, rule set is defined by fuzzy logic which is further optimized by using genetic algorithm. The simulation and implementation process of the proposed approach is carried by comparing it in terms of kappa value and entropy measurement with the other standard edge detection operators in literature

Janne Koljonen et.al [33] proposed a theory of optimizing fuzzy pattern matching using genetic algorithm. The authors have taken the advantages of Genetic algorithms in the field of pattern matching. The developed algorithm firstly perform fuzzy segmentation

and further membership function and template are optimized by stochastic search strategy of genetic algorithm The accuracy of the algorithm is measured by comparing them with traditional pattern matching algorithms in literature in terms of Pearson correlation coefficient.

M.Abdulghafour [34] has developed image segmentation approach that utilizes fuzzy logic and genetic algorithms. The author has taken the help of genetic algorithms at every step of image segmentation in order to develop the membership functions that are required to categorize the presence of image features through Fuzzy logic. The effectiveness of the proposed approach for producing successful results was demonstrated. The proposed approach makes novel improvement when it is compared with its ideal counterparts.

IV. Analysis and Inferences

In previous sections work related to the edge detection with application of soft computing techniques is presented. In this section, inferences from review of previous sections are presented. Most results have been taken on grey scale images where as only few studies are available on application of soft computing techniques that directly work on true colored images. Since substantial loss of information occurs when we transform image to grey scale therefore studies could focus in this direction. Comparisons shall be drawn in context to present trends where as almost every paper has considered classical operators for sake of comparisons. Work on reducing the computational time of soft computing approaches may be another area for exploration. Hybrid techniques such as Neuro-fuzzy, Fuzzy –GA had been utilized recently but studies on neural and GA are still limited. Recent Approaches in Soft computing like Ant Colony Optimization and its various variants like Max-Min ant system, Rank based Ant-system, continuous orthogonal ant colony and ant colony with fuzzy logic may also be explored. There are few papers in this direction. Edge detection approaches as an application in medical field for detection of diseases and satellite images can be an effective tool.

V. Conclusion

The paper has tried to expend encroachment of soft computing techniques to edge detection accessible in literature. Both hybrid and non-hybrid approaches discussed had sound foundation in field of Edge detection as noteworthy literature is available. The paper has also listed down areas where improvements and explorations can be made by researchers in this unending field. This can be accomplished that even vast amount of literature available is not any hindrance to scope of improvements that can be made in this direction.

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