QUANTUM DOT CELLULAR AUTOMATO PROCESS IN IMAGE CLASSIFICATION TO DETECT LEUKAEMIA CELLS

M.SUBHASHINI

Department of Electronics and Communication Engineering, India.

Abstract

Objective: This paper presents the important of employing Quantum Dot Cellular Automato in Image processing to detect leukemia cells.

Method: Here we discussed nonlinear median filter designed using CA by employing quantum dots for removal of impulse noises in image and the denoised image is processed for tamura texture extraction using Fuzzy-c-mean segmentation algorithm. The extracted tamura feature fed as input to back propagation neural network classifier tool for image classification.

Findings: The classified results used to detect leukaemia cells. QCA based designs reduces number of logic gates and total area consumption compared to conventional CMOS based designs. All the QCA circuits are implemented in QCA Designer software. Thus, artificial neural network classifies carcinoma and non-carcinoma cells used in breast cancer diagnosis. Classification is performed using Tamura Feature. The features are coarseness, contrast, directionality, line likeness, regularity, roughness. The output is observed as Region of Convergence (True Positive Rate vs False Positive Rate is obtained. It is implemented using MATLAB software.

Novelty: It is used in medical diagnosis such as detecting leukaemia cells.

Keywords: Quantum Dot Cellular Automato, Image Processing, Nano electronics.

1. Introduction

In today's age of digitalization, the presence of digital images and videos is almost omnipotent. These images may be of various qualities and have different levels of noise subject to a lot of parameters. The most common factors which introduce noise into a digital image or video are: unrestricted motion of the camera while recording the image, uncontrollable conditions of the indoor and outdoor environment and lighting, presence of useless objects in the vicinity as well as the susceptibility of the signal to noise while transmission. These images could be required to be processed for numerous applications in a variety of fields. The major image processing is done for the purpose of noise reduction, feature extraction, face recognition and verification, skeletonising, segmentation, thinning, thickening, shape extraction, object detection and tracking, etc. All these and more are usually addressed in the field of Mathematical morphology which is a less complex way of carrying out the image processing. Noise reduction performed using conventional filters results loss of useful and un affected images while denoising the affected ones but in case of qca based median filters first the noisier image is identified and filtering process takes place. QCA based designs reduces number of logic gates and total area consumption compared to conventional CMOS based designs.

1.1 Digital image processing

Digital image processing is a two-dimensional light intensity f (x, y) value of f at spatial co-ordinates x and y. Color image processing employs colors which simplifies object identification and extraction. Human eye can discern nearly thousands of color shades. Three quantities for quality description includes radiance, luminance, brightness where radiance describes total energy from light source in watts, luminance describes amount of energy observed by observer from light source and brightness describes color sensation. The primary colors are blue, green and red. These primary colors added up to produce secondary colors. Magenta produced from the combination of red and blue where cyan is the combination of green and blue, yellow is the combination of red and green and white is the combination of all the three primary colors. The color models facilitate specification of colors in a standard 3-D co-ordinate system and subspace where each color represented as dots (single point). There are three color models they are represented in below table.

COLOR MODELS	**APPLICATONS**
RGB	Color monitors, color video camera
CMY	Color printer
YIQ (where I, Q are chromatic components such as in phase and Quadrature)	Color Tv broadcast

Table 1: Color models and their applications

1.2 Digital image processing flow chart

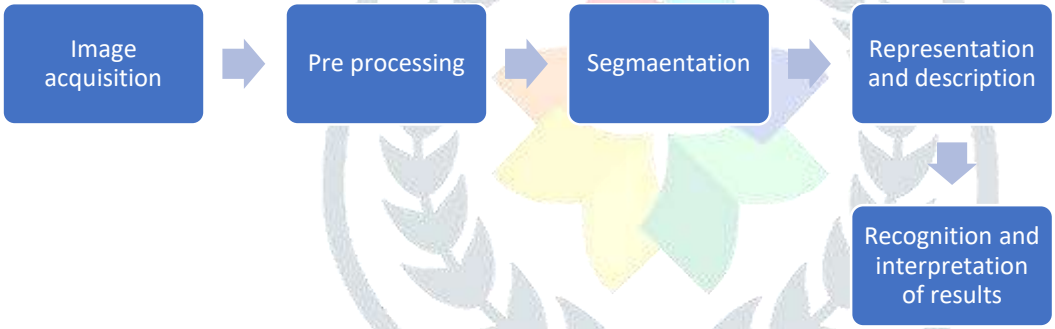

Figure 1: Flow chart of digital image processing techniques

The above flow chart explains steps in digital image processing. Image enhancement is defined as aggregate of pixels composing an image either in spatial or frequency domain where in spatial domain direct manipulation of pixel is taken place in case of frequency domain modification of Fourier transform of image will take place followed by convolution. Image enhancement techniques are discussed in figure 2. Point processing modifies grey level of pixel independently of neighbor whereas mask processing modifies each pixel in image to be enhanced.

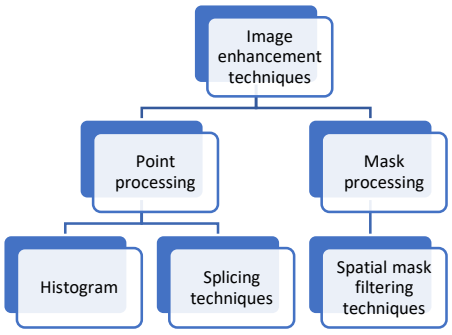

Figure 2: Image enhancement techniques

Point processing includes contract stretching technique to improve low contrast images explained in figure 3. Compression of dynamic ranges when it exceeds the capability of display device. Gray level splicing to highlight specific range of grey level. Example: Flaws in x-ray images, masses of water in satellite images. Bit plane splicing instead of highlighting intensity range highlights specific bit and Histogram processing denotes the probability of occurrence of grey level which gives us useful information about possibility of contrast enhancement and it is further classified as histogram equalization.

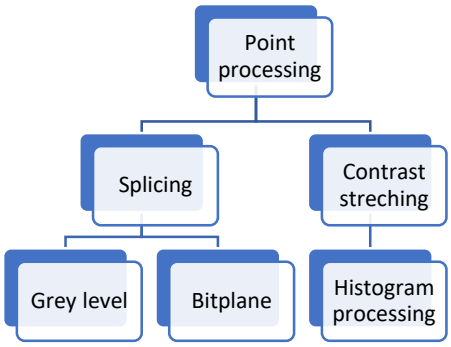

Figure 3: Point processing techniques.

There are different types of spatial filters used in image enhancement techniques. The techniques are discussed in Figure 4.

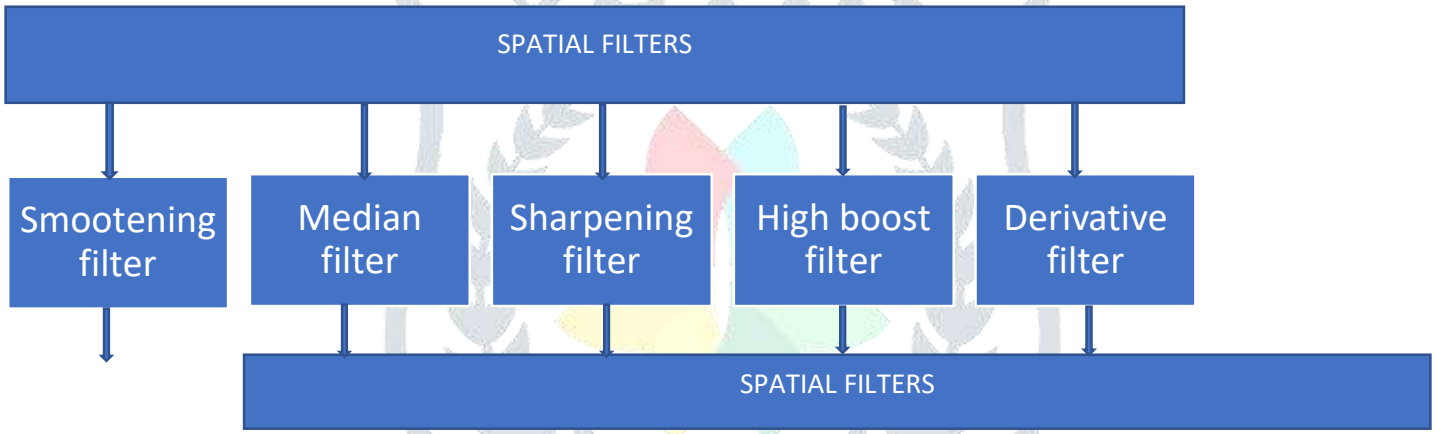

Figure 4: Types of spatial filters

Smoothening filters used for blurring and noise reduction in pre-processing steps and removes small details from image. Median filters are used in noise reduction instead of blurring a grey level of pixel replaces median of grey level in neighbor of pixel. It preserves edge sharpness. Sharpening filters are used to highlight fine details and enhance blurred detail as a part of image acquisition. Image restoration involves Inverse filtering and Least Mean Square (LMS) filter also called as Weiner filter, Image segmentation involves edge detection by Laplacian filter and uniform cost algorithm of Dijkstra. Thresholding process involves Global thresholding and Local thresholding methods. Gray level interpolation is classified as zero order interpolation and cubic convolution. Derivative filters make use of Robert cross gradient operator, prewitt operator and sobel operator.

1.3 Image classification

The digital image classification is an area under the umbrella of image processing and basically dealt with pixel grouping in a raster image with the purpose for information extraction, after raster image is processed by applying image classification techniques, the resultant raster can be employed for the creation of thematic maps. These would further be analyzed or processed with suitable technique so that the final goal of image processing is met. The image classification techniques are classified in to three types depending on interaction between operator and the computer,

1. Supervised image classification

2. Un supervised image classification

3. Object oriented image analysis

2. Nano electronics

Electronic device today reduced to Nano scale size. Most image and video processing algorithms resulted in demand of speed and computational power. The Very Large-Scale Integration technologies includes silicon Nano wires, carbon Nano tubes, single electron transistors, resonant tunneling diode and single molecule device replaces conventional CMOS technology. Quantum Dot Cellular Automato (QCA) resulted in parallel pipelined architecture and speedy operation using electric charges position for coding information instead electric current flow and resulted in reduced power consumption and computational complexity. In today's age of digitalization, the presence of digital images and videos is almost omnipotent. Various quality image subjected to different level of noise parameters such as unrestricted motion of the camera on recording image, uncontrollable conditions of indoor and outdoor environment and susceptibility of noise while transmission. Image processing is done for purpose of noise reduction, Feature extraction, face recognition, skeletonizing, segmentation, thinning, thickening, shape extraction, object detection and tracking. Mathematical morphology which is a less complex way of carrying out the image processing. VLSI implementation in image processing includes Implementation of nonlinear filters and video noise reduction.

3. Quantum dot cellular automato process

Cellular automata are the process for simplified mathematical modelling of complex structures which when implemented using coupled quantum dots is known as Quantum Dot Cellular Automata. It is a design of complex architecture in Nano scale size using modern VLSI technique an alternative for CMOS. QCA is transistor less architecture with electrons doped in quantum dots of QCA cell results in both positive and negative charges and on columbic interactions results in bistability that helps in binary information exchange and to perform computation. This is an advanced computing practice eliminates need of transistors in processing binary data. The fundamental phenomenon is utilization of coulomb's force for interactions between subatomic particles. Hence binary digits are represented as charge configurations in place of the conventional current level's representation. Coulomb interactions are responsible for device- device coupling and eliminates the need of current flow. With the help of clocked control of the device the functions like power gain, control of power dissipation as well as pipelined computation are put through. It improves integration density up to 1012 cells/cm and terahertz of switching frequency. Important notable feature is its potential to cross wires in a plane. This new information representation method called a processing in wire method. Innovative designs from QCA are

1. QCA T Flipflop

2.5 Input majority gates

3.Serial communication system

4. 2n to 1 multiplexer

QCA also involves in morphological edge detection, thresholding, noise removal. Quantum Dot Cellular Automato overcomes hardware implementation difficulties in existing algorithm. Mathematical morphology algorithm for implementing complex algorithm is a field of image processing using tools in image processing applications. Mathematical morphology process involves two tasks erosion and dilation. It involves two sets of input the input and structuring element which is binary structuring element white pixel representing back ground and black pixel representing fore ground. Superimpose input and structure elements. In conventional technique 0 and 1 are represented as voltage or current where in quantum dot array the information is stored as electron pairs. The QCA cell representation is denoted in Figure 5. QCA cell is a combination of four quantum dots in a square array by tunnel barrier. Interaction between the dots by coulomb interactions and Quantum mechanical tunneling. The electron tunnels across dots but not outside the cell. The two motion electrons are represented on opposite corners of a cell.

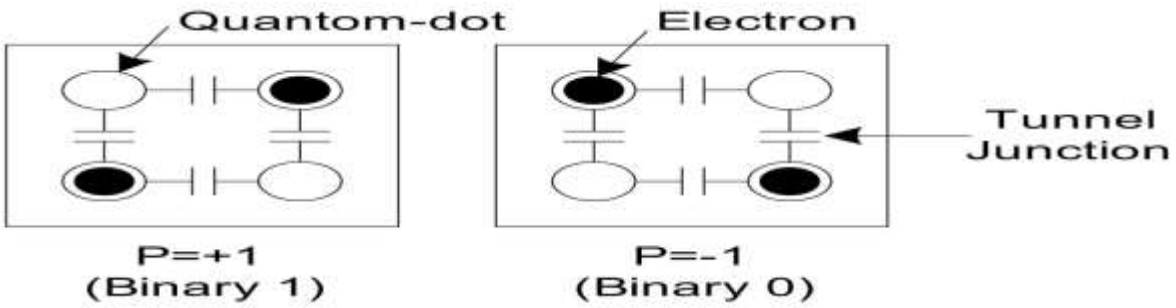

Figure 5: QCA cell representing binary representation "0" and "1".

QCA designs include successive placement of QCA cells that act as a binary wire, 3 input majority gates implemented using five cells. Majority gate act as a configurable AND or OR gate with 2 input A and B and Sel that controls behavior. When QCA AND or OR gate connected with not gate sequential and combinational circuits can be designed. Figure 6 explains various QCA designs.

Figure 6: QCA cell designs

The majority gate with two input A and B results in logic AND output when third input Sel is 0 and logic OR when Sel value is 1. Thus, tunnel junction act as a capacitor couple's potential on dot to other to provide path for quantum mechanical tunneling shows rearrangement of single charges with neighbor cell to perform computation task.

4.Applicational role of quantum dot cellular automato process in image processing techniques

4.1 Image masking

QCA plays an important role in image masking techniques includes designing of low power encoder circuit. Stegnalysis performed to show retrieval of encoded image without employing secret key. This methodology involves conversion of input image in to binary image and key from the user called the cipher image undergoes xor operation and resulted in binary image. The encoding operation is explained in the Figure 7.

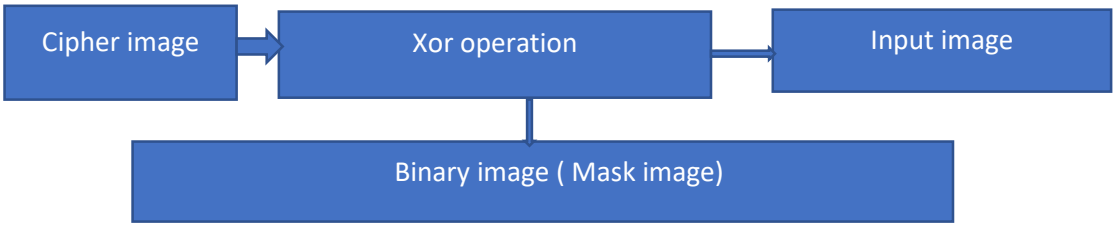

Figure 7: Encoder design resulted with mask image

The process is divided in to four processes. The cipher image when undergoes xor operation with mask image results in original input image. The decoding operation is explained in the figure 8. This resulted in retrieval of original image.

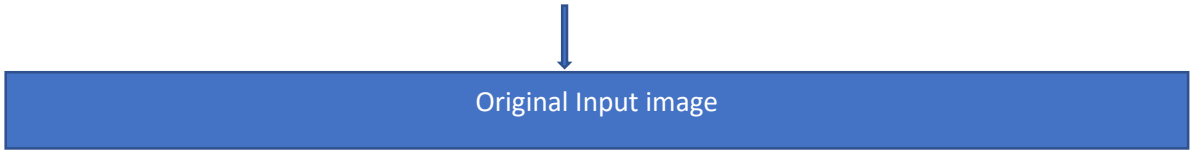

Figure 8: Retrieval of original image using decoder circuit

Morphological erosion and dilution involve the process of superimposing the structure element on image. If black pixel of the structuring element coincides with black pixel is black at the output. The Sel input decides logic gate at the output. In case of Sel input set as "0" erosion operation takes place and resulting in AND majority gate at the output. If Sel input is set to "1" then the dilation operation takes place and resulting in OR majority gate at the output.

4.2 Image enhancement

Filtering of multichannel images play an important role in processing color images as colors conveys information about objects in scene. Degradation of signal quality due to noise, aperture correction causes destruction in image. Impulsive noises caused due to manmade activities or natural phenomenon including Television signal transmission through UHF and VHF. Two stage directional marginal median filters used for reduction of image noises and for lower computational complexity. The Quantum Dot Cellular Automato steps involves threshold decomposition, binary median filter and adder operation. In threshold decomposition an element M is converted in to 2^b bit element applied to first stage binary filter designed using 5-bit binary median filter. Second stage binary filter using m as input and output of previous stage. The sum of output at second stage filter.

4.3 Existing system problem

For the purpose of image classification from a given image, the noise has to be removed which is best done by converting the image to a grayscale. This grayscale image is considered as a binary image which could be subjected to various computing techniques which operate on binary data. For the said study, the technique of Quantum dot cellular automata would be employed to the image in the grayscale or binary data format for the purpose of image processing which is specifically image classification.

5. Proposed technique

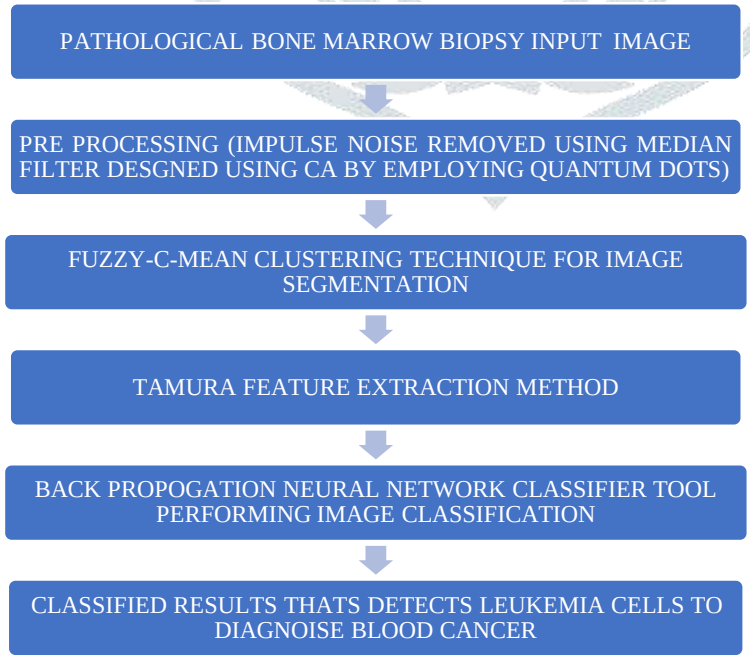

Figure 6: Block diagram for proposed technique

5.1 Process flow chart

The input RGB or colour pathological input image is pre-processed by nonlinear median filter designed using CA by employing quantum dots for removal of impulse noises in image and the denoised image is processed for tamura texture extraction using Fuzzy-c-mean segmentation algorithm. The extracted tamura feature fed as input to back propagation neural network classifier tool for image classification. The classified results used to detect leukaemia cells.

5.2 Cellular automata

Cellular automata are the process for simplified mathematical modelling of complex structures which when implemented using coupled quantum dots is known as Quantum dot cellular automata. The Quantum dot cellular automata are a nanotechnology-based process which is widely employed in the field of computing. This is an advanced computing practice because it altogether eliminates the need for using transistors for the processing of binary data. This is because of the fact that, this process is built on a fundamental physical phenomenon and utilizes the coulomb's force which is responsible for interactions between subatomic particles. Hence, the binary digits are represented as charge configurations in place of the conventional practice to represent them as current levels. Here, the Coulomb interactions are responsible for the device-device coupling and eliminates the need of current flow. With the help of clocked control of the device the functions like power gain, control of power dissipation as well as pipelined computation are put through.

5.3 Leukaemia cells

Leukaemia is a group of cancers that usually begin in the bone marrow and result in high numbers of abnormal white blood cells. These white blood cells are not fully developed and are called blasts or leukaemia cells. They are classified as acute and chronic forms. Additionally, the diseases are subdivided according to which kind of blood cell is affected. This divides leukaemia's into lymphoblastic or lymphocytic leukaemia's and myeloid or myelogenous leukaemia's. In lymphoblastic or lymphocytic leukaemia's, the cancerous change takes place in a type of marrow cell that normally goes on to form lymphocytes which are infection-fighting immune system cells. In myeloid or myelogenous leukaemia's, the cancerous change takes place in a type of marrow cell that normally goes on to form red blood cells some other types of white cells, and platelets.

5.3.1 Input image

The pathological input RGB image contains lots of data which may not be required for image processing. Image conversion discards lot of images which are not required for processing.

Complexities in employing RGB image for processing

1. Difficulty in identifying important edges and features
2. Complexity of code
3. Requires more processing time
4. Difficulties in visualization
5. Complexity in manipulating lots of data's and storing lots of data.

5.3.2 Pre-processing

Pre-processing results in modified image with dimensions same as original image. The processing includes image enhancement or removal of noise such as gaussian noise and impulsive noise from input image dirtied by noise. The conventional filters neighbour pixel replacement to noisy pixel applied to both corrupted and un corrupted image but dynamic **cellular automata**-based technique involves following processing steps.

1. First select corrupted pixel
2. Then replace it by neighbourhood value
3. Uncorrupted image remains unchanged
4. Identifies noise and remove it from corrupted image

The input image is pre-processed where the processing steps involves removal of impulsive noise by employing non-linear filter such as median filter implemented as stack designed by cellular automata using quantum devices such as quantum dots. Impulsive noises are classified as salt and pepper noise and random valued impulsive noise. The salt and pepper impulsive noises can be removed by median filter. It also preserves edges in image. Median filter processing involves if pixel value lies between maximum and minimum value then left unchanged or else replaced by median value. Directional Marginal median filter implemented as stack to avoid time consumption in process. The filtering processes results in undesirable side effects that it tends to blur fine details or destroy edges while filtering out impulses. To trade off detail preservation against noise reduction "decision-based" or "switching" are employed in filters. Adiabatic switching is implemented here by employing cellular automata with quantum devices such as quantum dots. The filtering process involves two phases. The first phase deals with identification of noisy pixel and replace it by median value leaving remaining pixel remains unchanged and the second phase is restoring image

using detail preserving regularized method. The computational parameter involves

1. NCD (Normalized Colour Difference)
2. PSNR (Peak Signal to Noise Ratio)
3. RMSE (Root Mean Square Error).

The expected outcome is binary image with high PSNR value and low NCA value. The filter design involves design of marginal median filter implemented as stack for avoiding time consumption and for its unique features such as low latency time and ease of implementation. The filtering operation at each level performed using Boolean filter and output of each filter is added. The fundamental QCA logic circuit is majority gate forms 3-point binary median. Marginal median filter is nothing but three scalar median filters. The main processing steps includes

1. Threshold decomposition
2. Binary median filters
3. Adding

The filtering operation can be implemented as

1. Define a processing direction
2. Threshold decompose an element
3. Apply first stage binary filters at every layer using 5-bit binary median filter
4. Apply second stage 4-bit binary filters at every layer m using as inputs the outputs of previous first stage binary filter
5. Obtained filtered value as sum of output from second stage filter.

In order to achieve proper performance of QCA implementation adiabatic switching is used. The computational parameters include PSNR (Peak Signal to Noise Ratio) and MSE (Mean Squared Error).

5.3.3 Median filter design by qca

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5.3.4 Adiabatic switching

The filtering processes results in undesirable side effects that it tends to blur fine details or destroy edges while filtering out impulses. To trade off detail preservation against noise reduction "decision-based" or "switching" are employed in filters. Adiabatic switching is implemented here by employing cellular automata with quantum devices such as quantum dots. The filtering process involves two phases. The first phase deals with identification of noisy pixel and replace it by median value leaving remaining pixel remains unchanged and the second phase is restoring image using detail preserving regularized method.

5.3.5 Noise removal using median filter designed by cellular automata process

1. Read input image affected by noise and add periodic boundary condition
2. Compute S max, S min, S med
3. Central pixel of Moore neighbourhood is pixel testing for impulse
4. If S min and S max value lies between central pixel value, then image is uncorrupted, and value remains unchanged
5. If it fails, the process continuous

5.3.6 Fuzzy-c- mean segmentation for extracting tamura features from denoised image

Feature extraction using Fuzzy-c-mean algorithm. Initially background and object are differentiated, and region of the object is segmented. The textures are classified as feature based and model-based textures. Segmentation performed using discontinuous method where segmentation is performed according to change in pixel. Edges are distinguished by detecting sudden pixel value change. Various segmentation algorithms are

1. Gradient algorithm
2. Sobel edge detection
3. Canny edge detection
4. Laplacian edge detection
5. Laplacian gaussian edge detection

Image with texture features are segmented using various processing methods such as

1. Threshold
2. Area splitting
3. Region splitting and merging
4. Clustering

The feature extraction method proposed by Tamura is called **Tamura feature extraction method**. It proposes six features correspond to texture features in psychological perspective. The features are

1. Coarseness
2. Contrast
3. Directionality
4. Line likeness
5. Regularity
6. Roughness

The key determinants are coarseness, contrast, directionality. The image texture is segmented by clustering technique. The image segmentation process involves following steps.

Texture analysis: The key features such as coarseness, contrast and directionality are extracted and computed using computational method proposed by Tamura so called **Tamura extraction method** and segmented using Fuzzy-c- mean clustering technique.

Segmentation by clustering technique

1. select a value for c
2. select cluster centre
3. determine features for every pixel (mean pixel)
4. define similarity between cluster centre and feature (Euclidian distance)
5. calculate cluster centre of new cluster
6. repeat step 4 and step 5 until cluster stop changing

Fuzzy-c- mean algorithm

1. Choose number of clusters.
2. Assign co-efficient randomly to each data point for being in cluster.
3. Repeat until algorithm has converged.
4. Compute centroid for each cluster.
5. For each data point compute its co-efficient of being in cluster.

5.3.7 Back propagation neural network classifier tool for performing image classification to classify leukaemia and non-leukaemia cells

Artificial neural network is alternative to classical pattern classifiers. It is also called as non-parametric supervised feed forward back propagation artificial neural network. It reduces noises and it is a solution to the optimisation problem. It is used to aggregate diagnosis prediction with high accuracy. It is a parallel distributed processor that has natural propensity for storing experimental knowledge which is available for future use.

Advantage of artificial neural network

1. Nonlinearity
2. Input output mapping
3. Adaptivity
4. Fault tolerance
5. VLSI implementation
6. Uniformity of analysis

5.3.8 Flow chart of artificial network

The flow chart of artificial network initiates with procuring of an input an RGB image. Any image in RGB or colour image would be the initial step or the input for this process. This image then would be converted to an image in binary which results after passing it through median filter designed by cellular automata using quantum dots. The resultant denoised image from the quantum dot cellular automata filter would be subjected to Fuzzy-c-mean image segmentation algorithm. The tamura feature extracted theoretical value is fed as input to the artificial neural network classifier that classifies leukaemia cell from normal cell used in blood cancer diagnosis.

Artificial neural network for leukemia cell detection

Artificial neural network classifies leukaemia and non-leukaemia cells used in blood cancer diagnosis. The output is observed as confusion matrix (True Positive Rate vs False Positive Rate) (output class vs target class) is obtained. Performance parameters included accuracy, sensitivity and specificity are evaluated.

5.3.9 Flow chart of artificial neural network

Figure 7: Flow chart of artificial neural network

Thus, artificial neural network classifies carcinoma and non-carcinoma cells used in breast cancer diagnosis. The output is observed as Region of Convergence (True Positive Rate vs False Positive Rate is obtained. The proposed system has been implemented on the same dataset and using the brute force search algorithm, an optimum weight factor of 0.5 in the sigmoid function lead to the following maximum achievable performance parameters. Here Fig. 8 shows the following experimental quantities.

6. Result analysis

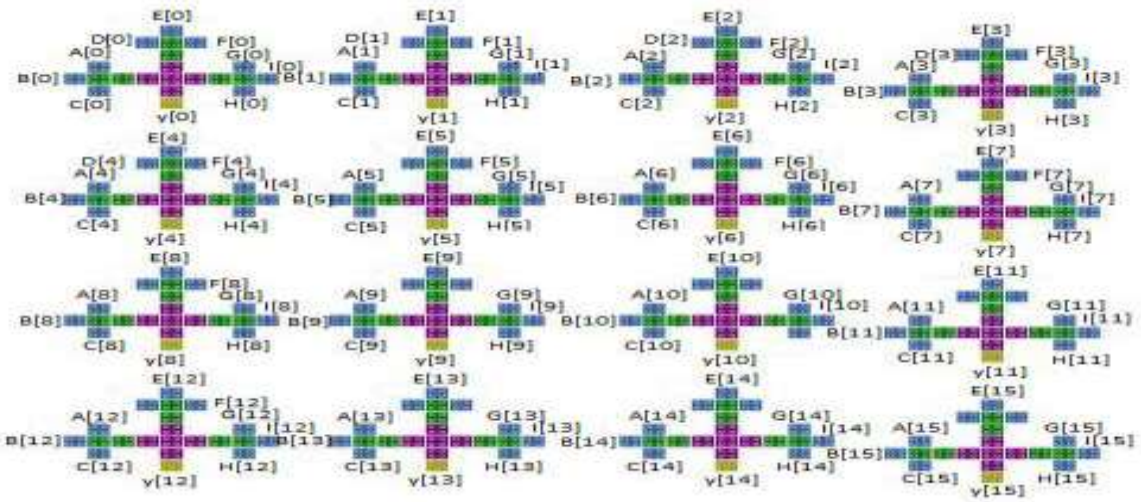


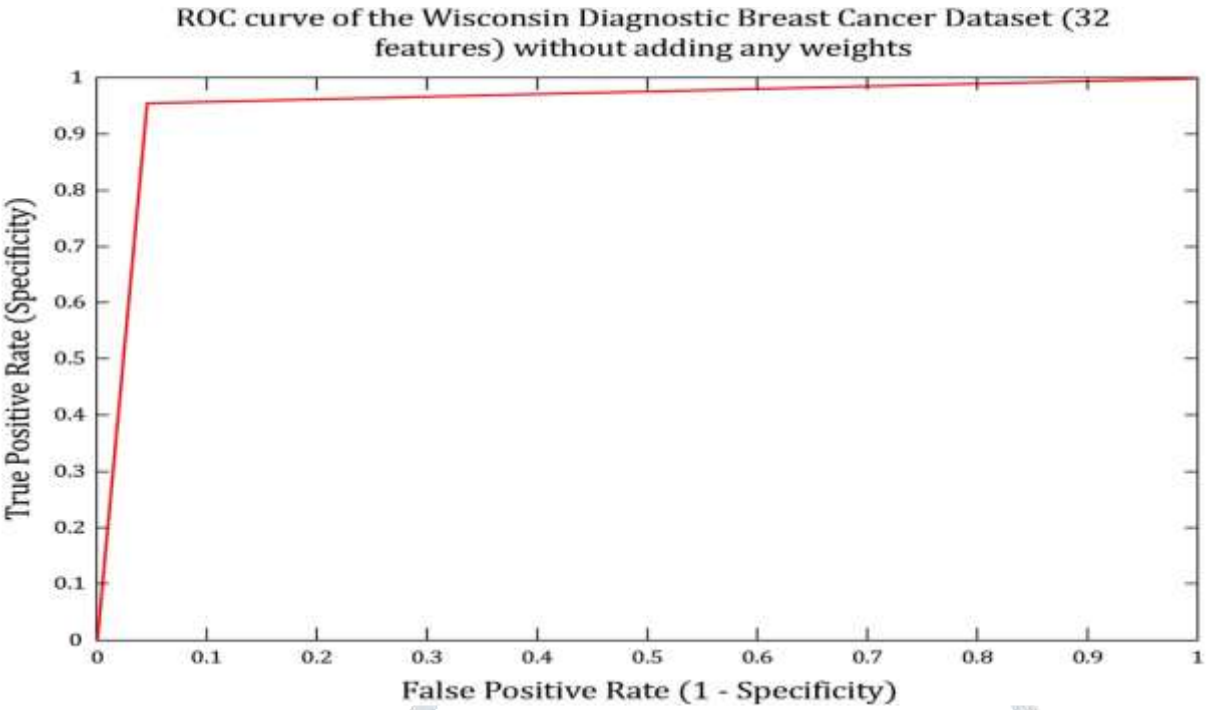
Figure 8. QCA layout of 4-bit numbers median finding architecture.

Table 1. Result analysis of the median finding QCA layouts.

Median filter	Number of Majority gates	Number of Cells	Total Area	Delay Clock
1-bit	4	0.05μm2	0.05 clk	0.5
2-bit	16	84	0.2	0.5
3-bit	64	336	0.8	0.5
4-bit	1024	5376	12.80	0.5

The proposed system has been implemented on the same dataset and using the brute force search algorithm, an optimum weight factor of 0.5 in the sigmoid function lead to the following maximum achievable performance parameters. Here Fig. 9 shows the following experimental quantities.

- Accuracy: 96.8310
- Error Rate: 0.0317
- Sensitivity: 0.9631
- Specificity: 0.9851
- Confusion matrix: 209 8 1 66



• Accuracy: 96.8310 • Error Rate: 0.0317 • Sensitivity: 0.9631 • Specificity: 0.9851 • Confusion matrix: 209 8 1 66

Figure 9: Region of Convergence (True Positive Rate vs False Positive Rate)

6.1 Classification of cancer cells from normal cells

For the detection and diagnosis of cancer from micro- scopic biopsy images, the histopathologists normally look at the specific features in the cells and tissue structures. The various common features used for the detection and diagnosis of cancer from the microscopic biopsy images include shape and size of cells, shape and size of cell nuclei, and distribution of the cells. The brief descriptions of these features are given as follows.

(A) **Shape and Size of the Cells**. It has been observed that the overall shape and size of cells in the tissues are mostly normal. The cellular structures of the cancerous cells might be either larger or shorter than normal cells. The normal cells have even shapes and functionality. Cancer cells usually do not function in a useful way and their shapes are often not even.

(B) **Size and Shape of the Cell's Nucleus**. The shape and size of the nucleus of a cancer cell are often not normal. The nucleus is decentralized in the cancer cells. The image of the cell looks like an omelet, in which the central yolk is the nucleus and the surrounding white is the cytoplasm. The nuclei of cancer cells are larger than the normal cells and deviated from the centre of the mass. The nucleus of cancer cell is darker.

(C) **Distribution of the Cells in Tissue**. The function of each tissue depends on the distribution and arrangements of the normal cells. The numbers of healthy cells per unit area are less in the cancerous tissues. These adjectives of microscopic biopsy images have been included in shape and morphology-based features, texture features, colour-based features, Colour Gray Level Cooccurrence Matrix (GLCM), Law's Texture Energy (LTE), Tamura's features, and wavelet features which are more biologically interpretable and clinically significant.

Normal cells	Cancerous cells	Description
		Large and variably shaped nuclei

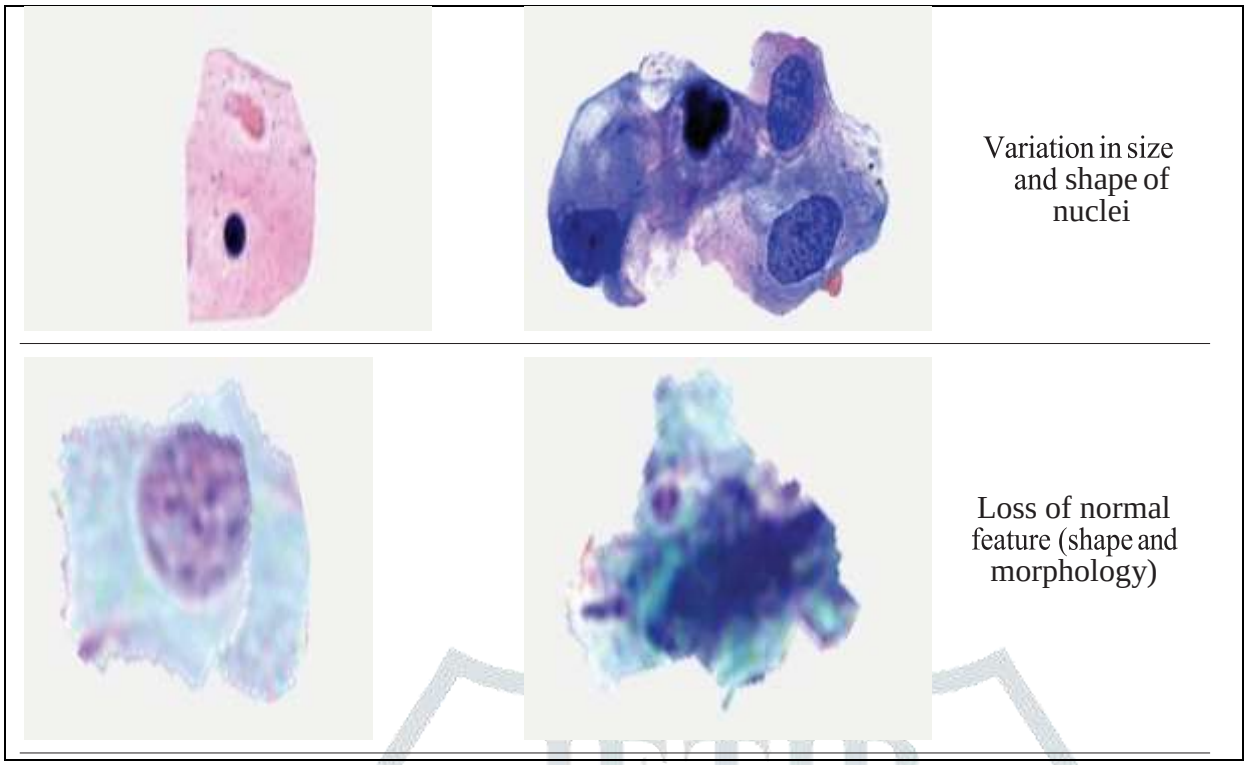


Table 2: Difference between normal and cancerous cells

7. Future scope

Image classification from given image initially requires the removal of noise which is best done by converting image to a gray scale. This gray scale image is considered as a binary image which could be subjected to various computing techniques which operate on binary data. The technique of Quantum Dot Cellular Automata would be employed to the image in the gray scale or binary data format for the process of image classification.

8. Conclusion

This paper presents the innovation technology called Quantum Dot Cellular Automato in designing VLSI architecture which finds its application in image processing resulting in reduced power consumption and reduced mathematical complexity. Thus, this paper dealt with the study of image processing techniques and the procedures carried out in ease way by employing Quantum Dot Cellular Automato process in it. Thus, median filter is designed using CA by employing quantum dots and impulse noises in image are removed and the denoised image is processed for tamura texture extraction using Fuzzy-c-mean segmentation algorithm. The extracted tamura feature fed as input to back propagation neural network classifier tool for image classification. Leukaemia cells are detected from classified results. Classification is performed using Tamura Feature. The output is observed as Region of Convergence (True Positive Rate vs False Positive Rate and a confusion matrix (output class vs target class) is obtained. It is implemented using MATLAB software.

9. References

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