ENGINEERING IN ADVANCED RESEARCHSCIENCE AND TECHNOLOGY

ISSN 2352-8648
Vol.02, Issue.04
February-2021
Pages: -241-250

Methods and Algorithms for Image Processing and Design Pattern Recognition

Somana Veeraiah[1]*., Dr.G.R. Babu[2] and Dr.Vaka Murali Mohan[3]

[1]Research Scholar, Department of computer science & engineering, Ch.Charan singh university,Meerut,U.P,India
[2]Professor of Computer Science & Engg., Swami Vivekanand Subharti University, Subhartipuram, NH-58, Meerut –U.P, India
[3]Principal & Professor of CSE, Malla Reddy College of Engineering for Women, Medchal, Hyderabad, Telangana, India.E- Mail: somanaveeraiah_2017@gmail.com

Abstract: *Sample Algorithms for Image Processing and Pattern Recognition is presented in this paper. Patron generation and Algorithms for certain traditional image processing operations like contouring algorithm, thinning algorithm and for pattern recognition operations like corners detection, lines detection and curves detection is explained in detailed. Cellular automata and their classification is also explained in detailed.*

Key Words: *Image Processing; Pattern Recognition; Design patterns; Contouring Algorithm, Thinning Algorithm, Corners Detection, Lines Detection, Curves Detection*

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1. Introduction:

Design patterns have been widely used for developing flexible, extensible and perceptible applications to produce effective, reliable, verifiable and easily maintained software systems. Pattern recognition is "the act of taking in raw data and taking an action based on the category of the pattern". Most research in pattern recognition is about methods for supervised learning and unsupervised learning. Pattern recognition aims to classify data (patterns) based either on a priori knowledge or on statistical information extracted from the patterns. The patterns to be classified are usually groups of measurements or observations, defining points in an appropriate multidimensional space. Several researchers did several researches in several fields of pattern recognition, some of them are G.Y. Chen., T.D. Bui and A. Krzyżak [1] proposed an invariant pattern recognition descriptor by using the radon transform, the dual-tree complex wavelet transform and the Fourier transform. The radon transform can capture the directional features of the pattern image by projecting the pattern onto different orientation slices. The dual tree complex wavelet transform can select shift invariant features in a multi resolution way.

Experiments conducted in this paper show that the proposed descriptor achieves high recognition rates for different combinations of rotation angles and noise levels. The descriptor is very robust to Gaussian white noise even when the noise level is very high. Vincent Canals et al [2] reviewed the basic principles of stochastic logic and propose its application to probabilistic-based pattern-recognition analysis and this technique is intrinsically a parallel comparison of input data to various pre-stored categories using Bayesian techniques. Ghulam Rasool et al [3] presented a design pattern recovery approach based on annotations, regular expressions and database queries. Nor Ashidi Mat Isa and Wan Mohd Fahmi Wan Mamat [4] introduced a modified version of the Hybrid Multilayer Perceptron (HMLP) network to improve the performance of the conventional HMLP network. Wenyin Zhang et al [5] proposed a new method to pattern recognition of gas–liquid two phase flow regimes based on improved local binary pattern (LBP) operator. G.Y. Chen and B. Kégl [6] proposed new methods for palmprint classification and handwritten numeral recognition by using the contourlet features. The contourlet transform is a new two dimensional extension of the wavelet transform using multiscale and directional filter banks. Gonzalo Bailador and Gracián Triviño [7] proposed a syntactic pattern recognition approach based on fuzzy automata, which can cope with the variability of patterns by defining imprecise models. Gracian Trivino et al [8] reported the field of human gait pattern recognition by providing a solution based on the computational theory of perceptions. I.K. Sethi and B. Chatterjee [9] developed an algorithm for the design of an efficient decision tree with application to the pattern recognition problems involving discrete variables. Rajan, E. G [10] presented Cellular Logic Array Processing, Techniques for high throughput Image Processing Systems by using Rajan Transforms.

The main advantage of using patterns is to take the edge of using best practices and experiences of others in solving the challenging tasks. Patterns have been extensively tested in different applications and reusing them yields the quality software. Standard normalization techniques are used to normalize the input pattern image so that it is translation and scale invariant. The Fourier transform can extract features that are invariant to rotation of the patterns.

1.1 Pattern Generation:

A cellular automaton evolves in discrete time steps, with the value of the variable at one site being affected by the values of the variables at sites in its neighborhood on the previous time step. The site-values corresponding to a configuration at a particular time step, say t, are updated, all at once, based on the values in their neighborhood, according to a definite set of updating rules. The resulting configuration at time stept+1, is the evolved version of the one at time step t. The initial configurations of a cellular automaton are broadly classified into two types:
(i) Single-site seed configuration and

(ii) Multi-site (say L sites) arbitrary configurations.

The pattern generated by a cellular automaton evolving from a single-site seed configuration on from a multi-site arbitrary configuration, indicates the behavior of the automaton. As already discussed in earlier sections, an N-ary valued r-neighborhood cellular automaton accommodates atmost N^{N^r} updating rules. Note that we can have, in this case, atmost (N-1) type-1 and (N^L-N) type-2 initial configurations. This amounts to saying that one can construct atmost N^{N^r} (N^L-1), N-ary valued r-neighborhood cellular automata.

1.2 Cellular automata are classified under four types:

(a) Cellular automata that evolve after a finite number of time steps from almost all initial states to a unique homogeneous state, in which all sites, have the same value.
(b) Cellular automata that serve as filters which generate stable structures or periodic structures with small periods from particular initial site value sequences.
(c) Cellular automata that evolve from almost all possible initial states to aperiodic, i.e., chaotic patterns.

(d) Cellular automata that evolve from several disordered initial configurations yield, after a finite number of time steps, either zero-valued configurations or stable and periodic structures or propagating structures. In this paper, we describe methods for generating patterns using cellular automata of the above four types. The realization of all these various cellular automata is hereby understood to be carried out using Generalized Markov Algorithms. Given below are certain high-throughput pattern- generating techniques.

2. Sample Algorithms for Image Processing and Pattern Recognition

Algorithms for certain traditional image processing operations like contouring and thinning and for pattern recognition operations like corners detection, lines detection and curves detection.

2.1 Contouring Algorithm

The given digital image is scanned by a 3X3 empty window. On each move, the boundary pixels of the 3X3 sub image covered by this window are stored in a temporary array and its RT found. Then the average value 'T' is calculated by dividing the CPI by 8. Now each RT element is compared with 'T'. The number of elements that are less than 'T' is counted.

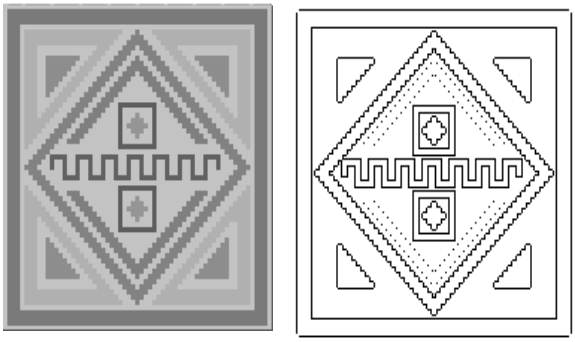

Figure 1: Original image and its contour map

If this count is greater than 6, then the central pixel is substituted with a value 0. Otherwise, the window moves to the right. This procedure is continued till the entire image is scanned. The overall effect is that the boundaries of regions that appear to be uniform are retained and the central pixels are erased. One can always choose the value of 'T' from 3 to 7 depending on the requirement. Figure 1 shows the digital image of a pattern and its contour map obtained the RT based algorithm.

2.2 Thinning Algorithm

Thinning is the complementing operation of contouring. The algorithm given for contouring is used in this case also but with the exception that instead of removing the central pixel, the boundary pixels are removed. This operation is otherwise called Onion Peeling. Repeated boundary removal leads to thinned version of the original image. Figure 2 shows the pattern and its thinned version obtained the above RT based thinning algorithm.

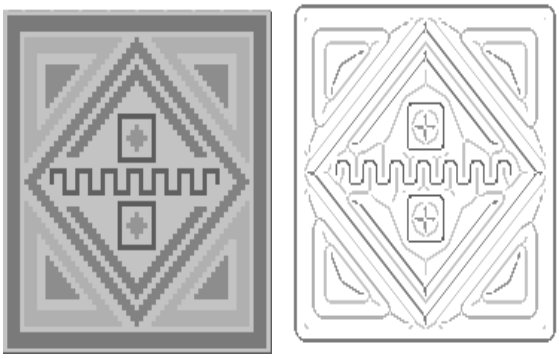

Figure 2: Original image and its thinned version

2.3 Corners Detection

On every move of the 3X3 window, the RT sequence, say, G[0], G[1], G[2], G[3], G[4], G[5], G[6], G[7] corresponding to the sequence of the numbered cell values is checked for the following conditions:

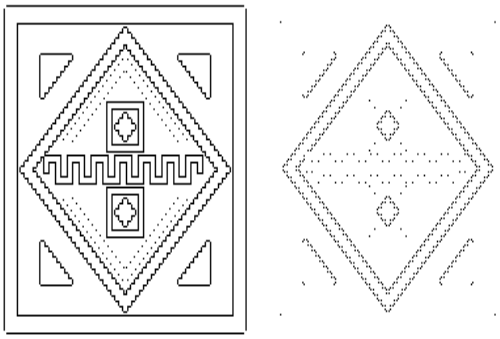

Figure 3: Contoured pattern and image consisting of corners

(i) Corners due to pairs of lines subtending an angle of 45° or its integral multiples, (ii) The number of RT elements that are less than 'T' must be 4 and (iii) Alternate RT elements G[0], G[2], G[4], and G[6] should be greater than 'T'. Corners due to pairs of lines subtending 90° or its integral multiples: (i) The number of RT elements that are less than 'T' must be 4 and (ii) The RT elements G[0], G[1], G[4] and G[5] should be greater than 'T'. This procedure is repeated till the entire image is scanned. The overall effect is that the resulting image would consist only of corner points. Figure 3 shows the image of the contoured pattern and its processed image consisting of corners only using the above RT based corners detection algorithm.

2.4 Lines Detection

On every move of the 3X3 window, the RT of each boundary values sequence is checked for the following condition: (i) The number of RT elements that are less than 'T' must be 4 and (ii) The first four RT elements including the CPI should be greater than 'T'. In such a case, the central pixel has to be a mid point of a line and so is chosen. The overall effect is that the resulting image would consist only of straight lines. Figure 4 shows the image of the contoured pattern and its processed image consisting of lines only using the above RT based lines detection algorithm.

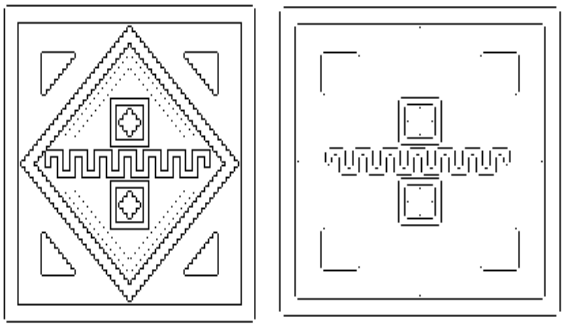

Figure 4: Contoured pattern and image consisting of lines

2.5 Curves Detection

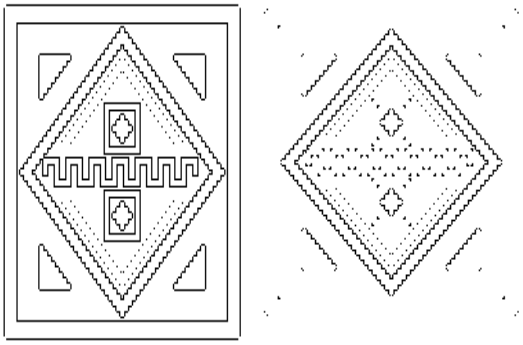

Figure 5: Contoured pattern and image consisting of curves

A curve is anything other than a straight line. So, the algorithm for detecting curves advocates the invalidity of the conditions for detecting a straight line. Figure 5 shows the image of the contoured pattern and its processed image consisting of curves only using the above RT based curves detection algorithm.

3. Conclusion:

Patron generation and Algorithms for certain traditional image processing operations like contouring algorithm, thinning algorithm and for pattern recognition operations like corners detection, lines detection and curves detection is explained in detailed. Cellular automata and their classification is also explained in detailed.

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