A Machine Learning Approach for Contrast Enhancement of Medical Images

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Abstract— Image contrast enhancement is important in medical applications. This is due to the fact that visual examination of medical images is essential in the diagnosis of many diseases. The proposed method use the applicability of the Neural Network approach for image quality classification using a set of key features extracted from the images. If the image is of low quality then it is enhanced with appropriate contrast enhancement technique. The technique can prevent over-enhancement and enhance small details of an image. We focus on chest x-ray and mammogram images.

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I. INTRODUCTION

Medical images plays an important role in diagnosing a disease and monitoring the effect of the selected treatments[1]. The term contrast, as observed in digital images, is the separation of dark and bright areas present in the image[3]. Image enhancement is dependent on the application context. An enhancement technique performing well in enhancing biomedical images may not be identically efficient in enhancing satellite images[2]. Emergency situations, environmental noises, patients' special conditions in photography, lighting conditions and technical constraints of imaging devices are among the reasons why images may have low quality[1]. In such situation radiologists required to go for reimaging of a particular part which is not clearly visible first time even after applying various enhancement techniques. Reimaging is done using cone shape beam in x-ray machine to clearly visualize particular body part. It is very time consuming process. In such cases, image enhancement techniques can be useful, especially when reimaging is impossible. It is used to repair the damaged images, an efficient contrast enhancement technique can enhance small details of an image so that radiologists can properly monitor patient's health condition, and they do not required to go for reimaging.

On the other hand contrast enhancement is a subjective process so to predict the quality of image by visualization is time consuming and it differ person by person so we require some expert system which replace human judgment of image quality with a machine evaluation and accurately classify the quality of an image. Applicability of Artificial Neural Network for classifying the quality of an image is presented in this paper. So first of all we classify the quality of a given image and then if the image is of low quality then it is enhanced with appropriate enhancement technique.

II. DESCRIPTION OF CHEST AND MAMMOGRAM X-RAY IMAGES

A. Description of chest x-ray image

Chest X-ray (CXR), or chest film, is a projection radiograph, using which we can examine the ribs, clavicles, aorta, phragm, heart, pulmonary artery used to diagnose many cases involving the chest wall, including its bones, and also structures contained within the thoracic cavity including the lungs, heart, and great vessels. Pneumonia and congestive heart failure are very commonly diagnosed by chest radiograph. Fig shows important features of a chest image[10].

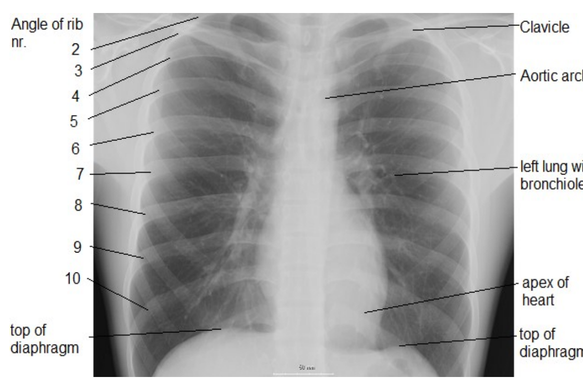


Fig. 1 Description of chest x-ray image

B. Description of mammogram image

Mammography (also called mastography) is the process of using low-energy X-rays to examine the human breast, which is used as a diagnostic and screening tool [11]. The goal of mammography is the early detection of breast cancer, typically through detection of characteristic masses and/or microcalcifications. fig shows important features of mammogram[11].

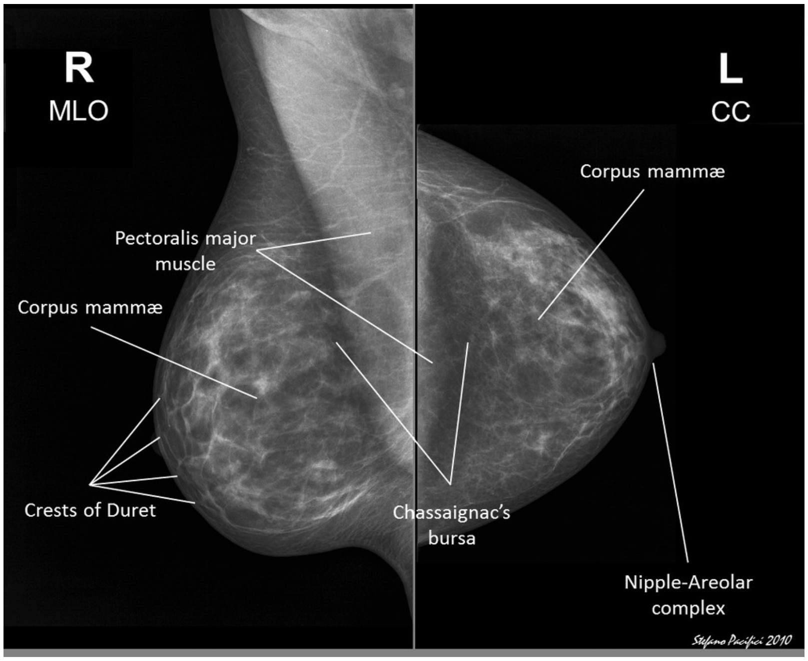


Fig. 2 Description of mammogram image

III. NEURAL NETWORKS IN IMAGE PROCESSING

Artificial Neural Network (ANN) is closely related to image processing task[4]. Nowadays researches in the field of image processing are actively used neural networks[4]. One advantage of using ANN is the ability of ANN to adapt, which appear in form of internal characteristics changing of ANN to perform particular task[4]. A neural network is a powerful data modeling tool that is able to capture and represent complex input/output relationships[4]. The role of feed-forward ANNs and Self Organizing Maps has been extended to encompass also low-level image processing tasks such as noise suppression and image enhancement[5]. The majority of the ANNs were applied directly to pixel data. Tsai et al. has train a Hopfield network for enhancement of endocardiac borders. Waxman et al. [6] consider the application of a centre-surround shunting feed-forward ANN (proposed by Grossberg) for contrast enhancement and color night vision. In several other applications, regression or classification (mapping) networks were trained to perform image restoration or enhancement directly from pixel data. Neural networks perform in two different modes, learning (or training) and testing. And there are algorithms in ANN, which trains net for different applications. We can see presence of these algorithms in medical science too[5]. As these algorithms train net for diagnosing different diseases of patients.

IV. PROPOSED WORK

The system uses X-ray images of chest and mammogram as an input and after processing all steps it provide enhanced image if image is of low quality. The diagram of this scheme is given as below in fig. 3.1.

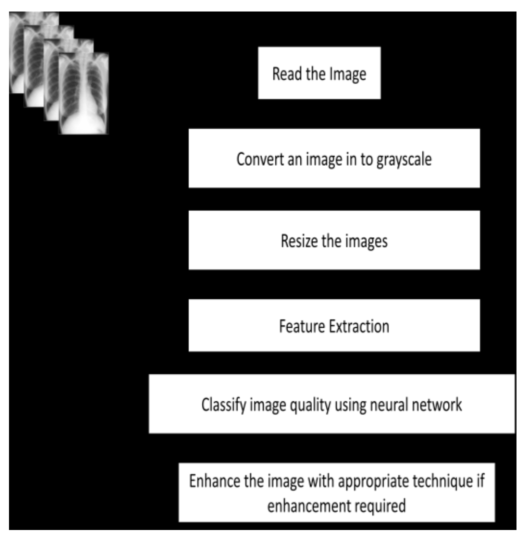


Fig. 3 framework of proposed scheme

Steps:

- The System first read the input images.

- Then image is converted in to grayscale because most of the diagnostic monitors are grayscale because they have better resolution.
- After that we resize the image.
- Then we extract features from image.
- The system use neural network to classify the quality of the image i.e. whether the image is of low quality or high quality.
- After that it performs contrast enhancement if the image is of low quality.

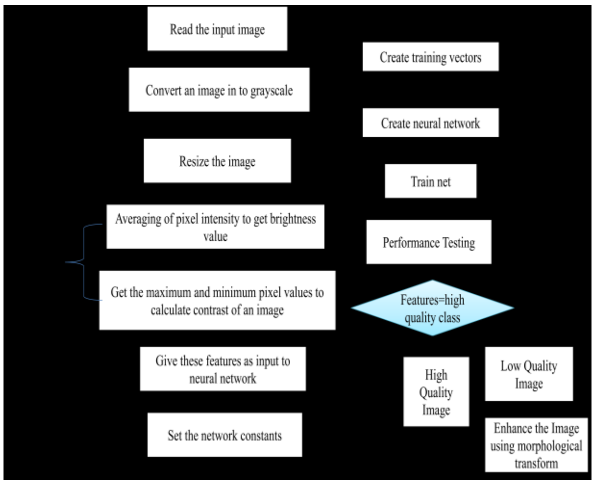


Fig. 4 Proposed work

A. Feature extraction

We extract some features from training as well as testing images in order to classify the quality of the image. Contrast, brightness and pixel values are important features to classify whether the image is of high quality or low quality.

Brightness:

The brightness of a grayscale image is the average over all pixel intensities[7].

[7]

$$B(I) = \frac{1}{wh} \sum_{v=1}^{h} \sum_{u=1}^{w} I(u, v)$$

Contrast:

Contrast which is defined as the difference in visual properties of pixels makes an object distinguishable from other objects and the background[1]. The contrast of a grayscale image is the amount to which different objects in the image can be visually distinguished from one another[1]. Contrast is how well an image utilizes the range of pixel intensities available[7]. It is independent of the brightness in an image[7]. Contrast is calculated using given formula.

$$\text{Contrast} = \frac{\text{Change in Luminance}}{\text{Average Luminance}}$$ [7]

$$C_M(I) = \frac{\max(I) - \min(I)}{\max(I) + \min(I)}$$ [7]

B. Neural network classification process

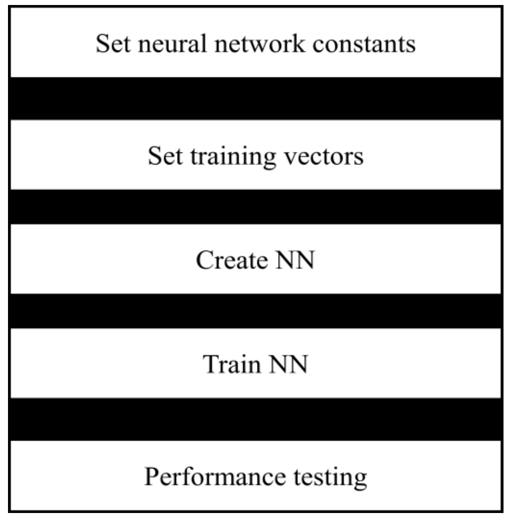


Fig. 5 Neural Network Classification

First of all we set neural network constants to avoid over fitting problem. There is very small value of error on the training set, but the error is very large when new data is presented to the network. If we have large amount of data and training set, then we do not need to worry about the techniques to prevent over fitting. We create a neural network by providing the number of hidden neurons and output ones, for that we use newff function to create new back propagation network. Activation and training functions are also set, which update weight values. We use feed forward neural network. As We have used feed forward neural network architecture, the back propagation training algorithm is used to train feed forward network. In that we first of all provide training set which contain input and desired output, then we set initial value for network weight and bias. After that each input values are multiplied with corresponding weight values, this values are summed up and the signal is send to activation function and passed to output node, it is called actual output. After that we calculate error by comparing actual output with desired output. If the actual output is not nearer to desired output then it is called error. Now we need to update weight values of each connection. Weight is updated using steepest descent rule. This procedure is continue until we get the desired output. In the proposed work Artificial

Neural Network (ANN) is trained with the high quality as well as low quality chest x-ray and mammogram images so that it will become clever to classify the quality of a given image. To test the performance of neural network approach, the new chest x-ray or mammogram images, which are not used for training have been used.

C. Image enhancement technique

In this technique we use disk shaped morphological structuring element (mask) and top-hat transform to enhance the image. For that first of all we initialize disk shaped structuring element with radius 30. After that we apply top-hat transform operation on image, equation of top-hat transform is given below…

A0=A+m(ATHi-ABHi)[1]

Where A is original image

ATH is top-hat transform on image A

ABH is bottom-hat transform on image A

m is a decimal number

In this process size of the mask is increasing in each step by applying dilation operation on mask. So we get enhanced image for each mask size. After that we calculate contrast improvement ratio (CIR) to make decision about number of steps required and to select final enhanced image. Value of CIR is increasing in each step, we stop the procedure when we get decreasing value of CIR and image with higher CIR value is selected as a final image. Contrast Improvement Ratio which compares the output images of two consecutive steps. If the value of the present comparison is greater than the past one, the process is continues. On the other hand, if CIR returns a smaller value than the previous step then it means that the contrast of the new enhanced image is less than that of the previous image. Therefore, the image of the previous step is selected as the best and final enhanced image. CIR is calculated using this formula…

$$\mathrm{CIR} = \frac{\sum_{(x,y)\in R}(c(x,y)-\hat{c}(x,y))^2}{\sum_{(c,y)\in R}c^2(x,y)} \quad [1]$$

where R is the region of interest and c and ^c are the local contrast measurements in original and enhanced images respectively[1]. CIR measures the effect of contrast enhancement on image quality[1]. In this method, we compute the mean value of luminance in two different concentric rectangular windows centered on each pixel[1]. More specifically, we can define the local contrast as the following ratio:

$$c(x,y) = \frac{|p-a|}{|p+a|} \quad [1]$$

where p and a are the average values of gray levels in the center window and the surrounding window of the pixel location (x,y) respectively[1]. The inner window is a 3 * 3 and the outer one is a 7 * 7 square[1]. Here c(x,y) is the contrast measurement and is in the range of [0, 1].

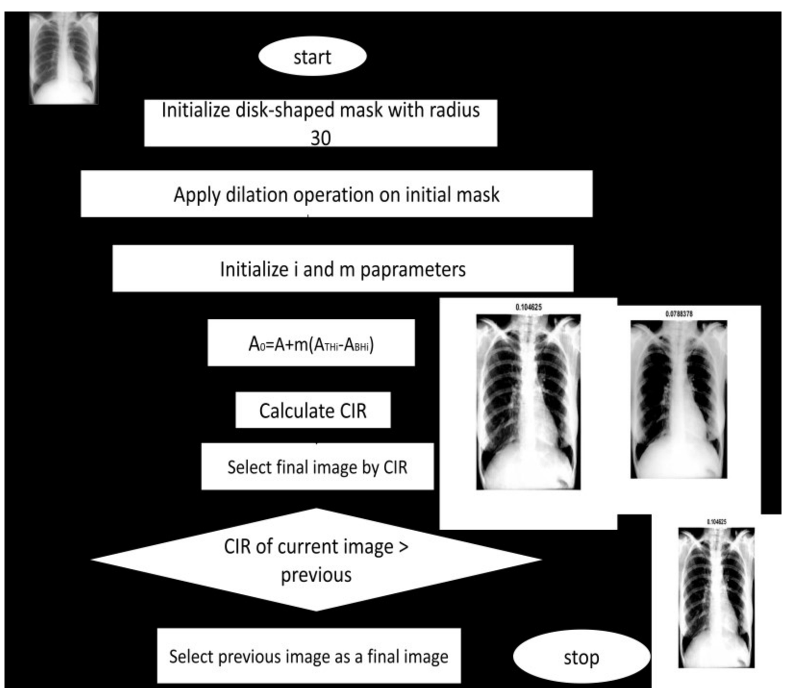


Fig. 6 Enhancement Technique

V. RESULTS

A. Neural Network Classification Results

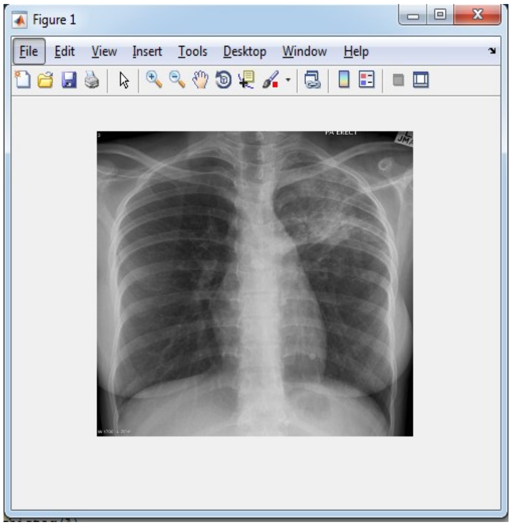


Fig. 7 Input image

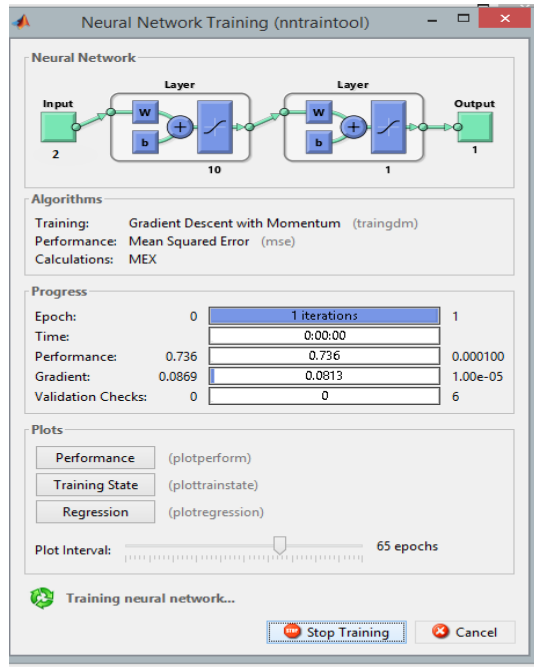


Fig. 8 ANN Training

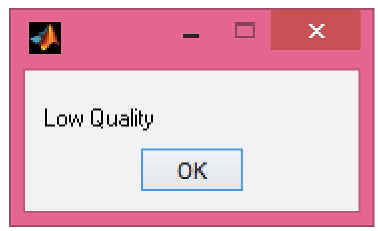
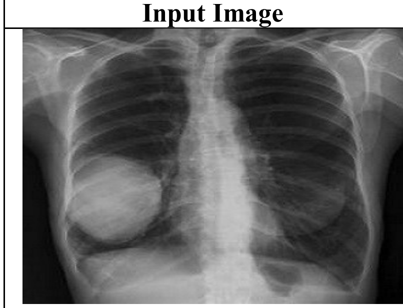
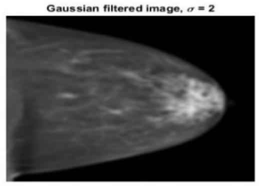
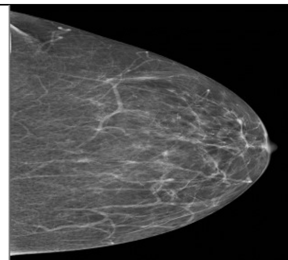
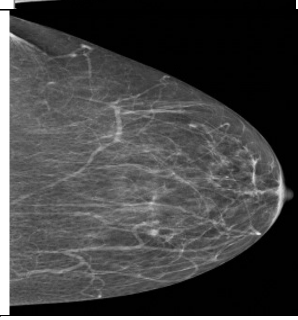
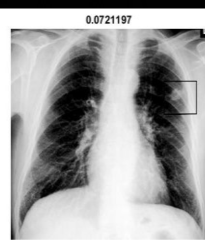
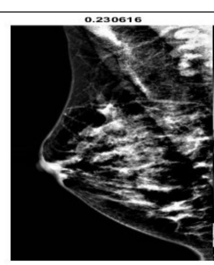
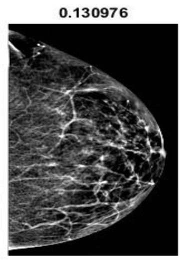


Fig. 9 classification result

TABLE I. CLASSIFICATION RESULTS ON OTHER CHEST X RAYS AND MAMMOGRAM

Input Image	Classification Result
	Low quality
	High quality

	Low quality
	Low quality
	Low quality
	Low quality
	High quality
	High quality

	High quality

B. Analysis
Performance analysis with hidden layer Neurons

TABLE II. PERFORMANCE ANALYSIS WITH HIDDEN LAYER NEURON

Hidden Neurons	Performance
5	10.333243 seconds
6	10.378847 seconds
10	9.130795 seconds
20	10.387201 seconds
25	10.277156 seconds

If we use less number of hidden layers then it require more time to train network. If we use large number of hidden layers then time complexity more. Hence we have to select correct number of hidden layers.

C. Image Enhancement Results

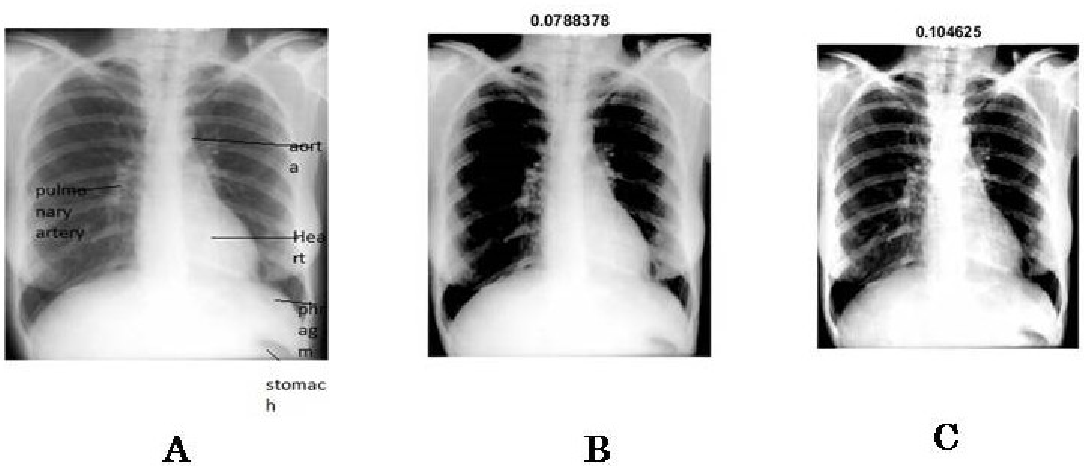


Fig. 10 Image Enhancement Results (A) Original Image, (B) Enhanced Image with CIR=0.078, (C) Enhanced image with CIR=0.104

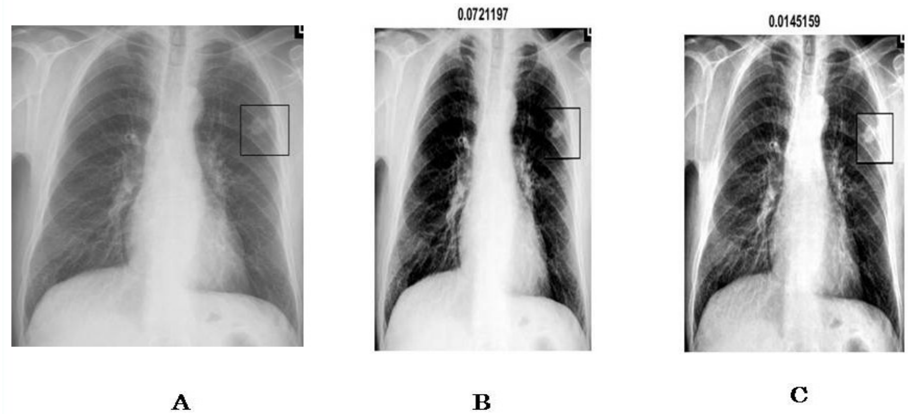


Fig. 11 Image Enhancement Results (A) Original Image, (B) Enhanced Image with CIR=0.072, (C) Enhanced image with CIR=0.0145

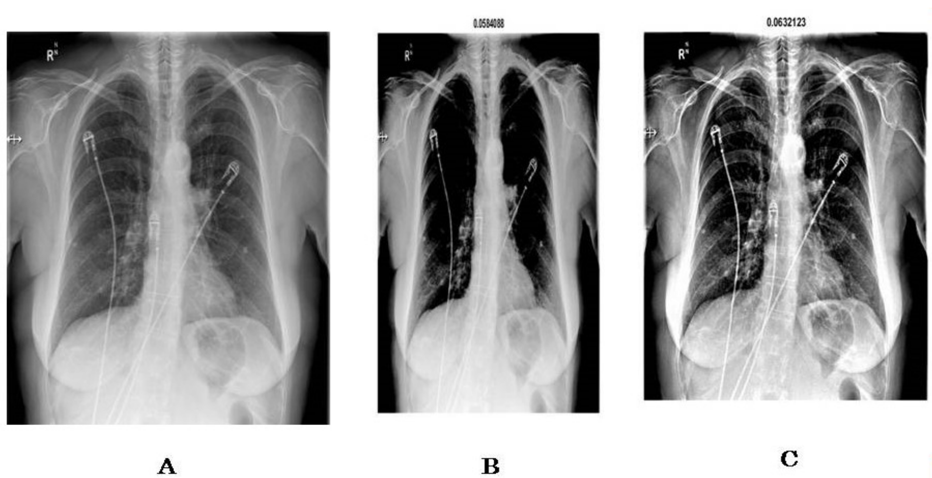


Fig. 12 Image Enhancement Results (A) Original Image, (B) Enhanced Image with CIR=0.072, (C) Enhanced image with CIR=0.0145

D. Observation from above results

Medical images with poor contrast are difficult or impossible to study and acquire information from that. So we should look for methods to enhance the quality of such images. Enhancement method which is based on mathematical morphology enhances the contrast of images and repairs their damaged parts. We have chosen above method based on morphological transform for contrast enhancement because Top-Hat transformation along with a disk structuring element extracts white features such as blood vessels, ribs and clavicles. It is difficult to use Top-Hat transforms in the images whose contrast changes much. Therefore, the method used to enhance medical images. The reconstructed images of chest shown in fig 10(c) have better resolution in lung tissue, In fig 11 the final image, small tumor have become clearer, especially those that are superimposed on the ribs and are different from the main tissue. This tumor which is circled in Figure. It shows cancer progress more clearly. In Fig 12, the patient's left lung is bronchogenic-carcinoma causing some of its tissue to be difficult to see. In such emergency situations, catheters are used as shown in figure[1]. After inserting the catheters, Radiology images are important in locating the end of catheters and evaluating the possible side effects during its insertion[1]. The enhanced image in Fig. 12 shows the left lung and the end of catheters more clearly.

VI. CONCLUSION

In this paper a neural network approach to classify the quality of given image and image enhancement technique are investigated. Experimental results show that a neural network can be trained to accurately classify the quality of images on the other hand the enhancement technique can enhance small details of an image. Proposed system were implemented on two kinds of images that are Chest x-ray and mammogram images provided by radiologists. Results are analyzed by radiologists and found satisfactory.

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