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A Review of Soft Computing Approaches for Edge Detection

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Abstract:-

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

Keyword-Soft computing, Neural Networks, Genetic Algorithm, Fuzzy logic

I. INTRODUCTION

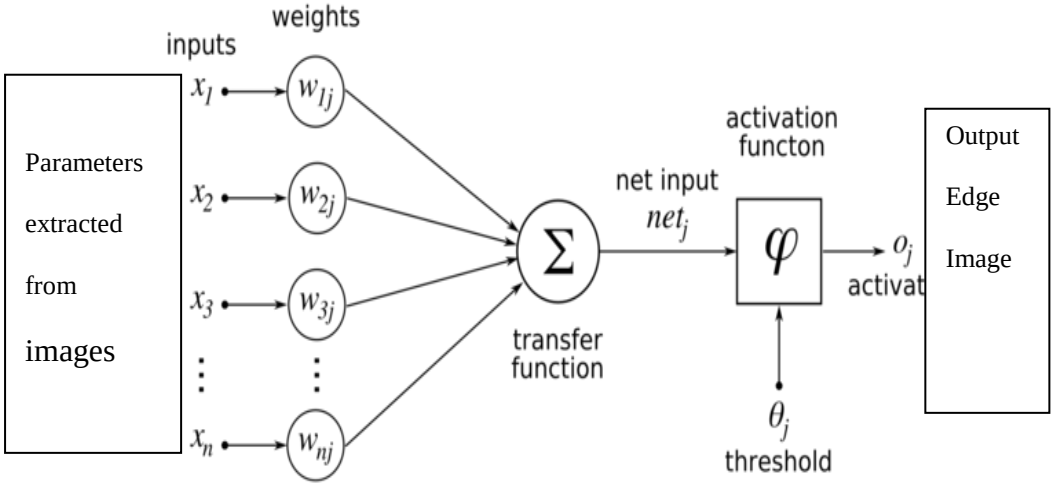
A classical problem in the field of computer vision and image processing is edge detection. This paper covers various edge detection techniques based on soft computing approaches such as Neural network, Fuzzy logic and Genetic Algorithm. This paper is organized as follows: At first, Neural networks based edge detection approach are presented which are basically inspired by the way information is processed in the nervous system. The basic difference between neural networks and other AI techniques is their ability to learn. The Second approaches, fuzzy logic based edge detection approach which takes into account vide 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 and which is followed by the conclusion and future directions in the next section.

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 . The details of Approaches as follows,

A. Neural network Based Approaches

Neural network is the emerging technology which can be used in many applications such as digital image processing. The edge detection approaches which are based on neural network provides better results than the classical edge detection approaches such as Sobel, Prewitt and Canny edge detection method. The conception of most of the neural network is model neuron. Basically this neuron is composed of multiple inputs and a single output as shown in Fig1. Each input can be modified by a weight, which multiplies with the input value [13]. The neuron will combine these weighted inputs and, with reference to a threshold value and activation function, use these to determine its output [12]. Various activation function employed includes binary sigmoid, bipolar etc.



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: combustion research and the industrial inspection of printed circuit boards. 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-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. 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.

Table1: 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 the highest edge pixels and performs well in case of noisy images also.	Less Training rules are used.

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. Thus, we can say that coding of image data (fuzzification) and decoding of the results (defuzzification) are steps that make possible to process images with fuzzy techniques. After the image data are transformed from gray-level plane to the membership plane (fuzzification), appropriate fuzzy techniques modify the membership values. This can be a fuzzy clustering, a fuzzy rule-based approach, a fuzzy integration approach and so on[11].

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. [6] 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.

SULIMAN1, et al. [7] 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.

Aborisade et al.[8], introduced the method that uses three edge strength values as fuzzy system inputs which were further fuzzified using Gaussian membership functions. Fuzzy if-then rules are used to change membership to one of low, medium, or high classes. Mamdani defuzzifier method is applied to produce final edge image. The efficiency of the introduced method is demonstrated through computer simulation against existing classical edge detector such as Sobel and Krisch edge detection operator.

Aijaz Ur Rahman khan et al. [9] 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. [10] introduced a new fuzzy based edge detection algorithm which includes two different methods, gradient and standard deviation of pixels value, which 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.

Table2: Summarization of Fuzzy Based Approaches

Author	**Approach**	**Types of images**	**Comparison Drawn**	**Analysis of given Results**	**Findings**
Noor Elaiza et al. [6]	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. [7]	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[8],	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[9]	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. [10]	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.

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 [14]. 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. Its helps in maintaining diversity of the population[15] Mutation is done with small probability and helps to avoid local minima/maxima. Zhang Jin-Yu et al. [16] put forward an approach to edge detection that automatically determines an optimal threshold. They proposed automatic threshold algorithm for images processing based on 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. [17] 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. [18] approach takes as input an entire image and pixels are classified as edges or non edges without preprocessing or postprocessing. Function set was formed by shifting and common standard operators. This approach is compared with 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.[19] presented a rising genetic programming approach in order to develop detectors with new fitness functions containing the accuracy of training images. The experimental approach points that fitness functions bounded on the ability of single training images can balance the accuracies across results of detection and joining the accuracy of overall pixels along with the accuracy of training images and and the results shows that the 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. [20] 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

Table3: Summarization of Genetic Algorithm Based Approaches

Author	Approach	Operators	Comparison Drawn	Analysis of given Results	Findings
Zhang Jin-Yu et al. [16]	Edge Detection of Images Based on 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. [17]	Gradient detection 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. [18]	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.[19]	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. [20]	Mallat wavelet transform	Quadric optimization genetics algorithm is applied	----		Fails at detecting thin edges

III 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 have been presented and following observations are made.

Most results have been taken on grey scale images where as only few studies are available on application on soft computing techniques that directly work on PET or true colored images. Since substantial loss of information occurs when we transform image to grey scale therefore studies could focus in this direction. The comparisons of almost all techniques have been done with classical edge detectors like Sobel, Prewits etc which have a long history and therefore in order to justify todays work there shall be intra domain comparison. Soft computing approaches have been found to be very slow and improvements with context of reducing computing time shall be explored further.

Hybrid techniques such as Neuro-fuzzy, Neural –GA can be combined where researchers can utilize advantages of one technique to overcome shortcomings of other. 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 be applied.

IV Conclusion

This paper has tried to outlay advancement of soft computing approaches to edge detection available in literature. Three major soft computing approaches had sound foundation in field of Edge detection as significant amount of work has been done in this direction. However some of the directions where improvements can be made and where the focus has been negligible have also been listed which can help researches to explore this unending field. This can be concluded that inspite of vast amount of literature available there is still scope of improvement.

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