An Improvement Approach for EDGE image enhancement using fuzzy set theory and cellular learning automata (CLA)

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Abstract:

The most common degradations in images is their poor distinction quality. Edge enhancement is an image process filter that enhances the edge contrast of an image in an effort to enhance its acutance (apparent sharpness). The projected paper uses the conception of hybrid edge detection technique supported fuzzy based and cellular learning automata to detect the gray level changes of neighbours of each pixel, and to notice the edge by using the ever changing regular of one-order or two-order directional calculation, however typically there's uncertainty of the edge, and man cannot distinguish whether or not it's the edge or not. So as to show the fuzzy sets to be clear and solve the matter above this paper mentions fuzzy set theory and cellular learning automata to comprehend improve image edge detection. In the end, we compare it with popular edge detection methods such as Canny and Prewitt.

Keywords: *Edge Detection, Fuzzy Sets, Heuristic Membership Function, Learning Automata, Cellular Learning Automata*

1. Introduction

Consider the task of recognizing boundaries, shadow transitions and alternative characteristic points of the image, many existing strategies are accessible supported Image process however, after using all such methodology we tend to still couldn't retrieved the sharp edges ,So rather than using image processing strategies that are direct signatures of the edge detection, we tend to address some totally different methods supported Fuzzy set theory and cellular automata. One such method is Edge Detection methodology supported Fuzzy set theory and Cellular Learning Automata ".

Many existing edge detection strategies make the most of the gradient of images and arithmetic operators. As an example, methods based on gradient contemplate edges to be a group of pixels wherever the gray level has associate abrupt modification in intensity. Canny edge detector [18], however, assumes that edges are step functions corrupted by Additive White Gaussian Noise (AWGN). a problem of those mentioned-above strategies is that the neighbourhood of an edge

isn't involved within the edge detection method, whereas in cellular learning automata (CLA), neighbourhood plays a substantial role in edge detection.

An initial model supported Image Detection technique supported Fuzzy set theory is planned by the Pal and King algorithmic rule [1] that has been used wide within the image processing. But this algorithm has some disadvantages, significantly in edge detection thus to overcome a brand new fuzzy-based weighted-set multiscale edge detection (FWOMED) [2] technique additionally as quick construction fuzzy enhancement edge detection (FMFED)[9] developed. After performing image enhancement the level of various regions is improved so the distinction between each side of the edge is enhanced however the particular collected images has a lot of noise .There is associate degree inconsistent contradiction between removing noise and edge maintenance, as a result of some noises is also considered as edges. Concept of cellular automata (CA) is planned by Ulam and Von Neumann [12], after a couple of year Amoroso and Fredkin and Cooper [12] described an easy replicator established on parity or modulo-two rules. Later on, Sir Leslie Stephen wolfram shaped the CA theory [11]. Nowadays, CA widely wide utilized in several tasks as a result of their useful characteristics and numerous functions. Cellular learning automata area unit models for systems that carries with it easy components and behaviour of every element is obtained and reformed upon the behaviour of its neighbours and their previous behaviour. The constructing parts of those models will do robust and complex tasks by interacting with one another. Cellular learning automata square measure wide utilized in several areas of image processing like denoising, enhance, smooth, restore, and extract options of images.

According to Hamid R. Ezhoosh [7], S Sinaie, A Ghanizadeh existing fuzzy approaches to edge detection are generally expensive in computing. A problem of these mentioned-above methods is that the neighbourhood of an edge is not involved in the edge detection process, while in cellular learning automata (CLA), neighbourhood plays a considerable role is edge detection. In this method, first edges are detected with the help of fuzzy sets, and then by using the repeatable and neighbourhood-considering nature of CLA, the edge pixels are strengthened and the non-edge pixels are weakened and noises of the earlier phase are also removed[[11]. The paper is organized as follows: the fuzzy pre-processing is defined in section 2. Section 3 begins with a brief description of cellular learning automata and then goes on to propose a new edge detection method based on fuzzy sets and cellular learning automata.

2. Proposed Approach
In this section the proposed methodology is described First, the original image is divided into windows with the size of $w \times w$-sized windows for which the heuristic membership function is then found using fuzzy set. After this stage, the edges of the image, including thick and unwanted ones, are detected. If the pre-defined patterns match each $w \times w$ window, the central pixel is penalized, otherwise rewarded. Later, the final image is produced using thresholding.

3. Fuzzy Pre-processing
In recent years, many fuzzy techniques for edge detection are suggested [2,3,4,16]. The edge pixels are the pixels whose gray level have high difference with the gray levels of their neighbourhood pixels. However, the definition of "high" is quite fuzzy and application dependant. To deal with the ambiguity and vagueness of edge pixel, edge image should be defined according to fuzzy logic [11]. In this section, a fuzzy approach, which can detect edges accurately within a reasonable time [12] is used for pre-processing. The purpose of using such technique is to determine a proper heuristic membership function for image pixels.

3.1 Using Fuzzy Sets

Let an M*N image X be the set of all pixels gmn $\in$ (0, L) , then X can be regarded as an array of fuzzy single tons $\mu_{mn} \in [0,1]$ indicating the degree of brightness of each gray level gmn

$$x = \bigcup_{m=1}^{M} \bigcup_{n=1}^{N} \frac{\mu_{mn}}{g_{mn}}$$

The membership function could be achieved as:

$$\mu_{mn} = \frac{g_{mn}}{i^{\max} \in \left[1.M \quad , j \in \left[1, N \right.^{g_{mn}} \right.}$$

The x' containing all edges:

$$x' = \bigcup_{m=1}^{M} \bigcup_{n=1}^{N} \frac{\mu'_{mn}}{g_{mn}}$$

Where μ'_{mn} indicates the degree of edginess for each pixel. The task of edge detection is therefore the determination of the membership function μ'_{mn} for each pixel. Here simple way of calculating μ'_{mn} by using heuristic membership functions is suggested.

3.2 Calculate Heuristic Membership Functions

In this section, a method for determining a proper membership function for each pixel gmn of the image at the position (m,n) surrounded by a 3 * 3 window is explained. Based on this window and general properties of an edgy neighbourhood, different membership functions can be introduced. A formula based on gray level differences in the neighbourhood of a pixel surrounded by a 3 × 3 window µmn could be given as:

$$\mu' = \frac{\sum_i \sum_j \left| g_{ij} - g_{mn} \right|}{\square + \sum_i^w \sum_j^w \left| g_{ij} - g_{mn} \right|}$$

Where $\Delta \in$ [0, L) is a proper parameter. Meaningful values are in [L/2, t]. The lower Δ the more edges are detected [7, 11]. The advantage of defining the degree of edginess as a fuzzy membership function is that in this case the entire fuzzy set theory becomes applicable for further modifications.
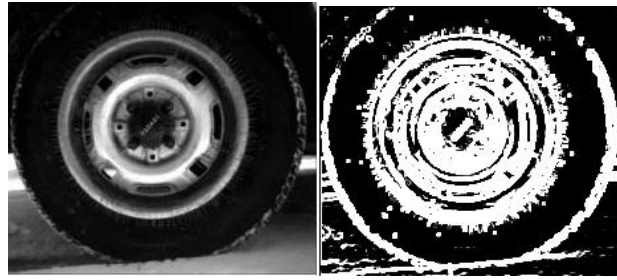
Fig. 1. (a) Original Barbara image (b) Edge output using fuzzy set theory

4. Learning Automata

Learning automata (LA) [11,14] area unit systems which might have infinite states. Every chosen state gets evaluated by a probabilistic environment and by means that of a positive or negative signal the result of analysis, which an automaton uses to work out consecutive state, is given to the automaton. the final word goal is teaching an automaton a way to choose the most effective state from all alternatives. The best state may be a state that maximizes the reward received by the environment. Environment are often delineate by the triplet E ={Q, R, U} wherever Q = may be a set of inputs for LA, R= may be a set of outputs, and U = may be a set of penalty probabilities. Variable structure learning automaton is delineate by the quadruplet { Q , R, U , T} . wherever Q = may be a set of states, R= may be a set of inputs, U = is that the chance vector of selecting every state by LA, and U (n +1)= T[Q (n), R(n), U (n)] is that the earning algorithmic program.
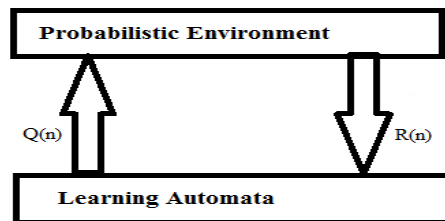
Fig. 2. The interaction between probabilistic environment and LA

5. Cellular Learning Automata

In many cases learning automata does not work properly. So we can use different kinds of neighbourhoods in CLA. In general, each set of cells can be considered as a neighbourhood, but the most common kinds of neighbourhoods are Von Neumann, Moore, Smith, and Cole, which are known as "nearest neighbours" neighbourhoods[11]. In this method, the Moore neighbourhood is used for CLA. These neighbourhoods are illustrated in

(a) Vou Newman   (b) Moore   (c) Smith   (d) Cole
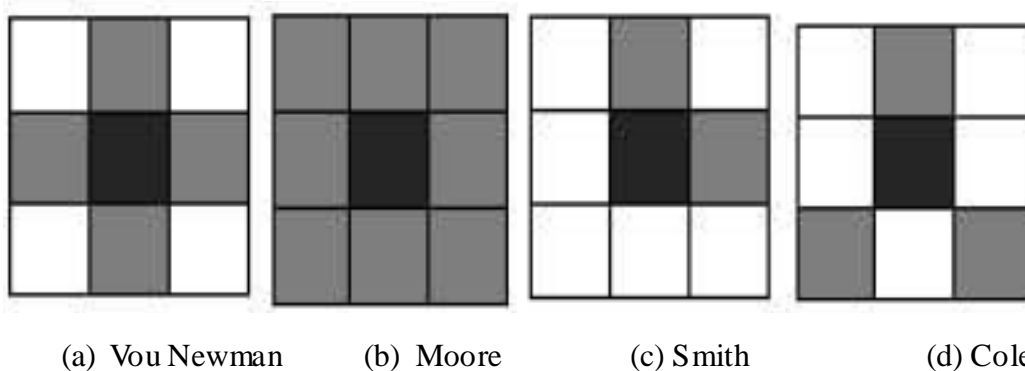
**Fig. 3. Types of neighbourhood**

Each cell of the image is considered to be a variable structure learning automaton, which has relations with its neighbouring automata by a "Moore neighbourhood" of radius 1. Each learning automaton has two states: edge and non edge. An initial state of each learning automaton is determined by the final image ´x of the pre-processing phase. Local rules of these CLA are defined in a way that in continuous repetitions strengthen edge pixels and weaken non-edge pixels and noises.

Apply the edge templates over the image by placing the centre of each template at each point (i,j) in the edge image. It should be able to strengthen edge pixels that are in the middle of two edge pixels which are detected as a non-edge pixel or a weak edge and on the other hand be able to weaken non-edge pixels which are detected as strong edges. The centre of each template is placed at each pixel position (i,j) over the normalized image. To improve the edges if two to four neighbours of a learning automaton and the central learning automaton decided that the pixel is an edge, the central pixel is rewarded and if not, it is penalized. If more than four neighbours of the central learning automaton or none of them decided that the pixel is an edge but the central learning automaton decided that it is an edge, the pixel is penalized in order to weaken the edge. Figure 5.9 provides a better understanding of the mentioned-above statement. The black cells imply that the learning automaton of that cell has decided it is an edge.
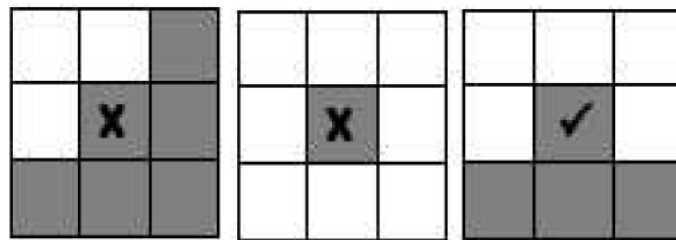

Fig.4. Strengthening and Weakening of Edges

If only two neighbours of the learning automaton think about their component as a grip and therefore the central learning automaton does an equivalent, it's rewarded. However, if the central learning automaton doesn't consider its component as an edge, it's punished. This can be done to improve or weaken the separated edges. Figure 5.10, describes the method consequently. Each time, all LA during a cellular learning automaton choose a state from their set of states. These choices are often based mostly upon either previous observations or random choice. Every selected state, with reference to neighbouring cells and therefore the general rules, receives an award or a penalty.
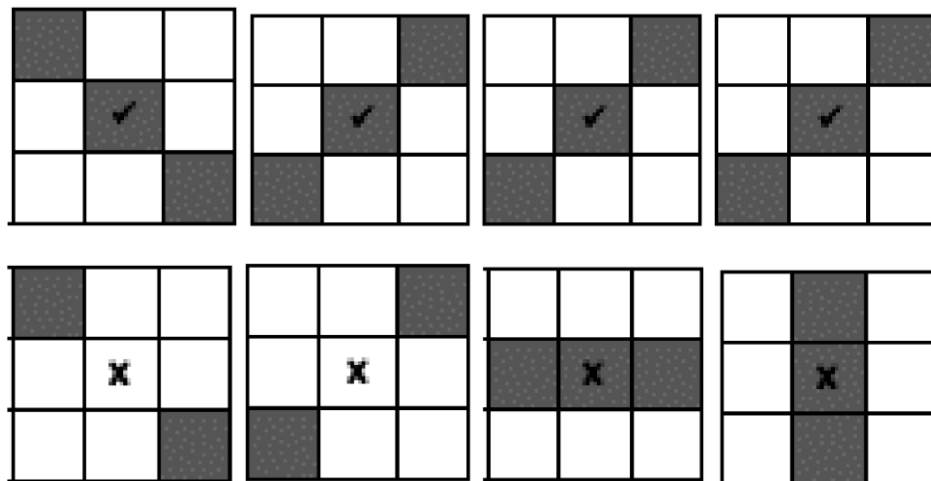
Fig.5. Strengthening and Weakening of Connected and Separated Edges

Patterns that result in a penalty are shown. In these patterns white cells are edges and black cells are non-edges. These patterns create thick edges, noises and unwanted edges. Some patterns shown in Fig. 6 are representing other patterns that receive penalty, which are obtained by rotating or flipping these patterns. Due to the similarities, these patterns are not shown in Fig. 6. All the other patterns receive a reward. The process of updating cells and giving penalties and rewards continues until the system reaches a stable state or satisfies a predefined condition.

(a)

(b)

(c)
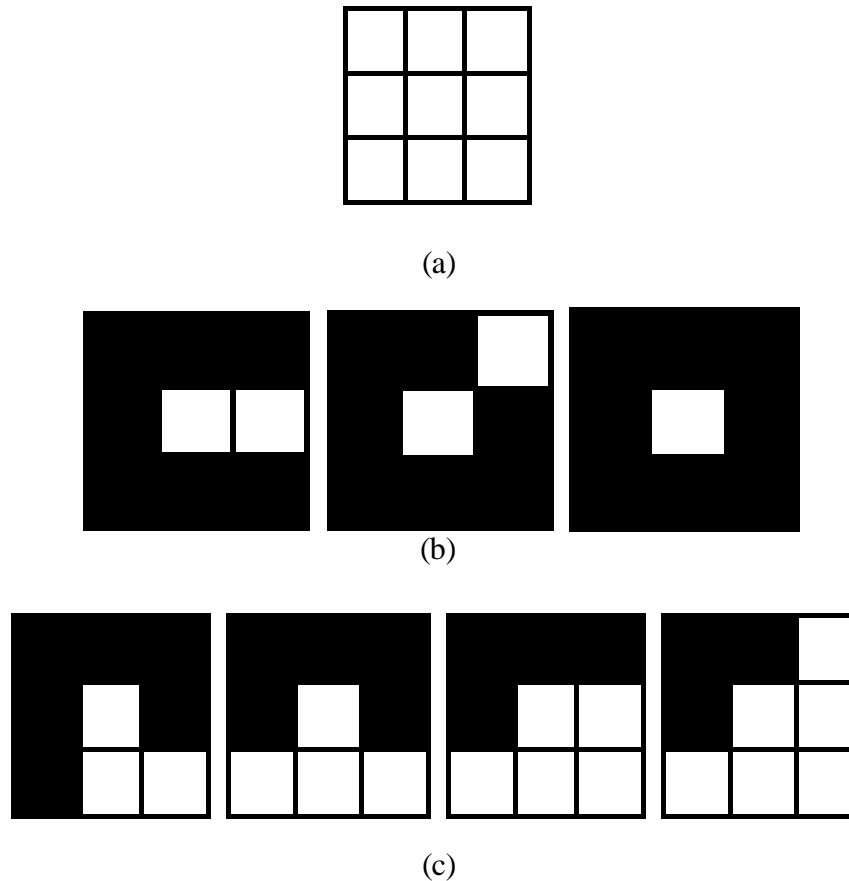
Fig. 6. Penalty Patterns. (a) Thick edge (b) Noises.(c) Unwanted edges

Penalty of CLA is given by following equation

$$X_i(n+1) = (1-\beta)Y_i(n)$$

$$X_j(n+1) = \beta(255 - X_j(n)), \quad \forall i = j$$

Reward is given by following equation

$$X_i(n+1) = X_i(n) + \alpha(255 - X_i(n))$$

$$X_j(n+1) = (1+\alpha)X_j(n) \ \forall i = j$$

Where, $\alpha(n)$ is the probability increase coefficient.

$\beta(n)$ is the probability reduction coefficient.

$X(n)$ is the probability vector of choosing CLA.

Where Q is the probability increase coefficient and R is the probability reduction coefficient (Q<<R). The obtained image by CLA is more precise than the image obtained in the pre-processing phase. The final image of the preprocessing phase, and the one obtained by the CLA are respectively shown in Fig. 7(a) and 7(b).
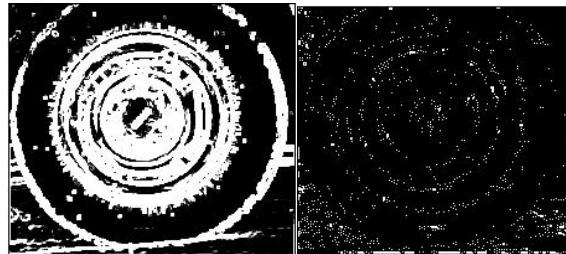

Fig 7. (a) Image obtained in fuzzy pre-processing phase. (b) Final image with CLA

6. Proposed Algorithm
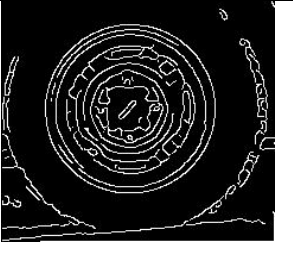
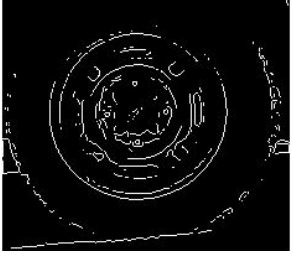| |
|---|
| Step1: Read the Original Image. |
| Step-2: Divided into non –overlapping 3x3 windows. |
| Step 3: Calculate Heuristic membership function for each cell of image window. |
| Step 4: Edgy image using fuzzy set. |
| Step5: Output edgy image is divided into non overlapping 3x3 window of 26 templates |
| Step 6: Apply the rule of giving Reward or Penalty based on templates. |
| Step 7: Are all 3x3 templates proceeds? |
| Step 8: Is this process repeated up to 100? If no then back to Step 5 |
| Step 9: Enhanced edgy image using CLA including thresholding |
| Step 10: Final Edgy enhanced Image |

7. Results and Conclusion

In this section, the results of the application of the proposed edge detection algorithm are presented. In order to evaluate the performance of the proposed algorithm, the results are shown and compared to famous edge detection methods such as Prewitt ,fuzzy and Canny[5,18]. Images that are not corrupted by noises are used here. Suitable parameters are obtained based on trial and error. In this paper, we used Z=64 to obtain the membership function Learning process of each learning automaton is implemented with values of Q =0.05, and R=0.01 and by repeating the algorithm <100 times. These values worked well enough for all images that have been tested. The more we repeat, the better the result will be.

The proposed method gives a better result than the Prewitt method, and in comparison with Canny, in some cases edges are detected slightly more smoothly, and with more details. One specification that makes this method more interesting compared to the other two methods, is that this method conserves the structure of the image, meaning that the important edges are kept so that it gives a better perception of the objects in the image and a more natural look to them despite the fact that methods based on gradient A basic edge detection process usually involves the following stages: (i) Smoothing—required for noise reduction and regularization of the numerical differentiation. It depends on the regularization parameter (scale) which determines the compromise between noise elimination and image structure preservation. (ii) Differentiation—an operation that evaluates the intensity variations in the image. (iii)

Labelling—the final decision stage that marks the identified edges. This stage usually involves a threshold parameter that separates true from false edges. In this method, first edges are detected using Fuzzy set theory and then resultant edgy image is enhanced using Cellular learning Automata (CLA), because of the neighbour-considering nature has been used in CLA, which has shown success in many tasks such as noise reduction and image segmentation. Thus edges detected by the proposed algorithm, look more natural than those of Canny's, and Prewitt's operators. The Comparison table is as under.

Original Image			
Result using Fuzzy Set Theory			
Result using Cellular Learning Automata			
Result using Canny Operator			
Result using Prewitt Operator			

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