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**Evaluation of Various Edge Detection Algorithms – Review**

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**Abstract**

Edge detection is the most common preprocessing step in many image processing algorithms such as image enhancement, image segmentation, tracking and image/video coding. Edge detection is the name for a set of mathematical methods that aims at identifying points in a digital image at which the image brightness changes sharply and it has discontinuities. The points in which image brightness changes sharply are typically organized into a set of curved line segments termed as edges. The step detection is the problem of finding discontinuities in 1D signals and change detection is the problem of finding signal discontinuities over time. Edge detection is a fundamental tool particularly in the areas of feature detection and feature extraction. There are different algorithm based edge detectors like Canny, Sobel, Iverson and they depend on the input parameters. The purpose of detecting sharp changes in image brightness is to capture important events and changes in properties of the world. In an image formation model, discontinuities in image brightness are likely to correspond to four assumptions: discontinuities in depth, discontinuities in surface orientation, changes in material properties and variations in scene illumination. Mamdani method is widely accepted for capturing expert knowledge. It allows us to describe the expertise in more intuitive, more human-like manner. This article discusses the recent development of edge detection algorithms available in image processing fields.

**Keywords:** Edge detection, Image Processing algorithms, Canny edge detector, Mamdani Fuzzy logic.

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**Introduction**

Edge detection is a very important image processing operation, used in various higher level tasks such as motion and feature analysis. Since last two decades many research work have done based on the performance of different edge detection algorithms by checking them with different images. The performance of the well known edge detectors like Canny, Sobel, Iverson, are used and they depends critically on the choice of the input parameters.

The Canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in images. To discover the optimal edge detection is the main aim of canny algorithm. An "optimal" edge detector means: good detection, good localization and minimal response of the algorithm.

Fuzzy logic refers to a logical system that generalizes the classical two-value logic for reasoning under uncertainty. The two key features of fuzzy logic include: (a) A mathematical formalism that represents human knowledge involving a vague concepts, and (b) a natural but effective mechanism for systematically formulating cost-effective solutions to complex problems characterized by uncertainty or imprecise information. The fuzzy logic have different types of inference technique, they are Mamdani, Sugeno, etc. The most commonly used fuzzy inference technique is that so-called Mamdani method. Mamdani method is widely accepted for capturing expert knowledge. It allows us to describe the expertise in more intuitive, more human-like manner. Sugeno method is computationally effective and works well with optimization and adaptive techniques, which makes it very attractive in control problems, particularly for dynamic nonlinear

systems. This article discusses the recent development of edge detection algorithms available in image processing fields.

## Materials and methods

### Edge Detection Analysis

Yitzhaky Y and Peli E (2003) analyzed the real-world images subjective to evaluation by human observers are used to select an edge detector. A statistical objective performance and detector parameter selection are proposed using detection results produced by different detector parameters. The correspondence used between the different detection results and estimated best edge map an estimated ground truth (EGT), is obtained. By using a receiver operating characteristics (ROC) analysis and a Chi-square test the trade off between information and noisiness in the detection results are obtained. Several edge detection techniques are compared and publish the subjective evaluation results.

Yongjian Yu and Scott T. Acton (2004) discussed that, the instantaneous coefficient of variation (ICOV) edge detector in ultrasound image is based on normalized gradient and Laplacian operators. A simplified version of the ICOVS detector, the normalized gradient magnitude squared, is scrutinized in order to reveal the statistical performance of edge detection and localization in speckled ultrasound imagery. Edge localization is characterized by position of the peak and 3-dB width of the detector response. By theoretical analysis, the compensatory effect of the normalized Laplacian operator in the ICOV edge detector for edge-localization error is revealed. An ICOV-based edge-detection algorithm is embedded in a diffusion coefficient of an anisotropic diffusion process. As a result with real ultrasound images the algorithm is effective in extracting edges in the presence of speckle.

Rakesh R.R et al., (2004) discussed that, many types of edge detectors are available in image processing literature where the input parameters are given by user. Most of the time, they are made on an ad-hoc basis. By using statistical principles the edge detector and threshold operation is performed. Depends upon the statistical variability of the gradient vector the Local standardization of thresholds for each individual pixel is obtained. Based on the gradient vector at each pixel is to determine the pixel to be an edge pixel. The results obtained here are found to be comparable to those

from many well-known edge detectors. Thus the values of the input parameters providing the results in the proposed detector are found to be more stable than other edge detectors.

Paul Bao et al., (2005) used the technique of scale multiplication is analyzed in the framework of Canny edge detection. A scale multiplication function is defined as the product of the responses of the detection filter at two scales. Constructing the Edge maps by thresholding the scale multiplication results. Scale multiplication is of detected and localized. A small loss in the detection criterion, the localization criterion can be much improved by scale multiplication. The product of the two criteria for scale multiplication is greater than that for a single scale, which leads to better edge detection performance.

Max W. K. Law and Albert C.S. Chung (2007) discussed that, the accurate detection of vessel boundaries is particularly important for a precise extraction of vasculatures in magnetic resonance angiography (MRA) by the use of weighted local variance (WLV)-based edge detection. The robustness and capabilities are essential for detecting the low contrast regions of images in boundaries of vessels that contain intensity in homogeneity, such as bias field, interferences induced from other tissues, or fluctuation of the speed related vessel intensity. The WLV based edge detection scheme can be embedded naturally in the active contour models for vascular segmentation. Using MRA images the WLV-based vascular segmentation methods is tested and achieves high-quality segmentation.

Shih-Lun Chen (2013) discussed that, a low-complexity adaptive edge enhanced algorithm is used for the implementation of 2-D image scaling applications. The novel algorithm consists of a linear space-variant edge detector, a low complexity sharpening spatial filter and a simplified bilinear interpolation. By a low-cost edge-catching technique the edge detector is designed to discover the image edges. The sharpening of spatial filter is added as a pre filter to reduce the blurring effect. An adaptive technology is used to enhance the effect of the edge detector by selecting the input pixels of bilinear interpolation. As a result it provides better quality, high performance than other image scaling methods.

Brajpal Singh Jadon and Neelesh Gupta (2013) discussed that, Edge detection in images significantly reduces the amount of data and filters out useless

information. A fuzzy rule based algorithm which is capable of detecting edges efficiently from the gray scale images is analyzed. This introduces a hand of computer vision application. Edginess at each pixel of a digital image is calculated using three linear spatial filters i.e. low-pass, high-pass and edge enhancement filters through spatial convolution process. As a result the ability and high performance of other algorithms such as Sobel, Robert, and Prewitt is obtained.

### **Canny Edge Detection**

Wenheo He and Kui Yuan (2008) discussed that, to design an optimal edge detector the Canny edge detector is used as a signal processing problem and have been widely used for edge detection. The traditional Canny edge detector has two shortcomings. First, manually set the algorithm for the threshold. Secondly, the algorithm is time consuming and can not be implemented in real time. A new self-adapt threshold Canny algorithm is discussed here to solve the first problem. A pipelined implementation on FPGA is designed to solve the second problem. The Experiment results are given to show the efficiency of the proposed method.

Gentsos C et al., (2010) In digital image processing, edge detection is one of the most fundamental algorithm. When images are contaminated by noise, the Canny edge detector is the most intensive algorithm to detect the edge. This is a time consuming algorithm and its implementations are difficult to reach real time response speeds. The demand for high resolution image processing is constantly increasing and the need for fast and efficient edge detector implementations is needed. A new parallel Canny edge detector FPGA implementation is explained. Without increasing the on-chip memory demands this design takes advantage of 4-pixel parallel computations to achieve high throughput. As a result the Synthesis and simulation are presented to prove the design's efficiency and high frames per second rate.

Hitesh Kapoor and Parikshit Singla (2012) Fuzzy using canny edge detection is analyzed. Two basic phases of edge detection, first the Global contrast intensification and local fuzzy edge detection are explained and to obtain better results specially for noisy images and low contrast images is merged with Canny operator. MATLAB software is used for the observation of edges in digital images because of its efficiency and convenience for handling images. The first-order linear filters constitute the algorithms most

widely applied to edge detection in digital images but they don't allow good results to be obtained where the contrast varies a lot, due to non-uniform lighting, as it happens during acquisition of most part of natural images.

Vijayarani S and Vinupriya M (2013) discussed that, edge detection is to identify and locate the sharp discontinuities in an image. In image analysis edge detection is a vital step and it is the key of solving many complex problems. It is a fundamental tool used in most image processing applications to obtain information from the frames as a precursor step to feature extraction and object segmentation. The object recognition, target tracking, segmentation, data compression, image reconstruction are done by edge detection. It transforms the original images into edge images benefits from the changes of grey tones in the image. The two edge detection algorithms namely canny edge detection and sobel edge detection algorithm are used to extract edges from facial images. Accuracy and speed of the algorithm are analyzed and results are obtained.

Chaithra N.M. and Ramana Reddy K.V. (2013) discussed that, the most important stages in image processing field is edge detection. Canny edge detection algorithm is most widely used edge detection algorithm. The implementation of Canny Edge Detection algorithm on Spartan 3E FPGA is discussed. Displaying the images on the monitor with the help of VGA interface. An image of size 128×128 is first stored in block ROM on FPGA and it is processed through Canny edge detection algorithm and displayed on VGA monitor. Using Spartan 3E FPGA board the entire system is developed, simulated and synthesized.

Bhadauria H S and Singh A (2013) proposed a computer-aided diagnosis (CAD) tool for various medical imaging modalities including computer Tomography (CT), magnetic resonance imaging and nuclear medicine. In thoracic CT images the Medical image edge detection is an important work for diagnosis of various lung diseases. Detecting the edges based on wavelet transform, the edge detection results are poor because of the noise influence. In wavelet domain, the low-frequency edges are detected by canny operator, and the high-frequency edges are detected by solving the maximum points of local wavelet coefficient model to restore edges after reducing the noise by wavelet. To evaluate the performance of algorithm a noisy CT image of abnormal lung infected by Honeycombing is used.

Experiment results show that detecting the image edges can not only get rid of the noise effectively but also enhance the image edge's details and locate the edge accurately.

Nishchal Gyan Upadhyay and Kamlesh Lakhwani (2013) Threshold decision is the uncertainty method in the edge detection algorithm. The need for general edge detector is still obtain after 20 years of research. A good mathematical framework in soft computing approach is dealing with uncertainty of information. Here fuzzy logic for Automatic Thresholding and generated threshold is used with different methods for edge detection. The results obtained are found to be comparable to those from many well known edge detector. In the proposed detector the values of the input parameters are provided with the appreciable results.

#### **Mamdani and Sugeno Fuzzy Logic**

Salamat A. et al., (2009) discussed that, Skin detection is a well known method to detect the appearance of human and human parts within an image. Several limitations exist in skin detection when using skin color as cue to detect the appearance of skin. Illumination, skin-like pixels and camera characteristic are the problems that occur in limitations. A set of modified fuzzy rules has been introduced to deal with the skin-like pixels problem and they were integrated with skin modeling method in order to discriminate skin pixel and non-skin pixel. Classification of human skin image and animal images is explained in this paper. The result is then compared with skin region and fuzzy Sugeno classification method and finally the proposed fuzzy rules are applicable if the RGB value of pixel does not close to low value.

Hosseini R. et al., (2010) Medical Digital Image Analysis System (MDIAS) such as computer aided detection (CAD) technology deals with another source of uncertainty in an image-based practice of medicine and the digital image analysis technology. The technology consists of image enhancement, segmentation and pattern recognition suffers from imperfection, imprecision and vagueness of the input data. In developing CAD applications, no attempt has been made to address, model and integrate the types of uncertainty because it directly affect the performance and accuracy. The Mamdani model and the Sugeno model of the fuzzy logic system are implemented and the classification results are compared and evaluated through ROC curve analysis and root mean squared error methods. The study is to

investigate the effect of training algorithms on the performance of the CAD system. As a result the fuzzy logic system with hybrid-training is superior to other models in terms of root-mean-squared error and ROC curve sensitivity and specificity rates.

Yilmaz A. et al., (2011) analyzed that, thousands of people die every year because of cancer due to limitation of medical sources and unable to use the existing sources effectively. By using the numerical techniques in the system of Medical and Health loss of patients get reduced. Cancer is a genetic disease which is developed by the abnormal cell increase and cell growth of DNA. If the cancer is diagnosed early the treatment would be successful. By applying the Mamdani Fuzzy Logic Model in the study, the risks of getting cancer for selected pilot people will be discovered and suggestions will be submitted to the persons to eliminate these risks. The reason for selection of fuzzy logic model is that it provides effective results depending on uncertain verbal knowledge just like logic of human being. The contribution of fuzzy logic model in the field of health and topics of artificial intelligence will also be examined in this study.

Shen Wang and Mahfouf M (2012) discussed that, constructing a data-driven Mamdani Interval Type-2 Fuzzy Modeling (MIT2FM) framework a modified center-of-sums (mCoS) type-reduction technique is used. The full area under the scaled consequent membership functions is considered and enables the commonly used Gaussian interval type-2 membership functions to be utilized in MIT2FM. By Gaussian membership functions the mCoS method is used for each rule instead of computing the geometric center. It is more efficient for data-driven fuzzy modeling applications. For validity testing the mCoS type-reduction and fuzzy modeling scheme are conducted on a benchmark for non-linear time series. The mCoS based interval type-2 fuzzy modeling approach is shown to handle uncertainties very well and to provide desired generalization capability.

Soylu S. et al., (2013) A Survey on diabetes is one of the popular fields of biomedical signal processing. Modified Stolwijk-Hardy glucose insulin interaction model is considered in a closed-loop system. By adding an exogenous insulin infusion term two control algorithms are used: a Mamdani type fuzzy logic controller (FLC), and a fuzzy-PID controller. Simulations are performed to assess control function in terms of keeping desired

steady state plasma glucose level (0.81 mg/ml) against to exogenous glucose input. By controlling blood glucose level (BGL) the Simulation results are noted. The control algorithms that applied to the model are firstly proposed; therefore this study is made a contribution to the literature.

Kumar E.B. and Sundaresan M. (2014) discussed that, the Edge detection approach is used most frequently for segmenting images based on local changes in intensity. Useless data, noise and frequencies are removed while preserving the important structural properties in an image. Fuzzy logic is used for a large number of rapid growth and in variety of applications. It is used in image understanding applications such as detection of edges, feature extraction, classification, and clustering. It effectively employs modes of reasoning to mimic the human mind that are approximate rather than exact form. Vary the ranges between 0 and 1 is the only condition a membership function can be satisfied. Membership function is applied to detect the edges in the given input image. Mamdani type method used a trapezoidal membership function to get effective results.

## Results and discussion

### Edge Detection Analysis

Yitzhaky Y and Peli E (2003) results shows that several edge detection techniques are compared and suggest a general tool to assist in practical implementations of parametric edge detectors by using an estimated ground truth (ECT) and ROC analysis. Yongjian Yu et al., (2004) result shows that the algorithm is effective in extracting edges in the presence of speckle. The instantaneous coefficient of variation (ICOV) edge detector provides a lower localization error and a dramatic improvement in edge-detection performance. Rakesh R.R et al., (2004) Depends upon the statistical variability of the gradient vector the Local standardization of thresholds for each individual pixel is obtained. Paul Bao et al., (2005) result shows that the localization criterion can be improved by scale multiplication and the product of the two criteria for scale multiplication is greater than that for a single scale, which leads to better edge detection performance. Max W. K. Law et al., (2007) result shows that the WLW-based vascular segmentation method is used for testing MRA image volumes. This can achieve high-quality segmentation of Vasculatures in MRA images. Shih-Lun Chen (2013) performs a low-complexity adaptive edge enhanced algorithm and it is used for the

implementation of 2-D image scaling applications with a better quality and higher performance than other image scaling methods. Brajpal Singh Jadon and Neelesh Gupta (2013) result shows that fuzzy rule based algorithm which is capable of detecting edges are compared with other Sobel, Robert, and Prewitt algorithms and the ability and high performance of algorithms are obtained.

### Canny Edge Detection

Wenheo He and Kui Yuan (2008) result shows that canny algorithm and pipelined architecture is used to solve the edge detection problem. Efficient results are obtained. Gentsos C et al., (2010) A new parallel Canny edge detector is designed and takes an advantage of 4-pixel parallel computations to achieve high throughput without increasing the on-chip memory demands. Hitesh Kapoor and Parikshit Singla (2012) Fuzzy using canny edge detection is explained. Global contrast intensification and local fuzzy edge detection gives a better result especially for noisy images and low contrast images when merged with Canny operator. S.Vijayarani et al., (2013) result shows that two edge detection algorithms namely Canny edge detection and Sobel edge detection algorithm are used to extract edges from facial images. Chaithra.N.M. et al., (2013) result shows that the implementation of Canny Edge Detection algorithm on Spartan 3E FPGA kit. VGA interfacing is developed for displaying the images on the monitor. Bhadauria H S et al., (2013) result shows that in thoracic CT images the Medical image edge detection is an important work for diagnosis of various lung diseases. Nishchal Gyan Upadhyay and Kamlesh Lakhwani (2013) result shows that the threshold decision is the uncertainty method in the edge detection algorithm. Fuzzy logic for Automatic Thresholding and generated threshold is used with different methods for edge detection.

### Mamdani and Sugeno Fuzzy Logic

Selamat A. et al., (2009) result show that a set of modified fuzzy rules has been introduced to deal with the skin-like pixels problem in order to discriminate skin pixel and non-skin pixel. Hosseini R. et al., (2010) results reveal that the fuzzy logic system with hybrid-training is superior to other models in terms of root-mean-squared error and ROC curve sensitivity and specificity rates. Yilmaz A. et al., (2011), results show that the Mamdani fuzzy logic model is used to provide effective results depending on uncertain verbal knowledge just like logic of human being. Shen wang et al., (2012) result shows that the mCoS based interval type-2 fuzzy modeling approach is

shown to handle uncertainties very well and to provide desired generalization capability. Soyle S et al., (2013) Simulations are performed to assess control function in terms of keeping desired steady state plasma glucose level against the exogenous glucose input by Mamdani type fuzzy logic controller (FLC), and a fuzzy-PID controller. Kumar E.B. and Sundaresan M. (2014) Membership function is applied to detect the edges in the given input image. Mamdani type method used a trapezoidal membership function to get effective results.

### Conclusion

This review article illustrates how various edge detection algorithms are used in many applications such as tumor detection and diagnosis, building and vehicle detection in satellite images and etc. The articles discussed above had not mention of detecting both thick and thin edges. The fuzzy types mentioned here are Mamdani and Sugeno logic. Mamdani is used for detecting edges in different still images and Sugeno is used to detect the electrical signals. Thus this article will provide knowledge about various edge detection algorithms and various other techniques involved in analyzing the features. This also promotes very high accuracy in detecting edges and a way for challenging applications.

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