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A REVIEW ON EDGE DETECTION METHODOLOGIES

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ABSTRACT: Image processing supports applications in different fields such as medicine, astronomy, product quality, industrial applications. Edge detection plays important role in segmentation and object identification process. Thispaper is a review of the various approaches adopted by several authors for edge detection in image processing.
Keywords: Edge detection, Fuzzy Logic, Genetic Algorithm, Image processing, Neural Network

I. INTRODUCTION

Soft computing was introduced by Lotfi A. Zadeh of the University of California, Berkley, U.S.A. in 1965. Soft Computing paradigm includes fuzzy logic, neural computing, machine learning and probabilistic reasoning. Soft computing is applied for solving real world problems. It is tolerant of imprecision, uncertainty, partial truth, and approximation. Soft computing tries to develop intelligence and aims to build a machine which can work like human. Human like system are required as the human systems are adaptable to change and under unknown circumstances. Soft computing differs from conventional computing.[31] Although Soft computing has various advantages it suffers from the problem of large computations.System used for solving real world problem requires intelligence and be able to take decision and give reasons to it. soft computing has several constituents[31]. The principal constituents of Soft Computing (SC) are

- Fuzzy Systems (FS), including Fuzzy Logic (FL),
- Evolutionary Computation (EC), including Genetic Algorithms (GA);
- Neural Networks (NN), including Neural Computing (NC);
- Machine Learning (ML);
- Probabilistic Reasoning (PR)

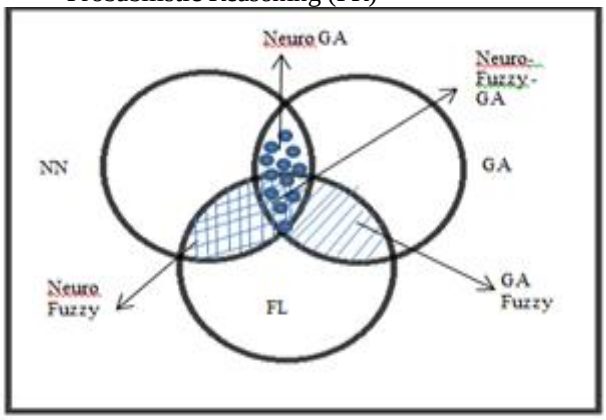

Fig. 1 Soft Computing Paradigm

Image processing is a form of signal processing in which image is given as an input that may in video form or photograph form or it may be a video frame. Output from any image processing can be either an image or a set of parameters of that image. Image processing mainly deals with the change in the nature of the digital image using computer in order to improve its pictorial information or make it more suitable for autonomous machine perception. Pictorial information is improved for real life applications in which human interpretation is required. Image processing supports applications in different fields such as medicine, astronomy, product quality, industrial applications. In the area of Image processing, there is uncertainty in data or task or result [11]. Reasons to uncertainty can be the randomness or vagueness or inherent ambiguity in image data. Uncertainty arises due to lot ambiguity in the area of image processing. The reasons for ambiguity can be due to image resolution, image segmentation, object recognition, scene analysis. It is required to design an algorithm which deals with such types of uncertainty. Soft computing allows to model uncertainty. Soft computing is widely being used in image processing for applications involving image compression, image segmentation, image enhancement, image transformation, image extraction, image classification, image retrieval morphology, noise reduction and edge detection. Edge detection is preliminary step in image processing. In images, edges characterize object boundaries and are therefore useful for segmentation, registration, and identification of objects in a scene. Further processes like image segmentation, registration, and identification as these processes depends on edge detection process for their accuracy. Edge detection techniques helps in feature extraction by locating edges between objects of interest and background information. Edge detection also helps in tracking and object detection. In biomedical field for identification and for detail study of tumours and X-rays, in industry for pattern recognition, in military for tracking etc. The principle of soft computing leads to near to optimum results. Soft computing can deal with the ambiguity and uncertainty in image processing in better way as compared to the traditional approaches. When soft computing is used for edge detection gives better result compare to the classical approach. The classical techniques like Sobel, Prewitt, Roberts, Canny edge detector have limitations of using fixed value of parameters or threshold. While the nature of edges is not constant due to which few edges left by being detected. Fuzzy logic a branch of soft computing provides us flexibility by allowing the values without any such restrictions. Fuzzy logichave IF-THEN rules and have simple

structure to implement. Simply by changing or adding few more fuzzy rules result can be changed and some techniques are knowledge based in which training is required. Fuzzy logic is a logical system which is an extension of multi valued logic. It is a propositional calculus in which there are more than two truth values [15]. By using fuzzy techniques edges having different thickness can also be detected. Fuzzy logic is conceptually easy to understand and is flexible and is tolerant of imprecise data. Fuzzy logic is to map an input space to an output space and for doing this a list of if then statements called rules are evaluated in parallel .These Rules are useful because they use variables and adjectives that describes those variables[15]. The paper focuses on several edge detection techniques and overview of several techniques to solve the edge detection and related problems. Related work in the field of image processing is in section II. Section III of the paper deals with the various techniques for detection of edge.

II. RELATED WORK

This section includes the growth in the field of edge detection. First traditional operators were used for edge detection In [7] comparative analysis of various edge detection techniques is given. It is shown that Canny, LOG, Sobel, Prewitt, Roberts's exhibit better performance. Initially Canny [5] proposed a method which proved more accurate in edge detection under noisy conditions and was also capable of detecting weak and strong edges. The several approaches were adopted by many researchers in this domain. Zhao Yu-qian et al. [16] proposed a algorithm for detection. The algorithm proved more efficient than the traditional operators LoG and Sobel. J Patel and et al. in [9] proposed algorithm in which these traditional approaches of Sobel and Lapalacian of Gaussian (LoG) are used with fuzzy system and fuzzy rules. In this approach first edges are calculated and then that result is applied to fuzzy system. This method detects multiple responses to single edge and reduces false detection. Abdallah A. Alshennawy and Ayman A. Aly [6] proposed a fuzzy logic technique for edge detection without determining the threshold value. This technique gives straight lines for the lines which are straight also smoothness was the result and when this algorithm was compared with Sobel it had given better result because number of double edges detected are less as that with Sobel. In both techniques [6][9] ground truth evaluation is not considered. Later Pushpajit A. Khaire and Nileshsingh V. Thakur [10][25] introduced an soft computing approach based on fuzzy logic in which the results are compared with canny using ground truth of respective image[10]. In this fuzzy logic is applied on the histogram of the image to enhance edge detection technique. In this approach RGB image is transformed into HSI image. Saturation is removed from the image and histogram is obtained from the remaining two. Fuzzy logic is applied on obtained histogram and membership is calculated and 4×1 operator is convolved in an output we get both strong and weak edges having different threshold. Liang and Looney introduced a competitive fuzzy edge detection (CFED) method [22]. These methods divide types of edges in six patterns and fuzzy classifier is being used for finding that under which pattern edge lies. CFED generates speckle noise. ArpitSinghal and MandeepSingh [12] proposed a mathematical morphology noise removal cum edge detection algorithm to remove speckle noise and find edges. Parameters used are Signal to noise ratio (SNR), correlation; Structural similarity index (MSSIM), Root mean square error (RMSE) and Edge preserving index (EPI).fuzzy approach is not used here. Fabrizio Russo [19] proposed a new approach which adopts fuzzy reasoning for edge detection without being deceived by the noise. Noise protected operator developed in this algorithm combines effective rules for edge detection and noise cancellation in same structure. Suryakant, NeetuKushwaha [17] proposed Fuzzy Inference based system in which 28 rules are there and in this algorithm noise removal is applied at intermediate levels of processing so that it removes the edges which are falsely detected as edge during processing. I. Laurence Aroquiaraj, K. Thangavel [18] has proposed hybrid soft computing methods for edge detection i.e Fuzzy Canny Edge Detector, Fuzzy Relative Pixel Edge Detector and Fuzzy Edge Detection Based on Pixel's Gradient and Standard Deviation Values (SDGD Edge Detector). In first method edges are found by isolating noise and without affecting the features and then tendency for critical value for threshold is applied. In second method convolution is applied, using fuzzy conditioned an intermediate image is generated. Then it is checked whether all pixels are checked or not then unwanted parts of the edges is removed. In third method the gradient and standard deviation of pixels value, edges are separately extracted and then based on fuzzy logic, final decision about whether each pixel is edge or not is made. Problematic results could be gained if each of the methods be used solely. It may causes on identifying of edge pixels as non-edge pixels and vice versa. Song Wang and et al. [6] introduced an approach for evaluating edge detection by checking the likelihood of object boundaries from the detected edges.Mrs.Abhradita Deepak Borkar and Mr.MithileshAtulkar[15] developed fuzzy inference system which have two fuzzy sets during input and three fuzzy set during output which can detect edges for fuzzy set and further middle of maximum method is used for defuzzification on the output image. SamanSinaie, AfshinGhanizadeh,andSitiMariyamShamsuddin and EmadaldinMozafari [20] proposed method uses fuzzy set theory and then output image is enhanced using Cellular learning Automata(CLA). Because of the neighbor-considering nature has been used in CLA. In this approach w×w window size is used to divide the original image. Using fuzzy set membership function is found. Enhancement of edges is done with the help of a set of rules CLA. Dhirajkumar Patel and S A More [21][23] proposed a hybrid method which uses fuzzy logic and CLA. In both papers a 10 step algorithm is proposed. In which edge is detected and edge enhancement is done. CLA is used for improving the quality of the image [23]. CLA is used for enhancement of the edges and to detect the grey level changes of neighbours of every pixel, and to detect the edge by using the changing

regular of one-order or two-order directional differential coefficient. But to detect the edges CLA is used to realize improve image detection and fuzzy enhancement is mentioned. [21]. Edge detection using fuzzy logic have large computation and also faces the problem of noise [29].

III. EDGE DETECTION MECHANISM

A. Traditional operators for edge detection

Edges are the high intensity component in an image. When there is an edge there is an abrupt change in colour intensity of the image introduces edge.Image having no edge will have a constant colour. Edges shows object boundaries and the process of detecting boundaries between object and background in image. Edge detection is most important task because further process of segmentation registration and identification are based on it. Edge detection process reduces significant amount of data and also filters out less relevant data and preserves important structural properties of an image [2]. The traditional operators for edge detections are summarised in fig.3.1.

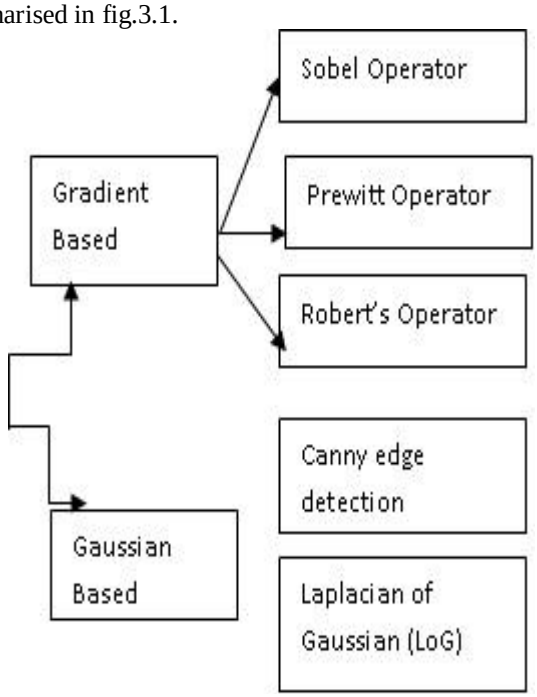

Fig 2. Traditional Operators for edge detection [24]

Classical operators such as Sobel, Prewitt are simple for implementation and are advantageous in case of detection/orientations. But they are sensitive to noise which leads to inaccurate result. Other operators are zero crossing operators which consist Laplacian, second directional derivative provide us an advantage of having fix characteristics in all directions but limitations with these is that it responds to some edges and is sensitive to noise. Other edge detectors are laplacian of guassian(LoG) and Gaussian(Canny) are complex to implement, problem of computation as well as time consuming. Several Soft computing approaches are applied for edge detection earlier but there are limitations to it as like continuous edge are not obtained, etc. More improvement can be done to improve the performance of the system.[7].

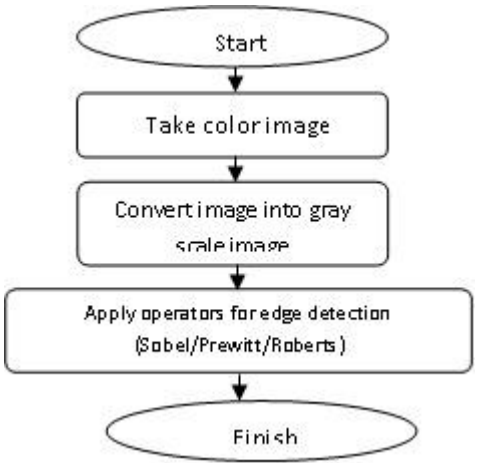

Fig 3. General process of edge detection [36]

B. Soft Computing approaches for edge detection

The various soft computing approaches such as fuzzy logic, genetic algorithm, and neural network are discussed in this section.

Fuzzy approach for edge detection:

Image processing possesses vagueness and ambiguity and fuzzy deals with the data uncertainty [11]. Fuzzy logic provides mathematical framework. General procedure of fuzzy logic is shown in Fig.3.3. Fuzzy methodology is generated to deal with brightness, edges and geometric features. Fuzzy logic also deals with subjective concepts. There are different possibilities for edge detection based on fuzzy logic.In case of edge detection uncertainty is high in neighbourhood pixel. One method is to define a membership function and using IF-THEN rules general edge detections can be performed. Membership function is determined.

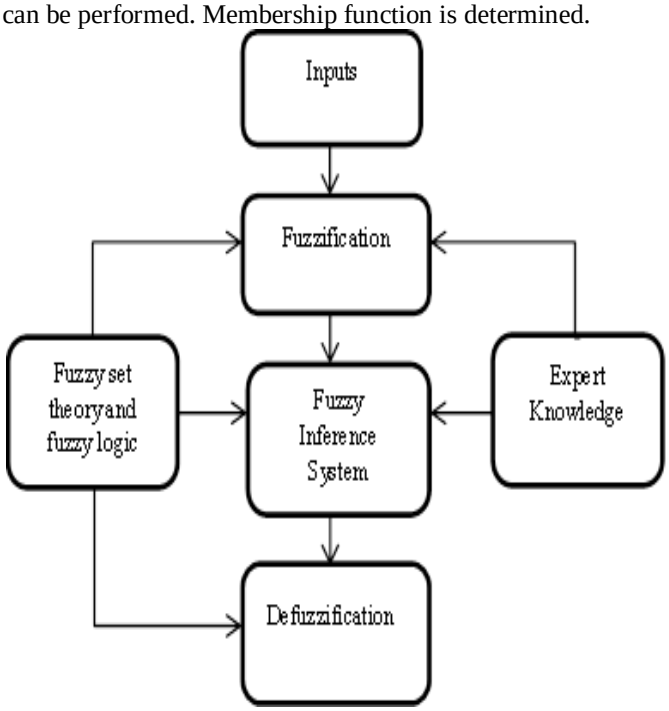

Fig. 4. General structure of fuzzy image processing.[26][15]

Heuristically. It is fast but has some limitations. Fuzzy clustering, fuzzy rule based system, fuzzy set theory are the methods of edge detection based on fuzzy logic. [11] The process of fuzzification is a combination of image processing and fuzzy approach. Fuzzy sets are created which consist of the segments, features and approaches which understand, represent and process the images. The problem to be solved and the fuzzy technique is solely reflects its representation and processing. Fuzzification is required because we do not possess fuzzy hardware. And this process of fuzzification makes it possible to process image with fuzzy techniques. There are three main stages in the process of fuzzy image: image fuzzification, modification of membership values and image defuzzification. Very important step in this process of fuzzy is the middle step i.e modification of membership values. 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 the representation depends on the technique used and the problem which is to be solved [11]. Defuzzification is a process in which decoding of the image is done. This step is done because we don't have fuzzy hardware. It's the process of converting the fuzzy output is called defuzzification. As like fuzzification there are various defuzzification techniques such as bisector, centroid, hich method is to be used depends upon the problem to be solved, method used for fuzzification.

- Genetic algorithm for edge detection
- Genetic algorithm is a problem solving methodology.

Genetic algorithm consists of

- Selection
- Crossover
- Mutation

Selection evaluates and keeps the fittest ones in the population. Crossover recombines two individuals remaining are removed from the current population. Mutation operator includes changes in chromosomes units. Its purpose is to maintain the population. Using genetic for edge detection. GA has ability to deal with complex, large search spaces when minimum knowledge is available [31]. GA takes all edges as chromosomes and after selection process operators are applied on it. The method used for selection as well as reproduction is matter of choice. Either crossover or mutation or both operators can be used. In The intermediate step fitness function is calculated. Based on the fitness function Suchendra M. Bhandarkar, Yiqing Zhang and Walter D. Potter [30] proposed edge detection approach using GA. Chromosomes in the population are represented by two dimensional binary arrays of 1's and 0's. Where 1 represents the edge and 0 represents non-edge pixel. Roulette wheel selection to select mates for reproduction based on the relative fitness value of each chromosome. Remark has been made about the size of population that the size of population must be large. More developments are done in image processing by using GA. [32][33][34].

Neural network approach for edge detection:

Neural networks are formed by several elements that are connected by links with variable weights. Neural network consist of three layers input layer, hidden layer and output layer. Neural network is widely used in image processing for edge detection, pattern recognition etc...Neural network is used to train edges and mostly neural network is used with fuzzy logic. Neural networks can be trained to detect edges of an image based on their adaptive learning ability and their nonlinear approximation capability. In [3] Becerikli and Demiray proposed an algorithm for detecting edges using ANN in images Laplacian method is applied on raw images to produce edges. NN uses these edges for training. Neural network performance is high in case of noisy images as compare to Laplacian and is flexible in edge detection on shady images. Dingran and Xiao-Hua[37] used hybrid approach for edge detection. They used nine neurons in the input layer which are converted from a 3x3 mask. The output to it is single neuron which indicates that the edge is detected. Fuzzy was used for improving the generalization ability of neural networks. The drawback of this method is that it doesn't deal with noisy images. In [38] Mehrara classified the edge patterns of binary images into 16 possible types of visual patterns. After training the edge patterns back propagation was used to correspond any type of edges. Rong Wang has proposed a combination of neural network with fuzzy logic. KRID and DorraSellamiMasmoudi proposed neural network based edge detection with pulse mode operations and floating point format precision in which a multilayer network is used for learning the canny operator. Pulse mode operations are used and activation function uses floating point operations. Learning performance of this method was good. Author has used standard deviation and gradient values for minimising errors. Back propagation training algorithm is used for training. This method works slightly better than other traditional methods.

IV. CONCLUSIONS

The field of image processing is fast developing field of research. The research is taking shape on many fronts. The applications of soft computing techniques have increased efficiency of the processing and the result outcomes. These approaches give flexibility in dealing with the variations in parameter value related to any application. The study of different Edge detection techniques shows that soft computing approaches are better than the traditional approaches. Soft computing approaches helps in eliminating the boundaries and restrictions of traditional fixed parameter values, which lead to give better results than the other approaches.

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