Indian J.Sci.Res. 17(2): 56-63, 2018
ISSN: 0976-2876 (Print)
ISSN: 2250-0138(Online)

BONE CANCER DETECTION USING ARTIFICIAL NEURAL NETWORK

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Abstract - A bone cancer is a serious disease causing deaths of many individuals. The detection and classification system must be available to diagnose cancer at its early stage. The early detection seems to be the only factor that increases the chance of survival of cancer affected patient. Cancer classification is one of the most challenging tasks in clinical diagnosis. This paper deals with the system which uses the image processing techniques to detect the tumor and classify cancer using Artificial Neural Network algorithm for MR images of different patients. The proposed methodology uses preprocessing techniques such as filtering and gray conversion and other image processing techniques like edge detection, morphological operation, segmentation, feature extraction and classification are done for the detection of bone cancer. The proposed method will drastically reduce the time required for detection and classification of cancer.

Keywords*:* bone cancer, preprocessing techniques, super pixel segmentation, feature extraction, artificial neural network.

I. Introduction

A tumor is an abnormal growth of new tissue and that can be formed in any of the organs in our body. There are about 200 different types of cancers has been detected in the human body. They are all characterized by the type of cell that is first affected. Bone cancer is considered to be one of the most dangerous and serious cancer in the world, with less survival rate. Bone tumors are developed by the uncontrolled division of cells in the bone. The most common types of bone cancer are chondrosarcoma, pleomorphic sarcoma, Ewing's sarcoma, osteosarcoma and fibrosarcoma. Mostly the bone cancer is classified as primary or secondary. Cancer that occurs in the bone is the primary one whereas if it initially occurs anywhere in the body and affects the bone is called the secondary. There are two types of bone cancer, non cancerous (benign) and cancerous (malignant). Most of the bone tumors are benign which means they cannot spread and non cancerous. Bone cancer that destroys the normal bone tissue and it spreads to the other parts of the body is called metastasis. Like any other cancer bone cancer also occur in four stages.

Stage 1- cancer is not aggressive and not spread out of the bone.

Stage 2- aggressive cancer.

Stage 3- cancerous cells exist in multiple places of the same bone.

Stage 4- spreading of cancer to other parts of the body.

Still, the exact cause of bone cancer is not known the prevention cannot be done for this uncommon cancer. Cancer will occur most often in long bones of the arms and legs. Obtaining an accurate result in bone cancer detection is very important in many imaging application. It mainly helps to plan for the treatment at the earlier stage and for the evaluation of the therapy. The early detection of bone cancer will decrease the mortality rate. To obtain more accurate results, we divided the whole process into three stages, image processing stage, image segmentation, feature extraction and classification. The main objective of our proposed method is to develop a robust system to detect the bone cancer in early stage and to obtain a more accurate result than many other existing techniques.

II. Literature Survey

Sinthia P and K. Sujatha [1] proposed a novel approach to detect the bone cancer using K-means algorithm and edge detection method. This methodology used Sobel edge detection to detect the edge. Sobel edge detector detects only the border pixels. K-Means clustering algorithm is used to detect the tumor area. Defining the number of clusters is the difficult step in K-Means clustering algorithm.

Kishor Kumar Reddy [2] proposed a novel approach for detecting the tumor size and bone cancer stage using region growing algorithm. This methodology segmented the region of interest by using region growing algorithm. Tumor size is calculated according to the number of pixel in the extracted tumor part. Depending upon the total pixel value cancer stage is identified. Selection of seed point depends on the image and it is difficult to select accurately.

Maduri Avula [3] proposed a method to detect the bone cancer from MR images using Mean pixel intensity. The input MR image is denoised and K-Means clustering algorithm is applied to extract the tumor part. From the extracted tumor part the total number of pixel is computed and the sum of pixel intensity is calculated for the extracted tumor part to calculate the mean pixel intensity. Mean pixel intensity is calculated to identify cancer. If the mean pixel intensity value is above the threshold value it is considered as cancer.

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Abdulmuhssin Binhssan [4] proposed a method to detect the enchondroma tumor. The input image is denoised using the bilateral filter and average filter. The bilateral filter has certain disadvantage It takes more time to denoise the image. The average filter provides better result compare to bilateral filter. Thresholding segmentation is carried out to segment the image and morphological operations are applied to enhance the tumor area.

Ezhil E.Nithila and S.S Kumar [5] proposed Automatic detection of solitary pulmonary nodules using swarm intelligence optimized neural networks on CT images. This methodology used the Gaussian filter to remove the noise and contour model to segment the image. Leakage problem arises due to the weak boundary. The nodule is detected from the segmented image. Borders of the nodule are corrected to recover the lung nodule. Various features are extracted to find the tumor accurately. The extracted feature is applied to back propagation neural network to train the data and to classify the tumor.

Mokhled S. Al-Tarawneh [6] proposed a method of Lung Cancer Detection Using Image Processing Techniques. This methodology used Gabor filter to denoise the image. Gabor filter has the best results. To segment the image two segmentation methods are used. Thresholding approach and marker-controlled watershed segmentation are the two algorithms. Marker-controlled segmentation technique provides better result compare to thresholding approach. The image features are extracted using binarization and masking approach to identify cancer.

Fatma Taher and Naoufel Werghi [7] proposed a method to detect lung cancer by using an artificial neural network and fuzzy clustering methods. This methodology used two segmentation methods Hopfield neural network and a fuzzy c-means clustering to segment the image. Computer Aided Diagnosis system is developed to identify cancer at its early stages. In this paper, 1000 sample images are tested using both the segmentation techniques. HNN has shown a better classification compare to fuzzy clustering technique.

Anita chaudhary [8] has developed a method of lung cancer detection on CT images by using image processing. In this methodology, Gabor filter is used for noise reduction. Segmentation is done by using two segmentation methods thresholding and marker-controlled watershed segmentation. Features are extracted to identify the tumor. Area, perimeter and roundness are the three features extracted in this paper.

Md. Badrul Alam Miah and Mohammad Abu Yousuf [9] proposed a technique to detect the lung cancer from CT image using image processing and neural network. In this methodology, several preprocessing techniques are used to enhance the image. Segmentation technique is carried out after preprocessing to segment the image. Features are extracted and applied to the neural network to train and classify cancer.

Nooshin Hadavi and Md.Jan Nordin[10] proposed a method for Lung Cancer Diagnosis Using CT-Scan Images Based on Cellular Learning Automata. This methodology used Gabor filter to remove the noise present in the input image. Region growing algorithm is used to segment the image. Various features are extracted from the segmented image and applied to the new algorithm cellular automata to identify cancer.

K. Jalal Deen and Dr. R. Ganesan [11] proposed An Automated Lung Cancer Detection from CT Images Based on Using Artificial Neural Network and Fuzzy Clustering Methods. Preprocessing techniques are applied to enhance the image. Dilation and erosion operation is applied to the preprocessed image. Lung border is extracted using edge detection technique. Lung regions and various features are extracted. Artificial neural network and Fuzzy C-Means clustering technique are used to identify the tumor from the extracted lung region. This proposed methodology used Artificial Neural Network for classification and to detect the tumor area accurately.

III. Image Processing Techniques

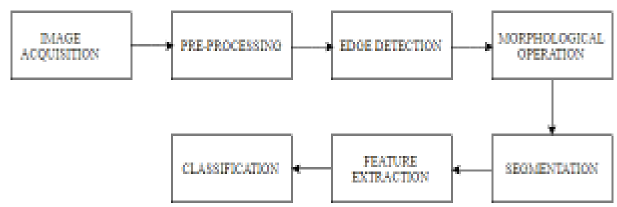

Figure 3.1 Block diagram of bone cancer detection using ANN

Acquisition Of Image

The image acquisition is the first stage in any of the vision system. There are different image modalities such as CT scans, MRI and X-rays.The MR images are considered to be the best because of its higher resolution. It is widely used in medical applications because of its ability to produce non invasively high quality images of the human body.

Figure 3.2 Input MRI scan image

Preprocessing

Preprocessing of an image significantly increases the reliability of an optical inspection. Preprocessing is a primary step to enhance the quality of an image. The image processing stage is started with the filtering technique. Image filtering is useful for many applications including smoothing, sharpening and removing noise. Filtering suppresses the noise or other small fluctuations in the image. So these noises must be denoised. In this methodology, Gabor filter is used to remove the noise and to smoothen the defective images. The main advantage of this filter is, it produces excellent noise reduction with less blurring when compared with other filters.

The next step after filtering is the gray conversion. This is the process of converting the pixels having RGB level into the gray level. Color image has more process complexity. So the conversion of the grayscale image is necessary. This conversion is mainly to eliminate the hue and saturation information by retaining the luminance.

Figure 3.3 Denoised image

Figure 3.4 Gray converted image

Edge Detection

An edge detector used to obtain a boundary between two regions with relatively distinct gray level properties. Edge detection used to extract useful features which help to detect cancer. In this proposed method, Canny edge detector is used to detect an edge of an image. The points at which image brightness changes are detected and marked as the edge. Canny edge detector has advantages like good detection, good localization and minimal response.

Figure 3.5 Edge detected image

Morphological Operation

It is a non linear operation related to the morphology of features in an image. Morphological operations are used to identify shape, size and connectivity. Two basic operations of the morphological technique are dilation and erosion. Dilation operation is used to expand the region. Erosion operation is used to erode away or to eliminate the small objects. It is also used to remove small spurious bright spots (salt noise) in images.

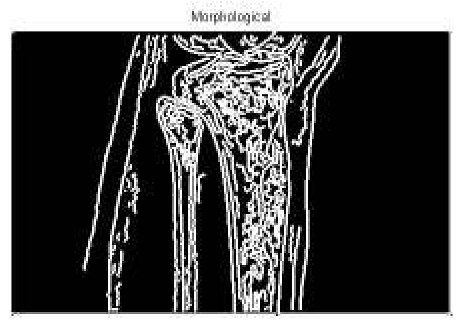

Figure 3.6 Morphological operation

Segmentation

The results of image segmentation is a set of segments that collectively corner the entire image or a set of contours extracted from the image.

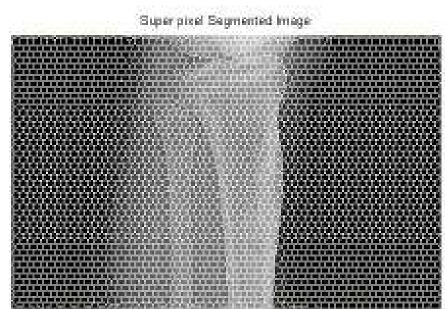

Figure 3.7 Superpixel segmentation

Figure 3.8 Multilevel segmentation

Feature Extraction

The image feature extraction is an important technique in image processing. It plays a major role in the cancer detection using image processing. Features are extracted from the segmented image to detect cancer. Feature extraction helps to represent the final results to predict cancer and non-cancer of an image. Feature extraction reduces the number of resources required to describe a large set of data. It is the process by which certain features of interest within an image are detected and extracted for further processing. The feature is described as a most representative information of the image. Each feature specifies some quantifiable property of an object and is computed such that it quantifies some significant characteristics of the object.

We classified various features such as Mean, standard deviation, contrast, correlation, energy, homogeneity, entropy, RMS, variance, smoothness, Kurtosis, skewness, IDM.

Mean

Mean is the measure of the average intensity value of the pixels present in the region.

$$\frac{1}{n}\left(\sum_{i=1}^{n} X_i\right)$$

Standard deviation

Standard deviation is the measure of how much that gray levels differ from its mean.

$$\sqrt{\frac{1}{n}\left(\sum_{i=1}^{n}(X_i - \overline{X})^2\right)}$$

Contrast

Contrast is the measure of the difference between the brightness of the objects or regions and other objects within the same field of view.

$$\sum_{i,j}|i-j|^2 p(i,j)$$

Correlation

Correlation is the measure of degree and type of relationship between adjacent pixels.

$$\sum_{i,j}\frac{(i-\mu i)(j-\mu j)p(i,j)}{\sigma_i \sigma_j}$$

Energy

Energy is the sum of squared elements in the Gray level co-occurrence of Matrix.

$$\sum_{i,j} p(i,j)^2$$

Homogeneity

Homogeneity is the closeness of the distribution of elements in the GLCM.

$$H=\sum_{i,j}\frac{p(i,j)}{1+|i-j|}$$

Entropy

Entropy characterizes the texture of the image.

E=sum (p.*log2(p))

RMS

RMS is the measure of root mean square value of an image.

$$X_{RMS} = \sqrt{\frac{1}{N}\sum_{n=1}^{N}|X_n|^2}$$

Variance

Variance is the measure of variance value of an image.

$$\frac{1}{n}\left(\sum_{i=1}^{n}(X_i - \overline{X})^2\right)$$

Smoothness

Smoothness is a measure of relative smoothness of intensity in a region.

Kurtosis

Kurtosis is a measure of peaks distribution related to the normal distribution.

$$k = \frac{E(x-\mu)^4}{\sigma^4}$$

Skewness

Skewness is a measure of asymmetry in a statistical distribution.

$$s = \frac{E(x-\mu)^3}{\sigma^3}$$

IDM

Inverse difference moment is a measure of image texture usually called homogeneity. IDM features obtain the measure of the closeness of the distribution of GLCM elements to the GLCM diagonal.

$m_k = E(x-\mu)^k$ Features	Patient1	Patient2	Patient3	Patient4	Patient5	Patient6	Patient7	Patient8	Patient9	Patient10
Contrast	0.1328	0.1951	0.2651	0.23	0.2129	0.5458	0.4956	0.4767	0.3379	0.2554
Correlation	0.1618	0.1522	0.1305	0.1618	0.1628	0.167	0.1326	0.1634	0.1253	0.1706
Energy	0.8927	0.92	0.8369	0.8711	0.8234	0.7822	0.7294	0.7438	0.7779	0.8616
Homogeneity	0.9709	0.9763	0.9532	0.9634	0.9509	0.9334	0.9221	0.9227	0.9357	0.9604
Mean	0.0022	0.0026	0.0032	0.0029	0.002	0.0059	0.0024	0.008	0.0047	0.003
Standard Deviation	0.064	0.0634	0.0821	0.0753	0.0811	0.1116	0.1147	0.1063	0.09273	0.079
Entropy	2.6426	1.3506	3.1958	2.3544	2.7827	3.0852	2.9799	2.444	3.206	1.6063
RMS	0.064	0.0635	0.0822	0.0754	0.9589	0.1118	0.1147	0.1066	0.0928	0.079
Variance	0.0041	0.004	0.0068	0.0057	0.0066	0.01241	0.01299	0.0113	0.0086	0.0062
Smoothness	0.956	0.9822	0.9721	0.9749	0.9589	0.9122	0.8021	0.9623	0.9678	0.978
Kurtosis	21.6003	47.2263	17.2783	26.5633	14.3405	15.662	12.5391	12.2595	1.0927	23.8225
Skewness	1.2933	3.287	1.5316	1.9942	1.0993	1.711	1.1937	1.1352	1.3078	1.6517
IDM	-0.0605	-0.0836	1.503	2.0195	-2.0379	0.2737	-0.0971	0.7171	0.2462	2.2526

Table 3.1 Feature extraction of bone cancer patients

Various features are extracted from 10 bone cancer patients and the extracted feature values are tabulated above in Table 3.1.

Classification

Classification is the important and last stage of our proposed system. The classifier differentiates normal tumor from the abnormal tumor. Various texture characteristics such as mean, standard deviation, contrast, correlation, energy, homogeneity, entropy, RMS, variance, smoothness, Kurtosis, skewness and IDM are extracted and applied to Artificial Neural Network to train the data.

Artificial Neural Network

A neural network is employed for bone cancer detection. A multilayer feed forward neural network with supervised learning method is more reliable and efficient for detection of bone cancer. Neural Network design of the proposed system is shown in figure.

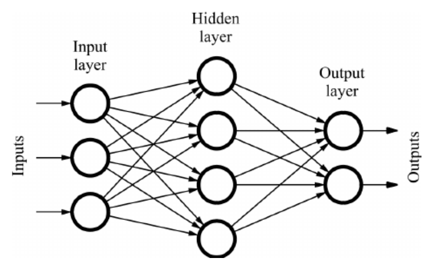

Figure.3.9 Neural Network Design

Artificial Neural Network is an information processing paradigm that is inspired by the way biological nervous system such as brain process information. Neural Network is composed of a large number of highly interconnected processing elements which is called neurons. Feed forward neural network travels in one way input to output. There are no feedback loops present in the feed forward neural network.

IV. Experimental Results

The work was tested on MRI images of bone cancer patients. The MATLAB application with

Graphical User Interface (GUI) was developed to enable users to perform interactive tasks.

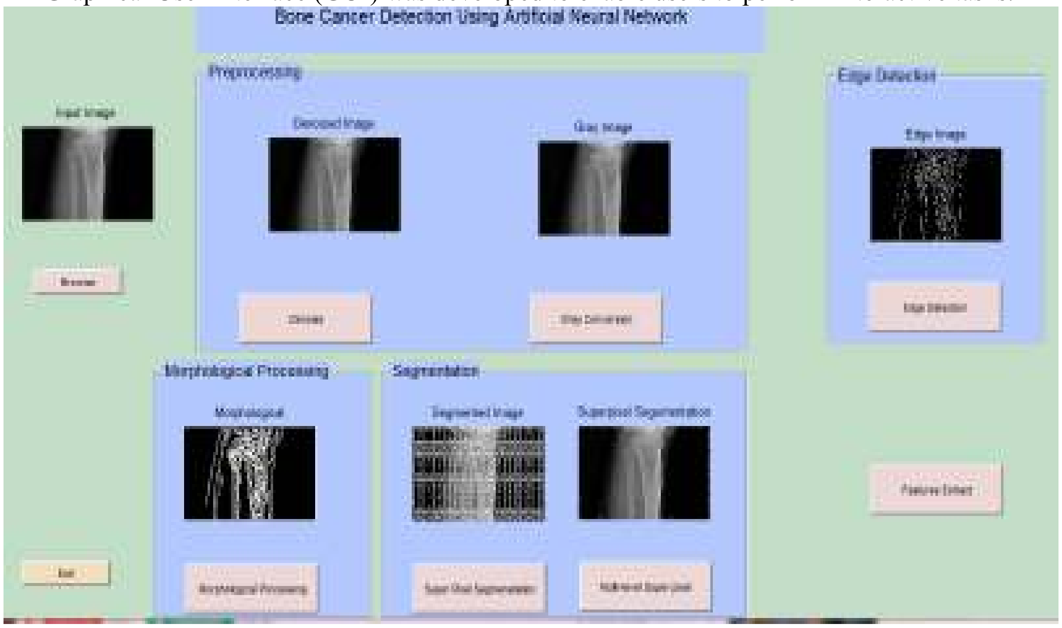

Figure 4.1 a) Input image b) Denoised image c) Gray converted image d) Edge detection e) Morphological operation f) Superpixel segmentation g) Multilevel segmentation f) feature extraction

The performance analysis of extracted features are represented as the bar graph in Figure 3.11. The classification of benign and malignant cancer was done based on extracted feature values.

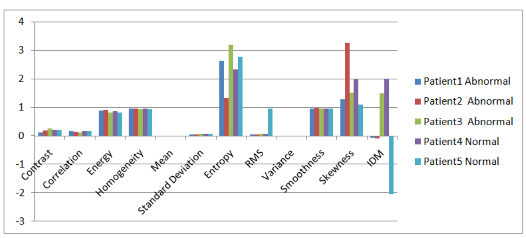

Figure 4.2 Performance analysis of feature extraction

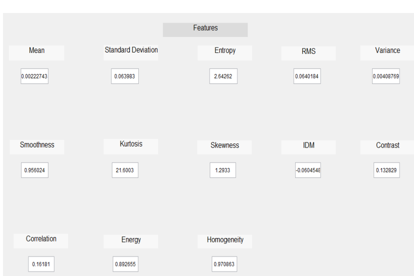

Figure 4.3 Feature extraction values for various features

	Predicted No	Predicted Yes	Total
Actual No	True Negative (TN)	False Positive (FP)	TN+FP
Actual Yes	False Negative (FN)	True Positive (TP)	FN+TP
Total	TP+FN	FP+TP	TN+FP+ FN+TP

Table 4.1 Confusion matrix

Accuracy= (TN+TP) ÷ (TP+FN+FP+TN)

Sensitivity=TP ÷ (TP+FN)

Specificity=TN ÷ (TN+FP)

Figure 4.4 Confusion Matrix

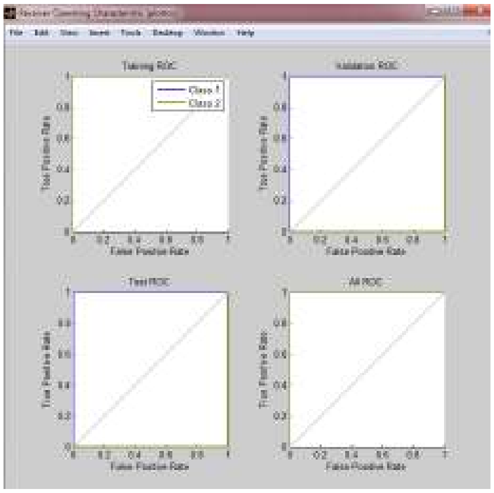

Figure 4.5 ROC curve

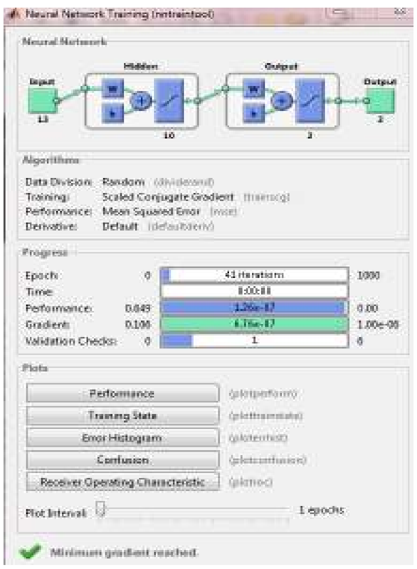

Figure 4.6 Neural Network Training

V. Conclusion

Bone cancer is one kind of dangerous diseases, so it is necessary to detect cancer in its early stages. But the detection of bone cancer is the most difficult task. From the literature review, many techniques are used for the detection of bone cancer but they have some limitations. In our proposed method pursue approaches in which the first step is preprocessing, edge detection, morphological operation, segmentation and then feature extraction, and then these features are used to train up the neural network and test the neural network. The proposed system successfully detects the bone cancer from CT scan images. The system achieves its desired expectation at the end of the system.

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