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Efficient edge detection methods for diagnosis of lung cancer based on two-dimensional cellular automata

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ABSTRACT

Lung cancer is one of the most serious health problems in the world. Lung Computer-Aided Diagnosis (CAD) is a potential method to accomplish a range of quantitative tasks such as early cancer and disease detection, analysis of disease progression. The basic goal of CAD is to provide a computer output as a second opinion to assist medical image interpretation by improving accuracy, consistency of diagnosis, and image interpretation time. Since a CAD system is only interested in analyzing a specific organ, edge detection of Computed Tomography (CT) images is a precursor to most image analysis applications. A fully automated method is presented to edge detection of lung CT scan images for diagnosis of lung cancer based on cellular automata. The proposed method is not only computational inexpensive, but also is robust and accurate in detecting lung borders.

Keywords: Cellular automata, lung cancer, computed tomography, noise filtering, edge detection.

INTRODUCTION

Computer-Aided Diagnosis (CAD) is a major research interest in diagnostic radiology and medical imaging. Many different types of CAD schemes are being developed for detection and/or characterization of various lesions for variety of imaging modalities, including conventional projection radiography, Computer Tomography (CT), Magnetic Resonance Imaging (MRI) and Ultrasound. Organs currently being targeted by CAD research include breast, chest, colon, brain, liver, kidney, and the vascular and skeletal systems. As edge detection of medical images is often a precursor to image analysis applications, its accuracy is of great concern as edge detection errors may potentially lead to misdiagnosis.

Medical image edge detection is an important work for object recognition of the human organs such as lungs, and it is an essential pre-processing step in medical image segmentation [1-2]. In some applications it may be useful to classify image pixels into anatomical regions, such as bones, muscles, and blood vessels, while in others into pathological regions, such as cancer, tissue deformities and multiple sclerosis lesions. The goal of the lung edge detection required for the computer aided diagnosis from CT scan images is to essentially separate the voxels corresponding to the lung cavity in the axial CT scan slices from the surrounding lung anatomy.

The work of the edge detection decides the result of the final processed image. Although many edge-detection evaluation methods have been developed in the past years, however this is still a challenging and unsolved problem. Conventionally, edge is detected according to some early brought forward algorithms like Sobel algorithm, Prewitt algorithm [3] and Roberts algorithm [4], but in theory they belong to the high pass filtering, which are not fit for noise medical image edge detection because noise and edge belong to the scope of high frequency. In real world applications, medical images contain object boundaries and object shadows and noise. Therefore, they may be difficult to distinguish the exact edge from noise or trivial geometric features. Then, Canny [5] first presented the well-known three criteria of edge detectors: good detection, good localization, low spurious response and showed

that the optimal detector for an isolated step edges. Based on these criteria, the canny edge detector first smoothes the image to eliminate the noise and then finds the edges but computationally inefficient. After studying all traditional methods of edge detection, it has been analyzed that for these situations, a new algorithm is needed which is optimal. Cellular Automata can be successfully applied for edge detection.

Cellular automata (CA) are new mathematical models which can be used to process and analyze the medical images. In this paper, efficient edge detection methods for diagnosis of lung cancer are proposed. These are better methods for edge information detecting and noise filtering than differential operation, which is sensitive to noise. They are also computationally efficient methods. According to our knowledge this is the first attempt to diagnose the lung cancer based on two dimensional cellular automata.

Cellular Automata

CA model is composed of cell, state set of cell, neighbourhood and local rule. Time advances in discrete steps and the rules of the universe are expressed by a single receipt through which, at each step computes its new state from that of its close neighbours. Thus the rules of the system are local and uniform. There are one- dimensional, two-dimensional and three-dimensional CA models. For example, a simple two-state, one dimensional CA consists of a line of cells, each of which can take value '0' or '1'. Using a local rule (usually deterministic), the value of the cells are updated synchronously in discrete time steps. With a k-state CA model each cell can take any of the integer values between 0and k-1. In general, the rule controls the evolution of the CA model.

A CA is a 4-tuple {L, S, N, F}: where L is the regular lattice of cells, S is the finite state of cells, N is the finite set of neighbors indicating the position of one cell related to another cells on the lattice N, and F is the function which assigns a new state to a cell where $F:S^{|N|}\rightarrow S$.

As the image is a two dimensional (2D), here we use 2D CA model. In a 2DCA the cells are arranged in a two dimensional grid with connections among the neighboring cells, as shown in the figure (1). The central box represents the current cell (that is, the cell being considered) and all other boxes represent the eight nearest neighbours of that cell. The structure of the neighbours mainly includes Von Neumann neighbourhood and Moore neighbourhood are shown in figure–(2):

Von Neumann neighbourhood, four cells, the cell above and below, right and left from each cell is called von Neumann neighbourhood of this cell. The radius of this definition is 1, as only the next layer is considered. The total number of neighbourhood cells including itself is five as shown in the equation (1)[6]:

$$N(I,j) = \{ (k,l) \in L : |k-i| + |l-j| \leq 1 \} \quad (1)$$

where k is the number of states for the cell and l is the space of image pixels. Besides the four cells of von Neumann neighbourhood, moore neighbourhood also includes the four next nearest cells along the diagonal. In this case, the radius r=1 too. The total number of neighbour cells including itself is nine all as shown in the equation (2)[6]:

$$N(I,j) = \{ (k,l) \in L : \max(|k-i|,|l-j|) \leq 1 \} \quad (2)$$

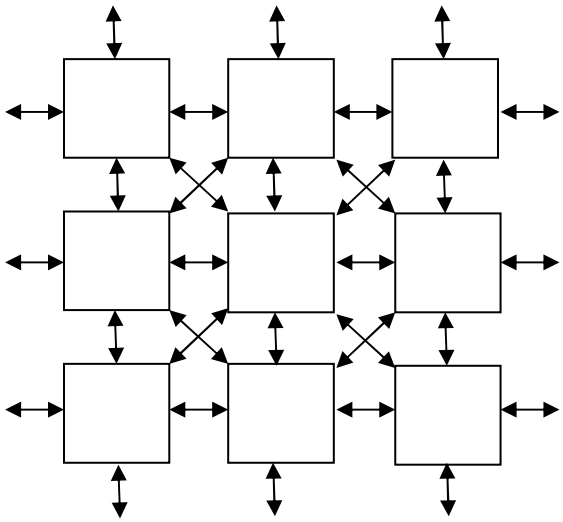


Fig. 1: Network Structure of 2DCA

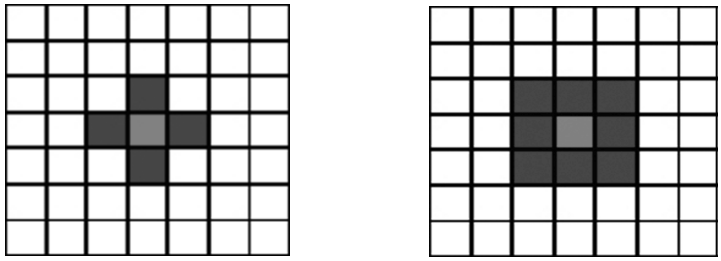


Fig. 2 : structure of neighbourhoods
(a) Von Neumann neighbourhood
(b) Moore neighbourhood

The state of the target cell at time t+1 depends on the states of itself and the cells in the neighbourhood at time t. In case of moore neighborhood, the next state (t+1) is given by:

$$S_{i,j}\ (t+1) = f\ (S_{i-1,j-1}(t) \oplus S_{i-1,j}(t) \oplus S_{i-1,j+1}(t) \oplus S_{i,,j-1}(t) \oplus S_{i,j} \oplus S_{i,j+1}(t) \oplus S_{i+1,j-1}(t) \oplus S_{i+1,j}(t) \oplus S_{i+1,j+1}(t) \quad (3)$$

Since operation $\oplus$ in Eq.(3) is logical Exclusive-OR.

Biological Concept of Lung Cancer

The organs and tissues of the body are made up of tiny building blocks called cells. Cells in different parts of the body may look and work differently but most reproduce themselves in the same way. Cells are constantly becoming old and dying, and new cells are produced to replace them. Normally, the division and growth of cells is orderly and controlled but if this process gets out of control for some reason, the cells will continue to divide and develop into a lump which is called a tumour. Tumours can either be benign or malignant, which is the same as cancerous or non-cancerous [7], as shown in figure 3. The main differences are that a benign tumour grows slower, will not spread and will usually not come back if it is surgically removed.

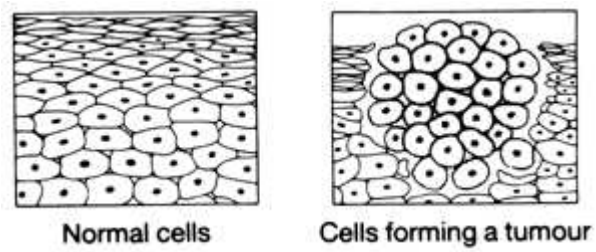


Fig. 3: Fig. 1 Normal and Benign cells

Cancer is the name given to a malignant tumour. A cancerous (malignant) tumour consists of cancer cells which have the ability to spread beyond the original site. If left untreated, they may invade and destroy surrounding tissues. Sometimes cells break away from the original (primary) cancer and spread to other organs in the body by traveling in the bloodstream or lymphatic system. When these cells reach a new area of the body they may go on dividing and form a new tumour, often referred to as a "secondary" or a "metastasis". It is important to realize that cancer is not a single disease with a single type of treatment. There are more than 200 different kinds of cancer, each with its own name and treatment.

The staging of lung cancer is an important step for deciding the right treatment. An international staging system (TNM classification) is often used, based on three characteristics [8].

- Growth of the primary tumor
- Extent of lymph node involvement
- Metastases in distant part of the body

Computational Tomography

Computational Tomography (CT) also known as computed axial tomography (CAT) was discovered independently by a British engineer named Sir Godfrey Hounsfield and Dr. Alan Cormack. It has become a mainstay for diagnosing medical diseases. For their work, Hounsfield and Cormack were jointly awarded the Nobel Prize in 1979. CT scanners first began to be installed in 1974. Because of advances in computer technology, CT scanners have vastly improved patient comfort because they are now much faster. These improvements have also led to

higher-resolution images, which improve the diagnostic capabilities of the test. For example, the CT scan can show doctors small nodules or tumors, which they cannot see on an x-ray.

CT or CAT scans are special x-ray tests that produce cross-sectional images of the body using x-rays and a computer. These images allow the radiologist, a medical doctor who specializes in images of the body, to look at the inside of the body just as you would look at the inside of a loaf of bread by slicing it. This type of special x-ray, in a sense, takes "pictures" of slices of the body so doctors can look right at the area of interest. CT scans are frequently used to evaluate the brain, neck, spine, chest, abdomen, pelvis, and sinuses. Figure (4) shows a typical CT scan image [9].

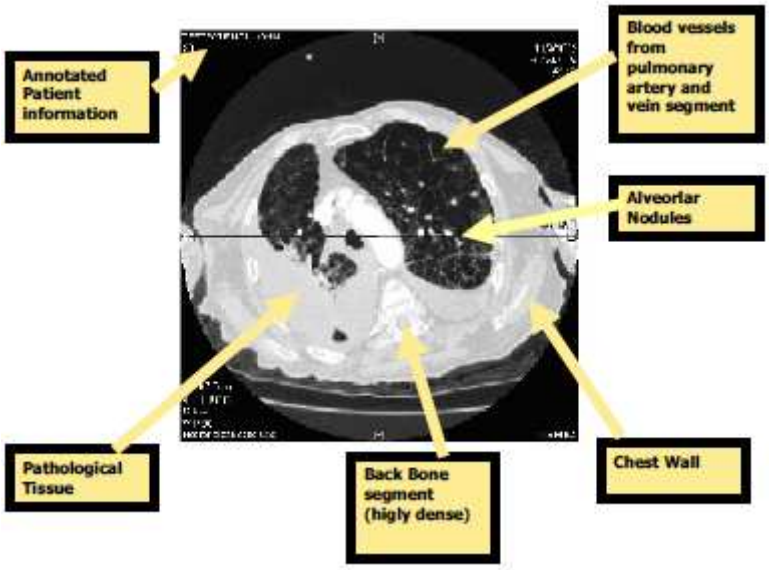


Fig. 4: Typical CT Image

The CT scanner contains an X-ray source, which emits beams of X rays; an X-ray detector, which monitors the number of X rays that strike various parts of its surface; and a computer. The resulting data are sent to the computer, which interprets the information and translates it into images that appear as cross-sections on a television monitor. This series of slices is then analyzed to understand the three-dimensional structure of the body.

A Merits:

- CT has become a commonly performed procedure. Scanners are found not only in hospital x-ray departments, but also in outpatient offices.
- CT has revolutionized medicine because it allows doctors to see diseases that, in the past, could often only be found at surgery or at autopsy. CT is noninvasive, safe, and well-tolerated. It provides a highly detailed look at many different parts of the body.
- A lung CT examines the various structures of the brain to look for a mass, stroke, area of bleeding, or blood vessel abnormality.
- A neck CT checks the soft tissues of the neck and is frequently used to study a lump or mass in the neck or to look for enlarged lymph nodes or glands.
- CT of the chest is frequently used to further study an abnormality on a plain chest x-ray. It is also often used to look for enlarged lymph nodes.

B Risks

CT is a very low-risk procedure:

- You will be exposed to radiation when undergoing a CT. However, it is a safe level.
- The biggest potential risk is if you need to get a contrast injection. This can help distinguish normal tissues from abnormal tissues. It also helps to distinguish blood vessels from other structures such as lymph nodes.
- Any time an injection is done into a vein, there is a risk of the contrast leaking outside of the vein under the skin. If a large amount of contrast leaks under the skin, in rare cases, this can cause the skin to break down.

Proposed Methods

Lung Cancer detection is important since if doctor may detect it earlier then it is easy to them to diagnose and may be possible to recover the disease in the early stage. The goal of the lung cancer detection required for the computer aided diagnosis from CT scan images is to essentially identify circular spots which can be nodules, vessels, bronchial airways, and other dense lung structures. Edge detected images also gives us different information such as accuracy of the voxels, deformation of lung structure, etc. The accurate interpretation of edge detection is one of most important step to go further for detection of abnormalities. We have proposed the following methods of edge detection for the diagnosis of lung cancer.

1 Linear Rules

In 2D CA Nine Neighborhood, the next state of a particular cell is affected by the current state of itself and eight cells in its nearest neighbourhood. Such dependencies are accounted by various rules. Linear rules (LR's) are the rules which can be realized by EX-OR operation only [10].

The state of the target cell at time t+1 depends on the states of itself and the cells in the moore neighbourhood at time t, that is:

$$S_{i,j}(t+1) = f\left(S_{i-1,j-1}(t), S_{i+1,j}(t), S_{i-1,j+1}(t), S_{i,j-1}, S_{i,j}(t), S_{i,j+1}(t), S_{i+1j-1}(t), S_{i+1,j}(t), S_{i+1,j+1}(t) \right) \quad (4)$$

In our previous work we have investigated all LR's [11]. However, here we consider the following two important rules; LR 511 and LR 68.

2 Game Of Life Rules

The two-dimensional CA game of life (CA GoL) was designed by Conway. It consists of an [M × N] matrix of cells, where each cell may take only two states: alive (represented by one) or dead (represented by zero). Each cell has eight neighbors, according to the Moore neighborhood. At every time step, also called a generation, each cell computes its new state by determining the states of the cells in its neighborhood and applying the transition rules to compute its new state. Every cell uses the same update rule, and all the cells are updated simultaneously.

Mathematically, the overall evolutions rules of the GoL can be described as follows:

$$\text{If } S^t = 1, \text{ then } S^{t+1} = \begin{cases} 1, & 4 < \text{Sum} > 1 \\ 0, & \text{Sum} \neq 2,3 \end{cases}$$

$$\text{If } S^t = 0, \text{ then } S^{t+1} = \begin{cases} 1, & \text{Sum} = 3 \\ 0, & \text{Sum} \neq 3 \end{cases}$$

Where, S^t is cell state at the t-0, S^{t+1} and sum is the number of "live" cells in the eight neighborhood cells. In our previous work we changed the standard definition of CA GoL and found excellent results [11]. Here, we will discuss one of such modification.

3 Totalistic Rules

In totalistic rules (TR's) [12], the state of the next state core cell is only dependent upon the sum of the states of the neighbourhood cells. For example if the sum of the adjacent cells is 4 the state of the core cell is 1, in all other cases the state of the core cell is 0. Here, we consider only two rules TR1 and TR2 and to judge the edge point and non-edge point, the centre cell needs to meet the following criterion as shown in table (1):

NAC	0	1	2	3	4	5	6	7	8	9
TR1	0	1	1	1	1	1	0	1	0	0
NS1	0	1	1	1	1	1	0	1	0	0
TR2	1	0	0	0	0	1	1	1	1	1
NS1	1	0	0	0	0	1	1	1	1	1

Table (1): TR Description

Where, NAC is the number of active cells and NS is the next state. If NAC is equal to '0', then the next state (NS) will be the bit first of the rule, for NAC = '1', then NS will be the bit second of the rule and similarly for the other NAC's upto '9'.

4 Fuzzy Rules

Fuzzy rules (FR's) are the rules which can be realized by IF-THEN-ELSE operation only. The rule is applied when its part neighbourhood coincides with a patch of the same dimension on the image. Then, we replace the central pixel of the patch by the value of the future state in the rule otherwise it is left unchanged. Here, we consider the following two important rules.

FR1

If $S^{i,j}(t) =$

1	1	1
1		1
1	1	1

Then $S^{i,j}(t+1) =$ "0", Else $S^{i,j}(t+1) =$ "$S^{i,j}(t)$"

FR2

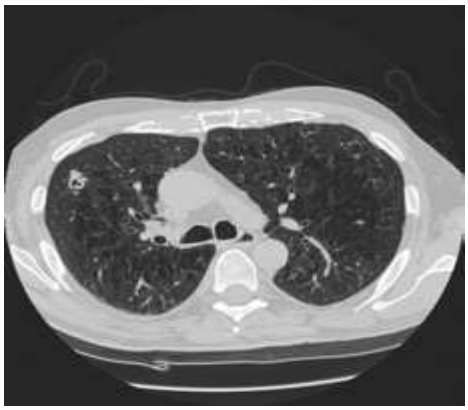
If $S^{i,j}(t) =$

0	0	0
0		0
0	0	0

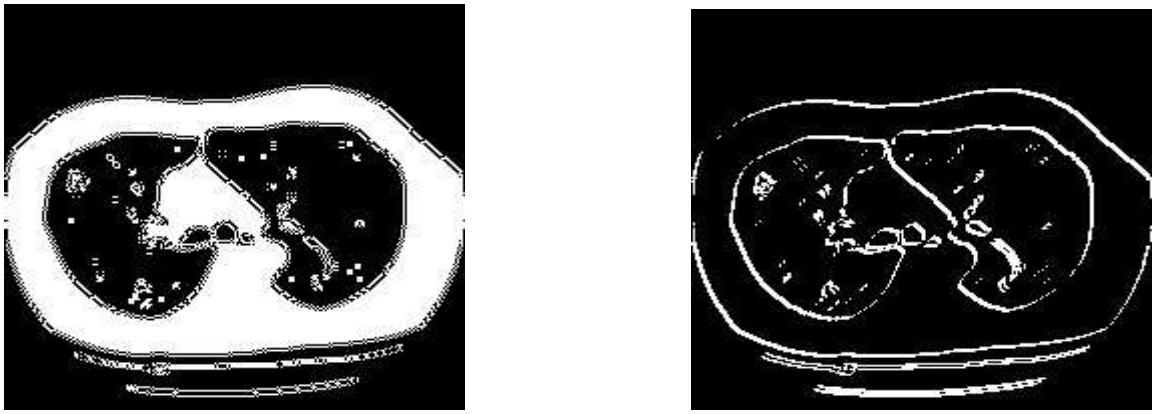
Then $S^{i,j}(t+1) =$ "1", Else $S^{i,j}(t+1) =$ "$S^{i,j}(t)$"

RESULTS AND DISCUSSION

The experimental image is selected as the lung CT Image, whose size is 256×256 as shown in the figure (5). In this subsection, the proposed edge detection methods for detection of lung cancer are applied and results are shown in the figures 6-10.

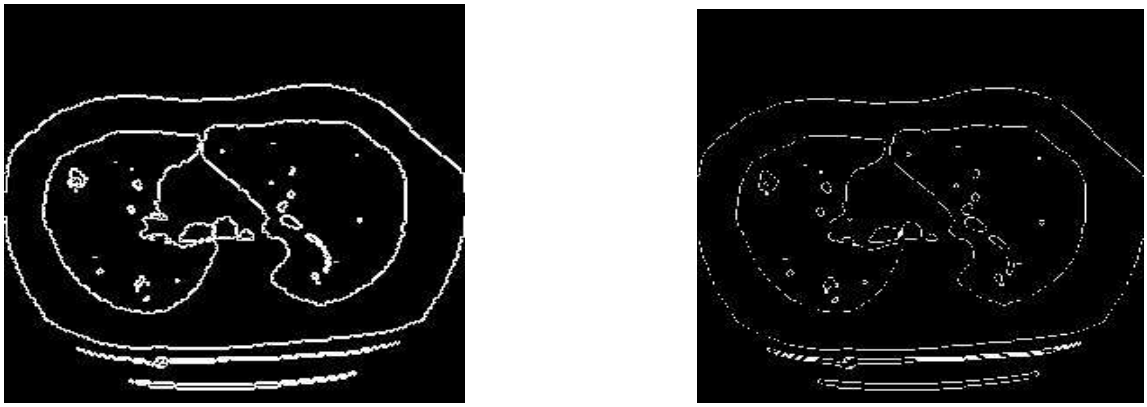


Figure(5) : Original image



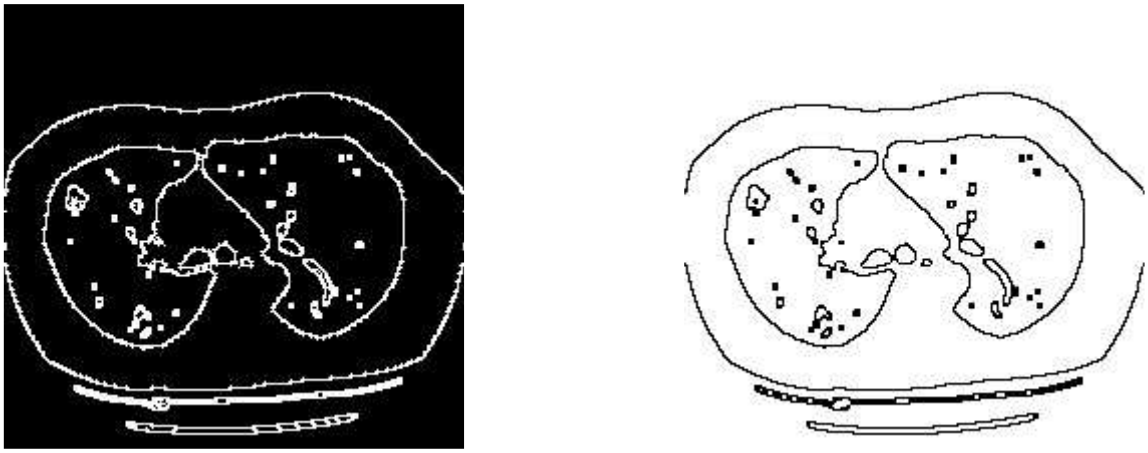
(a) (b)

Figure (6): Results obtained after applying LR's; (a) LR 512 (b) LR 68



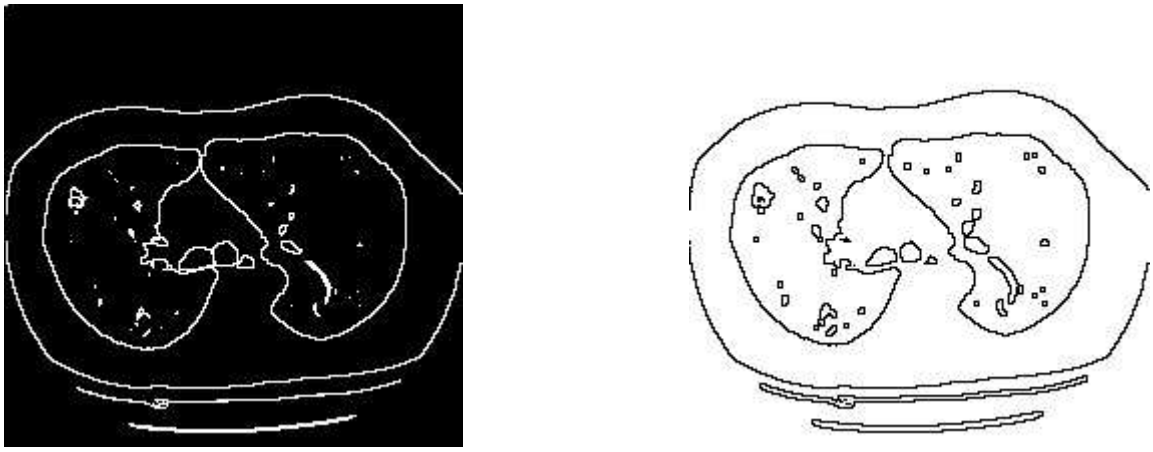
(a) (b)

Figure (7): Results obtained after applying GoL (a) GoL (b) changing parameters of GoL



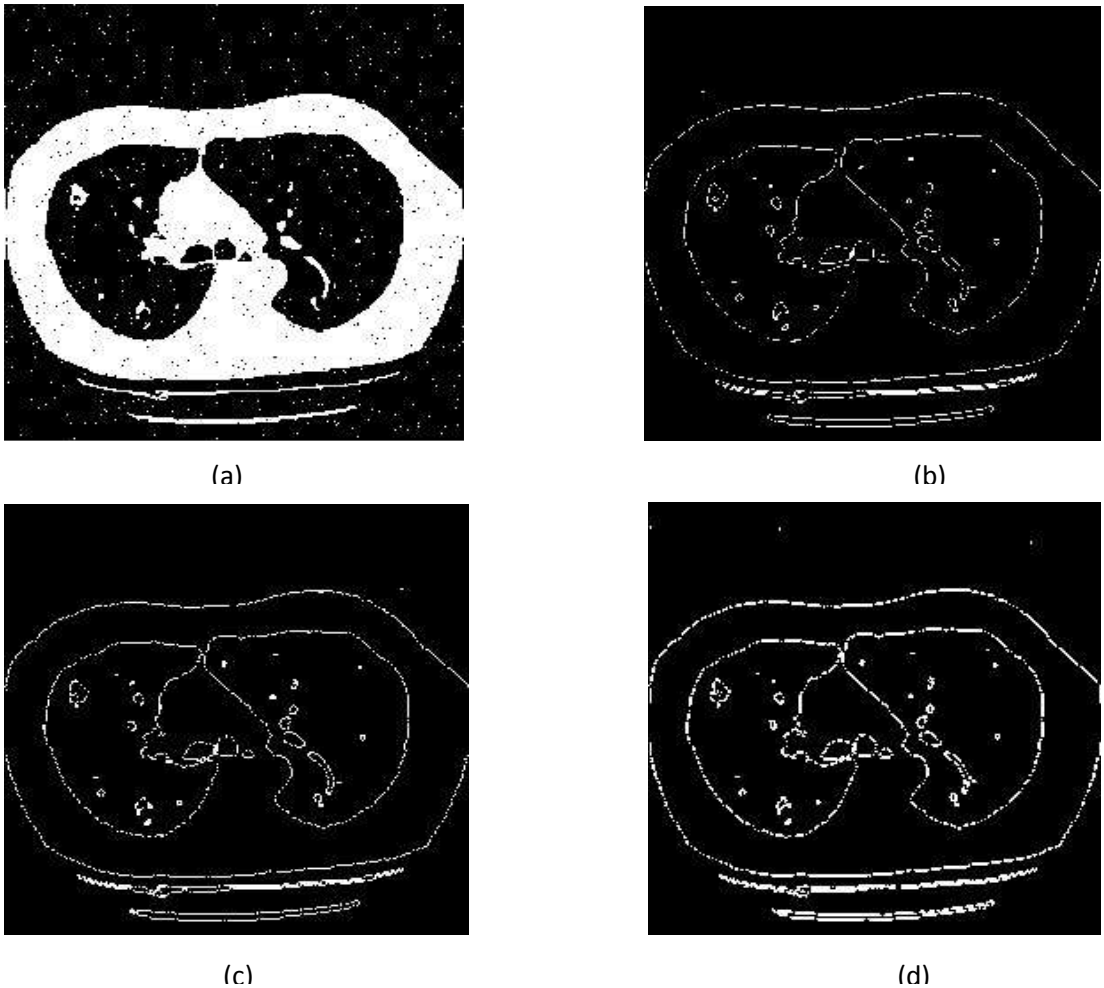
(a) (b)

Figure (8): Results obtained after applying TR's ;(a) TR1 (b) TR2



(a) (b)

Figure (9): Results obtained after applying FR's; (a) FR1 (b) FR2



(a) (b)

(c) (d)

Figure (10): Results obtained after applying GoI; (a) original lung CT image corrupted with impulsive Noise, (b) GoL, (c) and (d) shows the results after changing the parameters of GoL.

Medical images are noisy in nature due to limitations of imaging techniques, device noise and health constraints (such as giving minimal radiation doses to patients). De-noising as preprocessing step is recommended in CAD systems even though de-noising may suppress some important image edge details; for instance in many techniques edges get blurred as result of de-noising. Therefore algorithms with low sensitivity to noise tend to give higher

performance in medical images processing problems. Figure (10.a) shows the CT image corrupted with noise. Figure (10.b) shows the simulations using standard GoL whereas figure (10.c) and figure (10.d) shows the simulations by changing the standard definition of the GoL.

CONCLUSION

In this paper we present different technique for recognizing the lung nodules for different diagnosis of lung cancer based on CT images. Edge detected images gives us different information such as accuracy of the voxels, deformation of lung structure, etc. The paper presents that (1) we apply image processing technique based on CA into lung tissue information recognition, the key and hardest task is auto-detecting the tiny nodules, which may present the information of early lung cancer; and (2) the newly developed edge detection algorithms is to diagnose indeterminate nodules correctly, allowing curative resection of early-stage malignant nodules and avoiding the morbidity and mortality of surgery for benign nodules.

REFERENCES

[1] Rajab M. I., Woolfson M. S., and Morgan S. P., *J. Comp. Med. Imag. and Graph*., **2004**, 28: 61–68.
[2] H. Tang, E.X. Wu, Q.Y. Ma, D. Gallagher, G.M. Perera, and T. Zhuang, *J. Comp. Med. Imag. and Graph*., **2000**, 24 : 349–357.
[3] Sobel., E., "Camera Models and Machine Perception", PhD thesis. Stanford University, Stanford, California.**1970**.
[4] Roberts L. G., "Machine perception of three-dimensional solids," Optical and Electro-Optical Information Processing, MIT Press Cambridge, Massachusetts, **1965**, 159-197.
[5] Price S., "Edges: The Canny Edge Detector",
http://homepages.inf.ed.ac.uk/rbf/CVonline/LOCAL_COPIES/MA,RBLE/low/edges/canny.htm.
[6] Songtao L., Hongquan C., Shaoqing Y., *IEEE*, **2008**, 03 : 294-297.
[7] Robin N. S., "Image Processing Techniques for Tumor Detection", Marcel Dekker Inc. New York, **2002**.
[8] Nisar A. M., Anwar M. M., and Gilani S.A.M., *In World Academy of Science, Engineering and Technology*, **2006**, 20 : 113–118.
[9] Malin D., "Every one's Guide to Cancer therapy; How Cancer is Diagnosed, Treated and Manged", 4th Edition, Andrews McMeel Publishing Kansas, USA, **2002**.
[10] Fasel Q., Khan K. A., *I. J. Comp. Net. and inform. Sec*., **2012**, 3: 47-53.
[11] Fasel Q., Peer M. A. and Khan K. A., *I. J. of Inform. Eng. And Elect. Busin*., **2012**, 2, 22-28.
[12] Goi H. T., "An Original Method of Edge Detection Based on Cellular Automata", Homework for EE817 Emerging Computing Technologies, www.ee.pdx.edu, **2003**.