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Full Length Research Paper

New method for edge detection and de noising via fuzzy cellular automata

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In this article, a new method is presented for eliminating noise and for detecting image edges through the use of fuzzy cellular automata. The algorithm based on the proposed method is used for edge detection in Gray level images and for noise elimination in images containing salt and pepper noise. In this method, eight specific contiguity states are considered for each pixel and sixteen numbers are derived from these states. These numbers are used as input for the fuzzy member ship function. The fuzzy rule base is constructed in such a way as to correctly recognize the state of each pixel. The ability to detect edges in different directions and to determine suitable edges in noisy images are among the advantages of the proposed method. In comparison to common methods of edge detection, like the Sobel and the Robert methods of edge detection and the mean-filter and the median-filter methods of noise elimination, our proposed method shows a higher efficiency.

Key words: Fuzzy cellular automata, image processing, noise elimination, edge detecting.

INTRODUCTION

The great expansion of image processing in military, medical, cinematic, and engineering science applications has caused the expansion of the techniques of extracting features of images. Through the extraction of image features, the process of presentation and interpretation of image scenes are facilitated. Image edge recognition and image noise elimination are among the features which are of great interest.

In machine vision and image processing , through the use of some mathematical operations such as edge recognition by gradient (Gonzales and Woods, 1995) or by employing suitable filters , it is possible to extract features of the image like the edges, the lines , the curves , the angles , and the boundaries. Extraction of these features facilitates the presentation and interpretation of image scenes.

The current methods of extracting image features are sensitive to noise, and for this reason noise elimination is carried out before the extraction of image features so as to improve the quality of the image. Noise is classified into the two types of independent and dependent noise. An independent noise is not dependent on the intensity of the signal, like the noise in image transmission channels or the noise added to the image by the camera, while in a dependent noise the noise added to each point of the image, like the quantization noise and the salt-pepper noise. Ideally, it is expected that noise elimination from the image will not bring about the loss of details and information present in the image. Many of the available filters like the mean filter (Gonzales and Woods, 1995) or the median filter (Gonzales and Woods, 1995), while eliminating noise from the images, because the image to be blurred and to lose part of its information; and the process of edge detection will also become substantially more difficult due to the blurring of the image. among the common methods of edge detection we can refer to classic edge detection methods, such as the Sobel and Robert methods (Gonzales and Woods, 1995), in which the maximum local gradients of the image are used s a representative of the image edge detection based on the morphology and the physics (Maragos and Pessoa, 2004;

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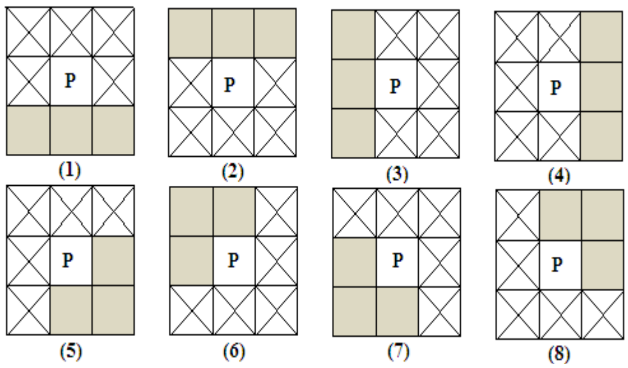

Figure 1. Mask FCA on pixel of image.

P1	P2	P3
P8	P9	P4
P7	P6	P5

Figure 2. Moor contiguity.

Elder and Sachs, 2003) of the pattern, cellular automata (Sahota et al., 2005; Yang et al., 2007; Popovici and Popovici, 2007), and cellular learning automata (Hosseine and Meybodi, 1386; Marchini and Meybodi, 2005) are also among the very act-used methods of detecting edges. All of these methods need a completely noise-free image to detect edges and they do not yield a satisfactory output for images which are a little noisy.

In this article, a new method is proposed for noise elimination and edge detection of images in which the processes of noise elimination and edge detection are carried out simultaneously. The fuzzy cellular automata can perform operation in parallel, and it has the ability of fuzzy processing of operation the use of this tool yields substantial results in noise elimination and in edge detection. In this method, fuzzy cellar automata with 32 rules are used for noise elimination and for edge detection. These rules are derived from eight of the states of the Moor contiguity of a pixel. Advantages of the method presented in this article include simultaneous noise elimination noise elimination and edge detection and the detection and the determination of edges based on their directions.

Fuzzy cellular automata

Due to the ability of fuzzy logic in processing nondeterministic data structure a cellular automata is introduced in which, instead of using deterministic data on cells and their transmission functions, non-deterministic and fuzzy data is employed. Different definitions of fuzzy cellular automata have been offered (Nasri and Nezam, 1385; Ross, 1997). In fuzzy cellular automata, the set of the states of a cell and its local transmission (lie, the rules) are fuzzy. The set of the set of the states of a cell makes up the linguistic variables which are determined by taking into account the available information about the problem. The state of each cell in the next stage depends on the current activity of the cell and on the current states of it, neighbors. This change in the state of the cell is brought about according to the function of local transmission of fuzzy cellular automata. The local transmission function is a fuzzy function, it is the same for all cells, and it uses the membership value of the contiguity of the cell and calculates this membership value for the next stage. The value of membership of the linguistic variables of the cell at each moment is used to represent the evolutionary trend of fuzzy cellular automata, and the variable is used for representing the output of a cell in each stage. Continuity is the same for all cells and remains constant over time.

Fuzzy cellular automata can be represented as a quartet (z, s, r, f) in which Z is a regular grid having N dimensions, S is the set of the states from among which each cell can choose as state at each stage, [0-1] is the interval for membership values of this set, R $\in$ N is the radians of contiguity, and $f: S^{2r+1} \to S$ is the function of fuzzy transmission.

Proposed method

The main purpose in this article is to eliminate noise and to detect image edges by using the unique features of fuzzy cellular automata. In the method, for noise elimination and edge detection in an $M \times N$ image a two-dimensional fuzzy cellular automaton with M lines and N columns is used. Each pixel of the image is mapped on one cell of the fuzzy cellular automata (Figure 1), then each cell, depending on its current state and the statues of the cells present in the Moor contiguity, and through the execution of 32 fuzzy rules, finally decides to which of the three classes of noise, edge, or back ground pixels the pixel corresponding to the cell it belongs. To determine the state of each pixel, eight different states in the Moor contiguity are defined (Figure 2). For each of the eight states in Figure 3, one value represented by the symbol a_i from the colored cells are obtained; and the index I shown by the symbol B_i from the colored cells are obtained, and the index I shows the specific state from among this eight states.

To calculate the a value of each state the mean of the subtractions of the Gray level of the pixel in the crossed cells from that of pixels in the mid-cell, and to calculate B the mean of

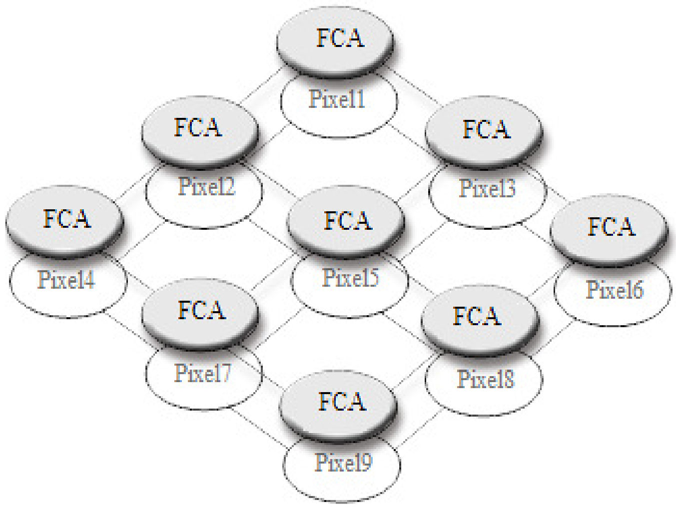

Figure 3. 8 state of neighbourhood for calculate α_i , B_i.

subtraction of the Gray level of pixels in the colour cells from that of pixels in the mid-cell, is determined(Formula 1).

$$\alpha_i = (\textstyle\sum_{j=Pertain\ to\ hatch\ cell}|P - P_j|)/5$$
$$\beta_i = (\textstyle\sum_{j=Pertain\ to\ fill\ cell}|P - P_j|)/5 \qquad (1)$$

For each cell, of the values of α_1 , to α_8 and B_1 to B_8 are calculated in the same way . then, a fuzzy system is designed which consists of one input and two outputs for input, a membership functions is considered like that seen in Figure 4a,and the membership functions of the output of the fuzzy system are also shown in Figures 4b and 4c.

For each of the states in Figure 2, depending on the derived A and B, four fuzzy rules are defined. Therefore, a fuzzy rule base is established that contains 32 rules (Table 1).

The proposed fuzzy system, which includes a multiplication inference engine, a single fuzzifier, and a defuzzifier of the mean of centers, can be seen in Formula 2.

$$f(x) = \frac{\sum_{i=1}^{N} \bar{y}^{i}.[\mu_A^i]}{\sum_{i=1}^{N} \mu_A^i} \qquad (2)$$

In Formula 2, N is the number of input sets-lie., N is two , $\bar{y}$ is the center of the fuzzy output set, and μ_a is the input membership function. Thus, by having the rule base and the inputs of the system, we can easily calculate the output of the fuzzy system with Formula 2. The fuzzy rule base proposed for the mentioned system is constructed on the basis of Table1.

EXPERIMENTAL RESULT

In the part about empirical results, the performance of the proposed method is investigated by carrying out the following four experiments:

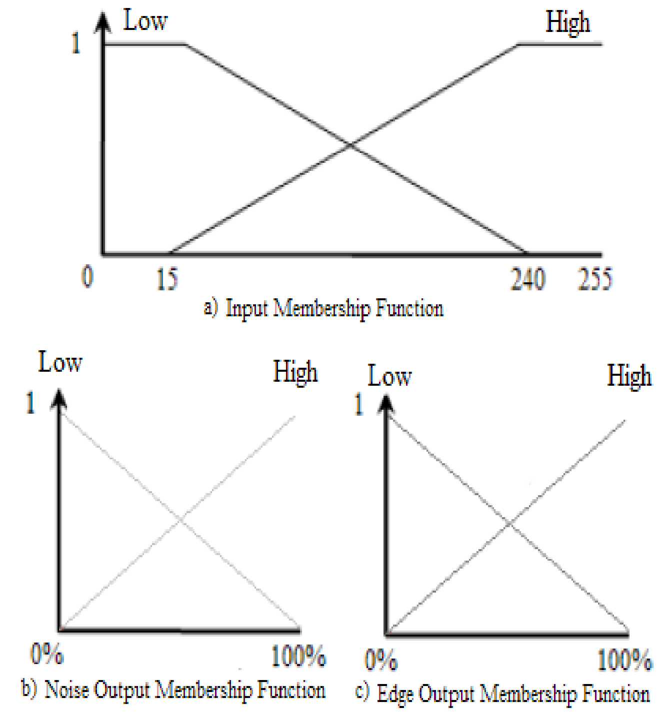

Figure 4. (a) Input membership function, (b,c)output membership function.

1. De noise from the image
2. Edge detection in noise free images
3. Edge detection in noisy images
4. Comparison of the proposed method with other methods

De noise from the image

In this part, the pepper image from the standard database misc is used as the standard image for the experiment. Noise is added to three different states of this image, and then the noise is eliminated by using the proposed method. In the first, second, and third states, one, two, and five percent of salt-pepper noise is added to the image respectively. Then, noise is eliminated from all three images by using the proposed method. Result obtained is shown in Figure 5.

As can be seen in Figure 5, this method shows a mainly good performance, even for images which have a high level of noise.

Edge detection in noise free images

In this stage we deal with edge detection in noise-free images. For this purpose, Lena and House images are used (Figures 6a and 6b).

Table 1. Fuzzy role database.

if	Then edge	Then noise	if	Then edge	Then noise	if	Then edge	Then noise	if	Then edge	Then noise
α_1 Low and β_1 Low	Low	Low	α_3 Low and β_3 Low	Low	Low	α_5 Low and β_5 Low	Low	Low	α_7 Low and β_7 Low	Low	Low
α_1 Low and β_1 High	High	Low	α_3 Low and β_3 High	High	Low	α_5 Low and β_5 High	High	Low	α_7 Low and β_7 High	High	Low
α_1 High and β_1 Low	High	Low	α_3 High and β_3 Low	High	Low	α_5 High and β_5 Low	High	Low	α_7 High and β_7 Low	High	Low
α_1 High and β_1 High	Low	High	α_3 High and β_3 High	Low	High	α_5 High and β_5 High	Low	High	α_7 High and β_7 High	Low	High
α_2 Low & β_2 Low	Low	Low	α_4 Low & β_4 Low	Low	Low	α_6 Low & β_6 Low	Low	Low	α_8 Low & β_8 Low	Low	Low
α_2 Low & β_2 High	High	Low	α_4 Low & β_4 High	High	Low	α_6 Low & β_6 High	High	Low	α_8 Low & β_8 High	High	Low
α_2 High & β_2 Low	High	Low	α_4 High & β_4 Low	High	Low	α_6 High & β_6 Low	High	Low	α_8 High & β_8 Low	High	Low
α_2 High & β_2 High	Low	High	α_4 High & β_4 High	Low	High	α_6 High & β_6 High	Low	High	α_8 High & β_8 High	Low	High

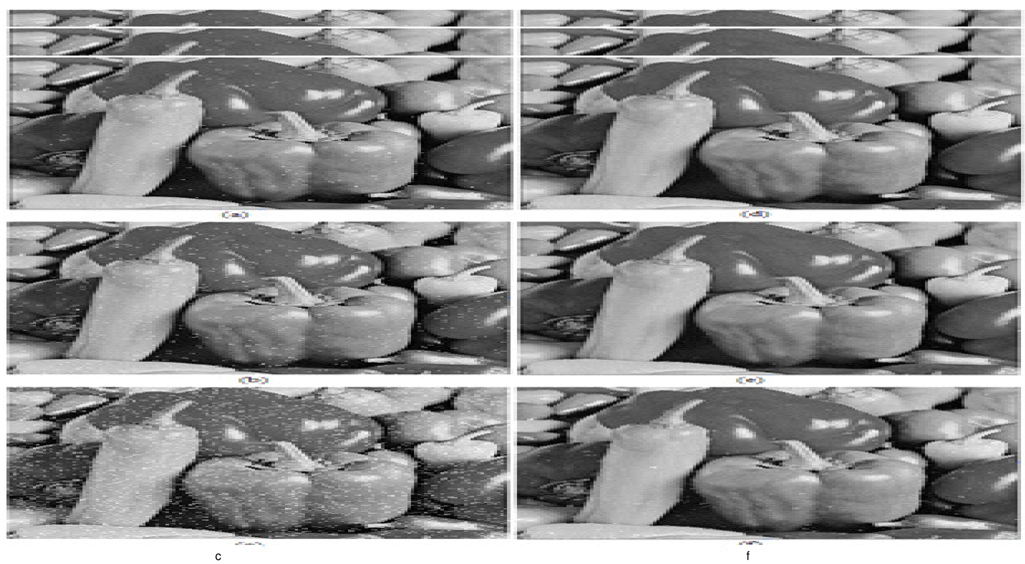

Figure 5. Images with (a) 1% (b) 2% (c) 5% noise (d, e, f) De noising image with proposed method.

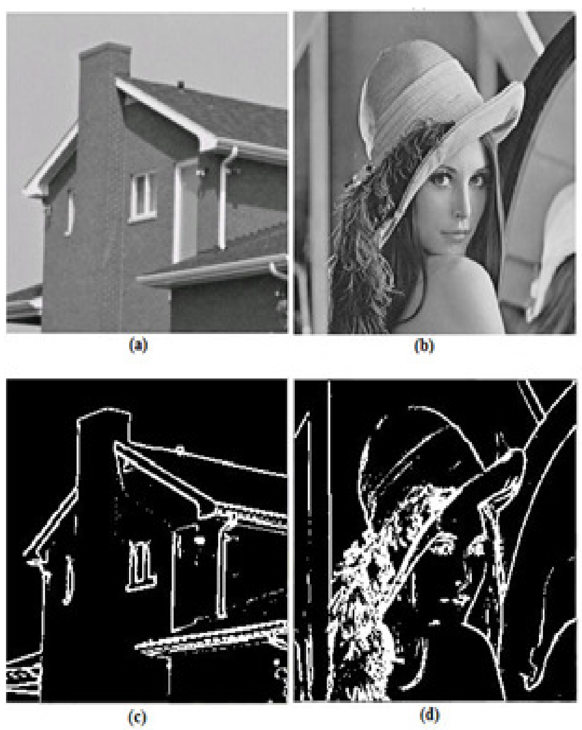

Figure 6. (a) House (b) Lena (c, d). The edge detection images.

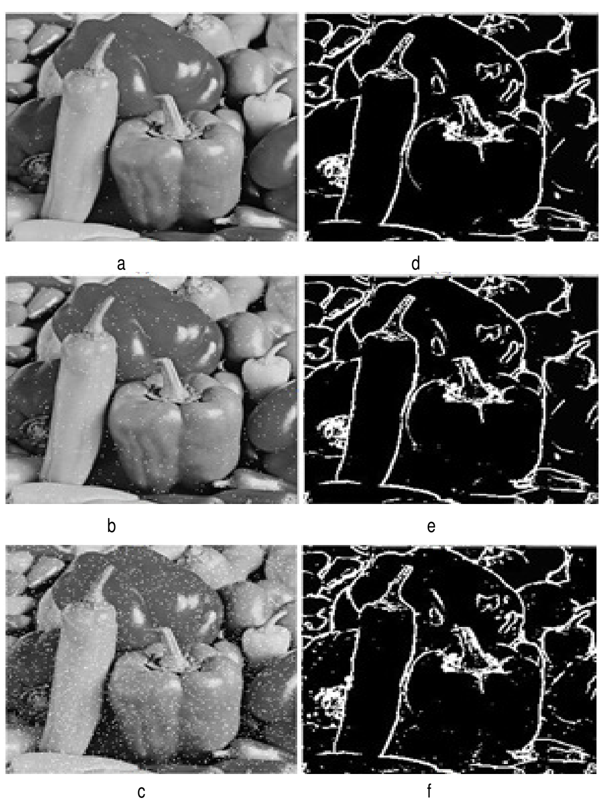

Figure 7. Images with (a) 1% (b) 2% (c) 5% noise (d,e,f) De noising image with proposed method.

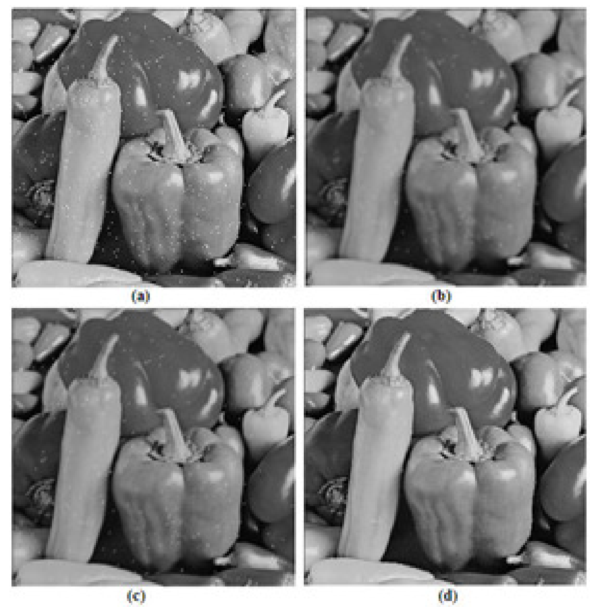

Figure 8. (a)Main image. Filter: (b) Mean (c) Median (d) proposed method.

Figures 6 c and 6d show the results obtained by using the proposed method.

The edges detected in the proposed method include the skeleton and the important details in the original images and the useless details in the original images are eliminated.

Edge detection in noisy images

In this part, edge detection is carried out in noisy images in this states, edge detection is performed on noisy images from Part 4 to 1(Figure 7). In the proposed method, decisions are made concerning each pixel of the images according to the determined fuzzy rules. The results obtained can be seen in the following images.

Comparison of the proposed method with other methods

In this part, the proposed method is compared with several other common methods of noise elimination. The results obtained are shown in Figure 8. The original image, noise elimination by using the mean filter, noise elimination by employing the median filter, and noise elimination by our proposed method are shown in Figures 8a, 8b, 8c and 8d, respectively.

As can be seen from the figure, in Figure 8b where the mean filter is applied on the images for noise elimination, the process of noise elimination is carried out rather well but the resultant image is very blurred, in Figure 8c, where

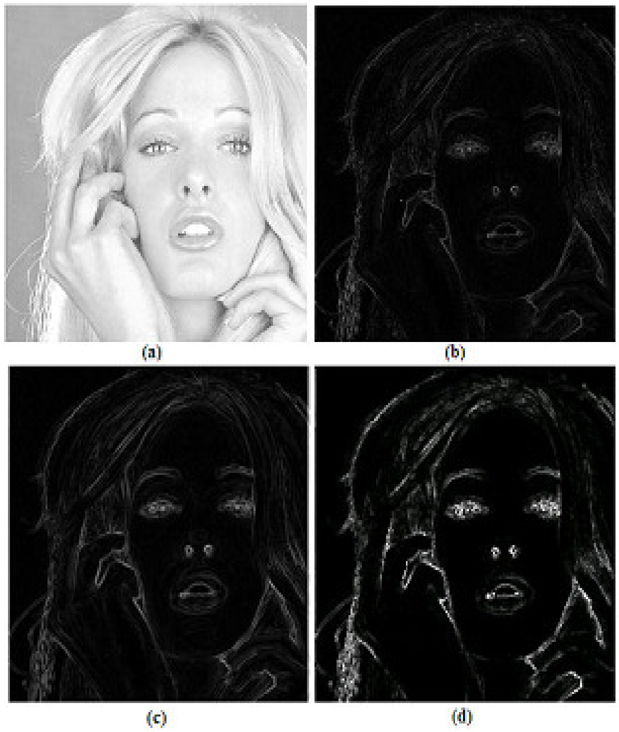

Figure 9. (a)Input image (b) Robert (c) Sobel (d) proposed method.

the median filter is used for noise elimination, the noise is partially elimination and some of the noises in the image remain. In Figure 8d, where the proposed method is employed for noise elimination the resultant images retain the quality of the original image while the noises in the original image are removed to high extent.

Comparison of the proposed method with the Sobel and Robert

In this part, our prepared method is evaluated by comparing it with the Sobel and the Robert methods of edge detection, which are commonly and widely used for edge detection. The results obtained are shown in Figure 9. The results obtained by applying the Robert method, the Sobel method, and our proposed method for edge detection are shown in Figures 9b, 9c and 9d, respectively. As can be seen in Figures 9b and 9c, the images optioned by using the Robert and the Sobel methods include back ground from the original image and non-edge parts, while these short comings are largely eliminated in our proposed method.

Conclusion

In our paper, a new method of noise elimination and detection of images is presented in which fuzzy cellular automata is used.

In most previous methods, first a common procedure is employed for noise elimination and then edge detection is carried out, while in our proposed method noise elimination and edge detection are performed simultaneously. The main advantages of proposed method are the determination of the eight-state type of continuity and the determination of fuzzy membership functions and fuzzy rule bases corresponding to the continuities. In our method, the state of each pixel (whether it is noise, edge, or background) is decided according to the fuzzy rules determined, and the pixel takes on the state decided for it. Experiments carried out in the empirical tests acknowledge the efficiency of our proposed method.

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