Adaptive edge detection via image statistic features and hybrid model of fuzzy cellular automata and cellular learning automata

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***Abstract*—in this paper a new approach for adaptive edge detection via image statistic features and hybrid model of fuzzy cellular automata and cellular learning automata is presented. Edge detection in image is one of the basic and most significant operations in image processing that edge detection have a lot of application in image processing. Presented method in first stage used of statistic feature of its image for primary edge detection, that cause adaptively for this method at all internal image. At the second stage fuzzy cellular automata and cellular learning automata are used for edges amplify and castrate these aren't edge. The result obtained from implementation shows That the performance of this method is much better Compared to other edge detection methods.**

Keyword- Cellular learning automata, edge detection, fuzzy cellular Automata, image processing, statistic feature

I. INTRODUCTION

The vast application of image processing in military and medical, cinema, engineer science cause to improv techniques in feature derivation of image .

Derivation feature of image make easy to show and analysis of image arena. Image edge detection is one of eatures, that it is very noteworthy. Different approach are used for edge detection in machine vision and image processing such as gradient operator[1], edge detection with edge detection synthetic methods[1,2], Cellula automata [3,4,5] cellular learning automata[6,7].

These methods that presented in past have an objection these are parametric and for different edges illustrating depended to a particular parameter. This paramete represents accuracy of edges.

In this paper used one process with 3 stages, for high quality edge detection. at the first stage via variance feature appear edges of original image[8] that this feature achieved of internal image's pixels gray level.

At second stage via fuzzy cellular automata determined potency of adaptive function for edge pixels and these aren't edge. at last Learner cellular automata used for amplify weakened edge and castrate these aren't edge that amplified in before stage.

In fact cellular learning automata are model of systems that these systems have simple component and behavior of each component is in the base of neighbor's behavior and last experience of it.

Section 2 introduces some preliminary definitions of Cellular Automata, Cellular Learning Automata, and Fuzzy Cellular Automata. It also explains the edge detection method . Section 3 describe the proposed algorithm in detail. Section 4 presents the experimental results and section 5 draws conclusion and talks about some suggestions for Future research in this area.

II. CELLULAR AUTOMATA

A. Cellular Automata

Cellular Automata (CA) are discrete dynamic systems whose behavior is completely based on Local relations. A cellular automaton consists of a grid of cells; each of them is in one of the finite number of states. In CA, the time is also discrete, and the state of a cell is a function of the previous states of its neighbor cells. A uniform rule is applied to each cell and its neighbours and each time it is applied, the new states of cells are generated [9].

B. Cellular Learning Automata

The Cellular Learning Automaton (CLA) is a mathematical model for modeling dynamics of a complex system which consists of a large number of simple components. In fact a cellular learning automaton is a CA in which every cell is equipped with at least one learning automaton. The Learning Automaton (LA) has a finite se of actions and its goal is to learn which action in this set is the optimal action. Like CA, there is a uniform local rule applied to the cells and based on this rule the selected action gets a reward or a penalty. If the learning algorithm is chosen properly, the iterative process of interacting with the environment can result in selection of the optima action in every cell [10].

C. Fuzzy Cellular Automata

Fuzzy Cellular Automaton (FCA) is a CA in which fuzzy logic is applied to the states of the cells and transition functions. There are some definitions for FCA [11]. The latest one was proposed by Meybodi and Anvarinejad [12]. In FCA, the states of cells are linguistic variables and

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the transition functions are fuzzy rules. The linguistic variables are determined based on our knowledge of the problem. The next state of each cell is determined by transition function. The current state of each cell and its neighbours are the input arguments of the transition function. The transition function is a uniform fuzzy function that takes the membership values of the neighbor cells and calculates the value of Membership of the next state. The membership Values of linguistic variables which represent the State of cells are used to present the evolution of FCA during the process. The set of neighbor cells is uniform and fixed during the process.

III. PROPOSED METHOD

In the image that different pixel's intensity of light is near together or in order hand image is steady, these images have a little edge such as sea's image or sky's image and in image with different pixel's intensity of light; it has a lot of edge. These subject explain the statistic description that if a image has a little edge its variance of pixels gray level is low and if a image has a lot of edge its variance of pixels gray level is high.

This feature can use for edge identification. For finding edge with image variance is used MOR neighborhood of one pixel(Fig. 1).

P1	P2	P3
P4	P	P5
P6	P7	P8

Figure1. MOR neighborhood for P pixel

In this neighborhood, obtained variance for all pixels of image and mount of variance in MOR neighborhood replaced with centric pixel (P). At the end each pixels variance of MOR neighborhood considered as image edge of original image. Result of this method illustrate in 3 sample image.

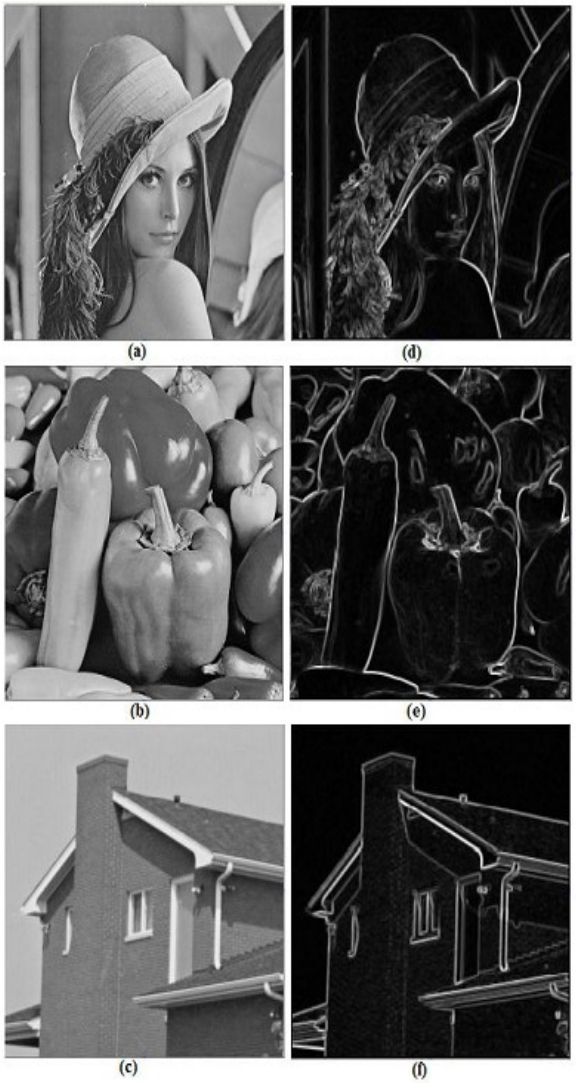

Figure2. (a,b,c) original image, (d,w,f) edge image with variance feature

Edges that generated with this method have high quality but fundamental infirmity of this method is existed of background of something that it isn't edge in edge image.For removing this background can use of optimizes function that this function will amplify edge point and castrate another point that aren't edge. this function will be describe as following formula that I(i, j) identify one pixel's of obtained image in first stage.

$$F(i,j) = \sqrt{I(i,j)^c}, c \text{ f } 2 \qquad (1)$$

C Adjusting is difficult in this function because for all pixels C will be bigger than 2 (C>2) this thesis cause any edge point and another point will be big in same scale.

For better work this function mount of C must be beg for pixels on the edge and for another pixels it must be small. For C determine used of fuzzy cellular automata. The rules

of this automaton have adjusted that it proportion with mount of each pixel edge.

In this method to determine the extent of belonging a pixel to an edge in an image with the dimension of M ×N a fuzzy cellular automata with an M line and N column is used. Each cell of fuzzy cellular automata is put on an image pixel. by running 32 rules Each automaton will finally decide whether and to what percent the overlapping pixel is belonged to that edge. The neighboring MOR is utilized To determine the extent of a pixel edging.8 different positions in the neighboring MOR are considered and in each of these positions the value of αi and βi are measured and 4 fuzzy rules are determined for them and the final status pixel is summed up regarding to the 32 rules in rule base.(fig. 3)

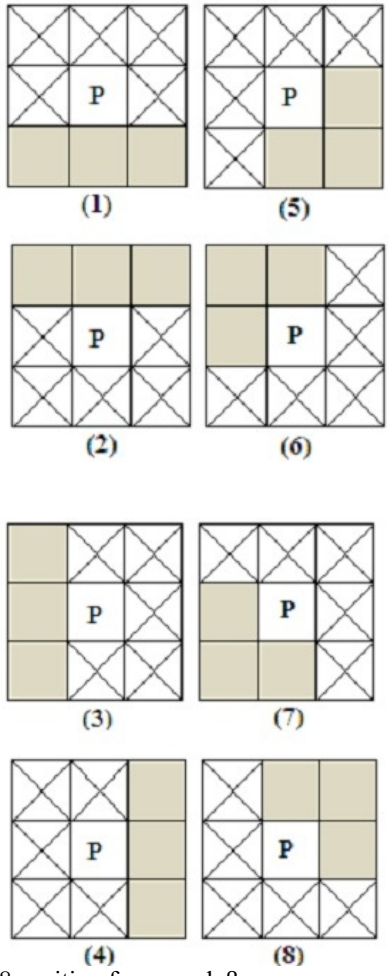

Figure3. 8 position for α_i and β_i

In all the above positions the crossed and filled cells are used to measure the αi and βi values respectively. To measure the α1 and β1 in each of the 8 positions in figure 4 the following formula is used.

$$\alpha_1 = \left(\left|P - P_1\right| + \left|P - P_2\right| + \left|P - P_3\right| + \left|P - P_4\right| + \left|P - P_5\right|\right)/5$$

$$\beta_1 = \left(\left|P - P_6\right| + \left|P - P_7\right| + \left|P - P_8\right|\right)/3 \qquad (2)$$

the same way is utilized to measure all values from α 1 to α 8 and β1 toβ 8 and then considering input and output membership function in (fig. 4), 4 fuzzy rules are described for each of the previously measured As and Bs and finally there will be 32 rules in the rule base.

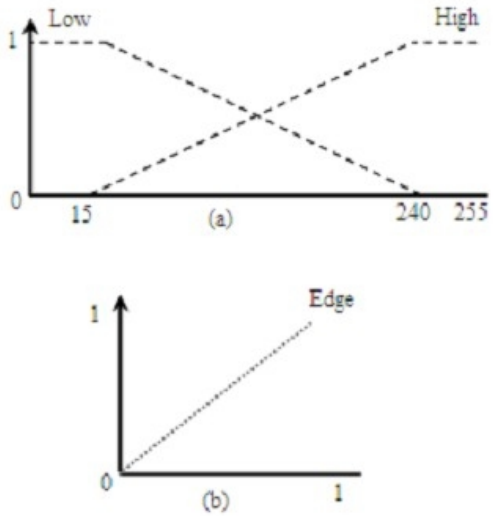

Figure 4. a)input membership function, b)output membership function

Rule base for α_1 and β_1 is shown in table1.

Table1. Rule base for α_1 and β_1

IF	THEN EDGE
α_1 Low and β_1 Low	NO
α_1 Low and β_1 High	YES
α_1 High and β_1 Low	YES
α_1 High and β_1 High	NO

These 4 rules are used for all the other αi and βi and regarding to the 32 measured rules the percent of edging is calculated in the following formula.

$$\text{final C value} = \text{minimum C value} + \text{output membership value} \times 2$$

Note: In this paper the maximum and minimum C values are 4 and 2 respectively. The determine of C value with the fuzzy cellular automata is shown in Fig 5.

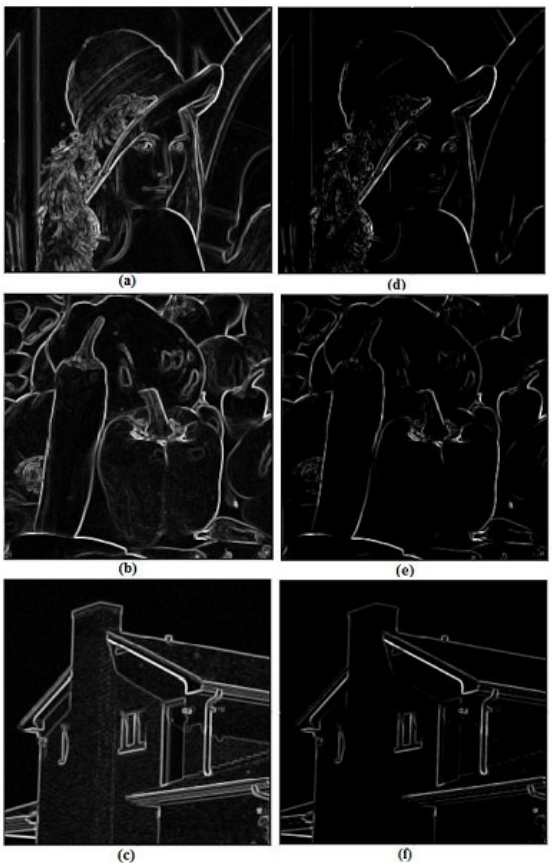

Figure 5. (a,b,c) edge image with variance feature, (d,e,f) edge image with fuzzy cellular automata

The last stage of this proposed method is committed to the improvement of the previously measured edging. In this stage It is tried to improve the image edges and deemphasize the extra pixels .the partly damaged image edges will be also repaired. to reach the mentioned goals, a cellular learning automata A with 2 learning automatons ()will be used in each cell of the image. The following rules is run for each cell:

1. Each cell of cellular learning automata is put on one pixel of image.
2. A probabilistic vector with two values (EDGE, NOT EDGE) is determined to each automaton.
3. The initial value to each vector is done by the pixel gray level and the average value of the image.

$$\text{Edge} = \frac{\dfrac{\text{Gray Level of pixel}}{\text{Average Gray Level of Image}}}{\text{Max}\left(\dfrac{\text{Gray Level of Image Pixel's}}{\text{Average Gray Level of Image}}\right)}$$

$$\text{Not Edge} = 1 - \text{Edge}$$

4. Each pixel's neighboring MOR is searched to count the number of the pixels which selected the edge order. If the counted number is between 2 and 4 and the pixel itself selects edge order, the EDGE will be rewarded and the NOT EDGE will be fined. Otherwise, the EDGE will be fined and the NOT EDGE will be rewarded.
5. The proposed method is ended when the result of the deducted Entropy of one stage from the former one is less than a defined value.
6. Finally the order with the highest probability is selected as the pixel order.

The results of the use of cellular learning automata are shown in fig 6.

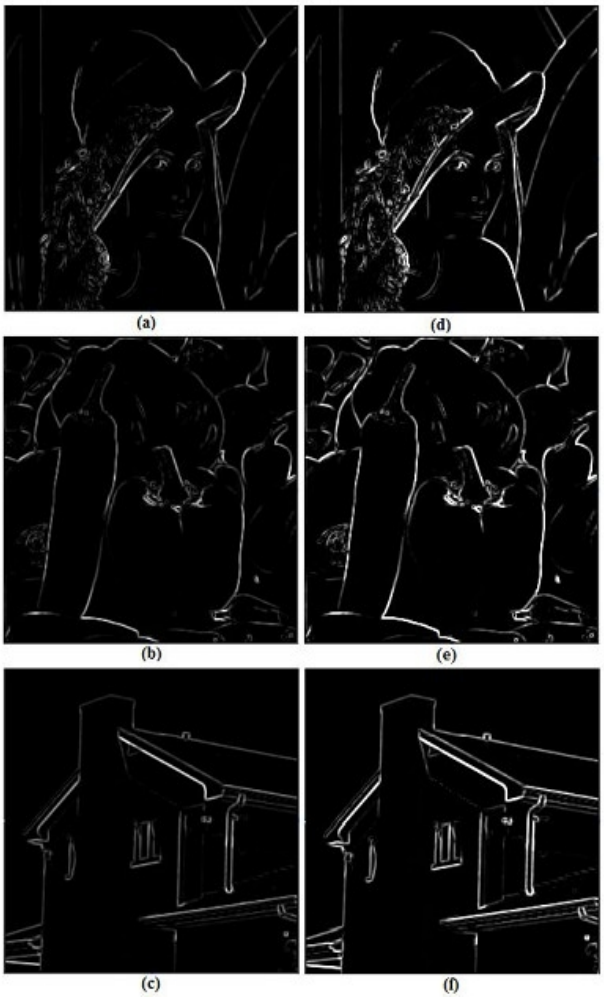

Figure 6.(a,b,c) edge image with fuzzy cellular automata, (d,e,f) edge image with cellular learning automata,

IV. . EXPERIMENTAL RESULTS

To evaluate the performance of the proposed method several experiments have been conducted. In the first

Experiment at section one study effect of C in 1 formula with fuzzy cellular automata, in the second experiment in section two compare proposed method with Robert and Sobel edge detection methods.

A. effect of appoint amount of C with Fuzzy cellular automata

In this section, study effect of variant C in formula 3. Figure a.7 is internal image and figure b.7 generate of extract edge with statistic variance feature. In next stage once we put figure b.7 with C=3 in formula 1 and edge detected with proposed method, obtained result illustrated in figure c.7 and d.7. As observed in figure d.7 edge is thinner than figure c.7 and it have best quality. Also other edge and background of original image in figure d.7 is lower than figure c.7.

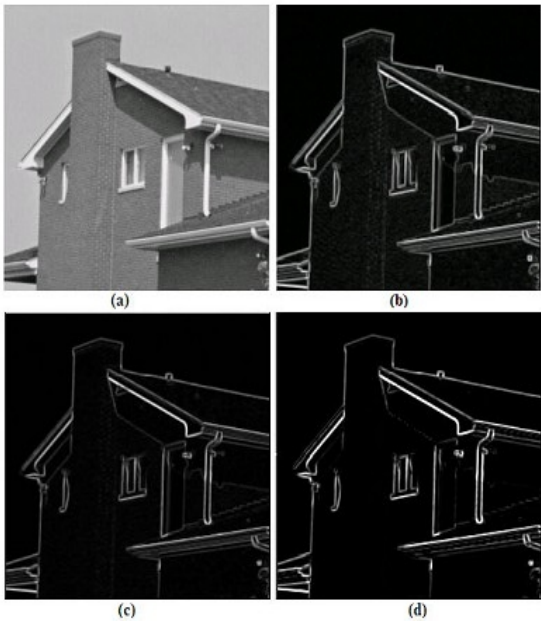

Figure7. (a) Original image, (b). edge image with variance feature, (c).static value of C=3, (d). determined potency of C with proposed method

B. compare proposed method and Robert and sobel edge detection method

For evaluate proposed method, it compares with two common edge detection methods and result illustrate in fig 8. Figure 8.b obtained of Robert edge detection[1] and figure C.8 obtained of Sobel method[1] and figure d.8 obtained of proposed method on figure a.8. As figures b.8 and c.8 show, obtained images of edge detection with Robert and Sobel method contain background of original image and other edge whereas edge detection with proposed method are solved this problem somedeal.

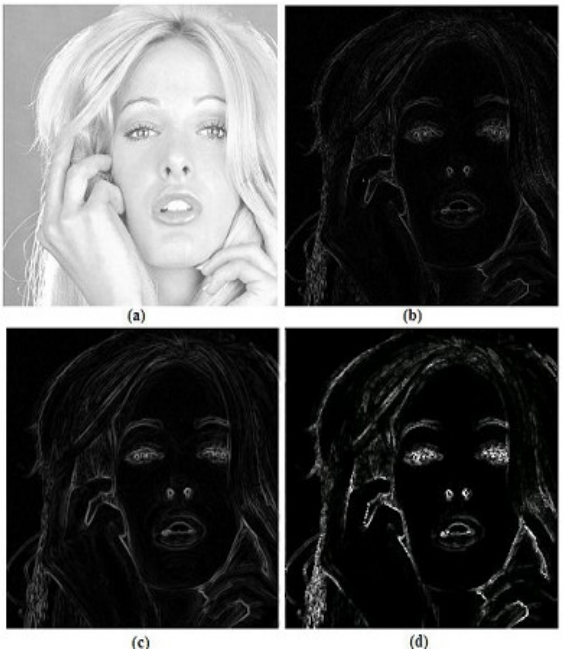

Figure8. (a) Original image, (b). edge image with Robert method, (c). edge image with Sobel method, (d). edge image with proposed method

V. CONCLUSION

in this paper presented a method base on variance statistic feature for edge detection. Because using of feature of internal image as an adaptive method with internal image. External images that generated with this method have best quality of edges detection and these have backgrounds of original image but that cause infirmity for this method. Solution for that in two stage process, at first we used of fuzzy cellular automata and so cellular learning automata. Fuzzy cellular automata used for finding amount of C in 3 formulas. Learner cellular automata used for final amplify at related point to edge and castrate another point that these aren't edge. Earned result especially for second stage show that C parameter adjusting with fuzzy cellular automata presented significant result.

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