"Edge detection using Fuzzy Inference System with Type-2 Fuzzy Logic"

DISSERTATION

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ABSTRACT

Edges in a digital image contain useful information that can be utilized in the processing of digital images. Edges of an image can be applied in disjoining of images, finding objects in images, for image registration etc. Edge detectors are the tools that find out all the edge pixels that are present in a digital image. Edges are the points in an image where the intensity level changes very sharply from one pixel to other pixel. In this research, edge detection using three different methods of fuzzy logic has been done. The three different methods of fuzzy logic for edge detection are Sobel fuzzy edge detector, Template fuzzy edge detector and Fuzzy Inference system. A comparison has been made among these three methods at different values of threshold. The result shows that the fuzzy inference system method gives more efficient results than other two methods under all outlines. This research also impersonates three edge detection methods by employing fuzzy logic-1, interval type-2 fuzzy logic with sobel operator and a proposed technique that utilized interval type-2 fuzzy logic with pseudo convolution mask. The results of these three edges tracking down techniques are compared. The results imitate that the proposed method provides more preferable edge pixels as compare to other two techniques. Also, histogram is computed for resultant edge images in order to make comparison. From the comparison it has been shown that the proposed method produce superior edges than other two techniques. The proposed technique provides more desirable outcomes and is powerful against noise. The proposed technique can be utilized in many areas e.g. to track down features of faces, tumour in brain, cyst or stone in kidney, numeral of vehicles in traffic etc.

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I am thankful to management of Lovely Professional University for giving me an opportunity to carry out studies at the university and providing the proper infrastructure like internet facility which is pool of vast knowledge to work in.

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I would like to thank God for the strength that keeps me standing and for the hope that keeps me believing that this research would be possible.

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DECLARATION STATEMENT

I, Rachita Katoch student of M.Tech (ECE) under Department of Electronics and Communication Engineering of Lovely Professional University, Punjab, hereby declare that all the information furnished in this research is based on my own intensive research and is genuine.

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CERTIFICATE

This is to certify that the Dissertation titled "**Edge Detection using Fuzzy Inference System with Type-2 Fuzzy Logic**" that is being submitted by **Rachita Katoch** is in partial fulfilment of the requirements for the award of Master of Technology (M.Tech), is a record of bona-fide work done under my guidance. The contents of this dissertation, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree or diploma and the same is certified.

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Examiner I **Examiner II**

TABLE OF CONTENTS

ABSTRACT		**ii**
ACKNOWLEDGEMENT		**iii**
DECLARATION STATEMENT		**iv**
CERTIFICATE		**v**
LIST OF TABLES		**vii**
LIST OF FIGURES		**ix**
LIST OF ABBREVATIONS		**xi**
1.	**Introduction**	**1-7**
	1.1 About Fuzzy Logic (FZLG)	1
	1.2 Types of FZLG	3
	1.2.1 Type-1 Fuzzy Logic (FZLG1)	3
	1.2.2 Type-2 Fuzzy Logic (FZLG2)	3
	1.3 Edge detection	5
	1.4 Several procedure for edge detection	5
	1.4.1 Method lean on gradient	5
	1.4.2 Method lean on laplacian	5
	1.5 Prototype for edge detection	6
	1.6 Fuzzy image processing (FIP)	6
2.	**Literature Review**	**8-14**
3.	**Scope and objective**	**15-17**
	3.1 Scope of study	15
	3.2 Objective of the study	16
	3.3 Work plan with timeline	16
4.	**Research methodology**	**18-29**
	4.1 Techniques of tracking down edges using fuzzy logic (FZLG)	18
	4.1.1 Sobel Fuzzy edge detector (SFED)	18
	4.1.2 Template fuzzy edge detector (TFED)	20
	4.1.3 Fuzzy Inference System (FZYIFS)	22
	4.2 Edge detection using types of FZLG	23

4.2.1 Edge detection using FZLG1 with SOB 24
4.2.2 Edge detection using INTFZLG2 with SOB 26
4.2.3 Edge detection using proposed technique 28
5. Results and Discussion 30-66
5.1 Parameters for analyses 30
5.2 Analysis on edge detection using FZLG 33
5.2.1 The outcome of SFED 33
5.2.2 The outcome of TFED 38
5.2.3 The outcome of FZYIFS 43
5.2.4 Comparison of FZYIFS, SFED and TFED 47
5.3 Analysis on edge detection using types of FZYIFS 50
5.3.1 The outcome of FZLG1 50
5.3.2 The outcome of INTFZLG2 with SOB 56
5.3.3 The outcome of proposed technique with SPCM 61
6. Conclusion and Future Scope 67-68
6.1 Conclusion 67
6.2 Future Scope 68
REFERENCES 69-71

LIST OF TABLES

Table 5.1: Outcome of SFED 37

Table 5.2: Outcome of TFED 42

Table 5.3: Outcome of FZYIFS 48

Table 5.4: Outcome of FZLG1 55

Table 5.5: Outcome of INTFZLG2 with SOB 60

Table 5.6: Outcome of the proposed technique (INTFZLG2 with SPCM) 63

LIST OF FIGURES

Fig. 1.1	A FZLG setup	2
Fig. 1.2	The general framework of FZLG1	3
Fig. 1.3	The general framework of FZLG2	4
Fig. 1.4	The generic framework of FIP	7
Fig. 4.1	Steps in execution of SFED	19
Fig. 4.2	Steps in execution of TFED	21
Fig. 4.3	Steps in execution of FZYIFS	23
Fig. 4.4	Steps in execution of FZLG1	24
Fig. 4.5	Steps in execution of INTFZLG2 with SOB	27
Fig. 4.6	SOB with pseudo convolution mask	28
Fig. 4.7	Steps in execution of the proposed technique with SPCM	29
Fig. 5.1	Example of an image with edges	31
Fig. 5.2	Image with edges	32
Fig. 5.3	Image with histogram	33
Fig. 5.4	Original images for implementation of FZLG	35
Fig. 5.5	The outcome of SFED on Cameraman image	33
Fig. 5.6	The outcome of SFED on Lenna image	35
Fig. 5.7	The outcome of SFED on Brain tumour image	36
Fig. 5.8	The outcome of SFED on Face image	36
Fig. 5.9	Bar graph of total edges of SFED	38
Fig. 5.10	Bar graph of total edge Percentage of SFED	38
Fig. 5.11	The outcome of TFED on Cameraman image	39
Fig. 5.12	The outcome of TFED on Lenna image	40
Fig. 5.13	The outcome of TFED on Brain tumour image	41
Fig. 5.14	The outcome of TFED on Face image	41
Fig. 5.15	Bar graph of total edges of TFED	43
Fig. 5.16	Bar graph of total edge Percentage of TFED	43
Fig. 5.17	The outcome of FZYIFS on Cameraman image	44
Fig. 5.18	The outcome of FZYIFS on Lenna image	45
Fig. 5.19	The outcome of FZYIFS on Brain tumour image	46
Fig. 5.20	The outcome of FZYIFS on Face image	46
Fig. 5.21	Bar graph of total edges of FZYIFS	48

Fig. 5.22	Bar graph of total edge Percentage of FZYIFS	48
Fig. 5.23	Comparison of FZYIFS, SFED and TFED	49
Fig. 5.24	MBFS of FZLG1	52
Fig. 5.25	Original images	53
Fig. 5.26	Edge images using FZLG1	53
Fig. 5.27	Bar graph of total edges from FZLG1	55
Fig. 5.28	MBFS of INTFZLG2	57
Fig. 5.29	Original image	58
Fig. 5.30	Edge images using INTFZLG2	58
Fig. 5.31	Bar graph of total edges from INTFZLG2	60
Fig. 5.32	Original image	61
Fig. 5.33	Edge images using FZLG2 with SPCM	61
Fig. 5.34	Bar graph of total edges from INTFZLG2 with SPCM	63
Fig. 5.35	Comparison of FZLG1, INTFZLG2 and the proposed method	64
Fig. 5.36	Histogram of INTFZLG2 with SOB	64
Fig. 5.37	Histogram of the proposed technique	65

LIST OF ABBREVATIONS

FZLG	Fuzzy Logic
FZLG1	Type-1 Fuzzy Logic
FZLG2	Type-2 Fuzzy Logic
ELA	Edge Localization Accuracy
FIP	Fuzzy Image Processing
TRSH	Threshold
CLA	Cellular Learning Automata
GRD	Gradient
SOB	Sobel
ANN	Artificial Neural Network
GA	Genetic Algorithm
FMFZYED	Fast Multilevel Fuzzy Enhancement Edge Detection
IMFZYED	Improved Fuzzy Enhancement Edge Detection
PK	Pal-King
GFZLG2	Generalized Type-2 Fuzzy Logic
INTFZLG2	Interval Type-2 Fuzzy Logic
MBFS	Membership Functions
SFED	Sobel Fuzzy Edge Detector
TFED	Template Fuzzy Edge Detector
FZYIFS	Fuzzy Inference System
FZINFRL	Fuzzy Inference Rule
HHF	High Pass Filter
LWF	Low Pass Filter
SPCM	Pseudo Convolution Mask
JPEG	Joint Photographic Expert Group
TIFF	Tag Index File Format
GIF	Graphic Interchange Format
PNG	Portable Network Graphic

1

INTRODUCTION

“A Theory that fits all the facts is bound to be wrong as some of the facts will be wrong"

Francis Crick

Fuzzy logic (FZLG) is a mathematical mechanism which is exploiting to handle the indefiniteness, uncertainty and obscurity. A FZLG is a logic having multiple of values that observe transitional values between customary appraisals e.g. true/false, yes/no, cold/hot up/down, high/low etc. The primary objective of FZLG is to prepare a system resemble to human so that the system can think and make decision on its own just like an ordinary human being. This chapter reveals the answer about what is fuzzy logic (FZLG), what are its types. It also provides information about what is “edge detection”, its criteria and applications and what is “image processing”.

1.1 Fuzzy Logic (FZLG)

The concept of Fuzzy Logic (FZLG) was popularized in 1965 and given by Lotfi Zadeh, professor of computer science at the University of California in Berkeley, in favour of provide mathematical rules which approved handling of questioning, doubts, uncertainty in natural language. The approach of FZLG is very diverse from the approach of conventional logics, in fact fuzzy logic is more considerable and nearest to accuracy than conventional logics. The main motive of FZLG is to serve a basis for terminology with main two human’s efficiency. The first efficiency is to thinking, communicate and make decisions in the surrounding of inexactness, doubtfulness, not wholly truth conditions and the second efficiency is to achieve huge amount of functions without any calculation, and measurement for example riding a fast bicycle in heavy traffic. FZLG is constructed in order to handle with defective information because in real world, not all information is fully accurate. Some information may be incomplete, partially true etc. FZLG is a multivalued logic, which carries out multiple values and gives permission to assign transitional values between standard yes/no, true/false, up/down, small/large etc. With standard logic something can specify with 1 (for true) and 0 (for false) but in real world there exist many problems for which the solution true or false is not sufficient, so the FZLG comes between 0 and 1 i.e. 0.7 for (partially true) and 0.3 (for false). In present world, there are many areas where fuzzy sets are used in huge amount such as in field of image processing, identifications of patterns, identifications of objects, identification of faces, decision making systems. In these areas, FZLG take care of obscurity, uncertainty, emptiness in data. The approach of fuzzy theory gives a contrivance for imitate linguistic words for example “many,” “more,” “large,” “small,” “huge.” This is more efficient way to solve a problem in a much organised manner.

In conventional mathematics, the approach of binary set theory that interprets crisp values that describe the particular event will occur or not. In FZLG set, elements carrying out extent of membership. In FZLG, the elements of fuzzy set can be a complete member with 100% membership or a half member with between 0% and 100% membership. The membership value elect to an element is not bounded for two values only but can have between 0 and 1. The chief gratification of FZLG theory is that any existing problem can be solved by giving command in natural language. A FZLG system gets inaccurate, vague, partially true, incomplete information etc. then apply several computation on the basis of given rules and present out decision. This working of FZLG setup is shown in fig. 1.1 [1].

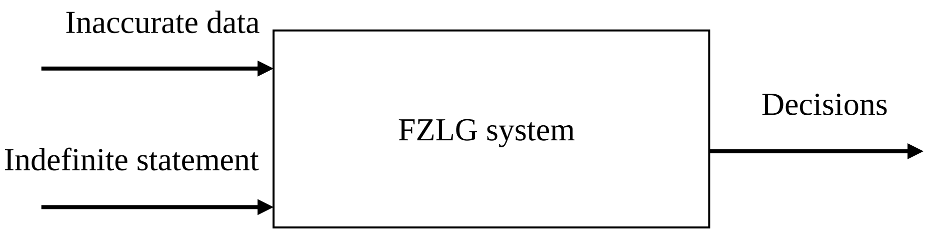

Fig 1.1 A FZLG setup

1.2 Types of FZLG

FZLG is a mathematical mechanism, which is exploiting to handle the indefiniteness, uncertainty and obscurity. A FZLG is a logic having multiple of values that observe transitional values between customary appraisals e.g. true/false, yes/no, cold/hot up/down, high/low etc. The primary objective of FZLG is to prepare a system resemble to human, so that the system can think and make decision on its own just like an ordinary human being.

1.2.1 Type-1 Fuzzy Logic (FZLG1)

The primary architecture of a FZLG1 contained three visionary constituent: a "knowledge base" which embrace rule base and on the basis of these rules outcome is given. Second, a data base which exhibit the membership functions (MBFS). Third, "fuzzification interface unit" and "deffuzification interface unit" which percolate the inference operation on the rules and inured facts to elaborate a justifiable output. Fig. 1.2 represents the block diagram of FZLG1.

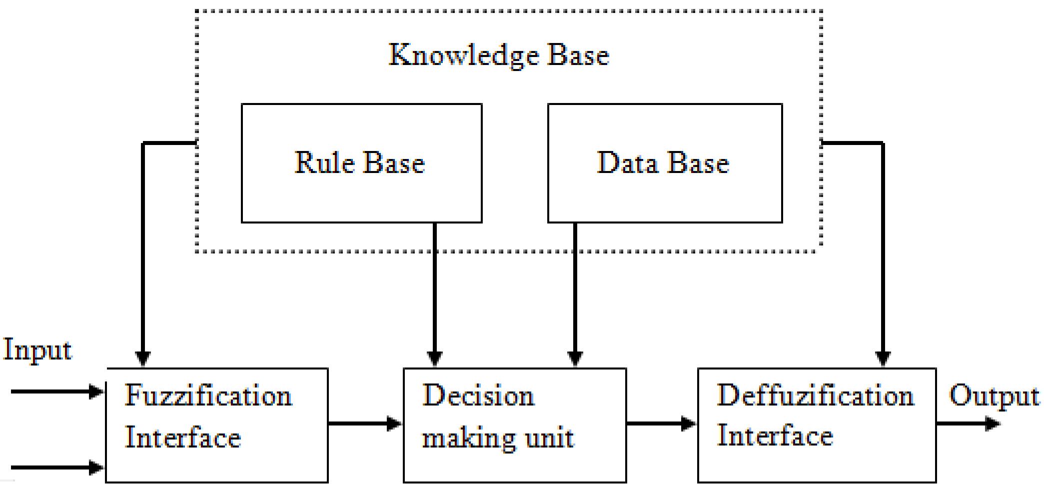

Fig. 1.2 The general framework of FZLG1

1.2.2 Type-2 Fuzzy Logic (FZLG2)

FZLG2 [2] is a leading version of conventional FZLG1, on the basis of uncertainty is not only reserved for the linguistic variables, however it is also commenced in the statement of the MBFS. Primarily FZLG sets are those sets which also embrace uncertainity of the MBFS. Take into account the passage of customary sets to fuzzy sets. When it become challenging to find out the MBFS of an element that exist within a set as 0 or 1, then this problem is resolve by making the exertion of type-1 sets of fuzzy correspondingly, when the stage is very indefinite, so that the complications are present to figure out the rank of MBFS for crisp number in the range [0, 1], this problem is resolve by making the exertion of type-2 sets of fuzzy. Sets of FZLG1 could be view as an approximation in the first order for the uncertainty that exist in the world and sets of FZLG2 could be view as an approximation of second order. For FZLG2, the way of representing MBFS is distinct from FZLG1. The MBFS of FZLG2 is a leading version of MBFS of FZLG1. In the block diagram of FZLG2, first of all a crisp input is inured to fuzzifier then fuzzifier convert this crisp input into fuzzy input set and this fuzzy input is refined in knowledge base of FZLG2. The knowledge base of FZLG2, consist of rule base and inference engine. The output of knowledge base is FZY output set which is given to output processing block of FZLG2. The output processing block hold defuzzifier, which gives crisp output and a type reducer which gives type reduced set. The FZLG2 is a leading version of FZLG1. The block diagram of FZLG2 is shown in figure 1.3.

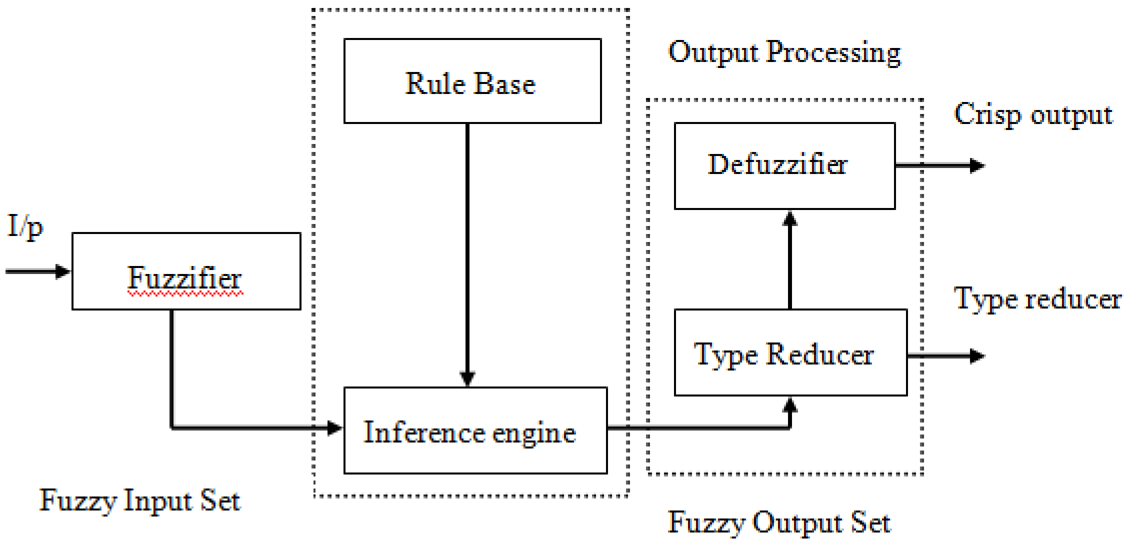

Fig.1.3 The general framework of FZLG2

1.3 Edge detection

Edges in image are very significant for many image processing operations. Edges look after an outline of any entity that is endure in an image. An edge that is prevail in an image, might be the consequence of variation in reception of light, variation in colour, obscurity and pattern and all these variation can be passed down to enumerate the location, measurement, deepness, and surface properties etc. in a digital image. The pixels with edges are labeled as edge points. When an edge is recognize, the redundant specifics are eliminated, and retain only the primary information. Implement an edge uncovering process to an image might cut down the chunk of data available for processing. The edge uncovering process drain out all material, that is less related and at the same time retains the meaningful properties that endure in an image.

Edge tracking down method has significant part in plentiful areas for example: In medical line, geography, army, robotics, in face verification, fingerprint verification, meteorology and pattern verification etc. [3]-[6].

1.4 Several procedures for edge detection

Edges are the points in an image where the intensity level changes very sharply from one pixel to other pixel. Several edge tracking down process have discovered for the purpose of uncover the perfect edges. The edge tracking down method could be split into two parts, first method is lean on gradient and second method is lean on Laplacian.

1.4.1 Method lean on gradient

In this edge uncovering technique, first of all the gradient magnitude is computed in the direction of parallel and perpendicular axis. This parallel and perpendicular's direction gradients are incorporate together to note down single gradient value and then enumerate its magnitude. The enumerated gradient magnitude is utilized to figure the location of edges in a digitized image. The methods that lean on gradient, figure out the location of edges using first derivative. Examples of methods that lean on gradient are sobel, prewitt, Robert etc.

1.4.2 Method lean on Laplacian

In the second technique that lean on laplacian, first of all the second order differentiation is enumerate of the image and after that zero junction is enumerate from the second order differentiation. Then on the basis of zero crossing edges are detected. The example of laplacian based method is laplacian of gaussian (LOG). The gradient based method is more societal than laplacian based method. In present, large counts of edge detector techniques are reachable. However, here is no solitary technique is reachable for figure out edge pixels that realize robustly in whole feasible image. Diversified edge detector techniques are passed down for figure out edge pixels like canny edge detector, Sobel edge detection, Krisch operator which is exercised on peculiar images. But the collection of edge detector that should exploit is gamble in on the properties of images like delicacy of noise, speed, delicacy of assimilation and potency.

1.5 Prototype for edge detection

Numerous algorithms do exist for finding out edges in an image. Every algorithm has its own advantages and weakness. A good edge detection algorithm should comfort all of the conditions mentioned below.

(i) *Good detection:* The edges should be supreme and should be highly accurate.

(ii) *Noise sensitivity:* Edge detection methods should uncover edges without any distraction from noise.

(iii) *Good localization:* The locus of edges as close as feasible to the precise locus, i.e. edge localization accuracy (ELA).

(iv) *Orientation sensitivity:* The method should find out edge magnitude along with precise orientation.

(v) *Speed and efficiency:* The edge uncovering methods should be uncover edges very rapidly and contribute efficiency.

1.6 Fuzzy Image Processing (FIP)

FIP include three main steps: fuzzification of image, alteration of MBFS values and deffuzification of image. The fuzzification and deffuzification steps are lean on coding not on hardware. Fig.1.4 presents the generic framework of FIP.

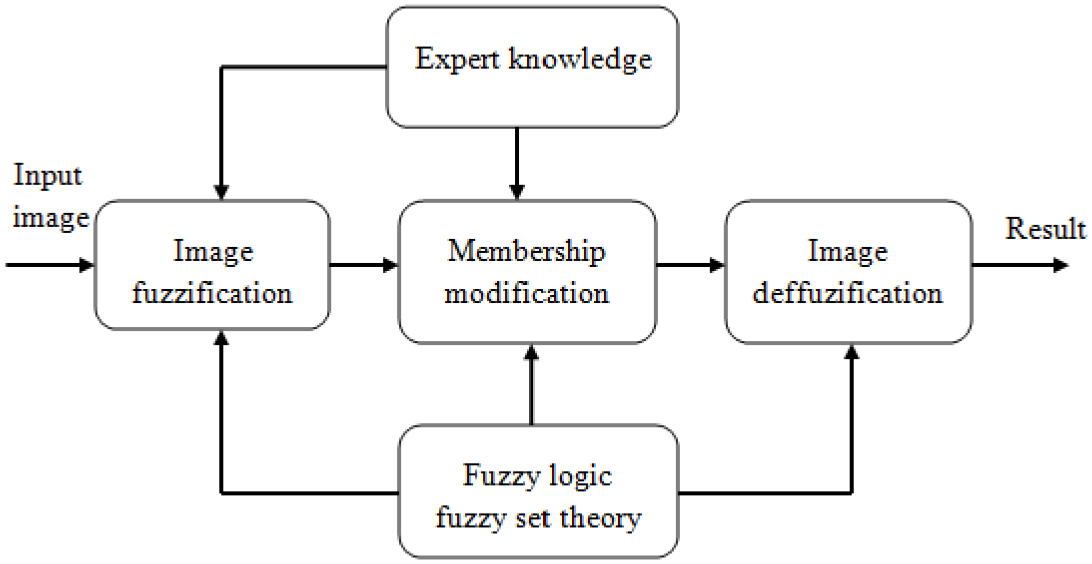

Fig.1.4 The generic framework of FIP

Fuzzification stands for coding of image and deffuzification stands for decoding of image. The preeminent function of FIP is lying in midmost stage (modification of MBFS values). First of all, input image is mutate from gray region to MBFS region (fuzzification), convenient FZY method alter the MBFS values. A FZLG system acquires imperfect data and indefinite statements for example lesser, moderate, huge and after that it evaluate data according to FZLG rules and indulge outcome. FIP is necessary to express uncertainty that exist in data. Some favors of FIP are:

(i) FZLG is prevailing tools for impersonate and processing of knowledge.

(ii) FZLG can hold down the indefiniteness and imperfection efficiently.

(iii) FZLG include strength to tolerate imprecise data.

(iv) FZLG is conceptually smooth to learn.

Also, many difficulties in FIP originate due to imperfection present in data. This imperfection in data results due to randomness along with doubtfulness, obscurity that exists in any information. Randomness can be regulating by probability concept. Imperfection in the data can be esteemed from doubt in grayness, geometrical fuzziness and indefinite knowledge.

***

2

LITERATURE REVIEW

"The difficulty of literature is not to write, but write what you mean; not to affect your reader, but to affect him precisely as you wish"

Robert Louis

Literature review is to provide an outline to figure out issues related to a particular research. It also describes which issue should be examining precisely. Also, justify someone's research. Review of literature is also explain how someone is decided his/her research and all the analysis on data.

Longtao Zhang, Yuqiu Sun, Fushan Chen (2015): In 2015, to track down edges several techniques like SOB, Robert, Prewitt etc. provide preferable outcome when illumination and heterogeneity of any image is large. But if heterogeneity of any image is very less, these techniques can't provide satisfactory outcome. Here after a FZYL edge tracking down technique conjoins with Pal-King (PK) technique is utilized which provide good outcome at less heterogeneity. But some issues are also present with PK technique i.e. if edges are having less level of grey then some information of edges is missed and resultant outcomes are not preferable. Thus, in this the PK technique and canny is and the resultant technique gives more suitable outcome [7].

Dhiraj Kumar Patel, Prof. Sagar A. More (2013): In 2008, a new type of edge detection method has been proposed that combines FZLG [8]-[9] with Cellular Learning Automata (CLA) [10]-[11]. In the proposed method first of all edges are detected by fuzzy logic and then CLA is used to enhance the detected edges because CLA possess repeatable and neighborhood considering nature. In this paper, MATLAB is used to prepare the algorithms and their results. The main advantage of the proposed method is avoiding double edges, robustness to contrast and provide sharp corners. But the proposed method requires extensive computation than the traditional methods. The examples of these traditional methods are sobel, canny, prewitt and Robert etc.

Shikha Bharti, Sanjeev Kumar (2013): In 2013, in this four inputs and one output is inured to the FZYL system. 2*2 mask of window is served as four inputs. Triangular MBFS is utilized for input as well as output. By observing the outcome it shows that the exactness of the edge tracking down technique is far accurate than other existing techniques. The main convenience of this technique is that it can be utilized by other intelligent techniques for example Artificial Neural Network (ANN), Genetic Algorithm (GA) etc. [12].

Mahdiyeh Alimohammadi, Javad A.Pourdeilami (2013): In 2013, this technique is lean on FZYL rules with derivation in first order is employed for tracking down of edges digital without employing TRSH value. Window mask is utilized to enumerate the edges for every pixel and mask of window glide in parallel on the image from one pixel to another pixel. FZYL System is employed and FZYL rules are inured for tracking the pixel is edge or not. For deffuzification, Mamdani technique is employed. This technique is compared with other existing technique e.g. SOB, Prewitt etc. and this technique provide more preferable outcome as compare to other techniques [13].

Meenakshi Yadav and A.Kalpna Kashyap (2013): In 2013, a smooth FZYL technique is utilized for the tracking down of edges. In this technique four inputs are inured to FZYL system. The pixel values of the mask of window are inured as these four inputs. The FZYL system for tracking down edges involves fuzzification; prescribe FZYL rules, MBFS and deffuzification. FZYL technique can modify the quality of edges and provide preferable outcome as compare with other existing methods [14].

Patricia Melin, Claudia I. Gonzalez, Juan R. Castro, Olivia Mendoza and Oscar (2013): In 2013, a new technique for edge tracking that is lean on GFZYL2 and the morphological GRD is employed. This technique contributes more suitable modelling of the irresolution that exists in the DIMP. This paper suggest the conjoin study of INTFZYL2, and GFZYL2 in conjunction with morphological GRD [15]. The proposed GFZYL2 for tracking down of edges give more suitable outcome than FZYL1 and INTFZYL2 because irresolution in tracking down of edges could be modified closely with GFZYL2. On the other hand FZYL1 and INTFZYL2 are not able to hold large degree of irresolution.

K. Somasundaram, K. Ezhilarasan (2012): In 2012, this paper proffered a novel technique for tracking down of edges that lean on 32 FZYL rules [16]. The utilization of the proposed technique on MRI of scan of human's head present that it uncover edges in more suitable manner than traditional canny and SOB. For given technique first of all the TRSH intensity is enumerated for an image. Then the 32 FZLG rules are tested to track down the edges. To find out the TRSH intensity Riddler's technique [17] is employed. By employing TRSH, an image is binary form is made. Here after on the binary image 32 FZLG are employed to track down the edge. The main convenience of given technique is that FZLG has low computational complication than the Canny and SOB and utilized very less time for tracking down of edge.

Suryakant, Neetu Kushwaha (2012): In 2012, a smooth but well organised technique that lean on FZYL rule that inoculate the intellection of artificial intelligence and DIP for the tracking down of edges. The technique in this is linked with the evolvement of a FZYL rules to unmask edges. A 3x3 window mask of pixel is applied on the image. The 28 FZYL rules is delineated to highlight the pixel as edge. The executed FZYL system is processed on eight inputs and one output. The window mask is utilized as the eight inputs. The main convenience of suggested technique is it provide more suitable outcome and high accuracy [18].

Aijaz Ur Rahman khan, Dr. Kavita Thakur (2012): In 2012, this impersonates a proficient FZYL system for tracking of edges. For the purpose of tracking down edges that exist in the image, a FZYL system is constructed that return distinct values of pixels in the form of inputs. Mamdani method [19] is selected for deffuzification and the outcome of the FZYL system is enumerated in the form of centroid for the MBFS. In the suggested technique 2×2 window mask tested because of scanning and four inputs are constructed from this mask. After this employ FZYL t-norms for enumerate strength of firing. Test the FZYL rules for entire input. Employ max operative to track down the results. The convenience of this technique is to return more suitable representation for edge detection than SOB and prewitt operative.

Mehul Thakkar, Prof. Hitesh Shah (2011): In 2011, in many conditions selection of TRSH is a very customary problem for tracking down of edges. This paper gives solution for the complication of choosing TRSH by employing soft computing technique for tracking down edges. In conventional method for tracking of edges, for input user gives TRSH value as per the image, but in this technique TRSH is not dependent on the specification of the input. In this FZLG is employing as a tool of soft computing to solve the difficulties that come in TRSH. In order to decide TRSH value by employing FZLG, the three techniques that have practised are Automatic TRSH employing FZLG approach, FZLG TRSH that lean on statistical specifications and TRSH selection by employing FZLG reasoning process [20]. By employing FZLG methods there is rise in computation complication but outcome is more preferable. The main advantage of this purposed technique is the counting of TRSH values by employing FZLG system is easy and gives more true and genuine results. Thus this technique can be utilized for tracking down of edges without inaccurate choice of TRSH.

TALAI Zoubir (2011): In 2011, a recent technique for tracking down of edges, by employing FZLG rule that cut down the time for processing has been proffered. In the suggested technique first of all a 3*3 neighbours of pixels are selected and from pixel whose locus is at mid confiscate four directions and enumerate difference in grey level along these four directions. The implementation of given technique is very eath and the rules are very homogeneous. Given method is not affected in contrary to noise and specification is not required as in canny. The main advantage of the given technique is it does ‘not require the set up of parameters as in canny and unaffected to noise and provide more suitable outcomes [21].

Manpreet Kaur and Ms. Sumet Kaur (2011): In 2011, in this three 3×3 linear spatial filters which are LWP, HHP and SOB with spatial process of convolution are utilized to enumerate potency for every pixel that exists inside the image. Nine coefficients for convolution which termed as mask of convolution are formalized. This mask is utilized for the inputs in order to make the FZLG system. Lean on this decision for FZLG it conclude that a whether a pixel under questioning is edge or not. This technique has low computational complications, hold very less time for tracking down of edges, it also modify edge’s quality as compare to other edge tracking techniques e.g. SOB, Prewitt and LOG operative etc [22].

Xiangtao Chen and Yujuan Chen (2010): In 2010, this paper provides a modification on a fast multilevel fuzzy enhancement edge detection (FMFZYED) produced by Jinbo Wu. FMFZYED technique buried the issue of intensify some edges for the sake of other rotten edges. But FMFZYED technique is unsatisfactory for noisy and blurry image. To solve this issue, improved fuzzy enhancement edge detection (IMFZYED) technique is employed. For tracking down of edges by employing this method, first of all TRSH is achieved and after this a new MBFS is describe then smooth the FZLG by utilization of a filter which is median and modify the FZLG set by transformation technique which is not linear next revert the MBFS and after that FZLG operative for entropy is employed to track down the edges. The IMFZYED technique is successful to track down the edges and also unaffected from noise. Thus IMFZYED conquered the disadvantage of the FMFZYED technique [23].

Manuel Gonzalez-Hidalgo, Joan Torrens Sastre (2009): In 2009, tracking of edge that leans on FZLG morphology by employing uninorms [24] has purposed. The main intention of this innovation is to find out and sustain features of edge pixel in the shallow-contrast space of medical images. In this innovation, FZLG opening and closing is employed. A comparison has been made with other techniques to estimate the functioning of the algorithm. The resultant outcome shows that the proposed technique is unaffected by noise. The main advantage of this technique is that even more Gaussian noise is added, there is no affect on the results. This technique is very profitable in the processing of medical images.

Olivia Mendoza, Patricia Melin, Guillermo Licea (2007): In 2007, in this first of all SOB is utilized to enumerate the GRD along parallel and perpendicular direction. Then edges are enumerated by employ FZLG1 and INTFZLG2 with the GRD enumerated by SOB. Four inputs are given to FZLG1 and INTFZLG2 system in which two inputs are GRD along parallel and vertical directions and two inputs are filters that estimated by tested two masks by spiral to the parent image. Histogram parameter is utilized to reveal the comparison between FZLG1 and INTFZLG2 system. And histogram delineates that the outcome of INTFZLG2 are more preferable than FZYLG1 [2].

Mario Ignacio Chacon M, Luis Enrique Aguilar (2001): In 2001, this suggested a new way to interpret edge level MBFS by a FZLG and study of GRD info by employing FZLG clustering. This Technique present clarification to the two issues the first one is linked with edges that are misplaced and the second one is linked to revolution in the level of edges. The two issues are linked to the aligning and the histogram of parent image is utilized to get aligning function. Large number of images is tested with this technique. By looking into the results of these images one can suggest that this technique gives solution of missing edges. Five centroids that interpret five classes of edges are picking up from FZLG clustering [25]. The main convenience of this FZLG for unmasking of edges is that it provides explanation of all the edges that are misplaced from their locus and revolution of level of edges originate from other techniques e.g. SOB, Prewitt etc.

Fabrizio Russo (1998): In 1998, a new technique to track down edges in the image that consist of noise is given. This technique utilized FLLG reasoning to uncover edges in given data that is affected from noise. FZLG reasoning operates at distinct levels [26]. In a condition when there is an estimation of noise, a comfortable process is applied to cut down the noise. The outcome of experiments represent that this technique is very suitable and provide preferable results in the existence of noise. This technique also adapts less set of input information. The main convenience of this FZLG reasoning technique is that it uncover edges very fast even for image that consist of noise.

Tae Yong Kim and Joon H. Han Kim (1998): In 1998, a technique for tracking down of edge by employing FZLG set is utilized which is highly genuine from other customary edge tracking technique. The specifications are estimated and choose by utilizing obscurity distance. The locus obscurity and obscurity of estimation of edges are merged with the help of obscurity distance. The attribute for the parent image is designated through the obscurity distance. From outcome it is concluded that the specifications chosen by the obscurity distance are appropriate for the presence of noise [27].

Todd Law, Hidenori Itoh, Hirohisa Seki (1996): In 1998, this research provides a technique to filter the image, tracking down edges, and co join structure of edges. This technique is employed and tested on large number of images and provide suitable outcome. In this three specifications are given that are GRD, straightness and regularity for the purpose of tracking down edges, corners. GRD is estimated as a difference in gray level and with GRD edges are tracked down. Regularity is estimated by returning pixels in the guidance of the GRD by transition from the mid pixel, and after that value of pixels are compared. Straightness is very similar to regularity but in this there is translation of pixel not returning of pixels. Then on the basis of value of GRD, regularity and straightness unmasking of edges and corners are accomplished [28].

Ching-Yu Tyan and Paul P. Wang (1993): In 1993, three image processing (IMP) techniques known as “enhancement”, “filtering”, and “edge detection” by employing FZLG has purposed. This paper delineates that by employing FZLG all information about image can be processed by using linguistic variables in natural Experiments by employing FZLG provide significant advantages. For the purpose of cut-down the noise of high frequency but keep necessary components of low frequency, LPF can be employ to cut-down more noise but cut fewer unwanted signal. The main convenience of this FZLG technique purposed in the paper is that it becomes easy to refine images by employing natural language provided by FZLG and hence the mission could be achieved by any user even in the absence of any high knowledge [29].

***

3

SCOPE AND OBJECTIVE

"The objective is to enlarge the scope of advantage that happen at someone's expense"

Bruse Henderson

The major importance of this chapter is to mention behind the scope and objective of tracking down edges using FZLG. The work plan is also mentioned along with timeline. In Chapter 1, it is discussed that fuzzy is a mathematical mechanism which is exploiting to handle the indefiniteness, uncertainty and obscurity. In addition, prototype of edge tracking and fuzzy image processing is also discussed.

3.1 Scope of study

Edges in a digital image contain useful information that can be utilized in the processing of digital images. Edges of an image can be applied in disjointing of images, finding objects in images, for image registration etc. Edge detectors are the tools that find out all the edge pixels that are present in a digital image. When edges are tracked, the nonessential details are cut down, and only the necessary information is maintained. The edge tracking down techniques that employing FZLG has reduced computational complication. It also takes less time for tracking down edges and it is very powerful against noise. Give more preferable results than other techniques which are responsive to noise. The scope of edge tracking technique using FZLG is

(i) Very useful in the analysis of medical images e.g. are detection of brain tumour, cyst in the kidney etc.

(ii) Features like corners, lines, curves etc. can be pick up from the edges and the resultant features are utilized by advance version of computer vision techniques e.g. in identification of face.

(iii) Play important role in automated driving.

3.2 Objective of the study

Tracking of edge is significant step in the processing of image. In some applications, there is need to track regions where intensity changes significantly. Therefore, a technique that is powerful against interruption in depth, interruption in orientation of surfaces, interruption in reflectance and interruption in illumination etc. is preferable. The objective of this dissertation is

(i) To provide an edge tracking technique, that is powerful against noise and provides location of leading cars in automated driving.

(ii) To provide an algorithm for tracking down edges that can give more valuable visible display of edges, which is not possible in case of SOB and prewitt operator. And able to display brain tumor and cyst clearly without any false detail.

(iii) To provide a technique that has reduced computational complication. Take less time for edges and gives accurate detail of features of face in identification of face and accurate detail of objects in identification of objects.

3.3 Work plan with timeline

Jan-Feb 2016: Study of papers on FZLG for tracking edges.

Mar 2016: Study of tracking edges using fuzzy inference system.

May-Jun 2016: Study of tracking edges using FZLG with SOB and template.

July 2016: Paper writing with title "Edge detection using fuzzy logic (sobel fuzzy, template fuzzy and FIS)"

Aug-Oct 2016: Study of edge tracking using FZLG1 and FZLG2.

Nov 2016: Comparison of FZLG1 and FZLG2.

Dec 2016: Paper writing with title “Edge detection using fuzzy inference system with type-2 fuzzy logic”

Jan 2017: Implementation of FZLG2 with pseudo convolution mask.

Feb-Mar 2017: Comparison of FZLG2 with sobel and FZLG2 with SPCM.

April 2017: Paper writing with title “Edge detection using type-2 fuzzy logic with sobel and SPCM”

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4

RESEARCH METHODOLOGY

"It is important to get results but the most important is the process in getting those results."

Dr. Nik Ahamad

Tracking edges using fuzzy logic (FZLG) is an accession that takes up any image to be fuzzy. In maximum cases, it is effortful to track down edges, where the locus of edges is not precisely represented, which means edges are damaged or indefinite. Remarkably for medical images, in which the images are indigent conflict, tracking down edges becomes very problematic and move to inaccurate investigation of the diseases. In these circumstances, FZLG is very favourable that work according to the obscurity and unclearness that exhibit in the image. This obscurity is expressed in the mode of MBFS and after that edges are uncovered.

4.1 Techniques of tracking down edges using fuzzy logic (FZLG)

In this three edge tracking down procedures that lean on FZLG has been employed, the methods are sobel fuzzy edge detector (SFED), Template fuzzy edge detector (TFED) and Fuzzy inference system (FZYIFS).

4.1.1 Sobel fuzzy edge detector (SFED)

In SFED, first of all gradients are determined by employ SOB technique which utilized two $\mathbf{3} \times \mathbf{3}$ mask that spiral with an image under examination. These masks enumerate the gradient in two directions and supreme gradient is estimated by bringing together the two outcomes. Fig. 4.1 displays the track of uncovering the edges by employing SFED.

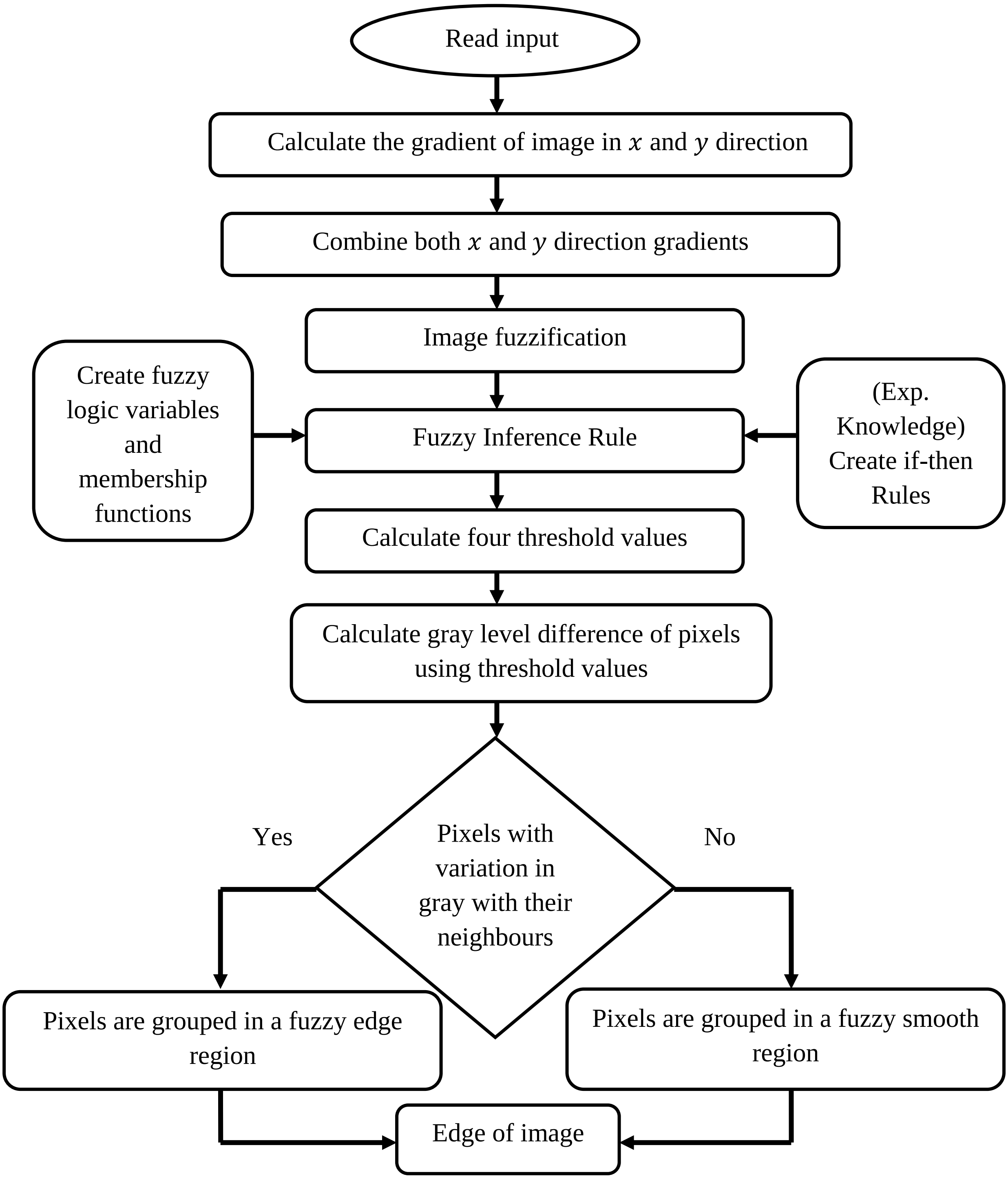

Fig. 4.1 Steps in execution of SFED

In SFED, gradients are estimated along parallel and vertical direction using SOB then two outcomes are merging to get the final outcome. Execute fuzzy inference rule (FZINFRL) on the estimated gradients. Then tracking down of edges is executed by employing threshold values [27]. Tracking of edges by employing threshold is lean on cut and try technique. If pixels hold huge diversity in shaded level from nearby region then pixels are restricted in FZLG edge range, otherwise pixels are restricted as FZLG non-edge range. Fig. 4.1 demonstrates step by step all the procedure of SFED.

The fuzzy rules that have been employed in order to tracking down edges are

$$E(x,y) = 255, if\ g(x,y) \geq ht \quad (4.1)$$

$$= 0,\ if\ g(x,y) \leq lt$$

Where, $g(x,y)$ is the gradient by employing SOB, $E(x,y)$ is the outcome of pixels at locus $(x,y), ht$ is high threshold and lt is low threshold.

4.1.2 Template fuzzy edge detector (TFED)

In TFED first of all a set of templates edge images (TEI) are made and after that convolution has been done of all these TEI with the original image. The size of the TEI is less than that of the image.

In initial step in order to get the pixels value between zero and one, normalized the values of intensity of every pixels. The total TEI that has been designed is designated as "n" and all TEI helps to determine all the position of edge pixels that are present in the image. Every TEI is taken on the image at a particular position and on the other image that is denoted by "S". The size of the image window should be similar to the size of the template [25]. In order to check the presence of an edge pixel at a particular position in an image, comparison is performed between the pixels of image and templates edge images. Fig. 4.2 delineated the steps of tracking down of edges by employing TFED. The templates for fuzzy method are as follows:-

$$\begin{bmatrix} a & a & a \\ b & b & b \\ c & c & c \end{bmatrix} \begin{bmatrix} a & b & c \\ a & b & c \\ a & b & c \end{bmatrix} \begin{bmatrix} a & c & b \\ b & a & c \\ c & b & a \end{bmatrix} \begin{bmatrix} a & 0 & b \\ a & 0 & b \\ a & 0 & b \end{bmatrix} \begin{bmatrix} 0 & b & a \\ a & 0 & b \\ b & a & 0 \end{bmatrix}$$

(4.2)

More templates can be established by reposition the elements that contain in a matrix.

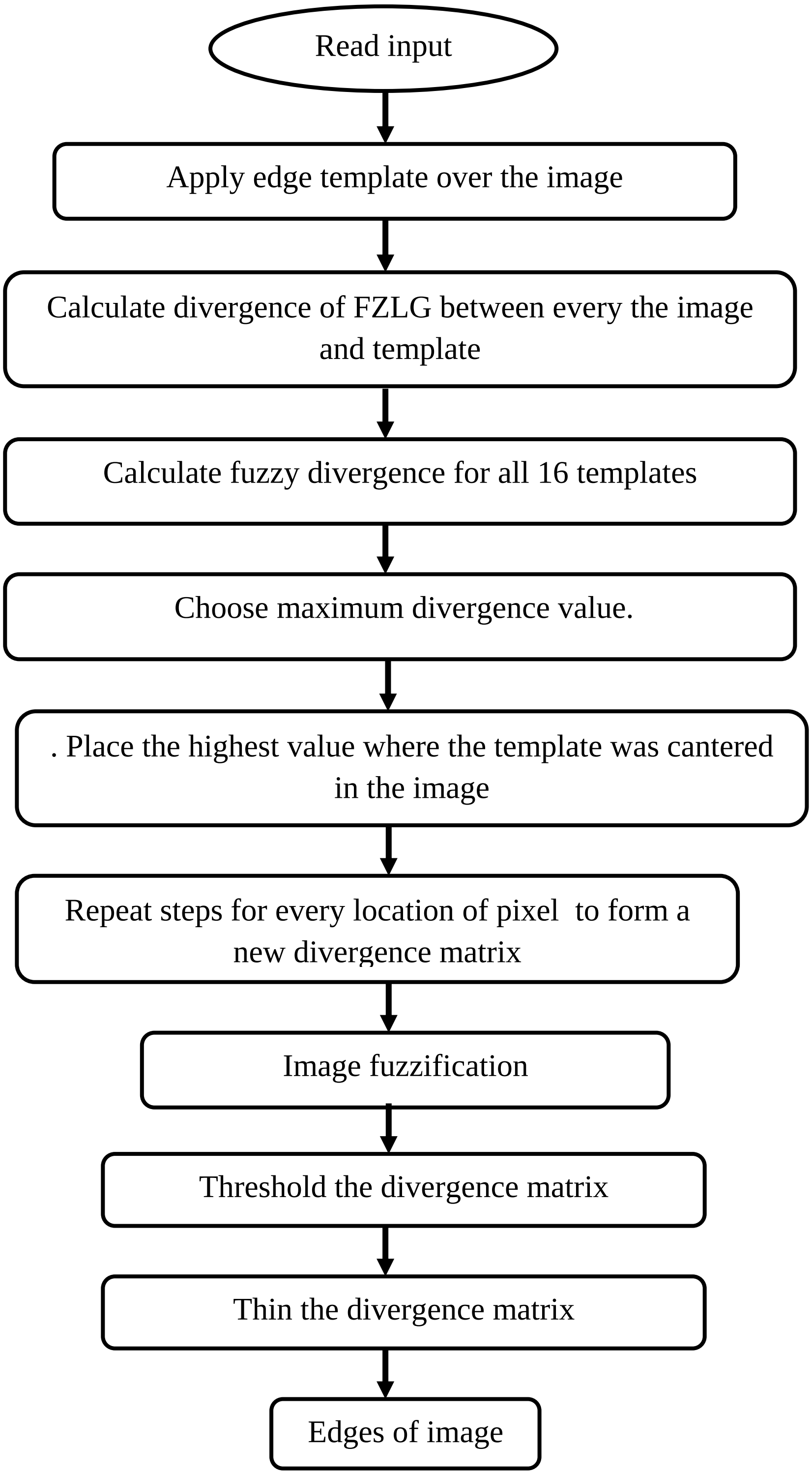

Fig. 4.2 Steps in execution of TFED

Place the templates of edge image on the complete image i.e. at each point on the normalized image place the centre of each template. Compute the divergence value of fuzzy between the template and every elements of the original image and choose the minimum value. Consider the position of pixel at location (x, y) in the TEI be (x_T, y_T) and the relative position in the original image be (x_I, y_I). After that the measurement of homogeneity between the original image and all the pixels of template is computed by using equation (4.2).

$$H_T(x,y) = 1 - \left| pixel_I(x_I \ \ y_I) - pixel_T\,(x_{T,} \ \ y_T) \right| \tag{4.2}$$

Where $pixel_I(x_I \ \ y_I)$, the locus of pixels for the original is image and $pixel_T\,(x_{T,} \ \ y_T)$ is the location of pixel for the template. Similarly for all the templates the same method is utilized. With the guidance of a normal max operation the similarity measures of all the templates are combined together for finding the existence of edges for the image and the template.

$$H(x, y) = max\,(H_T\,(x,y)),\ T = 0,1,2,\ldots,n \tag{4.3}$$

Where n = number of templates.

In order to show the best position of the presence of edge pixels, the resultant image has been operated using threshold method. All the values that lie below the threshold value are considered as 0 and other values that lie above the threshold value are considered as 1.

4.1.3 Fuzzy inference system (FZYIFS)

FZYIFS is a technique that that takes the values from the input and gives output based on the rules defined by the user. In this technique, image gradients are enumerated along parallel and perpendicular direction. After that, define FZYIFS and specify the image gradient as an input to FZYIFS. Specify input and output MBFS and specify FZYIFS rule. Last step is to evaluate FZYIFS and edges will be detected. The complete processing of FZYIFS is shown in Fig. 4.3. The calculated gradient values changes with respect to the selected threshold value. And at every threshold values, the resultant gradient values are suitable to calculate preferable number of edge pixels. And the resultant edge image gives clean edges.

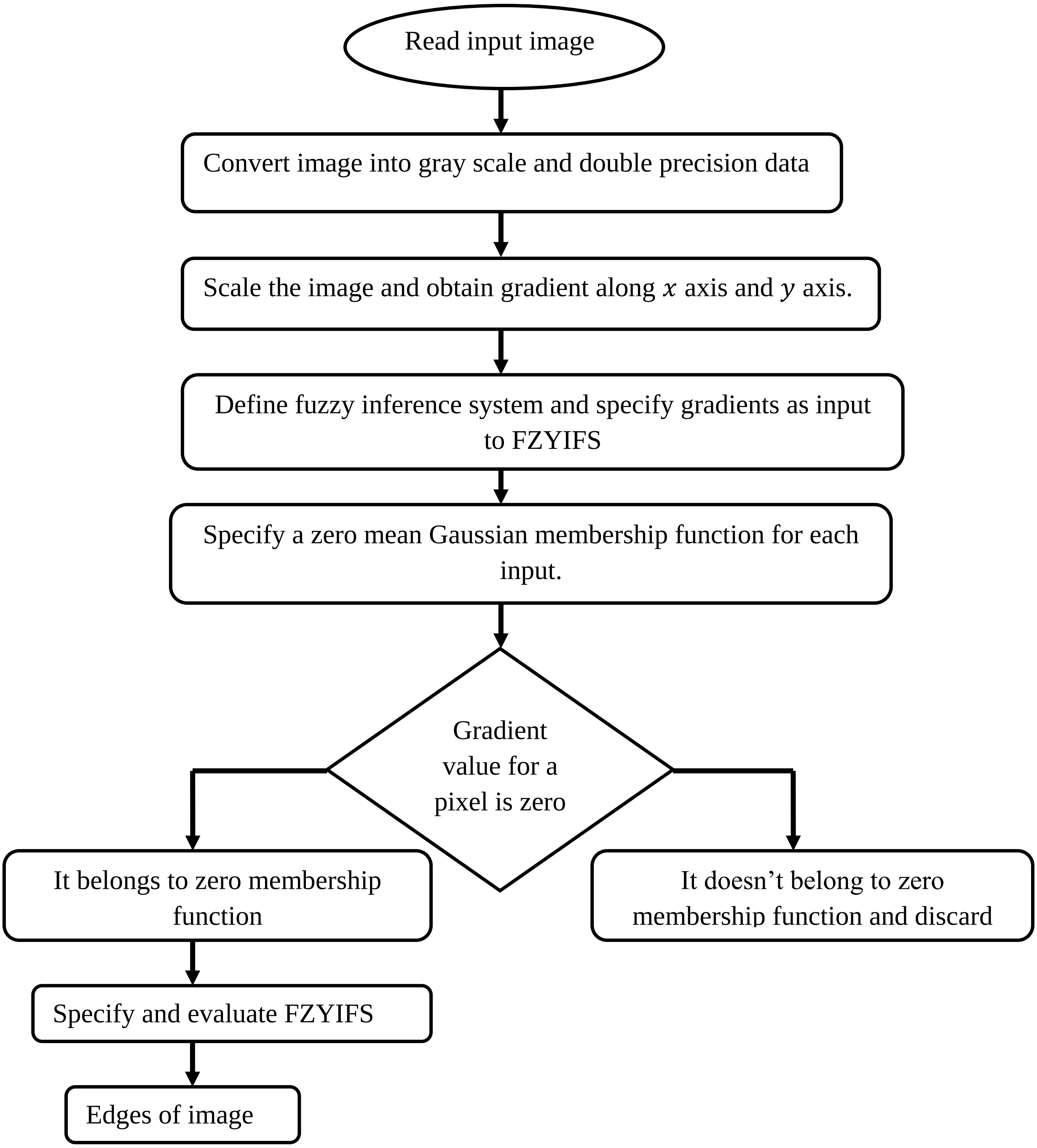

Fig. 4.3 Steps in execution of FZYIFS

4.2 Edge detection using type of fuzzy logic (FZLG)

In this section, types of FZLG are employed to track edges. The types of FZLG are type-1 (FZLG1) and interval fuzzy logic type-2 (INTFZLG2). The INTFZLG2 used SOB operative to enumerate the gradients. In this, the proposed technique is also mentioned that utilized INTFZLG2 with pseudo convolution mask (SPCM) to track down edges.

4.2.1 Edge detection using Fuzzy logic type-1(FZLG1) with SOB operator

FZLG1 has three main systems: a "knowledge base" that carry rules, a "fuzzification interface unit" and "deffuzification interface unit" which carry out the inference proceeding on the rules and on inured uncertainty to obtain a satisfactory turnout. Fig.4.4 shows the steps in execution of FZLG1.

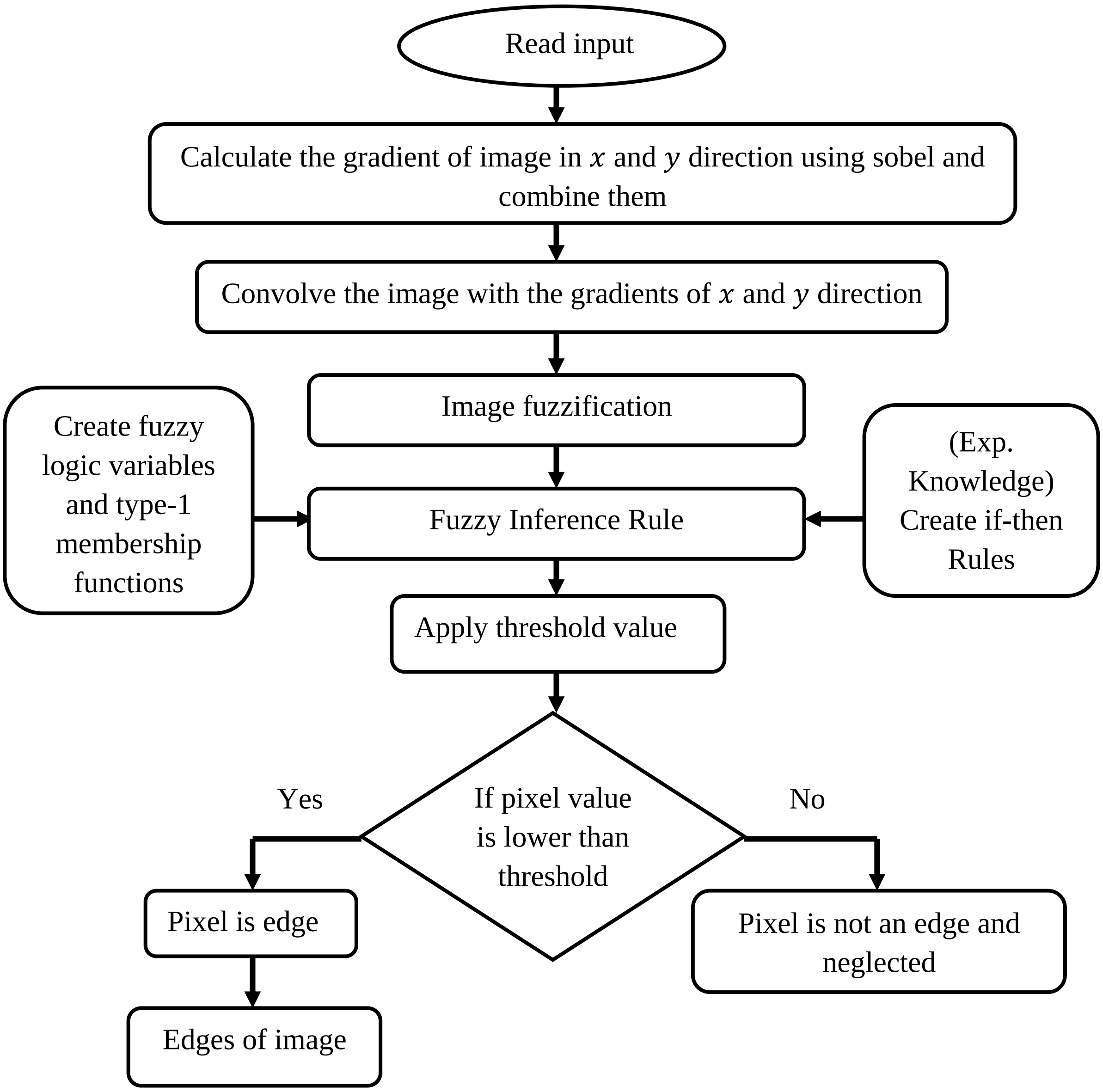

Fig. 4.4 Steps in execution of FZLG1 with SOB

4.2.1.1 Inputs for FZLG1

In order to detect edges using FZLG1 four inputs are given, from these two inputs are gradients along x and y directions calculated by using equation (4.6) and (4.7) and the other two inputs are filters that calculates when two mask i.e. $'hhf'$ and $'lwf'$ are convolved with the image under processing. $'hhf'$ and $'lwf'$ are given by equation (4.8) and (4.9). The $'HHF'$ calculates the image's contrast in order to find out the border. $'LWF'$ detects those pixels for which the grey level is very less in the input image.

$$sob_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \tag{4.4}$$

$$sob_y = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \tag{4.5}$$

Where, sob_x is the sobel operator along parallel axis and $\mathrm{sob_y}$ is the sobel operators along perpendicular. Let G_x and G_y be the two images that exhibit horizontal and vertical derivative approximations and let I be the source image then G_x and G_y can be calculated using equation

$$G_x = sob_x * I \tag{4.6}$$

$$G_y = sob_y * I \tag{4.7}$$

Where, G_x is the gradient of the image in parallel direction and G_y is the gradient in the perpendicular direction.

$$hhf = \begin{bmatrix} -1/6 & -1/8 & -1/6 \\ -1/8 & 3/4 & -1/8 \\ -1/16 & -1/8 & -1/16 \end{bmatrix} \tag{4.8}$$

$$lwf = \frac{1}{25} * \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{bmatrix} \tag{4.9}$$

Thus, the four inputs for FZLG1 are as follow:

$$GX=G_x,\ GY=G_y,\ HHF=hhf*I,\ LWF=lwf*I \quad (4.10)$$

Where 'I' is the source image and '*' is the convolution operator.

4.2.1.2 Fuzzy Inference Rule for FZLG1

The seven rules for FZLG1 that are utilized in order to track edges are:-

Rule 1:- If (GX is Small) and (GY is Small) then (OUTCOME is Small)

Rule 2:- If (GX is Mediocre) and (GY is Mediocre) then (OUTCOME is Large)

Rule 3:- If (GX is Large) and (GY is Large) then (OUTCOME is Large)

Rule 4:- If (GX is Mediocre) and (HHF is Small) then (OUTCOME is Large)

Rule 5:- If (GY is Mediocre) and (GX is Small) then (OUTCOME is Large)

Rule 6:- If (LWF is Small) and (GY is Mediocre) then (OUTCOME is Small)

Rule 7:- If (LWF is Small) and (GX is Mediocre) then (OUTCOME is Small)

4.2.2 Edge detection using Interval type-2 Fuzzy logic (INTFZLG2) with SOB

The INTFZLG2 is a generalization of conventional FZLG1. INTFZLG2 is a leading version of conventional FZLG1 on the basis of uncertainty is not only reserved for the linguistic variables however, it is also commenced in the statement of the MBFS. Primarily FZLG sets are those sets which also embrace uncertainty of the MBFS. Take into account the passage of customary sets to fuzzy sets. When it become challenging to find out the MBFS of an element that exist within a set as 0 or 1, then this problem is resolve by making the exertion of type-1 sets of fuzzy. Correspondingly, when the stage is very indefinite so that the complications are present to figure out the rank of MBFS also for crisp number in the range [0, 1], so this problem is resolve by making the exertion of FZLG2. Sets of FZLG1 could be view as an approximation in the first order for the uncertainty that exist in the world and sets of INTFZLG2 could be view as an approximation of second order. For INTFZLG2 the way of representing MBFS is distinct from FZLG1.

The procedure for edge detection using INTFZLG2 is same as FZLG1. The complete procedure of tracking down edges using INTFZLG2 with SOB is delineated in fig. 4.6. The same inputs are given to INTFZLG2 system. The only opposition is lie in mode of defining membership function, because in INTFZLG2 the wide FOU (Footprint of Uncertainty) has been chosen for all membership functions that provides more preferable result as compare to FZLG1. The SOB employed on any kind of digital image in gray form, calculates the gradient of every pixel's intensity, provide the guidance of larger possible increment from black to white, along with this SOB also calculates the amount of all the changes occur along that direction.

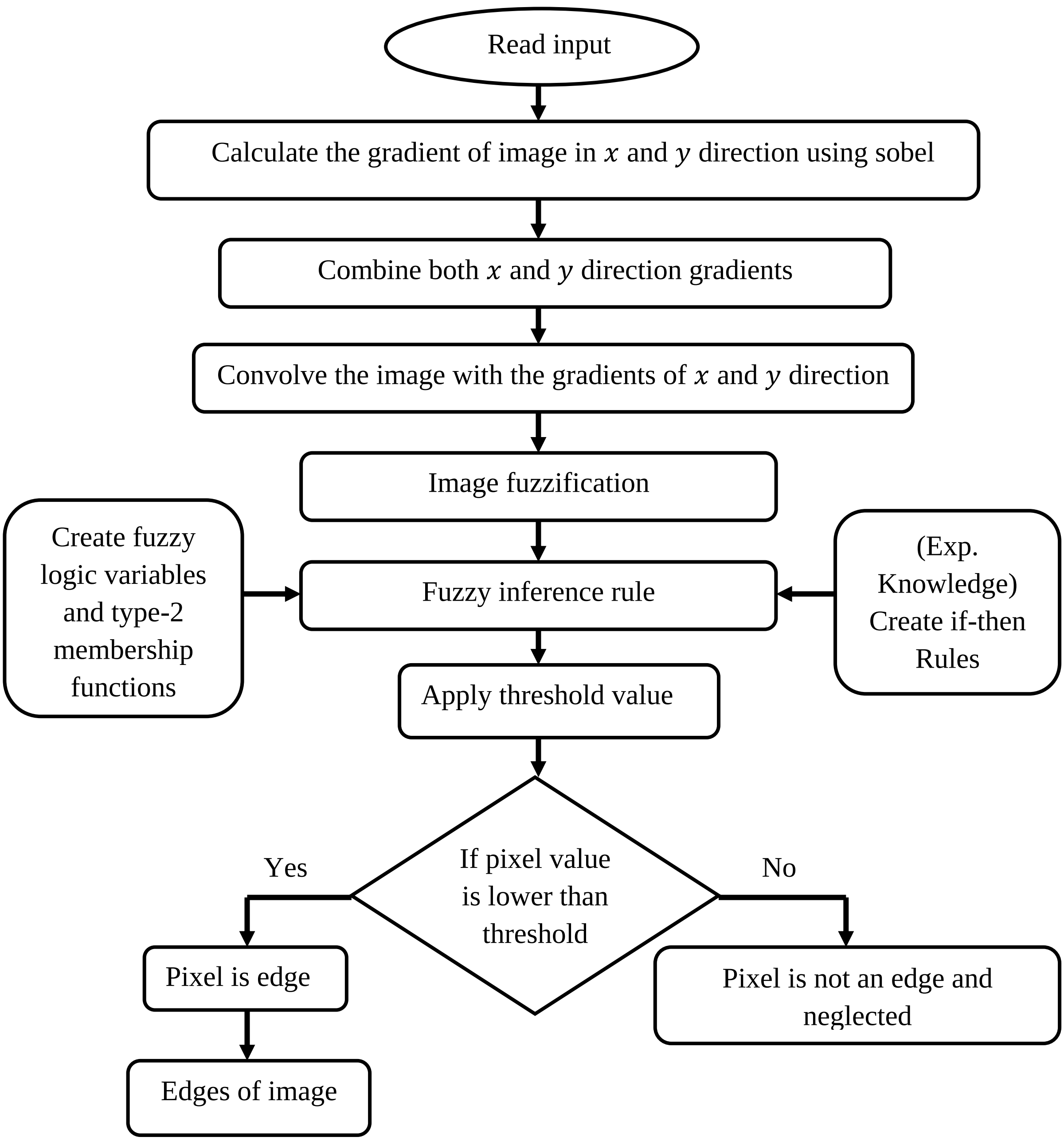

Fig. 4.5 Steps in execution of INTFZLG2 with SOB

4.2.2.1 Fuzzy Inference Rules for INTFZLG2 with SOB

Like FZLG1 seven fuzzy rules is adopting in INTFZLG2. The seven rules for INTFZLG2 are given as

Rule 1:- If (GX is Small) and (GY is Small) then (OUTCOME is Small)

Rule 2:- If (GX is Mediocre) and (GY is Mediocre) then (OUTCOME is Large)

Rule 3:- If (GX is Large) and (GY is Large) then (OUTCOME is Large)

Rule 4:- If (GX is Mediocre) and (HHF is Small) then (OUTCOME is Large)

Rule 5:- If (GY is Mediocre) and (GX is Small) then (OUTCOME is Large)

Rule 6:- If (LWF is Small) and (GY is Mediocre) then (OUTCOME is Small)

Rule 7:- If (LWF is Small) and (GX is Mediocre) then (OUTCOME is Small)

4.2.3 Edge detection using proposed technique (INTFZLG2 with pseudo convolution mask)

In FZLG1 and INTFZLG2 with SOB, gradient along parallel and in vertical direction is determined by employing sobel but in proposed technique (INTFZLG2 with SPCM) gradients along parallel and vertical direction is determined by employing pseudo convolution mask (SPCM). For the computation of gradients, SPCM is passing from the whole image and by this technique gradients are computed. The SPCM is delineated in fig. 4.6.

P_1	P_2	P_3
P_4	P_5	P_6
P_7	P_8	P_9

Fig. 4.6 Sobel with pseudo convolution mask

The gradient along parallel and perpendicular direction is determined by equations (4.11) and (4.12).

$$G_x = (P_7 + 2P_8 + P_9) - (P_1 + 2P_2 + P_3) \quad (4.11)$$

$$G_x = (P_3 + 2P_6 + P_9) - (P_1 + 2P_4 + P_2) \quad (4.11)$$

The gradient magnitude G is estimated by applying equation (4.13).

$$G = \sqrt{G_x{}^2 + G_y{}^2} \tag{4.13}$$

The rules and input values are same for the proposed technique as for FZLG1 and INTFZLG2 with SOB.

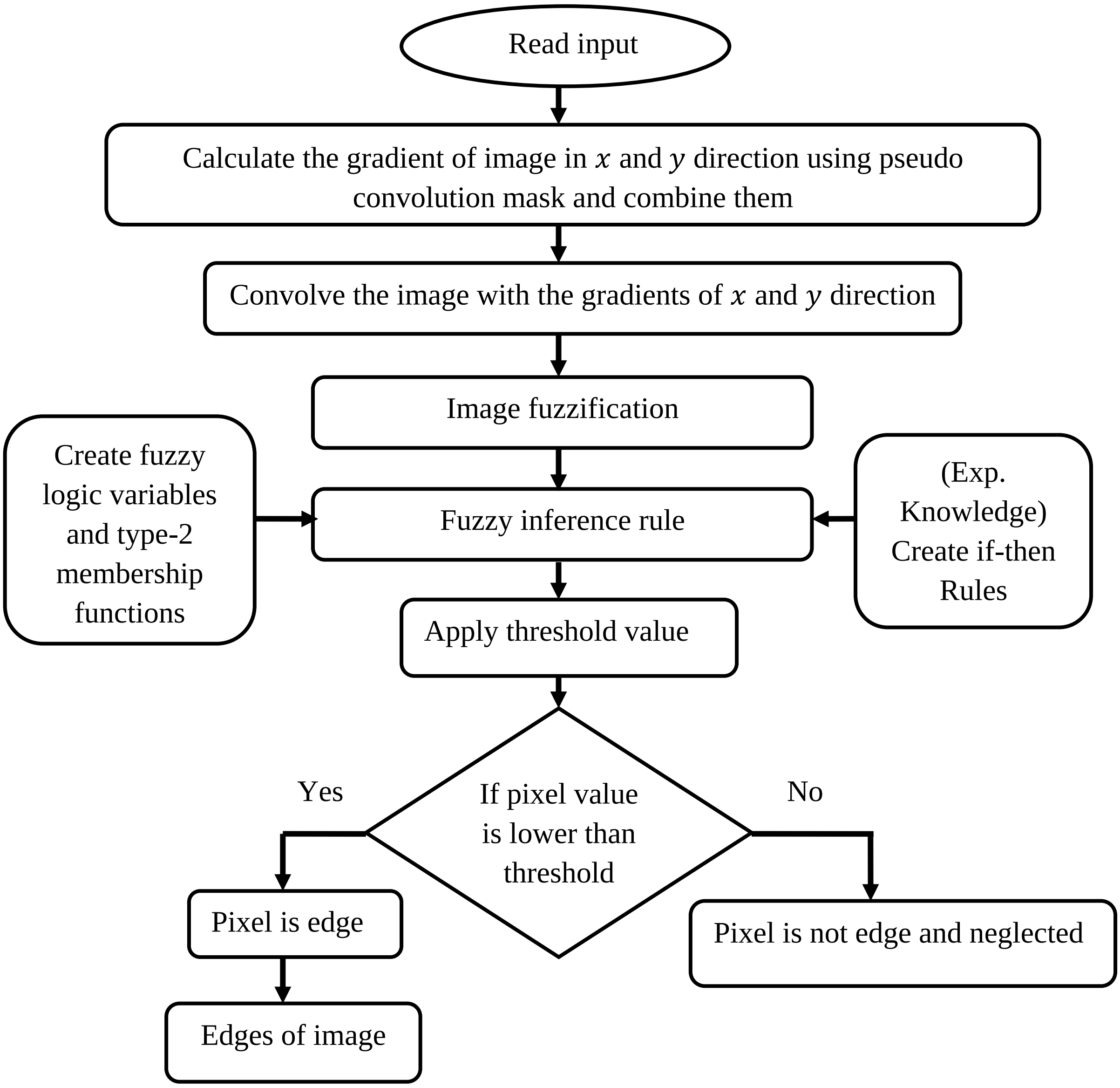

Fig. 4.7 Steps in execution of the proposed technique (INTFZLG2 with SPCM)

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5

RESULTS AND DISCUSSION

"It is the weight, not numbers of experiments that is to be regarded"

Isaac Newton

In the first part, implementation of edge detection is done by SFED, TFED and FZYIFS. Then comparison has been made among these three methods. In all the three methods, different values of threshold have been selected. For each value of threshold the implemented methods gives different values of edges. The value of threshold is compared with gradient value of all the pixels to decide that, each pixel consists of an edge or not. In the second part, results of FZLG1 and INTFZLG2 logic have been shown and then a comparison is drawn of these two methods with the proposed method i.e. INTFZLG2 with pseudo convolution mask.

5.1 Parameters for Analyses

In order to make analyses on distinct edge tracking techniques by utilized FZLG, different parameters are used. On the basis of these parameters, results are analyzed of different edge detection techniques and comparison is established among all these edge tracking techniques. The parameters are:

5.1.1 Threshold

Threshold is employed after gradients of pixels are enumerated. It is the mechanism that constructs an image of black and white colour from a gray level image and labels those pixels to white, which are having value greater than threshold and label remaining pixels to black. For example, if T=1 (threshold) and gradient values in an image are shown in fig. 5.1. The pixels with value greater than ‘T’ is track as edge pixel and represented in circle.

2	**0**	**0**
0	**2**	**0**
0	**0**	**2**

Fig. 5.1 Example of an image with edges

5.1.2 Image format

Image format is a designation for saving or conveying a photographic image in the form of digital file. The examples of image format are

5*.1.2.1 JPEG (Joint Photographic Expert Group)*

It is a lossy compression technique. It saves 8-bit for grey level image and 24-bit for colour image. It is used when there is requirement of a photographic film with smaller size. JPEG files can be design by utilizing different compression techniques. If compression is more, the quality will be low. All web browser supports JPEG.

5.1.2.2 TIIF (Tagged Image File Format)

It is a lossless compression technique and used LZW compression. It is very flexible. It saves 8-bit or 16-bit of colour into 24-bit and 48 bit. It is used when there is requirement of a photographic film with higher resolution. Mostly used for professional photos.

5.1.2.3 GIF (Graphics Interchange Format)

It is also a lossless compression technique and used LZW compression. It saves 8-bit palette and 256-bit colour. It is preferable for simple images for example diagram, shapes and cartoon images. It is also used for images with restricted colours such as logos.

5.1.2.4 PNG (Portable Network Graphics)

It is also a lossless compression technique It is formed as a substitute of GIF because of some issues with LZW compression It saves 8- bit palette and 24-bit colour.

It contains large options for colour than GIF. Animation is not supported by PNG.

5.1.3 Total edge

Total edge is the numeral of edge pixels that consist in an image. For example, consider an image with edges represented by circle in fig 5.2. The edges in this image are pixels with circle and total edges are 4.

0	**(1)**	**0**
0	**(1)**	**0**
(1)	**0**	**(1)**

Fig. 5.2 Image with edges

5.1.4 Percentage of edge

It is the percentage of total numeral of edges that consist in an image. It is given by

$$Edge\% = \frac{\text{Total edge pixels}}{\text{Total number of pixels}} \times 100 \tag{5.1}$$

5.1.5 Executing time

Executing time is the overall time taken by the software to accomplish the given task.

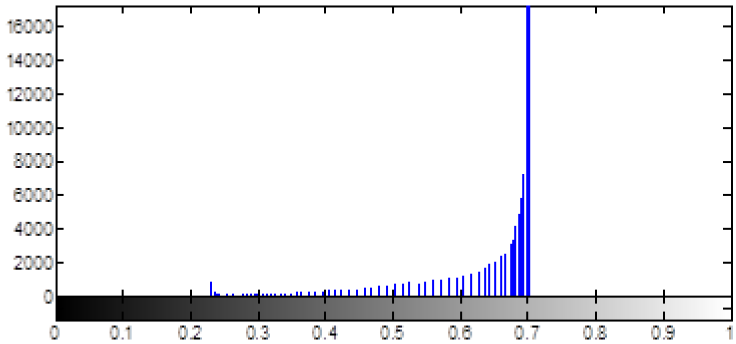
$$ET = (No.\ of\ instruction\ executed) \times CPI \times C \tag{5.2}$$

Where, CPI = Cycle per instruction and C = CPU clock cycle

5.1.6 Histogram

Histogram is a graphical picture of frequency allotment. In histogram parallel axis gives total numeral of classes and perpendicular axis gives related frequency. It provides values of edge pixels graphically. Fig. 5.3 shows the image and histogram of its edges.

(a)

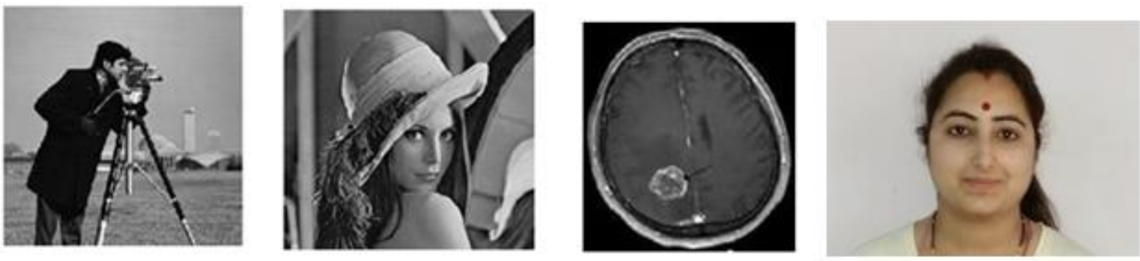


(b)

Fig.5.3 (a) original image (b) Histogram plot

5.2 Analysis on edge detection using Fuzzy Logic (FZLG)

In this section, three techniques are utilized to track down the edges in an image. These three techniques are Sobel fuzzy edge detector (SFED), Template fuzzy edge detector (TFED) and fuzzy inference system (FZYIFS). In order to study the results of these three techniques, four images are used with different size. The images are “Cameraman image”, “Lenna image”, “Brain tumour image” and “Face image”. For comparison, threshold parameter is utilized. The four images are



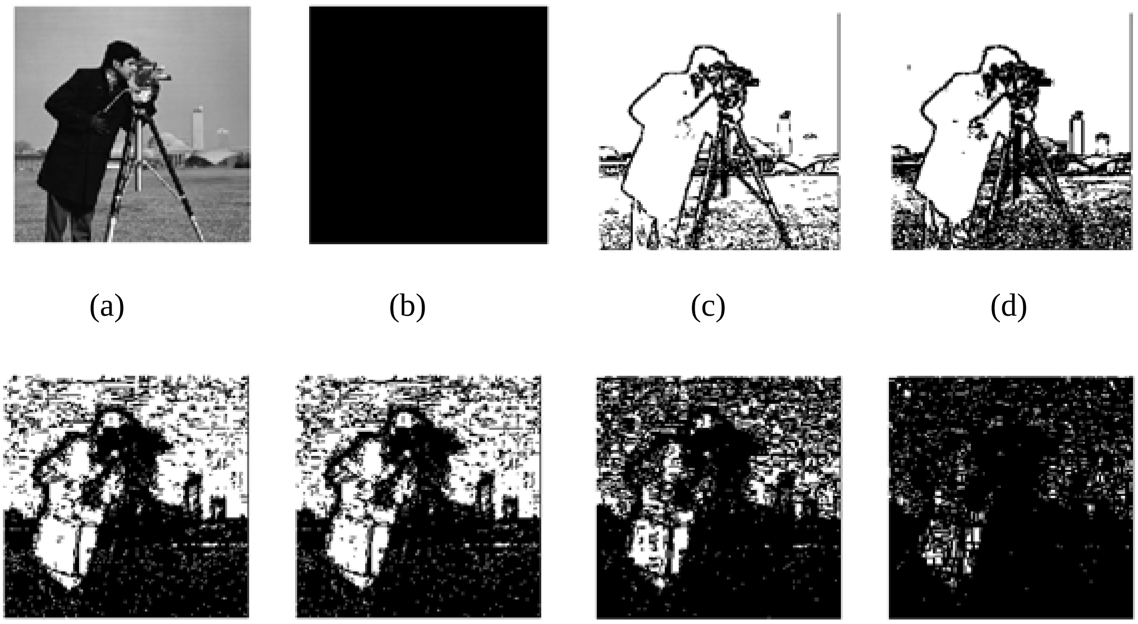
(a) (b) (c) (d)

Fig.5.4 (a) Lenna image (b) Cameraman image (c) Brain tumour (d) Face image

5.2.1 The outcome of Sobel fuzzy edge detector (SFED)

In SFED, first of all gradient is calculated in two directions using sobel operative (SOB) and after that conjoins the outcome of SOB in deuce directions i.e. x and y direction to get the finishing gradient. In this approach edge pixels are tracked by using different values of threshold that gamble on the user. In SFED, the image is split into two different sectors. If the gray level value of the pixels having more diversity than their neighborhood pixels, then those pixels of the image are considered as edge pixels and if gray level value of the pixels having less diversity with their neighborhood pixels, then those pixels of the image are considered non-edge pixels.

The SFED has been applied on four images i.e. Cameraman image of size 256×256, Lenna image of size 436×436, Brain tumor image of size 219×236 and Face image of size 213×237. The original images and edge images at distinct values of TRSH has been shown for all the four images. SFED gives best result at value 0.01 but as the threshold value increases results are not desirable, because this technique label an edge when the pixel is higher than threshold and it stop the labeling of edge when the pixel is fall lower than TRSH and therefore, after 0.01, SFED shows false edges. When 0.01, is selected all the gradient values of pixels that are greater than 0.01 value of threshold is considered as edge pixels. And at TRSH above 0.01, there exist some pixels that consists values that misunderstood and considered as edges but in real they are not edge pixels.



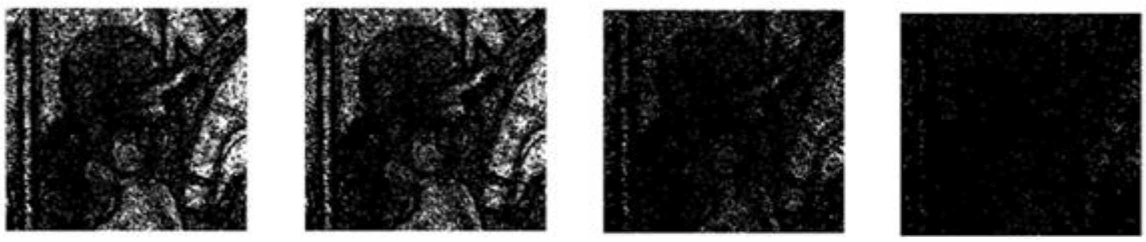
(a) (b) (c) (d)

(e) (f) (g) (h)

Fig.5.5 (a) original image with edges for thresholds (b) 0.00 (c) 0.01 (d) 0.02 (e) T=0.09 (f) 0.10 (g) 0.20 (h) 0.50

The outcome of Lenna image and Brain tumour are shown in fig. 5.6 and 5.7. SFED gives best result at value 0.01 but as the value increases results are not good because this technique label an edge when the pixel is higher than threshold and it stop the labelling of edge when the pixel is fall lower than threshold and therefore, after 0.01, SFED shows false edges. When 0.01 is selected all the gradient values of pixels that are greater than 0.01 value of threshold is considered as edge pixels. And above 0.01, there exist some non edge pixels that consists values that misunderstood and considered as edges.

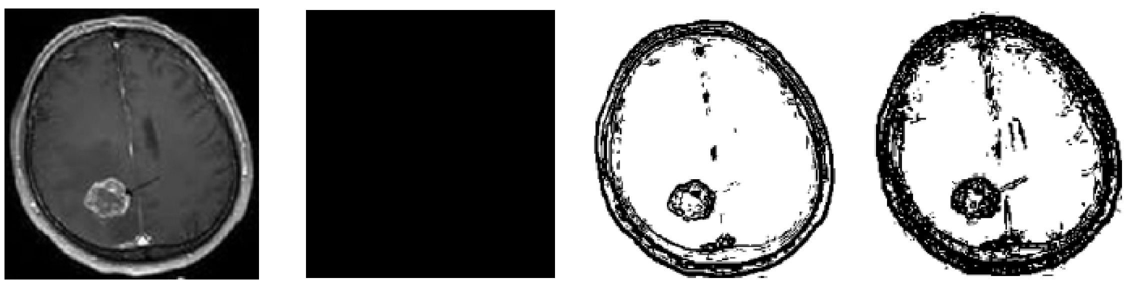
(a) (b) (c) (d)



(e) (f) (g) (h)

Fig.5.6 (a) original image with edges for thresholds (b) 0.00 (c) 0.01 (d) 0.02 (e) T=0.09 (f) 0.10 (g) 0.20 (h) 0.50

The outcome of Brain tumour image is shown in fig. 5.7. At value 0.01, SFED gives preferable outcome and after 0.01, SFED shows false edges.



(a) (b) (c) (d)

(e) (f) (g) (h)

Fig.5.7 (a) original image with edges for thresholds (b) 0.00 (c) 0.01 (d) 0.02 (e) T=0.09 (f) 0.10 (g) 0.20 (h) 0.50

The outcome of Face image is shown in fig. 5.8. At value 0.01, SFED gives preferable outcome.

(a) (b) (c) (d)

(e) (f) (g) (h)

Fig.5.8 (a) original image with edges for thresholds (b) 0.00 (c) 0.01 (d) 0.02 (e) T=0.09 (f) 0.10 (g) 0.20 (h) 0.50

The total numeral of edge pixels and the percentage of edge pixels for distinct thresholds are represented in the table 5.1. To execute the results, the total time taken by this technique for all the four images i.e. “Lenna image”, “Cameraman image”, “Brain tumour image” and “Face image” and the total percentage of pixels that consists of edges is also mentioned in the table.

Table 5.1 Outcome of Sobel fuzzy edge detector

S.no	Image	Size	Threshold	Edges	Time	Edge%
1	Cameraman	256X256	0	0	5.36141	0
			0.01	**12056**	5.405413	18.39
			0.02	20245	5.304742	30.89
			0.09	64516	5.372036	98.44
			0.1	40189	5.331734	61.32
			0.2	53478	5.399139	81.6
			0.5	60987	5.330985	93.05
2	Lenna	436X436	0	0	5.997856	0
			0.01	**33235**	6.000757	17.48
			0.02	66197	5.999755	34.8
			0.09	188356	6.064719	99.08
			0.1	163744	6.117225	86.13
			0.2	181733	6.077389	95.6
			0.5	186634	6.10619	98.17
3	Brain tumour	219X236	0	0	5.375822	0
			0.01	**5191**	5.365848	10.04
			0.02	10710	5.276425	20.72
			0.09	49585	5.327779	95.93
			0.1	31306	5.303969	60.57
			0.2	40570	5.353328	78.49
			0.5	46569	5.267749	90.1
4	Face	640X480	0	0	6.973317	0
			0.01	**5731**	7.007661	1.86
			0.02	20290	7.069301	6.60
			0.09	304964	7.013178	99.27
			0.1	237105	7.130217	77.18
			0.2	287505	7.016168	93.58
			0.5	300603	6.991447	97.85

5.2.1.1 Graphical analysis of SFED

The graphical analysis of SFED is in fig. 5.9 and 5.10. It can be inspect from the graph that at 0 value of threshold, no edges are tracked for all the images. Edges are recognized from 0.01. As value of threshold increases, total number of edges also increases. This technique gives true edges at 0.01 for all the images. SFED marks those pixels as edges which are larger than threshold. At 0.01, all the pixels having gradient value higher than 0.01 i.e. above 100 is marked as edge pixel and at 0.02 or above, actual values of threshold are decreases from 100 and all the pixels having value below

100 are marked as edges, and provide false edges. The quality of edge image is poor after 0.01.

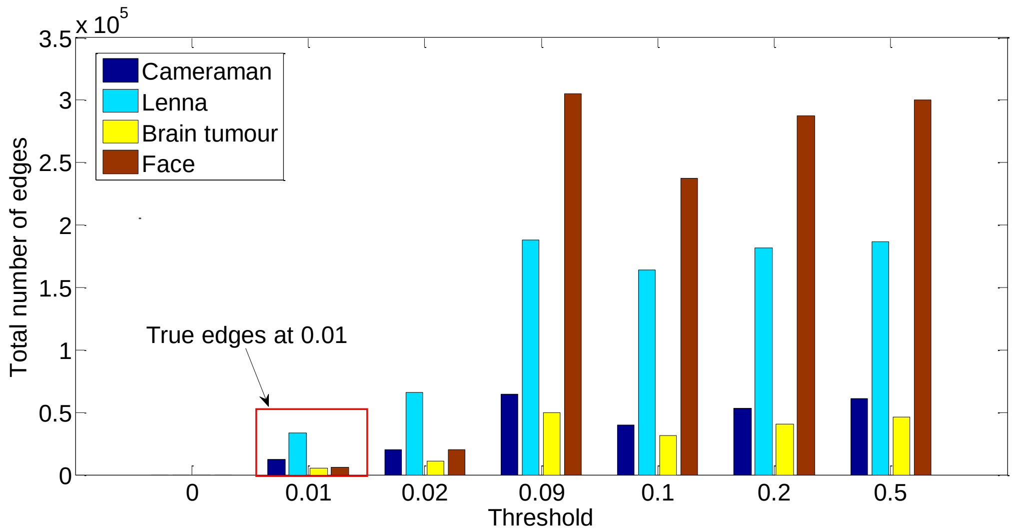


Fig. 5.9 Bar graph of total edges

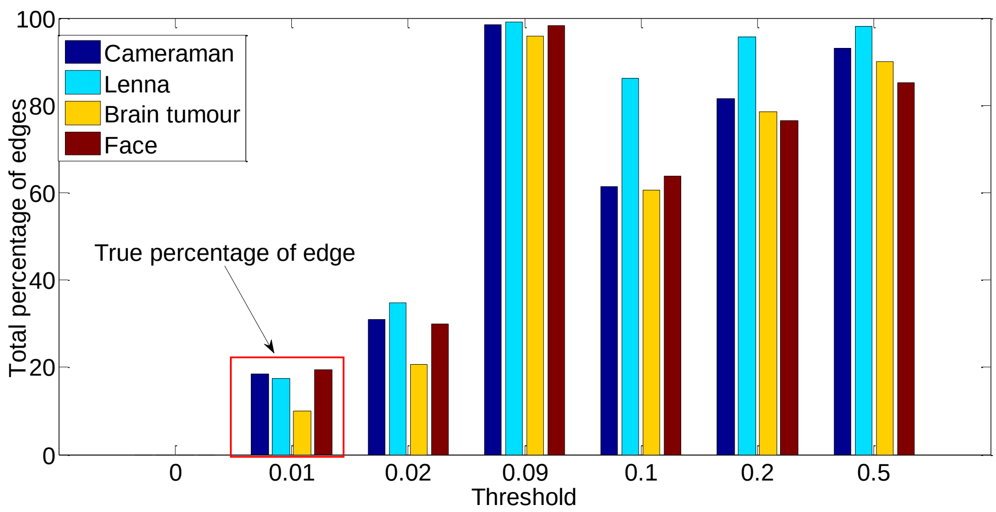


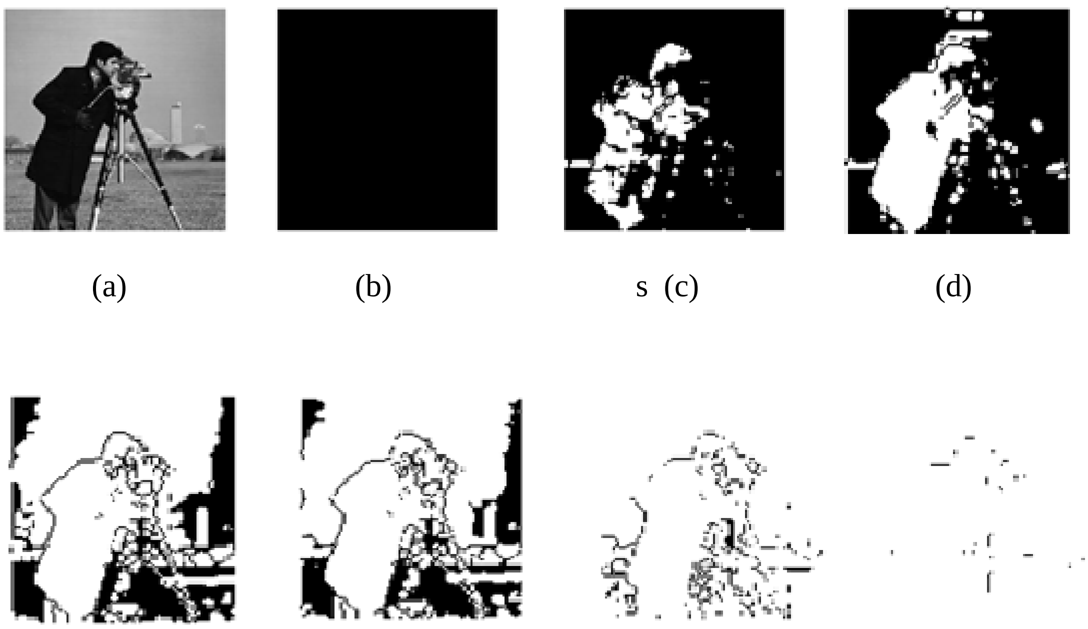
Fig. 5.10 Bar graph of Total edge Percentage

5.2.2 The outcome of Template fuzzy edge detector (TFED)

In TFED, first of all a set of templates edge images (TEI) are made and after that convolution has been done of all these TEI with the original image. The size of the TEI is less than that of the image. In initial step, in order to get the pixels value between zero and one normalized the values of intensity of every pixel. The total TEI that has been designed is designated as "n" and all TEI helps to determine all the position of edge.

pixels that are present in the image. Every TEI is taken on the image at a particular position and on the other image that is denoted by $'S'$. The size of the image window should be similar to the size of the template. Then the measurement of FZLG similarity for every pixel in $'S'$ and the values for each template are enumerated that track down the existence of an edge at any particular locus in the input image.

The TFED has been applied on four images i.e. Cameraman image of size 256×256, Lenna image of size 436×436, Brain tumor image of size 219×236 and Face image of size 213×237. The original images and edge images at distinct values of threshold has been shown for all the four images. The results obtained by TFED are given in figure 5.11, 5.12, 5.13 and 5.14. Fig. 5.11 gives outcome of "Cameraman image", fig. 5.12 gives outcome of "Lenna image", fig. 5.13 gives outcome of "Brain tumor image" and fig. 5.14 gives outcome of "Face image". TFED gives best result at threshold value 0.09 but the results are not good for all value less than and greater than 0.09. At less value of threshold, TFED tracks edges of unrelated features and count of edges is more and at high threshold, TFED skip some related edges and count of edge is very less.



(a) (b) s (c) (d)

(e) (f) (g) (h)

Fig.5.11 (a) original image with edges for thresholds (b) 0.00 (c) 0.01 (d) 0.02 (e) T=0.09 (f) 0.10 (g) 0.20 (h) 0.50

The outcome of Lenna and Brain tumour image is in fig. 5.12 and 5.13. TFED gives best result at threshold value 0.09, the results are not good for TRSH value less than and greater than 0.09. At less value of threshold, TFED tracks edges of unrelated features and count of edges is more and at high threshold, TFED skip some related edges and count of edge is very less.

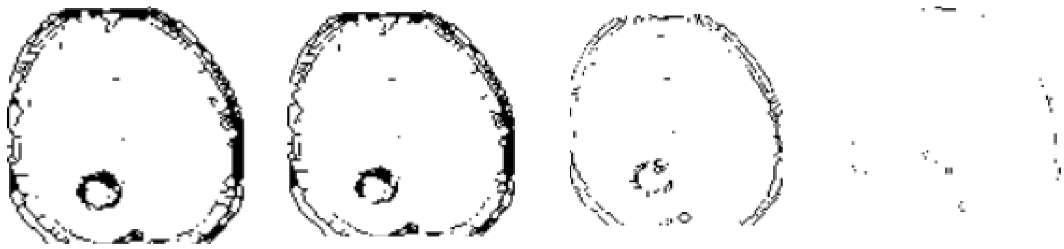
(a) (b) (c) (d)

(e) (f) (g) (h)

Fig.5.12 (a) original image with edges for thresholds (b) 0.00 (c) 0.01 (d) 0.02 (e) T=0.09 (f) 0.10 (g) 0.20 (h) 0.50

The outcome of Brain tumour image is in fig. 5.13. At threshold value 0.09, TFED provides more preferable edges than other values. Results are not desirable for value less than and greater than 0.09.

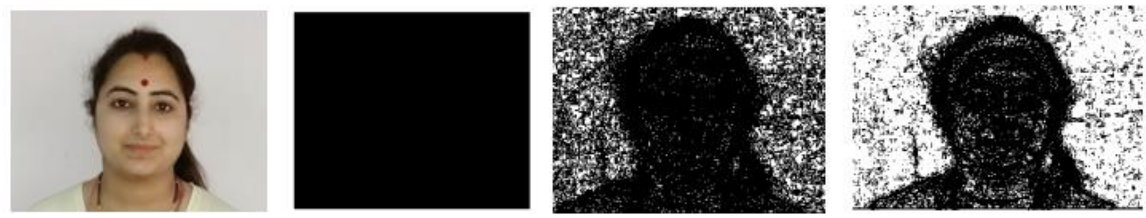
(a) (b) (c) (d)



(e) (f) (g) (h)

Fig.5.13 (a) original image (b) Threshold=0.00 (c) TRSH=0.01 (d) TRSH=0.02 (e) TRSH=0.09 (f) TRSH=0.10 (g) TRSH=0.20 (h) TRSH=0.50

The outcome of Face image is in fig. 5.14. At threshold value 0.09, TFED provides more preferable edges than other values. Results are not desirable for value less than and greater than 0.09. At less value, TFED tracks edges of unrelated features and count of edges is more and at high value, TFED skip some related edges and count of edge is very less.



(a) (b) (c) (d)

(e) (f) (g) (h)

Fig.5.14 (a) original image with edges for thresholds (b) 0.00 (c) 0.01 (d) 0.02 (e) T=0.09 (f) 0.10 (g) 0.20 (h) 0.50

The total numeral of edge pixels and the percentage of edge pixels for distinct thresholds are represented in the table 5.2. To execute the results, the total time taken by this technique for all the four images and the total percentage of pixels that consists of edges is also mentioned in the table.

Table 5.2 Outcome of Template fuzzy edge detector

S.no	Image	Size	Threshold	Edges	Time	Edge%
1	Cameraman	256x256	0	0	1.446493	0
			0.01	6993	1.355857	10.67
			0.02	5853	1.303703	8.93
			0.09	**1307**	1.300013	1.99
			0.1	1190	1.274661	1.81
			0.2	204	1.319509	0.31
			0.5	22	1.262173	0.03
2	Lenna	436x436	0	0	1.261579	0
			0.01	6742	1.343654	5.05
			0.02	5233	1.320943	3.54
			0.09	**1431**	1.307968	2.75
			0.1	1189	1.293636	0.09
			0.2	190	1.320789	0.75
			0.5	10	1.314695	0.62
3	Brain tumour	219x236	0	0	1.312285	0
			0.01	3279	1.313612	6.34
			0.02	2493	1.350558	4.82
			0.09	**1130**	1.334126	2.18
			0.1	1062	1.357067	2.05
			0.2	468	1.350739	0.9
			0.5	51	1.285874	0.09
4	Face	640x480	0	0	3.461928	0
			0.01	1638	3.413267	0.53
			0.02	1442	3.357067	0.46
			0.09	**1031**	3.428905	0.33
			0.1	921	3.357067	0.29
			0.2	251	3.313612	0.08
			0.5	45	3.135078	0.01

5.2.2.1 Graphical analysis of TFED

The graphical analysis of TFED is in fig. 5.15 and 5.16. After calculation of gradient, TFED marks those pixels as edge which is stronger than threshold. At small value of threshold, TFED gives high edges. With increase in threshold value, those pixels which are stronger than threshold also decreases and resultant in lower edges. This technique gives true edges at TRSH 0.09. Before 0.09, those pixels which are not consist edges are recognize as edge pixels and because of this it provide false edges along with true edges. After 0.09, the total numeral of true edges gets reduced. The true percentage of edge is also at 0.09.

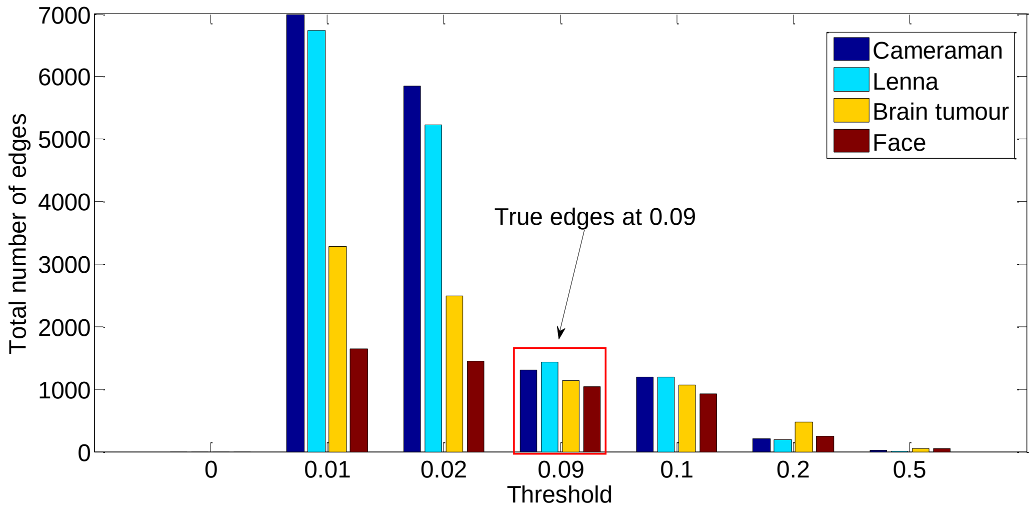


Fig. 5.15 Bar graph of total edges

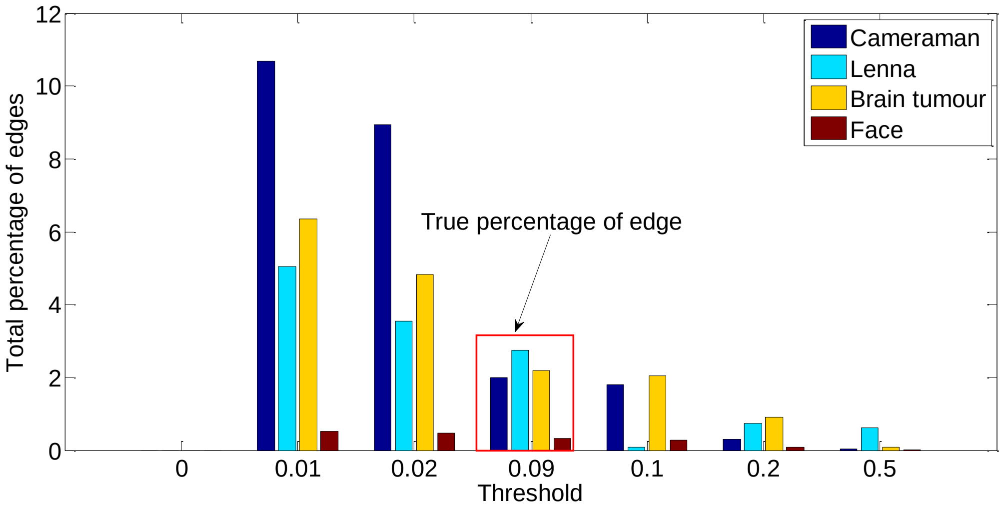


Fig. 5.16 Bar graph of Total edge Percentage

5.2.3 The outcome of Fuzzy inference system (FZYIFS)

In this technique, image gradient are enumerated of a gray scale image along parallel and perpendicular direction. After that, define FZYIFS and specify the image gradient as an input to FZYIFS. Then specify input and output MBFS and specify FZYIFS rule. Last step is to evaluate FZYIFS and edge will be detected.

The FZYIFS has been applied on four images i.e. Cameraman image of size

256×256, Lenna image of size 436×436, Brain tumor image of size 219×236 and Face image of size 213×237. The original images and edge images at distinct values of TRSH has been shown for all the four images. Fig. 5.17 gives outcome of “Cameraman image”, fig. 5.18 gives outcome of “Lenna image”, fig. 5.19 gives outcome of “Brain tumor image” and fig. 5.20 gives outcome of “Face image”. This method gives approximately same number of edges for all the value of threshold. This method gives best result for all the values except at 0.50 and above. The calculated gradient values changes with respect to the selected threshold value. And at every value, the resultant gradient values are suitable to calculate preferable number of edge pixels. And the resultant edge image gives clean edges. FZYIFS presents very high strength against deviation in contrast and light and also avoid tracking of double edges.

(a) (b) (c) (d)

(e) (f) (g) (h)

Fig.5.17 (a) original image with edges for thresholds (b) 0.00 (c) 0.01 (d) 0.02 (e) T=0.09 (f) 0.10 (g) 0.20 (h) 0.50

The outcome of Lenna image is in fig. 5.18. FZYIFS gives approximately same number of edges for all the values of threshold. This method gives best result for all the value of except at 0.50

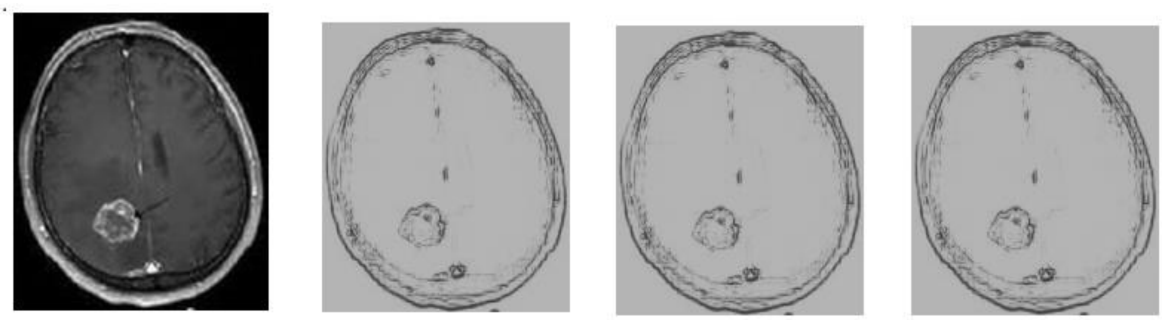
gradient values are suitable to calculate preferable number of edge pixels. And the resultant edge image gives clean edges.

(a) (b) (c) (d)

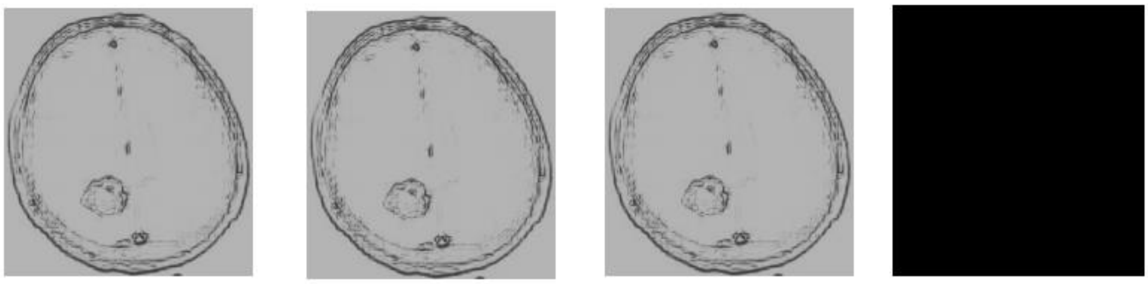
(e) (f) (g) (h)

Fig.5.18 (a) original image with edges for thresholds (b) 0.00 (c) 0.01 (d) 0.02 (e) T=0.09 (f) 0.10 (g) 0.20 (h) 0.50

The outcome of Brain tumour image is in fig. 5.19. FZYIFS gives approximately same number of edges for all the value of except at 0.5.



(a) (b) (c) (d)



(e) (f) (g) (h)

Fig.5.19 (a) original image with edges for thresholds (b) 0.00 (c) 0.01 (d) 0.02 (e) T=0.09 (f) 0.10 (g) 0.20 (h) 0.50

The outcome of Face image is in fig. 5.20. FZYIFS gives approximately same number of edges for all the value of except at 0.5.

(a) (b) (c) (d)

(e) (f) (g) (h)

Fig.5.20 (a) original image with edges for thresholds (b) 0.00 (c) 0.01 (d) 0.02 (e) T=0.09 (f) 0.10 (g) 0.20 (h) 0.50

The total numeral of edge pixels and the percentage of edge pixels for distinct thresholds are represented in the table 5.3. To execute the results, the total time taken by this technique for all the four images and the total percentage of pixels that consists of edges is also mentioned in the table.

Table 5.3 Outcome of Fuzzy inference system

S.no	Image	Size	Threshold	Edges	Time	Edge%
1	Cameraman	256x256	0	8097	2.115647	12.35
			0.01	**8097**	**1.969693**	**12.35**
			0.02	8097	1.994898	12.35
			0.09	8097	2.014915	12.35
			0.1	8097	2.025018	12.35
			0.2	8097	2.007685	12.35
			0.5	0	2.053433	0
2	Lenna	436x436	0	10601	2.561485	5.57
			0.01	10601	2.629994	5.57
			0.02	**10601**	**2.464523**	**5.57**
			0.09	10601	2.736995	5.57
			0.1	10601	2.570469	5.57
			0.2	10601	2.574726	5.57
			0.5	0	2.558162	0
3	Brain tumour	219x236	0	3926	1.988856	7.59
			0.01	3926	2.138981	7.59
			0.02	3926	1.789961	7.59
			0.09	3926	1.819734	7.59
			0.1	**3926**	**1.773427**	**7.59**
			0.2	3926	1.837681	7.59
			0.5	0	1.802416	0
4	Face	640x480	0	2285	3.21715	0.74
			0.01	2285	3.076038	0.74
			0.02	2285	3.291713	0.74
			0.09	2285	3.292188	0.74
			0.1	2285	3.241063	0.74
			0.2	**2285**	**3.073365**	**0.74**
			0.5	0	3.011375	0

5.2.3.1 Graphical analysis of FZYIFS

The graphical analysis of FZYIFS is in fig. 5.21. FZYIFS mark edges by keep both high as well as low threshold. Therefore, this technique gives true edges for maximum values of threshold but after 0.20 no edges are tracked. FZYIFS is supreme beyond all techniques, as FZYIFS can preserve the purity of proven information. FZYIFS can certify exactness of locality of images. This method gives best result for all the values. The true percentage of edge is also from 0.00 to 0.20 is shown in fig. 5.22.

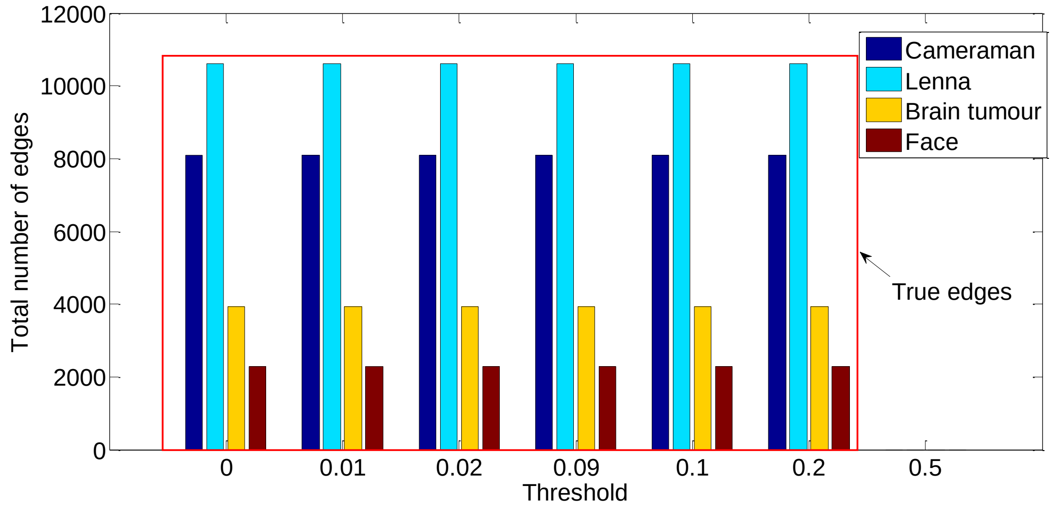


Fig. 5.21 Bar graph of total edges

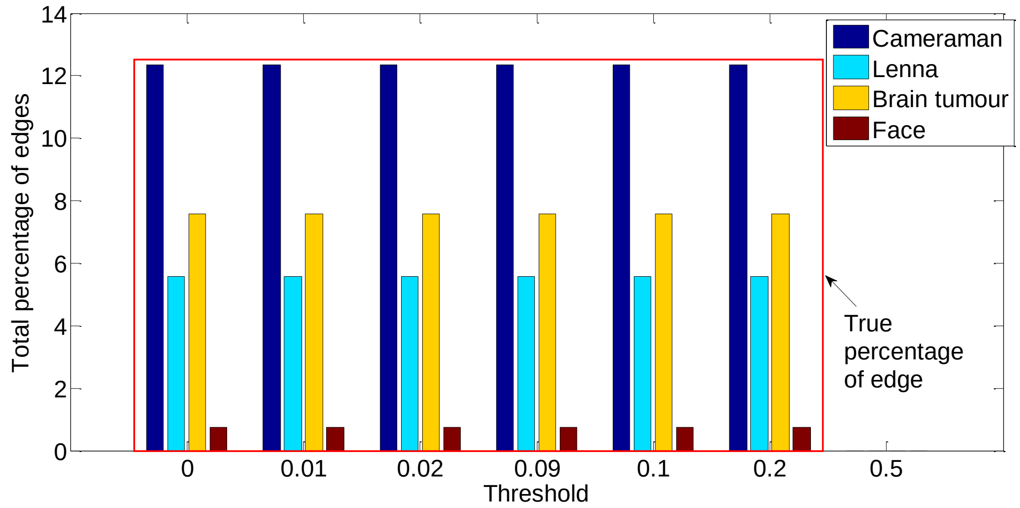


Fig. 5.22 Bar graph of total edge Percentage

5.2.4 Comparison of FZYIFS, SFED and TFED

The comparison of FZYIFS, SFED and TFED is in fig.5.23. The FZYIFS system gives plentiful edges for all threshold values. SFED gives best result at 0.01and above 0.01the result is getting poor. TFED gives best result at 0.09 values of threshold and at other values the result is not desirable. FZYIFS is supreme beyond all techniques, as FZYIFS can preserve the purity of proven information. FZYIFS can certify exactness of locality of images. Further, the FZYIFS has less computational complication than the TFED and SFED and takes less time for edge detection.

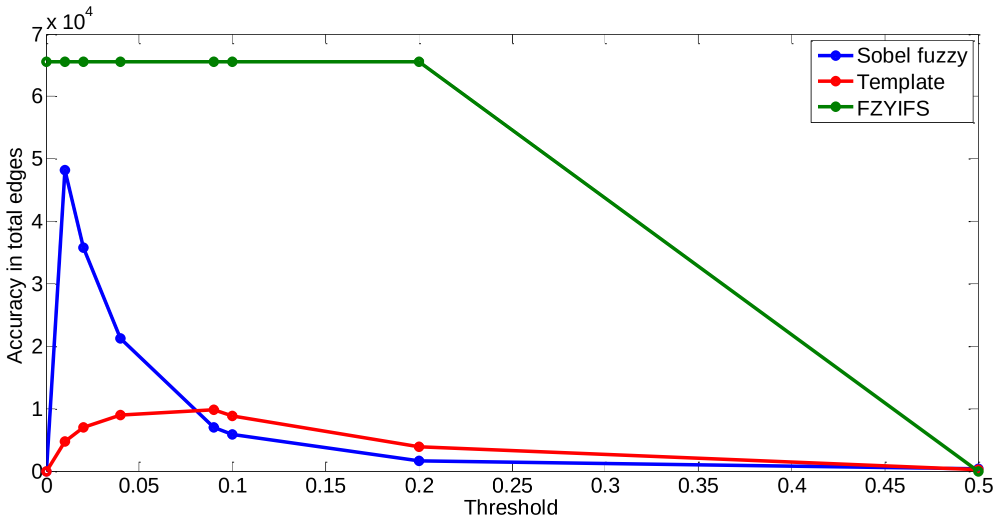


Fig. 5.23 Comparison of FZYIFS, SFED and TFED

5.3 Analysis on edge detection using types of Fuzzy inference system (FZYIFS)

In this section, fuzzy logic type-1 (FZLG1) and interval fuzzy logic type-2 (INTFZLG2) with sobel (SOB) operative are utilized to track down edges. In order to study the results of these two techniques, ten images are used with different size and different formats. The images are “Cameraman image”, “Lenna image”, “Building image” and “Rice image”, “Jupiter image”, “Fruit image”, “Rose image”, “Brain tumour image”, “Face image” and “Traffic image”.

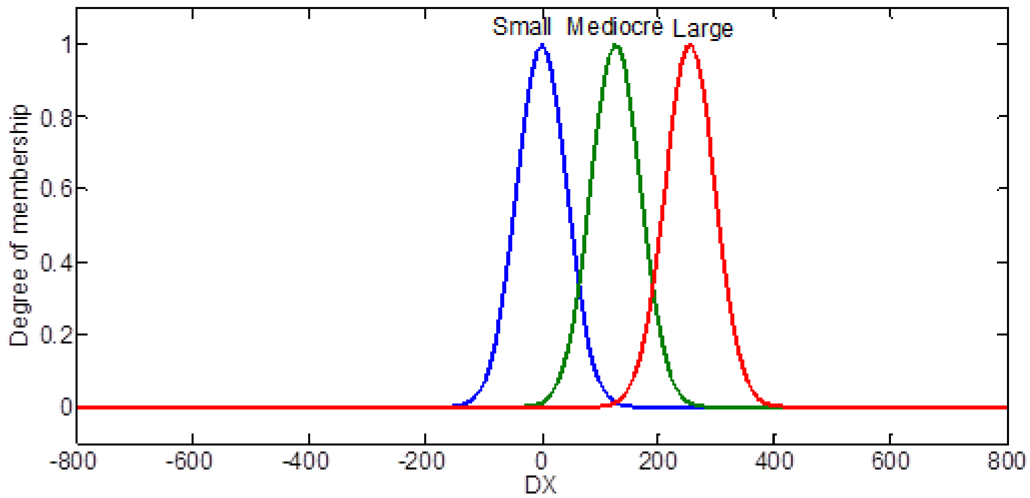
The proposed method utilized FZLG2 with pseudo convolution mask (SPCM), implemented on the same ten images. Histogram parameter is also utilized to compare the result of ITFZLG2 with SOB and ITFZLG2 with SPCM.

5.3.1 The outcome of FZLG1

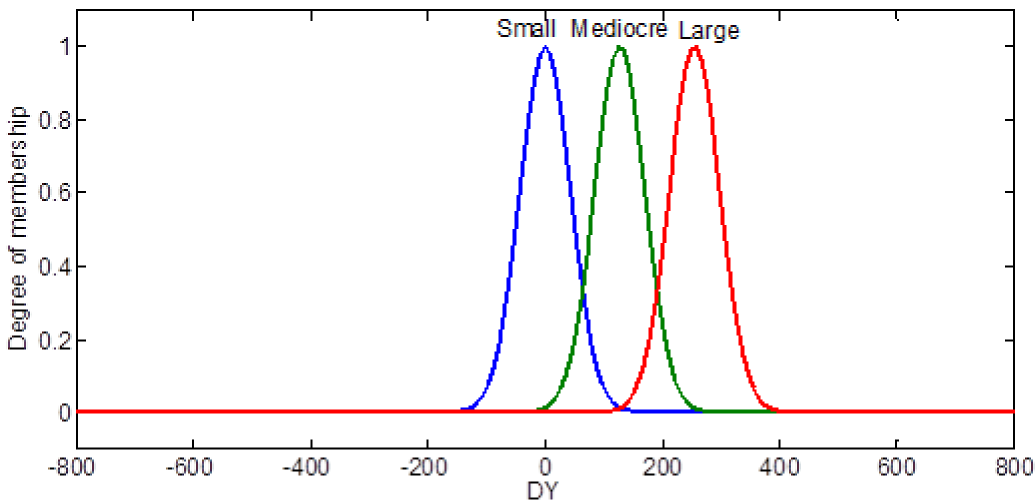
In FZLG1, it is important to apply SOB to the parent images and then utilized a FZYFIS to track down the edges. The SOB tested on any digital image to enumerate the GRD value for every pixel, granting the direction of higher desirable increment from black to white, along with this it also enumerate the extent of change in that direction.

5.3.1.1 Graphical representation of MBFS

For FZLG1, four inputs are enforced. Two of them are the GRD along parallel and perpendicular directions, nominated as DX and DY respectively. The other two inputs are filters i.e. HHF and LWF that enumerate by employ two masks that convolve to the parent image. The range of inputs DX, DY and HHF is keep from -800 to 800. But the range of input LWF is different from other three inputs i.e. DX, DY and HHF. The range of LLF is keep from 0 to 250. And therefore the MBFS for LWF is broader than other three inputs i.e. DX, DY and HHF. The plot of these four inputs and one output in the form of MBFS is delineated in the diagram.

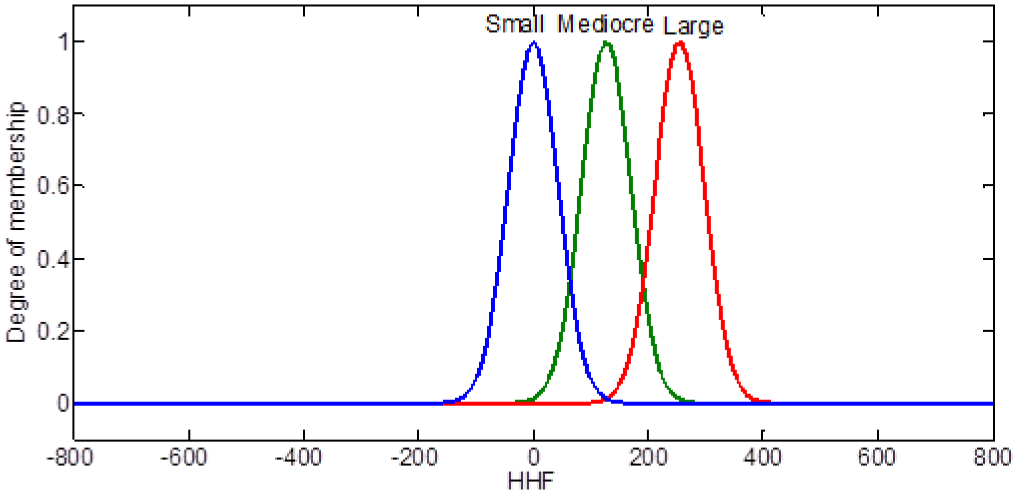


(a)



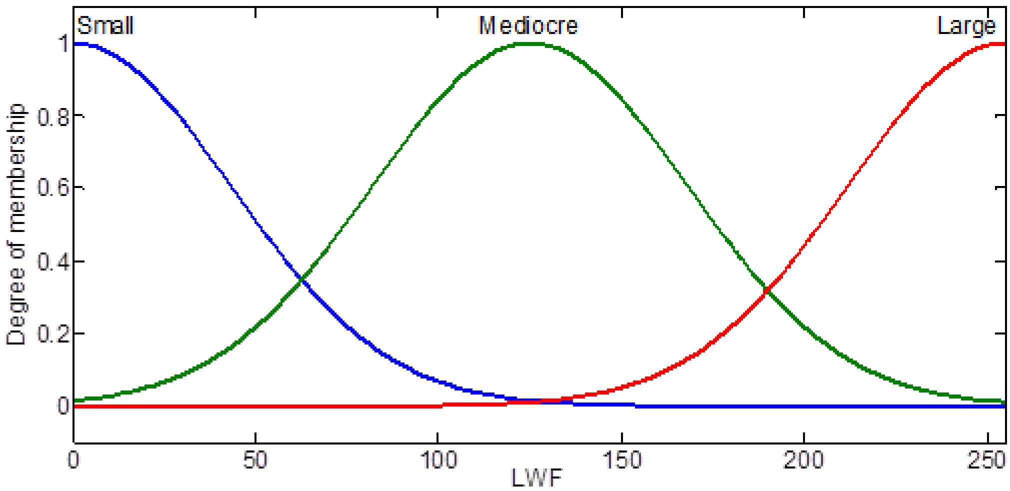
(b)

The range of inputs DX, DY and HHF is keep from -800 to 800. But the range of input LWF is different from other three inputs i.e. DX, DY and HHF. The range of LLF is keep from 0 to 250. And therefore the MBFS for LWF is broader than other three inputs i.e. DX, DY and HHF.

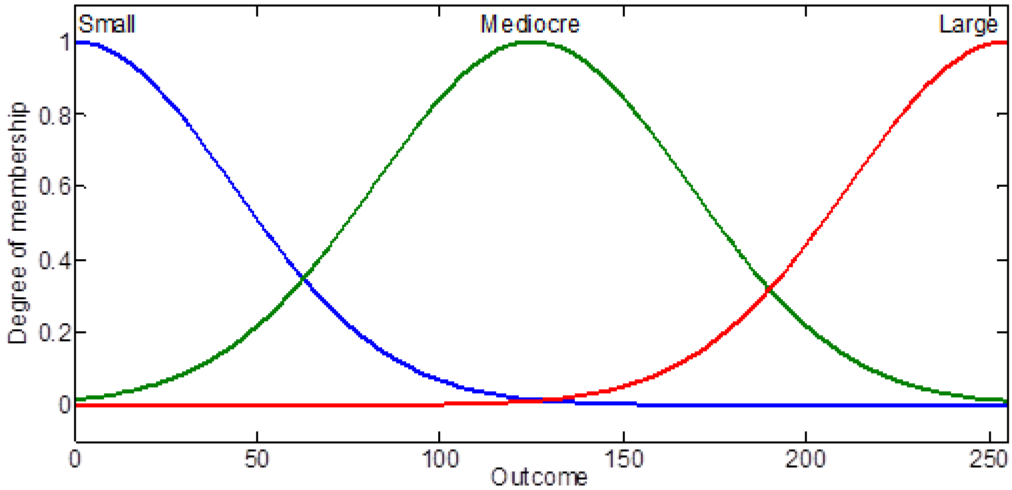


(c)

The input LWF has different range from other inputs i.e. DX, DV and HHF. The range of LWF is keep from 0 to 250, but the range of DX, DV and HHF keep from -800 to 800. In figure 5.24 (e) the variable for output edges is designated as Outcome. The range of Outcome is same as range of input variableLWF. The range of Outcome is keep from 0 to 250. And like in LWF the MBFS of Outcome is broader than the three inputs i.e. GX, GY andHHF. The input LWF is represented in fig. 5.24 (d) and the output i.e. outcome is represented in fig. 5.24 (e).



(d)



(e)

Fig.5.24 (a) Input DX (b) Input DY (c) Input HHF (d) Input LWF (e) Output Outcome

5.3.1.2 Outcome edge images of FZLG1

The FZLG1 is implemented on ten different images with different sizes. The images are “Cameraman image” of size 256×256, “Lenna image” of size 436×436, “Building image” of size 1114×834 and “Rice image” of size 600×600, “Jupiter image” of size 556×416, “Fruit image” of size 666×666, “Rose image” of size 1024×1024, “Brain tumour image” of size 219×236, “Face image” of size 640×480 and “Traffic image” of size 168×300. Fig.5.25 shows all the ten parent images.

The edge image that contains edge pixels are obtained for all the ten images and the total number of edges is calculated for all the ten images. The different formats of the images that are JPG, TIFF, GIF and PNG of these ten images are also taken under examination.

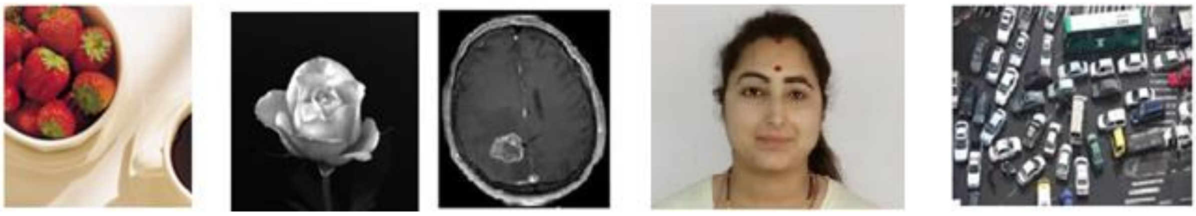
(a)

(b)

(c)

(d)

(e)

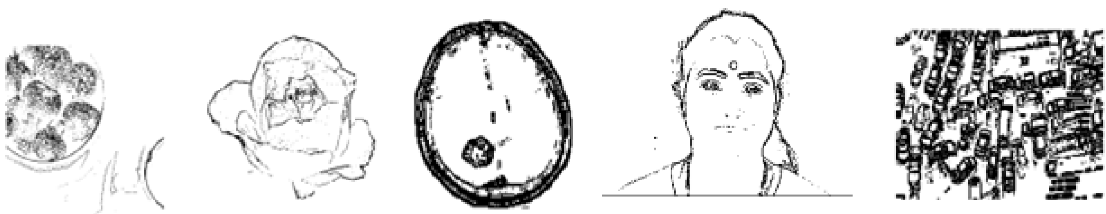


(f) (g) (h) (i) (j)

Fig. 5.25 (a) Cameraman (b) Lenna (c) Building (d) Rice (e) Jupiter (f) Fruit (g) Rose (h) Brain tumour (i) Face (j) Traffic

The edge image that contains edge pixels are obtained for all the ten images, total number of edges is calculated for all the ten images. The different formats that are JPG, TIFF, GIF and PNG of these ten images are also taken under examination. Fig. 5.26 shows the edge images of the original images. The total numeral of edge pixels and the percentage of edge pixels for the entire ten images are represented in the table 5.4. The table also represent the total time taken by the FZLG1, in order to give the outcome of all the images with different formats.

(a) (b) (c) (d) (e)



(f) (g) (h) (i) (j)

Fig. 5.26 (a) Cameraman edge image, (b) Lenna edge image, (c) Building edge image (d) Rice edge image, (e) Jupiter edge image, (f) Fruit edge image, (g) Rose edge image

Table 5.4 Outcome of FZLG1

S.no	Image	Size	Format	Edges	Time	Edge%
1	Cameraman	256x256	**JPG**	**11980**	**3.966908**	**18.28**
			TIFF	11924	3.980372	18.19
			GIF	11978	3.962402	18.27
			PNG	11978	4.099579	18.27
2	Lenna	436x436	**JPG**	**33008**	**7.640701**	**17.36**
			TIFF	33007	7.085368	17.36
			GIF	33007	7.199707	17.36
			PNG	33007	7.05605	17.36
3	Building	1114x834	JPG	164235	29.34929	17.67
			TIFF	164436	29.98908	17.69
			GIF	93544	28.35584	10.06
			PNG	**164436**	**28.21587**	**17.69**
4	Rice	600x600	**JPG**	**32070**	**12.01252**	**89.08**
			TIFF	31313	12.16243	86.98
			GIF	31313	12.15273	86.98
			PNG	31313	11.81957	86.98
5	Jupiter	556x416	JPG	14900	8.821909	6.44
			TIFF	14850	8.990213	6.42
			GIF	**39337**	**8.966868**	**17**
			PNG	14850	8.979698	6.42
6	Fruits	666x666	**JPG**	**44318**	**14.22589**	**9.99**
			TIFF	43979	13.50974	9.91
			GIF	40231	13.57196	9.07
			PNG	43979	13.57196	9.91
7	Rose	1024x1024	**JPG**	**24544**	**30.91499**	**2.34**
			TIFF	24380	31.46682	2.32
			GIF	6472	31.57386	0.61
			PNG	24380	31.87685	2.32
8	Brain tumour	219x236	JPG	4072	2.256989	7.87
			TIFF	**4077**	**2.240309**	**7.88**
			GIF	4077	2.436565	7.88
			PNG	4077	2.370809	7.88
9	Face	640x480	JPG	5659	9.996352	1.84
			TIFF	**5657**	**9.626014**	**1.84**
			GIF	5657	10.02921	1.84
			PNG	5657	9.764256	1.84
10	Traffic	168x300	**JPG**	**22441**	**3.213279**	**44.52**
			TIFF	22438	3.295568	44.51
			GIF	26603	3.326389	52.78
			PNG	22438	3.173912	44.51

5.3.1.3 Graphical representation of the outcome of FZLG1

The bar graph of total edges of all the ten images with different formats is shown in fig. 5.27. The cameraman image, Lenna image, Rice image and Tumour image gives same percentage of edges for all formats. Building image, Rice image and Traffic image gives less numeral of edges for GIF format than other. This is because GIF reduces the intensity value of pixels. In case of Building, Rice and Traffic, intensity value is cut down at more extent and lower edges are tracked.

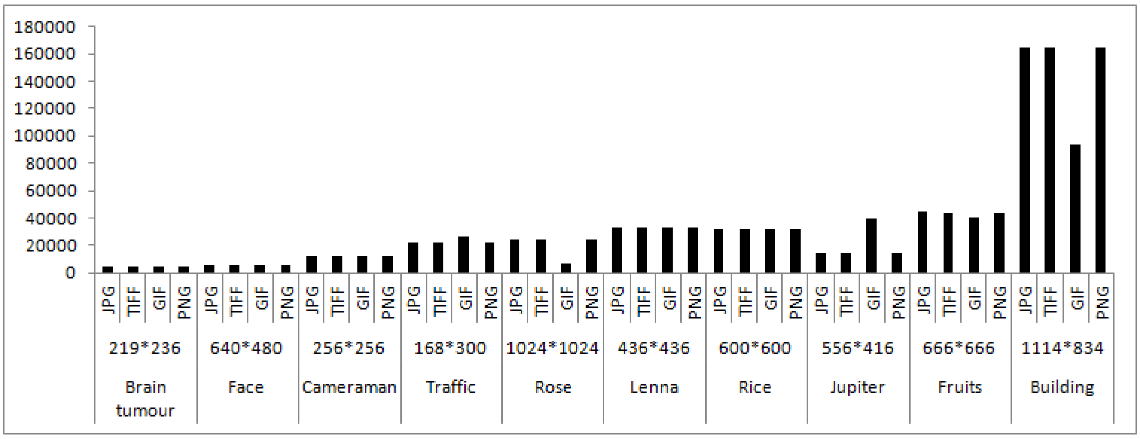


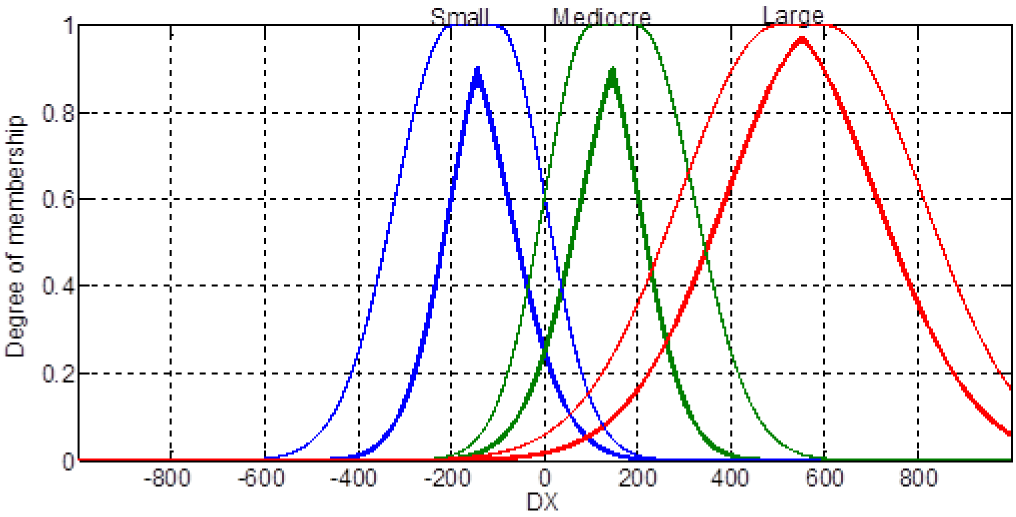
Fig. 5.27 Bar graph of total edges from FZLG1

5.3.2 The outcome of INTFZLG2 with SOB

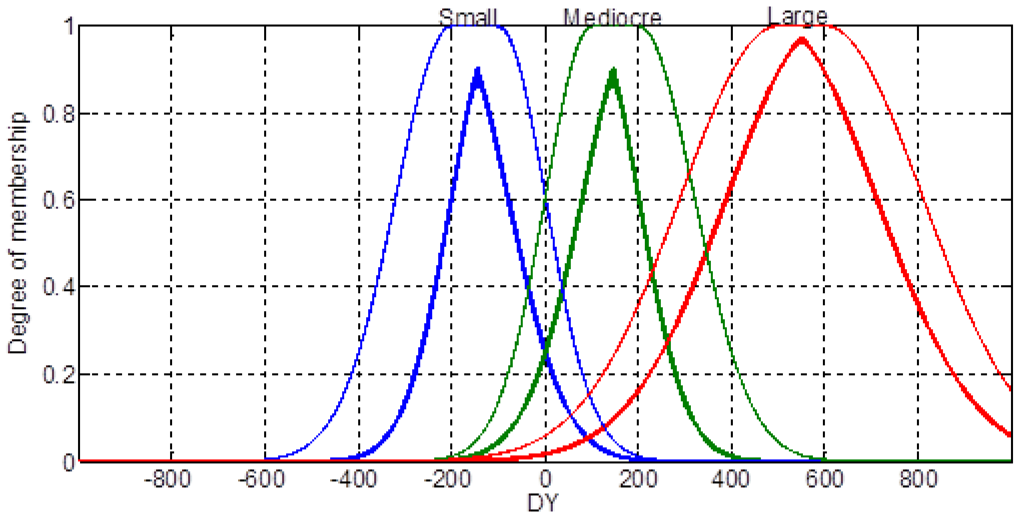
INTFZLG2 is a leading version of conventional FZLG1. The procedure for edge detection using FZLG2 is same as that of FZLG1. The only difference comes in the way of defining MBFS.

5.3.2.1 Graphical representation of MBFS

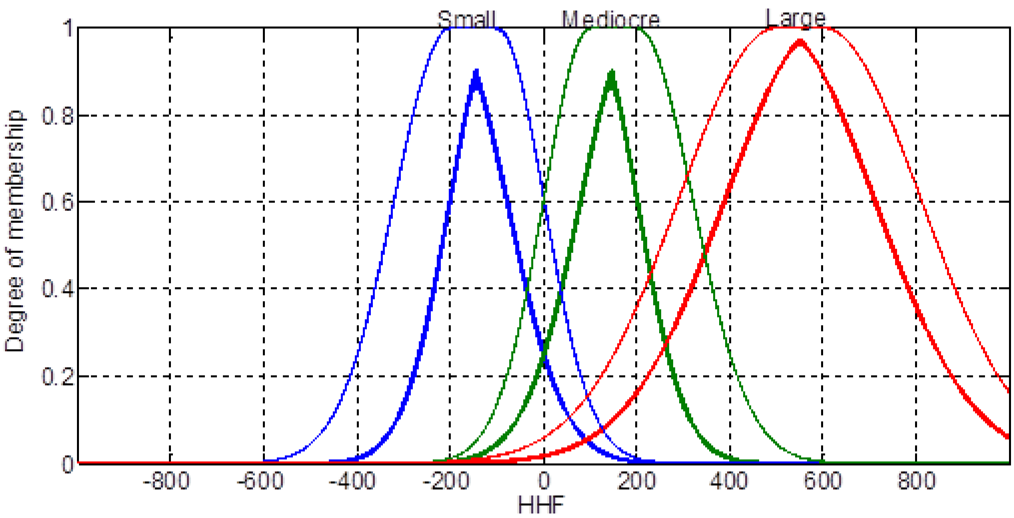
For FZLG2, four inputs are enforced. Two of them are the GRD along parallel and perpendicular directions, nominated as DX and DY respectively. The other two inputs are filters i.e. HHF and LWF that enumerate by employ two masks that convolve to the parent image. The range of inputs DX, DY and HHF is keep from -800 to 800. But the range of input LWF is different from other three inputs i.e. DX, DY andHHF. The range of LLF is keep from 0 to 250. And therefore the MBFS for LWF is broader than other three inputs i.e. DX, DY and HHF. Fig. 4.28 shows the MBFS for INTFZLG2.


Small
Mediocre
Large
Degree of membership
0
0.2
0.4
0.6
0.8
1
-800
-600
-400
-200
0
200
400
600
800
DX

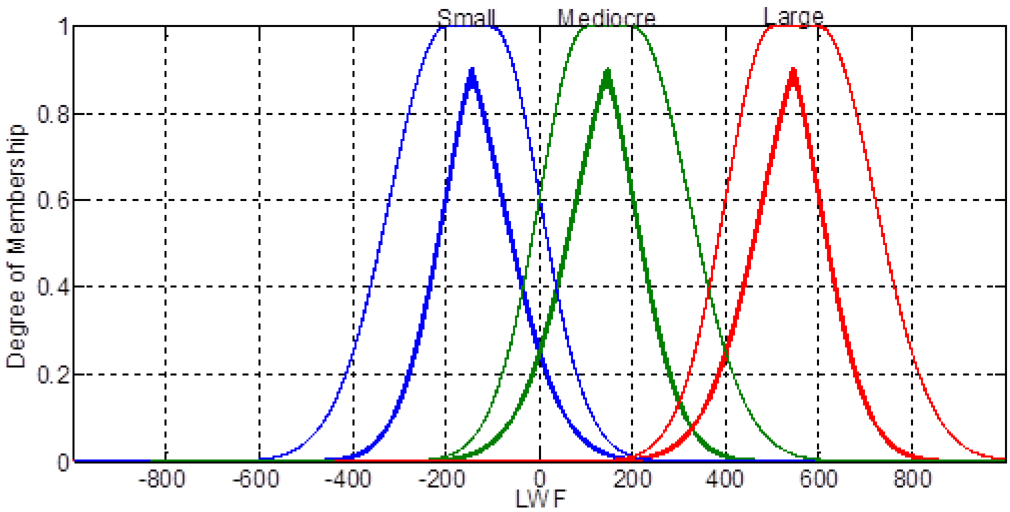
(a)


Small
Mediocre
Large
Degree of membership
0
0.2
0.4
0.6
0.8
1
-800
-600
-400
-200
0
200
400
600
800
DY

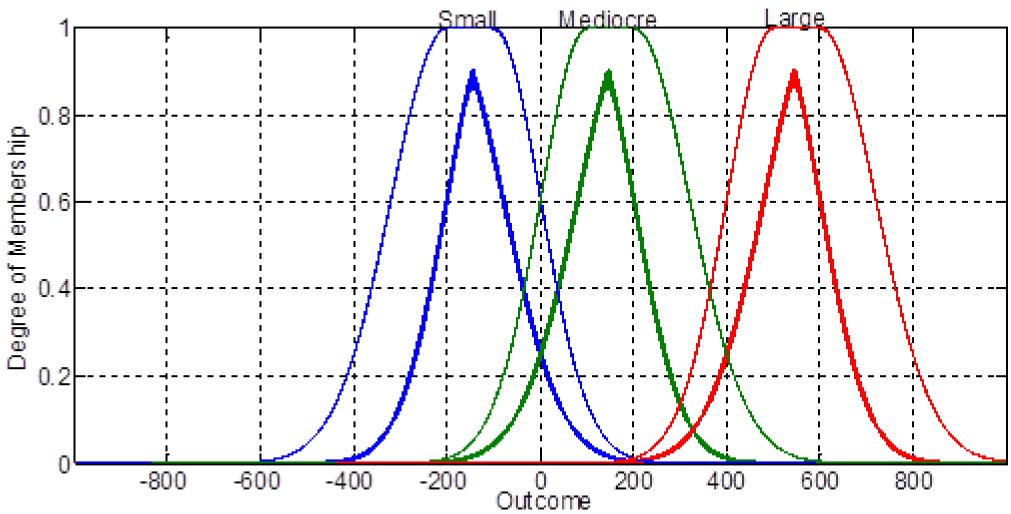
(b)


Small
Mediocre
Large
Degree of membership
0
0.2
0.4
0.6
0.8
1
-800
-600
-400
-200
0
200
400
600
800
HHF

(c)



(d)



(e)

Fig.5.28 (a) Input DX (b) Input DY (c) Input HHF (d) Input LWF (e) Output Outcome

5.3.2.2 Outcome edge images of INTFZLG2

The INTFZLG2 with SOB is implemented on ten different images with different sizes. Fig.5.29 shows all the ten parent images. Fig. 5.30 shows the edge images of the original images. The total numeral of edge pixels and the percentage of edge pixels for the entire ten images are represented in the table 5.5. The table also represents the total time taken by the INTFZLG2, in order to give the outcome of all the images with different formats.

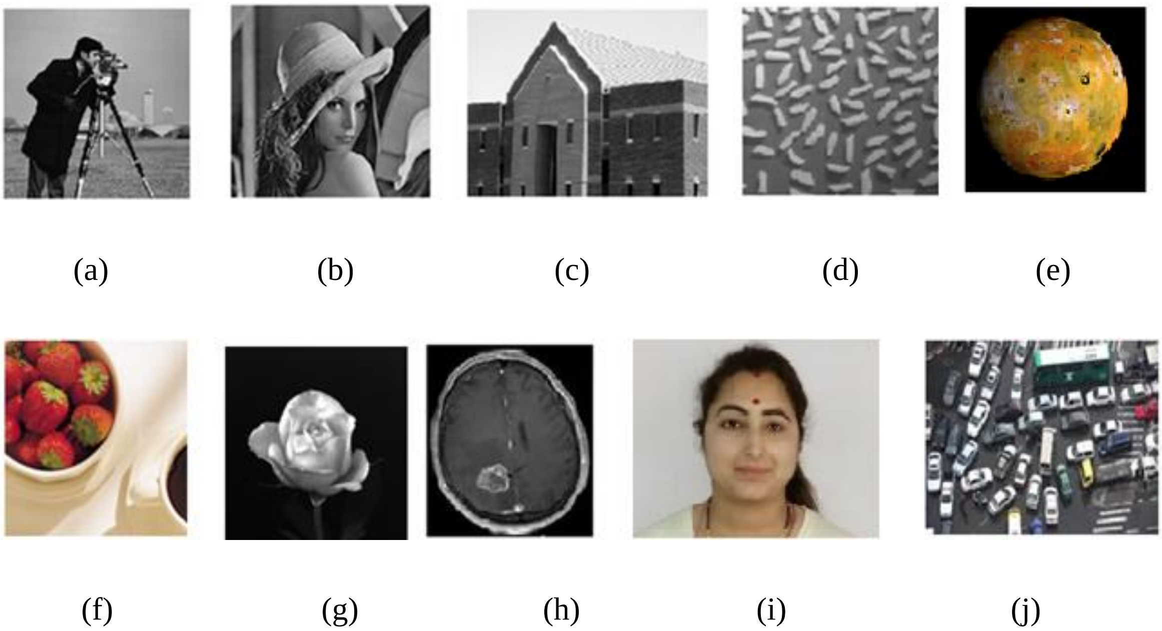


Fig. 5.29 (a) Cameraman (b) Lenna (c) Building (d) Rice (e) Jupiter (f) Fruit (g) Rose (h) Brain tumour (i) Face (j) Traffic

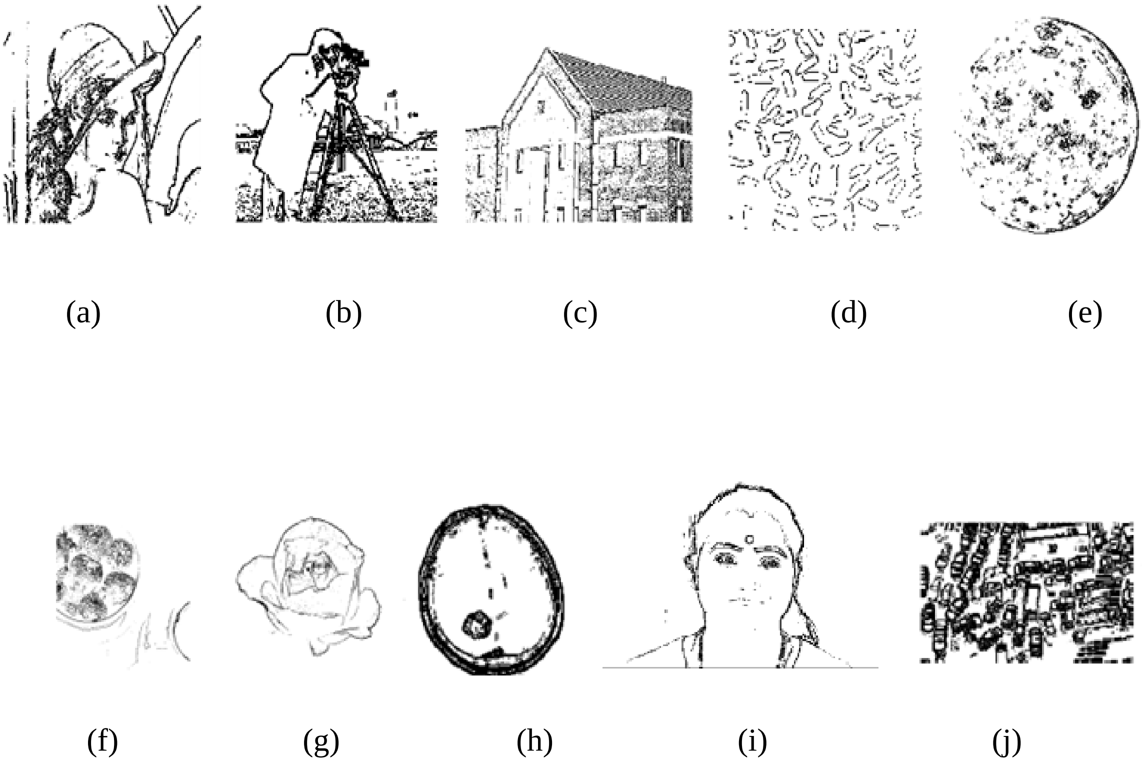


Fig. 5.30 (a) Cameraman edge image, (b) Lenna edge image, (c) Building edge image (d) Rice edge image, (e) Jupiter edge image, (f) Fruit edge image, (g) Rose edge image

Table 5.5 Outcome of INTFZLG2 with SOB

S.no	Image	Size	Format	Edges	Time	Edge%
1	Cameraman	256x256	JPG	12056	5.844771	18.39
			TIFF	11977	5.748246	18.27
			GIF	**12059**	**5.833184**	**18.4**
			PNG	12059	6.154047	18.4
2	Lenna	436x436	JPG	33235	9.672719	17.48
			TIFF	33243	9.63281	17.48
			GIF	**33243**	**9.50426**	**17.48**
			PNG	33243	9.603828	17.48
3	Building	1114x834	JPG	165609	25.54414	17.82
			TIFF	**165831**	**26.24066**	**17.84**
			GIF	94288	25.34335	10.14
			PNG	165831	27.11207	17.84
4	Rice	600x600	JPG	32225	14.71978	8.95
			TIFF	31470	15.28389	8.74
			GIF	**31470**	**14.87687**	**8.74**
			PNG	**31470**	**14.87687**	**8.74**
5	Jupiter	556x416	**JPG**	**14902**	**9.819594**	**6.44**
			TIFF	14852	13.24758	6.42
			GIF	39339	9.746193	17
			PNG	14852	9.385414	6.42
6	Fruits	666x666	**JPG**	**44617**	**15.90476**	**10.05**
			TIFF	44276	16.01271	9.98
			GIF	40311	1.876845	9.08
			PNG	44276	1.876845	9.98
7	Rose	1024x1024	**JPG**	**24546**	**33.42459**	**2.34**
			TIFF	24383	33.01448	2.32
			GIF	6472	32.66416	0.61
			PNG	24383	33.01448	2.32
8	Brain tumour	219x236	JPG	4075	4.696147	7.88
			TIFF	**4080**	**4.548426**	**7.89**
			GIF	4080	4.711204	7.89
			PNG	4080	4.822162	7.89
9	Face	640x480	JPG	5731	11.76426	1.86
			TIFF	**5732**	**11.56508**	**1.86**
			GIF	5732	11.80963	1.86
			PNG	5732	11.86165	1.86
10	Traffic	168x300	JPG	22522	5.40382	44.68
			TIFF	22520	5.41173	44.68
			GIF	**26679**	**5.654689**	**52.93**
			PNG	22520	5.54924	44.68

5.3.2.3 Graphical representation of outcome of INTFZLG2 with SOB

The bar graph of total edges of all the ten images with different formats that are, JPG, TIFF, GIF and PNG is in fig. 5.31. The cameraman image, Lenna image, Rice image and Tumour image gives same percentage of edges for all formats. Building image, Fruits image and Rose image and Traffic image gives less numeral of edges for GIF, due to reduction in intensity value of pixels in GIF format.

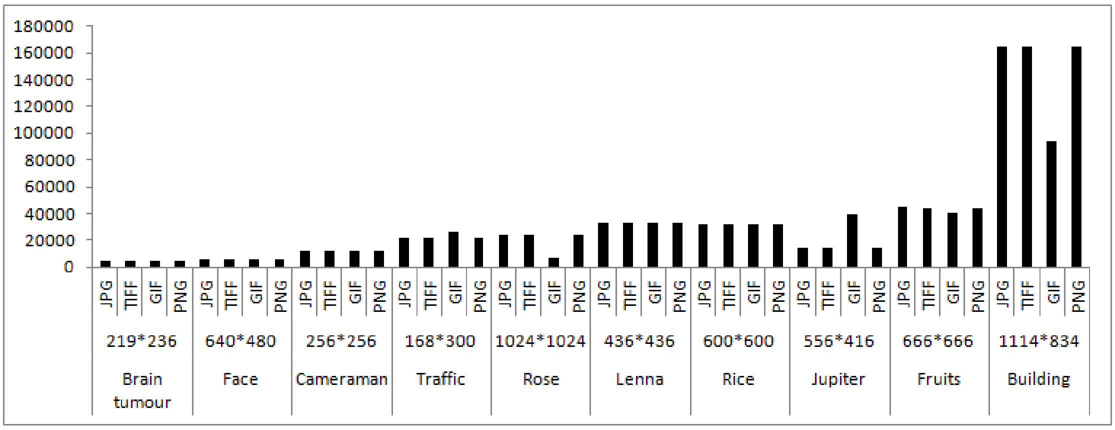


Fig. 5.31 Bar graph of total edges from INTFZLG2 with SOB

5.3.3 The outcome of the proposed technique i.e. INTFZLG2 with pseudo convolution mask (SPCM)

In FZLG1 and in INTFZLG2 with SOB operative, gradient along parallel and in vertical direction is determined by employing sobel but in proposed technique gradients along parallel and vertical direction is determined by employing pseudo convolution mask (SPCM). The rules and input values are same for INTFZLG2 with SPCM as in FZLG1 and FZLG2 with SOB. The complete procedure is coequal with FZLG2 with SOB except the mode of finding gradient magnitude.

5.3.3.1 Outcome edge images of proposed technique (INTFZLG2 with SPCM)

The proposed technique i.e. INTFZLG2 with SPCM is implemented on ten different images with different sizes. Fig.5.32 shows all the ten parent images. Fig. 5.34 shows the edge images of the original images. The total numeral of edge pixels and the percentage of edge pixels for the entire ten images are represented in the table 5.6. The table also represent the total time taken by the INTFZLG2 with SPCM, in order to give the outcome of all the images with different formats.

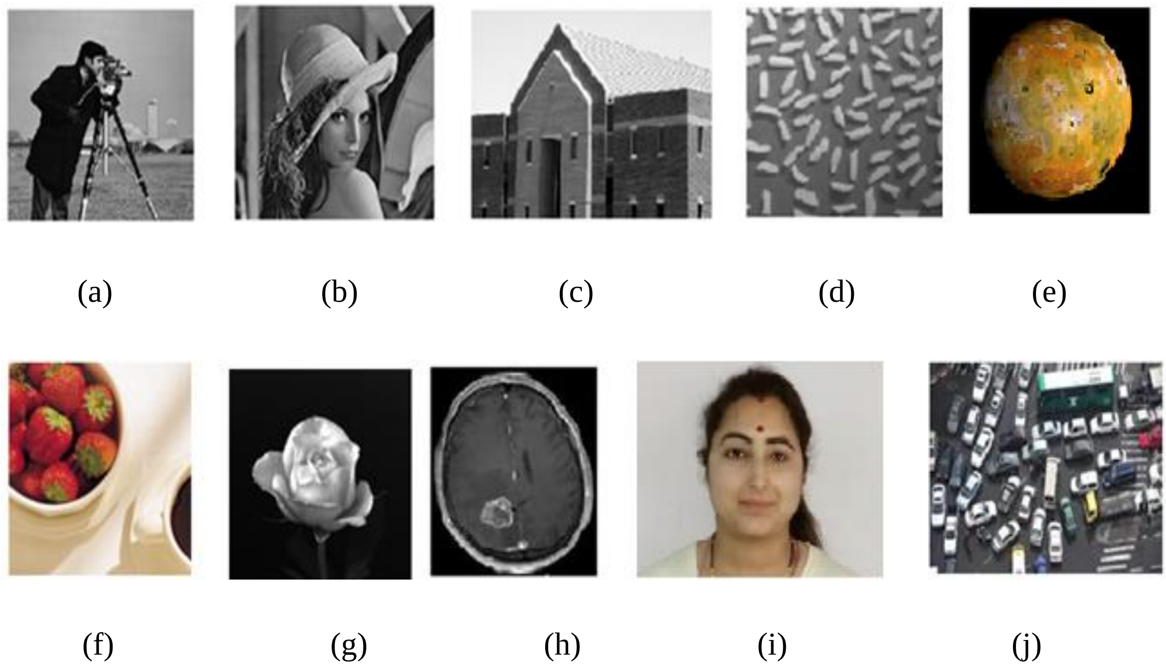


Fig. 5.32 (a) Cameraman (b) Lenna (c) Building (d) Rice (e) Jupiter (f) Fruit (g) Rose (h) Brain tumour (i) Face (j) Traffic

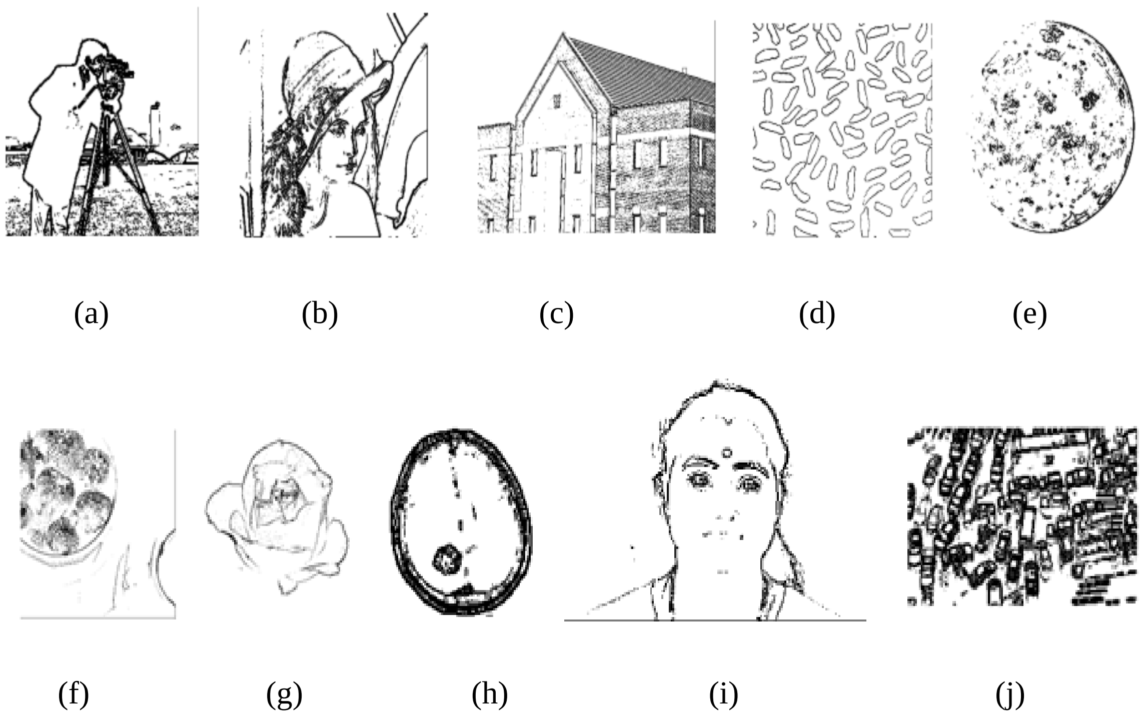


Fig. 5.33 (a) Cameraman edge image, (b) Lenna edge image, (c) Building edge image (d) Rice edge image, (e) Jupiter edge image, (f) Fruit edge image, (g) Rose edge image

Table 5.6 Outcome of the proposed technique (INTFZLG2 with SPCM)

S.no	Image	Size	Format	Edges	Time	Edge%
1	Cameraman	256x256	JPG	**12773**	**7.682313**	**19.49**
			TIFF	12725	7.051662	19.41
			GIF	12771	7.548249	19.48
			PNG	12771	7.286633	19.48
2	Lenna	436x436	JPG	**33871**	**10.46346**	**17.81**
			TIFF	33870	10.82223	17.81
			GIF	33870	10.7483	17.81
			PNG	33870	10.40156	17.81
3	Building	1114x834	JPG	166257	32.63901	17.89
			TIFF	166477	32.65132	17.91
			GIF	94687	31.14025	10.19
			PNG	**166477**	**30.55791**	**17.91**
4	Rice	600x600	JPG	**33094**	**15.64019**	**91.92**
			TIFF	32337	15.91782	89.82
			GIF	31564	15.51495	87.67
			PNG	32337	15.5406	89.82
5	Jupiter	556x416	JPG	15042	11.25157	6.5
			TIFF	14985	11.6395	6.47
			GIF	**39543**	**11.80939**	**17.09**
			PNG	14985	11.42478	6.46
6	Fruits	666x666	JPG	**46442**	**1.232673**	**10.47**
			TIFF	46101	1.743651	10.39
			GIF	44102	15.56977	9.94
			PNG	46101	15.57986	10.39
7	Rose	1024x1024	JPG	**24710**	**27.68979**	**2.35**
			TIFF	24589	28.57706	2.34
			GIF	6540	28.2389	0.0062
			PNG	24589	28.3157	2.34
8	Brain tumour	219x236	JPG	4085	4.610322	7.9
			TIFF	4090	4.505235	7.91
			GIF	4089	4.622414	7.91
			PNG	**4090**	**4.27317**	**7.91**
9	Face	640x480	JPG	**5799**	**12.41835**	**1.88**
			TIFF	5797	12.57272	1.88
			GIF	5797	12.80086	1.88
			PNG	5797	12.45412	1.88
10	Traffic	168x300	JPG	**22667**	**5.768568**	**44.97**
			TIFF	22664	5.843288	44.97
			GIF	26876	5.775866	53.32
			PNG	22664	5.573141	44.96

5.3.3.2 Graph of the proposed technique (INTFZLG2 with SPCM)

The bar graph of total edge percentage of all the ten images with different formats that are, JPG, TIFF, GIF and PNG is in fig. 5.34. In this, the cameraman image, Lenna image, Tumour image and Face image display no variation in the outcome for all formats with same edge percentage. On the other hand Building image, Rice image, Fruits image, Rose image and Traffic image display variation in the outcome. Rice image gives different numeral of edges for all the formats. Building image, Jupiter image, Rose image and Traffic image shows variation in GIF format.

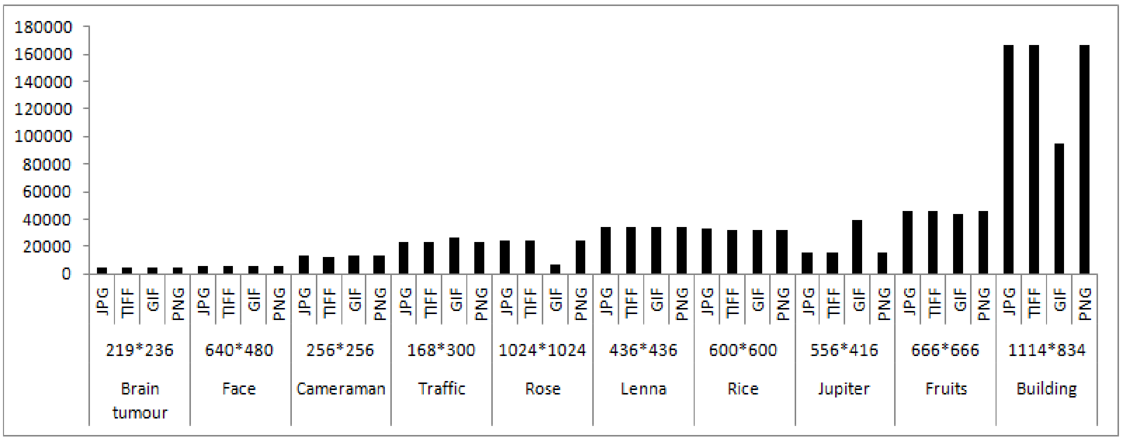


Fig. 5.34 Bar graph of total edges from INTFZLG2 with SPCM

5.3.4 Comparison of FZLG1, INTFZLG2 with SOB and the proposed technique (INTFZLG2 with SPCM)

The proposed technique (INTFZLG2 with SPCM) provides more desirable results as compare to INTFZLG2 with SOB. For the similar images, the proposed technique presents finer and clear edges as compare to INTFZLG2 with SOB. The SPCM allot more weights during convolution of image with gradient image as compare to SOB and provide more desirable edges than SOB. In order to accomplish a judicial comparison between proposed technique and INTFZLG2 with SOB, It can be examine from the graph 5.35, the proposed technique provides more numeral of edge pixels than ITFZLG2 with SOB for all images.. Cameraman image, Lenna image, Building image, Rice image, Jupiter image, Fruits image, Rose image, Brain tumour image, Face image and Traffic image with all the formats. Thus, the proposed technique is more preferable than INTFZLG2 with SOB.

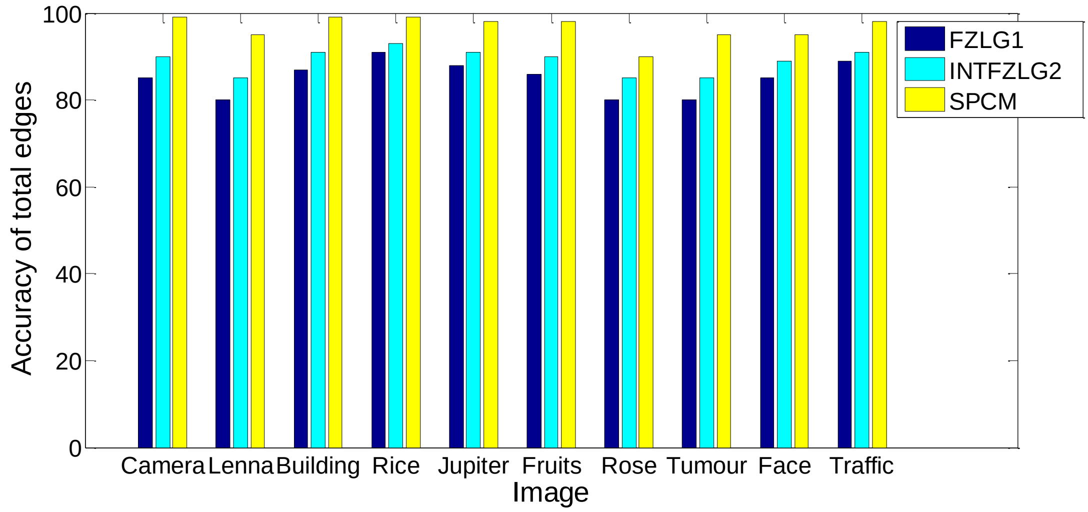


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Fig. 5.35 Comparison of FZLG1, INTFZLG2 and the proposed method

Histogram parameter also utilized to compare the result of INTFZLG2 with SOB and the proposed technique (INTFZLG2 with SPCM). Histogram plot is computed separately for both edge images obtained by using INTFZLG2 with SOB and from proposed technique. The histogram plot shows the range of gray tones corresponding to each image along y-axis and the frequency in which the gray tone appears as pixel with each tone is shown along x-axis. The histogram plot for INTFZLG2 with SOB is shown in fig. 5.36 and the histogram plot for the proposed technique (INTFZLG2 with pseudo convolution mask) is shown in fig. 5.37.

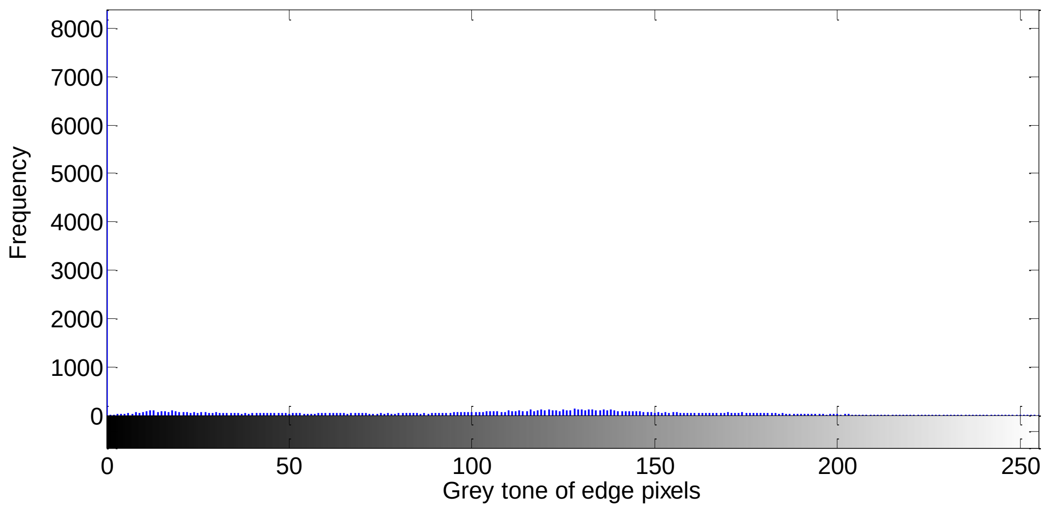

Fig. 5.36 Histogram of INTFZLG2 with SOB

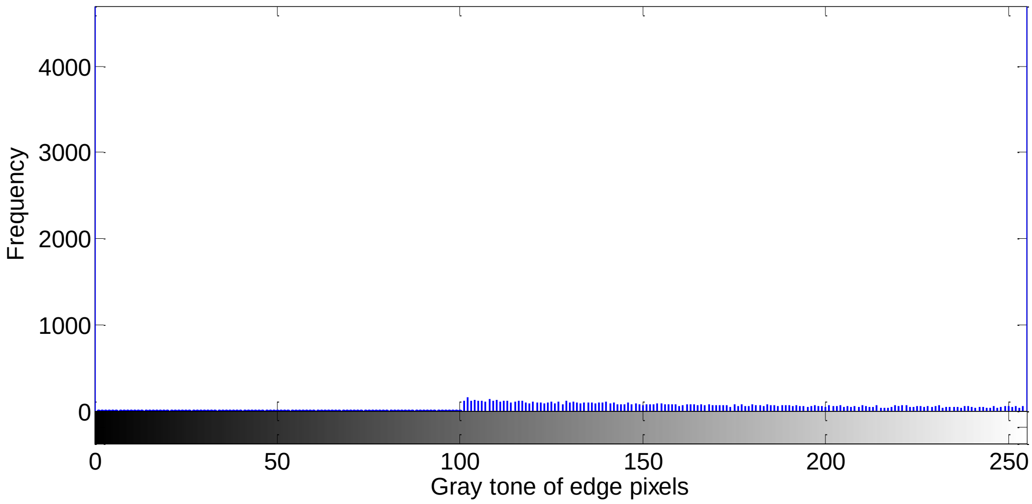

Fig. 6.37 Histogram of the proposed technique

From figure 5.36, INTFZLG2 with SOB gives edges by taking the tone around 0 to 200, as a result of this the appearance of edges are not good but the proposed technique gives edges from very complete form, taking the tones from 50 to 250 as shown in figure 5.37. Thus, ITFZLG2 with SPCM eliminates every pixel that is out of the range between 50 and 255 and provides good quality edges.

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6

CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

In first section, three distinct edge tracking techniques are applied using FZLG. These techniques are SFED, TFED and FZYIFS. The SFED, TFED and FZYIFS are very smooth and short but very efficient techniques to compress the concept of artificial intelligence and in processing of image. These three fuzzy rule based algorithms recover all edges from the image. The applied techniques can be utilized in numerous areas. At the end, a comparison is elevated for all the three techniques. FZYIFS is supreme beyond all techniques, as FZYIFS can preserve the purity of proven information. FZYIFS is having exactness of locality of images. Further, the FZYIFS method has less computational complication than the SFED and TFED and takes less time for edge detection.

In second section, FZLG1 and INTFZLG2 are implemented for tracking of edges and a comparison is performed between them. The proposed technique, employ INTFZLG2 with SPCM. These techniques are implemented on ten different images. The images are Lenna image, Cameraman image, Rice image, Building image, Jupiter image, Traffic image, Face image, Rose image, Fruits image and Brain tumour image. “with disparate formats i.e. JPG, TIFF, GIF and PNG. The proposed technique provides more desirable results than FZLG1 and INTFZLG2 for all images. Comparison on the basis of distinct parameters delineates that the proffered technique gives more preferable outcome.

6.2 Future Scope

In future, tracking down of edges can be implemented by employing generalized FZLG2 with SPCM. The technique can also be implemented for applications like tracking of weapons, verification of fingerprints etc.

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