



# A Hybrid Method for Edge Detection Using Fuzzy Rules and Coordinate Logic Operators

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*Abstract— Edge Detection Has Been One of the Most Prominent Issues in Image Processing. in This Study a Novel and Hybrid Method Is Proposed Based on Fuzzy Rules, Coordinate Logic Operators and Canny Operator. Using Fuzzy Rules, Image Pixels Are Assigned to Three Different Sets Including black, White and Edge. This Operation Improves Performance of Canny Operator. The Results Are Further Improved Using Coordinate Logic Operators. in This Study Results of the Proposed Hybrid Method Are Compared To Its Counterparts While Different Images with Various Brightness Modes Are Tested. The Results Reveals That the Proposed Method Is Much More Efficient in Edge Detection.*

*Keywords: Edge Detection, Coordinate Logic Operator, Canny Operator, Fuzzy Logic, Machine Vision*

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## 1. Introduction

The Most Essential Step Is Each Machine Vision System Is Extracting Key Features of Image. Feature Extraction Is Performed Based on Edge Detection. Edge Detection Is Referred To A Set of Mathematical Operations Which Are Followed To Determine Points Where Brightness Variations Are More Significant Comparing To Other Points of the Image. the Main Goal of Image Processing Is Simplifying and Minimizing Image Data So That More Process and Analysis Are Possible (Ziou,1998). Edge of An Object Is Rarely Located on Pixel Boundaries. So, Sub-Pixels of the Image Must Be Investigated To Achieve Appropriate Edge Detection. Edge Detection Is Mostly Applied in Biomedical Images, Remote Sensing and Satellite Images (Lee, 2015).

There Are Several Methods for Edge Detection Which Might Be Divided into Several Groups: 1- Edge Detection Based on First and Second order Derivatives Such as Sobel Operator (Sobel, 1970), Roberts Operator (L. G. Roberts, 1965), Prewit Operator (Prewit, 1970) and Laplacian Operator. These Operators Perform Convolution Using Different Masks on the Image. They Are Extremely Noise Sensitive. 2- Edge

Detection Using Optimal Operators Such as Canny Operator (Canny, 1986), Marr-Hildreth (Marr,1980) and Rakesh (G. Chi, 1980). 3- Other Methods Including Fuzzy Logic Based Methods (D. L. Zhan, 2001) and Neural Networks (Bezdek, 1991); However, None of These Schemes Are Comprehensive and They May Encounter Problems for Specific Noises. in Most Methods Which Have Been Proposed for Edge Detection Based on Fuzzy Logic, Fuzzy Base Rule Method Is Utilized. in These Methods, Neighboring Nodes of Each Point Are Considered as Classes. Fuzzy Inference System Is Implemented Exploiting Appropriate Membership Functions Defined for Each Class. for Instance in (Liang,2003) Neighboring Points Are Considered as 3\*3 Sets Around the Central Point. Then, Predetermined Membership Functions Are Employed To Detect Discontinuity in Group Color. the Mentioned Method Uses 5 Rules and Fixed Membership Functions for Edge Detection. These Rules Examine Color Discontinuity in the Vicinity of Central Point. if Difference Is Observed in A Class Its Centralpoint Is Considered as the Edge. Despite High Computational Complexity, Edge Detection Capability of This Method Is Relatively Low. A Similar Method Is Introduced in (Ziou, 1998) for Fuzzy Edge Detection. in This Approach, Points Neighboring Each Pixel Are Considered in the Form of Six Sets. Afterwards, Using Suitable Membership Functions (Which Are Assumed To Be Bell Functions) A Value Between Zero and One Is Set for Each Class. Subsequently, Fuzzy Base Rules Are Utilized To Determine Edge and Its Direction Based on Membership order of Each Class. the Most Prominent Point Which Must Be Taken into Account Is Computational Complexity and Large Number of Evaluation Rules in Fuzzy Inference System.

In the Paper At Hand, Fuzzy Logic Is Utilized for Edge Detection While the Minimum Number of Pixels Surrounding the Desired Point Are Exploited for Fuzzy Inference. as A Result Computation Complexity Issue of Previous Methods Is Addressed. Moreover, the Proposed Method Uses Coordinate Logic Operators To Eliminate Non-Edge Details as Well as Amplifying the Edge. Implementation of Coordinate Logic Operators Is Really Fast as They Process Image Bits in Binary Domain. Besides, They Properly Perform All Morphological Operations. Furthermore, Coordinate Logic Operations Are Flexible and Can Be Implemented Using Various Approaches.

### **Noise Removal/Elimination**

In This Step Appropriate Noise Removal Filters Are Exploited To Eliminate Image Noise. in This Study, Median Noise Removal Is Used To Eliminate Noise and Smooth the Image (Eng, 2001). Median Filter Removes Noise of Each Pixel According To Median of Its Surrounding Pixels. in This Paper A 3\*3 Mask Is Used for Median Filter Operation.

## **2. Edge Detection Algorithm**

When Brightness Varies Differently in the Vicinity of A Point It Is the Edge of Image. in Other Words, the Pixel Which Is Candidate of Edge Pixel Clearly Differs from Its Neighboring Pixels. To Detect These Pixels Fuzzy Rules and Fuzzy Inference Are Exploited. After This Step, Difference Between Edge Pixel and Its Surrounding Pixels Is Intensified. Canny Edge Detection Algorithm Provides Desirable Results After This Step as Pixels Which Are Not Probable To Be Edge Pixels Are Eliminated in Fuzzy Rules.

in This Study, Image Pixels Are Divided into Three Groups: 1) Black, 2) White 3) Edge. if Brightness in the Vicinity of A Pixel Is Close To White It Would Be Categorized as White. Inversely, if the Brightness Is Close To Back the Corresponding Pixel Would Be Categorized as Black. Finally, the Pixels Which Are Probable To Be Edge Are Selected as Edge Pixels.

The Input Image Is A Gray Image or Colored One (Which Will Be Converted To Gray One) and Brightness Is Scaled Between 0 and 255. Each Pixel Is Assigned To One of the Above-Mentioned Groups Using Fuzzy Inference and According To Membership Functions of Three Groups and 16 Defined Fuzzy Rules. in the Designed Fuzzy System the Whole Image Is Traversed Using A Quadrature Mask in the Vicinity of Each Pixel. Pixels Are Divided into Three Groups According To 16 Rules. the Mask By Which Image Is Traversed Is as Follows.

	P1	
P2	P5	P3
	P4	

Figure1. Mask for Traversing the Image

Figure 1 Depicts the Mask Used for Traversing the Image. P5 Is the Pixel Which Is Going To Be Categorized.

Four Inputs and One Output Are Considered for This Fuzzy System. for the Inputs Two Membership Functions (White and Black) Are Defined While for Output Three Membership Functions Including White, Black and Edge Are Defined. All Membership Functions Are Triangular Fuzzy Functions. Figure 2 Illustrates Membership Functions of Inputs (White and Black).

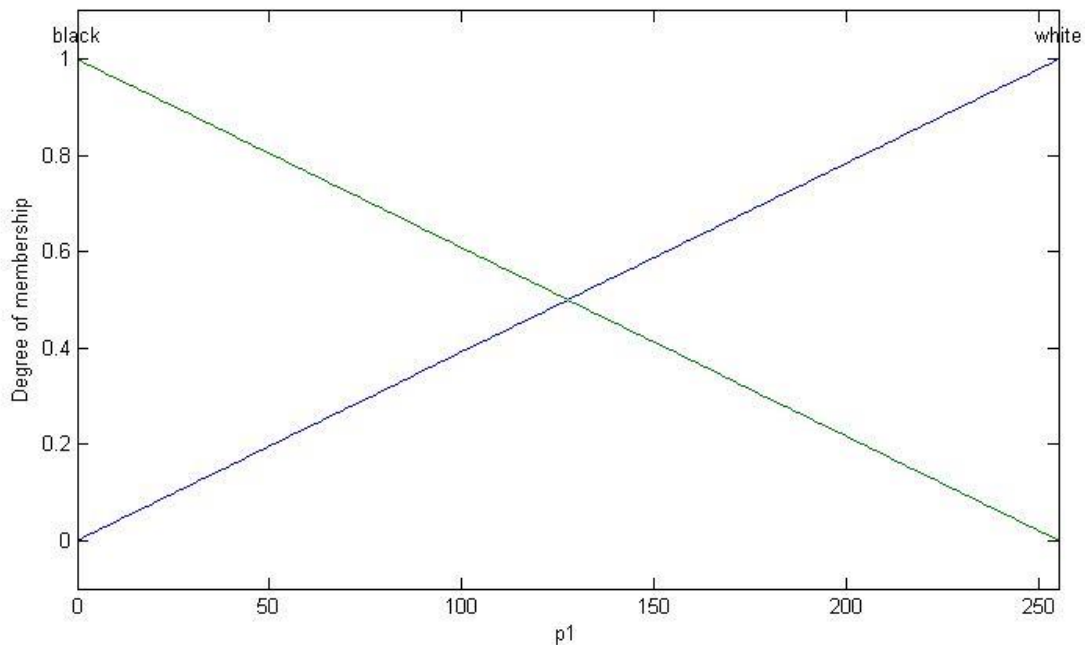


Figure2. White and Black Membership Functions for Four Inputs

For the Output Three Membership Functions Demonstrated in Figure 3 Are Utilized.

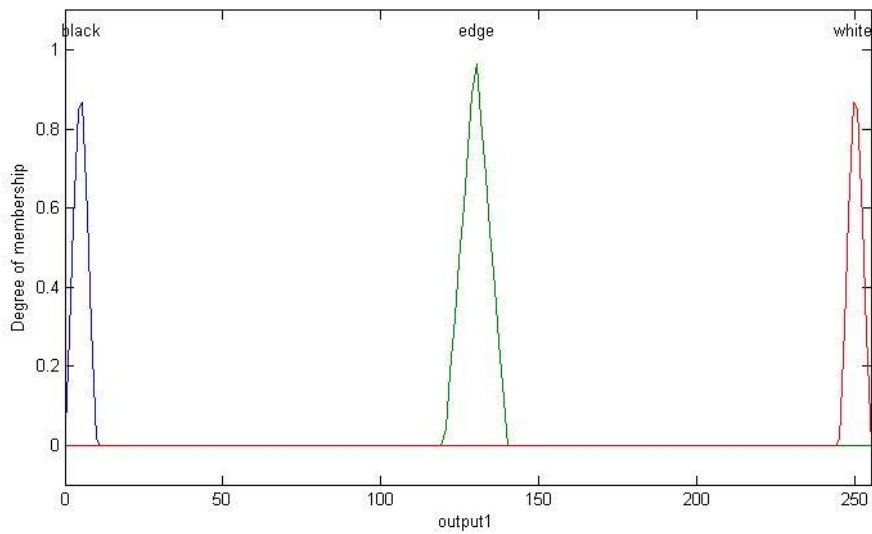


Figure3. Output Membership Functions

The Fuzzy Rules Are as Follows.

For Fuzzy Inference System Mamdani Implication Is Exploited. Parameters of Fuzzy Inference System Are Presented in Table1.

parameter	method
And method	Min
Or method	Max
Implication	Min
Aggregation	Max
Defuzzification	centroid

Table1. Parameters Used in Fuzzy Inference

The Next Step for Edge Detection Is Using Coordinate Logic Operators. To Amplify Edges and Filling Empty Pixels Erosion Operation Is Used.

### 3. Improving the Edge

Coordinate Logic Operators Are One of the Most Important Tools for Pattern Recognition and Image Processing. They Are Widely Used for Noise Reduction and Elimination of Binary and Gray Level Images, Filling Objects and Regions of the Image, Edge Detection and Medical Diagnosis. One of Their Applications Is Generating Various Filters for Specific Purposes. Coordinate Logic Filters Are A Group of Nonlinear Digital Filters Built Using Logic Operators (Tsirikolias, 1997). Their Effect on Binary Signals and Images Is Similar To Morphological Filters; However, They Are Faster for Gray Level Images. the Utilized Coordinate Logic Operators Used in Filters Consist of XOR, OR, AND and Their Combination. the Basis of the Proposed Models Is Generating Coordinate Logic Filters. Filters Are Constructed Based on

Relations and Characteristics of Logic Operators. Coordinate Logic Operation for Two Decimal Numbers (V and W) in Binary System Is Defined as Follows.

$$V \cdot W \quad 1$$

Where “.” Might Be AND, OR, XOR or Combination of These Operators. To Improve Edge in An Intelligent Manner I.E. Such That the Main Edge Is Amplified and Empty Points Are Filled, OR Operator Is Used. This Is Similar To Opening Operator in Morphology; However, After Fuzzy Inference and Edge Detection Opening Operation Is Performed Rapidly. Finally, Edges Are Detected Using Canny Edge Detection Algorithm. This Operation Is Called Coordinate Logic Filter. This Filter Combines the Number and Location of Some Pixels of the Desired Point in the Form of An OR Logic Operation. Then, the Results Are Substituted for Brightness of the Desired Point. in This Study Right, Left, Upper and Lower Pixels Are Utilized. Afterwards, CAND Operation Is Applied Which Is Somehow Similar To Erosion Operator in Morphology. in the Latter Operation Only Left and Upper Pixels Are Used. CAND Coordinate Logic Operation Converts Edges To Their Normal Status and Avoid Thick Edges.

#### 4. The Results of the Proposed Model

To Demonstrate Capabilities of the Proposed Model Different Images Are Tested. Examining the Images One May Find Out That the Proposed Model Eliminates Negligible Details Which Are Not Probable To Be Edge.

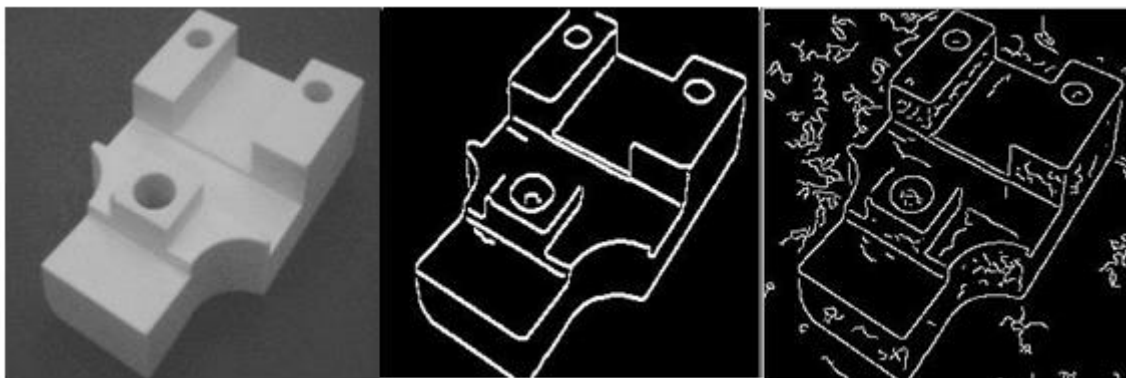


Figure4. Simulation Results, Middle Image (the Proposed Method), the Right One Is Canny Edge Detection

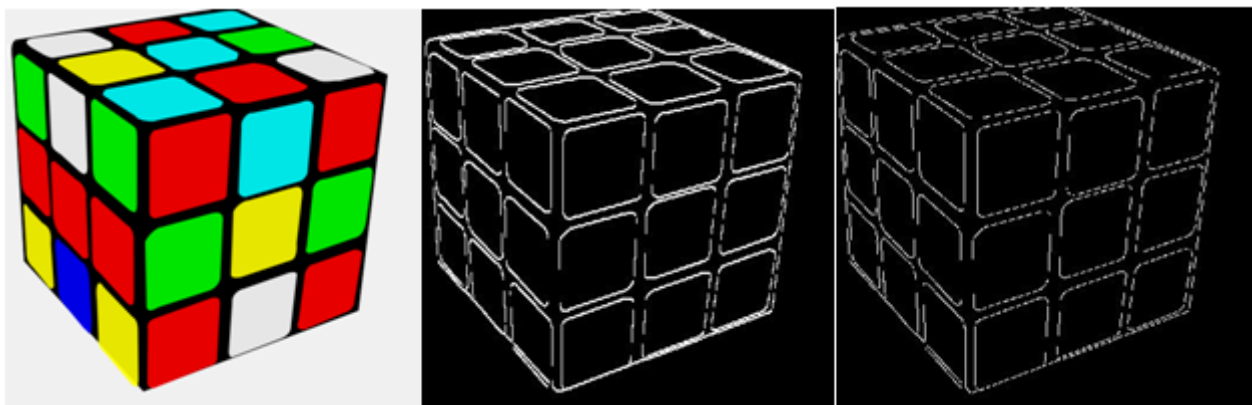


Figure5. Simulation Results, Middle Image (the Proposed Method), the Right One Is Canny Edge Detection

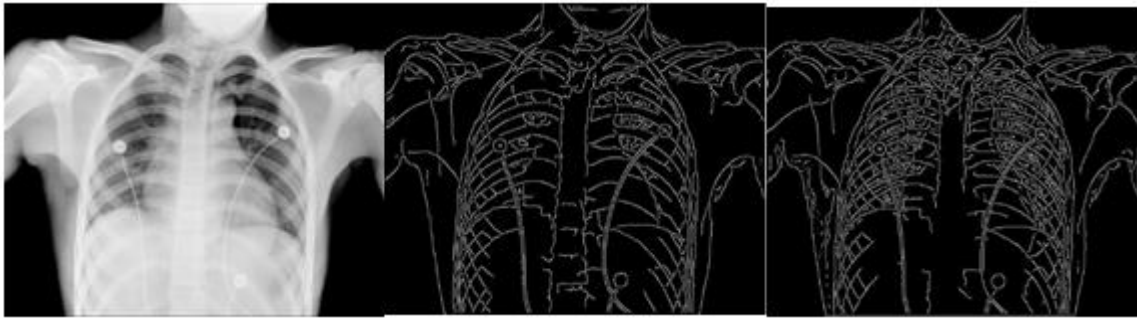


Figure6. Simulation Results, Middle Image (the Proposed Method), the Right One Is Canny Edge Detection

In Medical Images It Can Be Seen That Irrelevant Details Are Eliminated in the Proposed Method Which Is Appropriate for Medical Images.



Figure7. Simulation Results, Middle Image (the Proposed Method), the Right One Is Canny Edge Detection



Figure7. Simulation Results, Middle Image (the Proposed Method), the Right One Is Canny Edge Detection

In Figure 7 Which Is A Colored Image, It Can Be Seen That the Proposed Method Is Able To Properly Eliminate Noises and Small Details While Improving Main Edges.





Figure8. Simulation Results, Middle Image (the Proposed Method), the Right One Is Canny Edge Detection

## 5. Conclusion

In This Paper A Novel Method Was Proposed for Edge Detection Combining Fuzzy Logic and Coordinate Logic Operators. Simulation Results Revealed That the Proposed Method Is Suitable for Different Types of Images. The Proposed Method Was Tested for Different Images Including Medical Images and It Obtained Much Better Results Comparing To Canny and Sobel Algorithms. Coordinate Logic Operator Is A Proper Alternative To Morphology Owing To Its Flexibility. Even Two Pixels Surrounding the Desired Point Might Be Sufficient for Providing Acceptable Results. the Proposed Method Is A Suitable Method for Detecting Tumors in Mammography Which Might Be More Investigated in Future Research.

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