International Journal of Engineering & Technology, 7 (4.25) (2018) 286-290

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Early Detection of Lung Cancerby using Fuzzy Logic

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Abstract

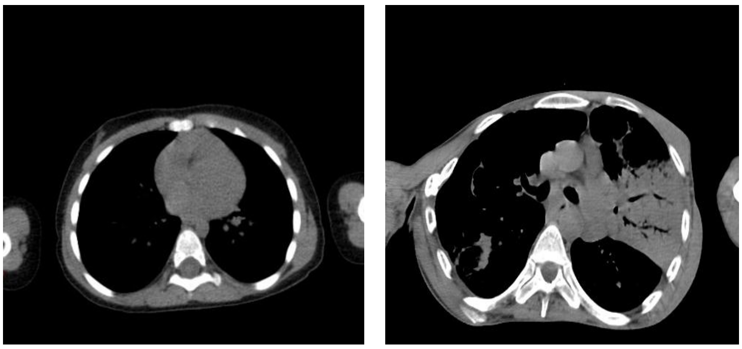
Lung Cancer is one of the heath challengesin the world it has been increased in the most of countries, so the early detection or diagnosis is most important issue to help the patients to recoverfrom the cancer. In this paper we proposed a new algorithm for Lung cancer disease diagnosis by using Discrete Wavelet Transform (**DWT**) and Fuzzy logic, where our algorithm consist from five steps; the first step is for image acquisition; the second step is for image preprocessing (image enhancement and de-noising); the third step is for image analysis by using discrete wavelet transform (**DWT**); the fourth step is for features extraction (in our paper there are seven texture features used for detection), the final step is for classification and diagnosis by using fuzzy logic to know wither the disease is cancer or not. The performance of our algorithm is gave high accuracy up to 97% in testing and 100% in training, by using 350 images from our collected database, we collected our database from Thi-Qar Heart Center, Iraq.

Keywords: *Lung Cancer; Image Enhancement;**DWT**, Feature Extraction; Detection, Fuzzy Logic.*

1. Introduction

Lung Cancer is one of the most serious health problems in the world field. The mortality rate of lung cancer is the highest among all other types of cancer.Lung Cancer is a malignancy that affects the different lung tissues and it is characterized by uncontrolled cell division of living cells, and the ability of these dividing cells into invade and spread other tissues of the lung, either by direct growth toward a nearby tissue or by the passage and invasion of distant tissues in a process known as transfer. There are two main types of it named according to their appearance under the microscope Small cell lung cancer(SCLC) andNon-SmallCell Lung Cancer (NSCLC). The main cause is exposure to tobacco smoke, which is the leading cause of 90% of lung cancer cases. These cases are often attributed to genetic factors or gas Radon or Asbestos [1-2].

Lung cancer at its onset does not necessarily cause pain or other symptoms, which makes its diagnosis late in most cases. Nearly 40% of cases of lung cancer are adenocarcinoma, which usually arise in peripheral lung tissue and are associated with most adenomas with smoking, The most common form of lung cancer. Symptoms include the appearance of pectoral pain that changes the nature of the chronic cough of the smoker or complaining of a new cough, tight blood flow, breathing pneumonia, especially frequent in the same place, accompanied by heat and shortness of breath, and finally weight loss[3-4]see **Figure (1)**. In order to reduce the mortality rate due to hardening of the lung cancer, it is necessary to be diagnosed at an early stage. This paper proposes algorithm for the diagnosis of lung cancer in the early stages.



(a) (b)

Figure 1: The Lung(a) Normal. (b) Cancer.

2. Methodology

In this paper we need to analysis the imagesto extract useful features by using DWT to reduce the hug information of redundant pixel or not useful by ignore the details parts, we may need to decompose the image into one level or two-levels and remove the sub-band which haven't the useful informationof the image.

2.1 Discrete Wavelet Transform (DWT)

To extract the best or the important features ofimages, the best way is by analysis the images by using one of the analysis methods such as DWT which have the highest accurate results.Wavelet transforms are widely applied in many fields for solving various problems, it can be obtaining by apply two filters; High pass filter and low pass filter by using the following equation [5].

1. Low pass filter

$$L_i = \frac{1}{2}\sum_{j=1}^{N} C_{j+1-2i} \times f_i \qquad (1)$$

2. High pass filter

$$H_i = \frac{1}{2}\sum_{j=1}^{N}(-1)C_{2i-j} \times f_i \qquad (2)$$

Where C is mother function coefficients

To obtain DWTby applying low pass filter into rows of the image and keep the results in half of new image then apply the high pass filter into the original image and keep the result into the second half of new image, then repeat the operations for the columns of new image to obtain four parts of decomposed image, where the component of four parts as following; three of these parts contains the details and the last one of these parts contain the approximately information (the result from apply the Low pass filter into both rows and columns)[6].

2.2 Fuzzy logic

Fuzzy logic examines human thinking and reasoning and mathematically applies it to conduct problem solving and decision making. Verbal rules and variables used in the human decision-making process are fuzzy, unlike the precise, numeric nature of computer logic. These verbal terms are expressed mathematically as membership functions. Fuzzy decision-making systems use symbolic verbal phrases rather than numeric values and can produce effective results based on indefinite verbal knowledge like humans. If a system's behaviour can be modelled by rules or requires very complex nonlinear processes, fuzzy logic can be applied to this system. Mamdani's fuzzy inference method is the most commonly used fuzzy inference system [7-8]. Fuzzy rule-based systems consist of three main steps; Fuzzification, Inference and Defuzzification as illustrated in **Figure (2)**.

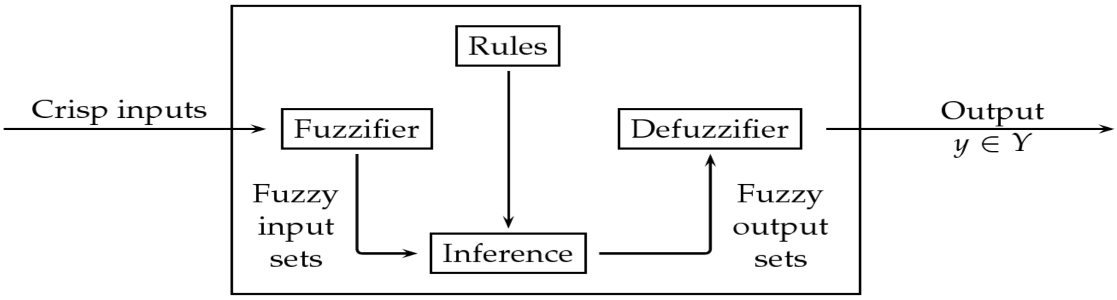


Figure 2: Fuzzy Inference System[9]

3. The Proposed Algorithms

Figure 3: Algorithm Diagram for Lung Cancer Detection

Our algorithm can be explainedinthe following steps:

3.1. Image acquisition

The images are collected from Thi-Qar Heart Center; there are 350 images from different patients used for training and testing, with format JPEG.

3.2. Image pre-processing

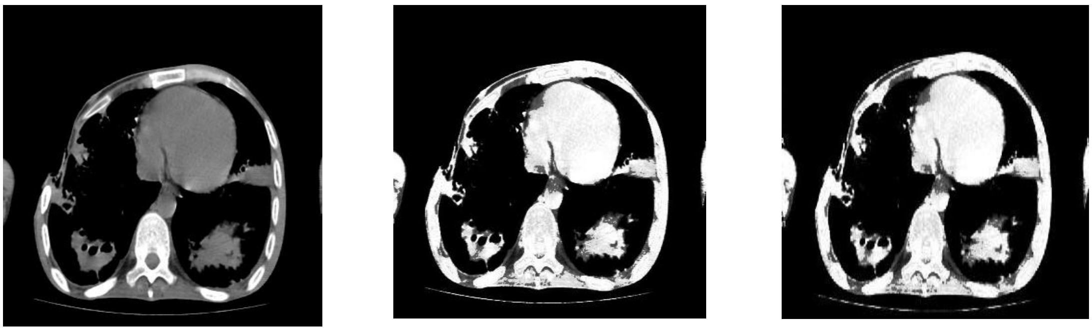
In this step all imagessize will beresize into (512*512 pixels) andcontrasts the brightness of image will be increase using adjustment filter and using logarithmic filter. As shown in **Figure (4)**.

Algorithm 1

Input: image from source

Output: enhanced image

1. Read image
2. Resize image for all images into 512*512 pixels
3. Increase the image contrast to make all image have the same environments.
4. Apply image adjustment filter and using logarithmic filter respectively.
5. End



A B C

Figure 4. (a) original image (b) after apply contrast (c) after apply Gaussian Filtering

3.3 Feature extraction

There are two types of features extracted one from binary image shape features (area, Eccentricity, diameter, perimeter and perimeter-to-Area Ratio) and the second from gray image texture features (Coarseness, Contrast and Directionality). As shown in Table (1).

Algorithm 2

Input: enhanced image

Output: feature vector

1. Convert image into gray
2. Calculate Coarseness, Contrast and Directionality
3. Convert gray image into binary
4. Calculate area, Eccentricity, diameter, perimeter and perimeter-to-Area Ratio
5. End

3.4 Fuzzy logic

There are seven features used fordiagnosis as shown in Table.1, these seven features we be inputs to build two rules for output (normal and Cancer)as following:

R1:if (input 1=low and input2=low andinput3=low andinput4=low andinput5=low andinput6=low andinput7=low then output 1 =low)

R2: if (input 1=high and input2=high andinput3=high andinput4=high andinput5=high andinput6=high andinput7=high then output 1 =high)

There are seven inputs and one output as shown in Figure (5).

Algorithm 3

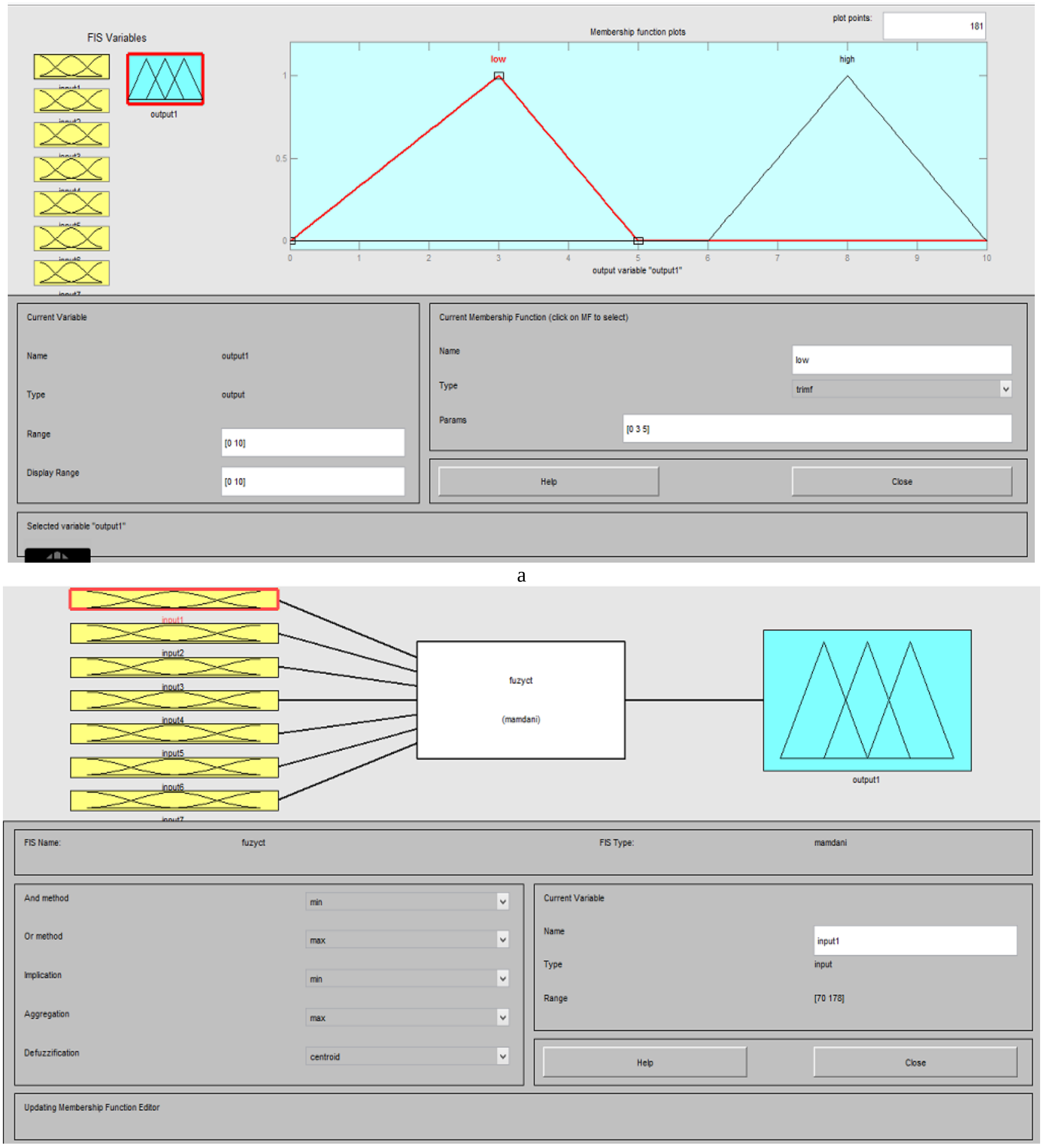
Input: feature vector

Output: fuzzy decision

1. Initialization: seven inputs $(i1, i2 \dots . i7)$ of universal set X.
2. $\mu_{i1\cap i2\cap i3\cap i4\cap i5\cap i6\cap i7} = min(\mu_{i1}(x), \mu_{i2}(x), \dots .. \mu_{i7}(x))$
3. Two rule for decision maker

R1: *if (input 1=low and input2=low and input3=low and input4=low and input5=low and input6=low and input7=low then output 1 =low)R2: if (input 1=high and input2= high and input3= high and input4= high and input5= high and input6= high and input7= high then output 1 =high).*

4. Output will be one (normal if rule is ture or cancer of rule is false)
5. End



a

b

Figure 5: (a) shows the 7 inputs ranges (b) shows the output ranges

4. Experiments and results

The experiments from our algorithm shows high accuracy comparedwith the others researcher's algorithms,the database usedin our paper are 350 images divided into 300 images for training stage and 50 for testing,Table 1 and Figure 5 shows the results of seven Textures features vectorsfor normal images, while the Table 2 and Figure 6 shows the features vectors of abnormal Cancer images.

Table 1: The features vector to samples of **normal**Lung images.

Input image	Textures feature						
	Feature1	**Feature2**	**Feature3**	**Feature4**	**Feature5**	**Feature6**	**Feature7**
Image 1	71.61559	155.4779	13.49326	143.3437	306.3836	37.02422	15.90383
Image 2	73.18577	157.959	13.11537	145.7742	311.0262	36.41639	15.88355
Image 3	74.22207	158.5106	13.82963	148.5566	312.3666	38.70145	16.42254
Image 4	76.10448	158.5163	14.1058	151.4479	311.5773	38.16418	16.34334
Image 5	74.45845	157.7763	13.34335	149.0389	310.9503	37.05552	16.64001
Image 6	80.69259	165.596	14.22173	161.3852	326.3501	40.79029	16.32986
Image 7	77.03034	160.9736	13.78084	154.0607	317.0228	39.47552	16.86648
Image 8	76.85758	159.0202	14.08001	152.9466	312.3307	39.88411	16.44702
Image 9	78.20073	162.8662	14.18461	155.6303	320.286	39.94927	15.94458
Image 10	79.2913	161.7016	14.62436	158.6235	318.3993	40.08616	16.93367

Table 2: The features vector to samples of **Cancer** Lung images.

Input image	Textures feature						
	Feature1	**Feature2**	**Feature3**	**Feature4**	**Feature5**	**Feature6**	**Feature7**
Image 1	174.6561	223.4269	16.67216	349.0504	442.3518	47.7195	17.74443
Image 2	176.1031	223.9656	17.6856	352.2063	443.1713	49.01122	18.95803
Image 3	175.1974	223.7497	17.65824	348.4481	442.3377	49.01035	18.40849
Image 4	177.4716	223.4868	17.34141	354.9433	442.0198	49.55512	19.44812
Image 5	164.2996	216.9257	17.4442	328.3535	428.8046	48.62291	18.95801
Image 6	162.3104	214.658	17.99931	322.6507	423.532	50.95677	19.31826
Image 7	158.858	213.3761	17.8259	315.7936	420.6526	50.10004	20.55104
Image 8	167.0815	215.9445	18.41869	333.9791	426.3592	52.16546	20.02644
Image 9	157.1957	212.8277	17.7301	312.7012	419.4664	50.60448	20.96629
Image 10	159.5389	213.5993	17.84149	319.0777	421.5197	50.81242	21.05249

As shown in Tables (1) and (2) the texture features have near values in same classes and far values in different classes which will increase the detection or diagnosis the normal and cancer of lung where the accuracy in training stage is 100% as shown in Table (3) while the accuracy in testing stage is 97% as shown in Table (4).

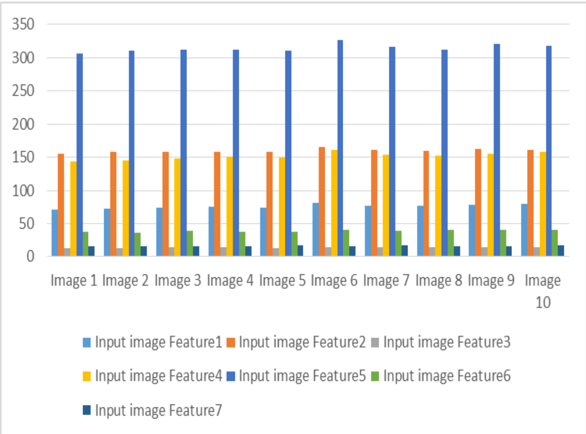


Figure 6: shows the features vectors of normal images.

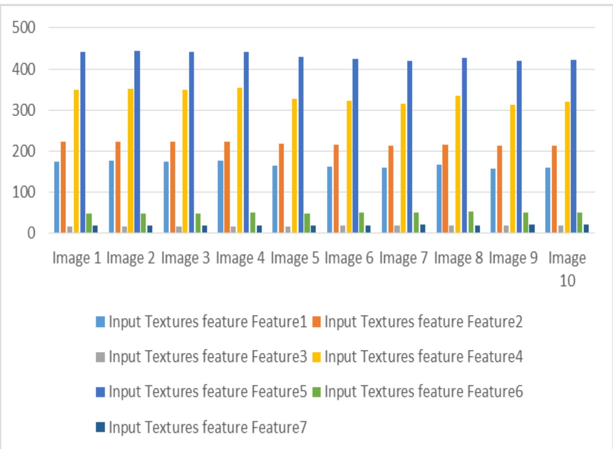


Figure 7: shows the features vectors of abnormal Cancer images.

Table 3: Shows the result from fuzzyforimagesin training stage

No of images	**Type of disease**	**Accuracy**
150	Normal	100%
150	Cancer	

Table 4: Shows the result from fuzzy for imagesin testing stage.

No of images	**Type of disease**	**Accuracy**
25	Normal	97%
25	Cancer	

5. Conclusion:

In this is paper we found that the DWT is useful in image analysis and give the best reducing the information and remove the unwanted information from images while the other method such as GLCM is not suitable for image analysis in our paper, also we found that the shape features of binary image such as (Area, Eccentricity, Diameter, Perimeter and Perimeter-to-Area Ratio) and the texture features of gray image such as (Coarseness, Contrast and Directionality) are givingbest feature for classification with high accuracy rather than use the others features such as statistical features (mean, STD,VAR…etc.),finally in decision making the fuzzy logic gave the best results and better classifier in our paper rather than classifier methods such as ANN or SVM.

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