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**Jasleen Kaur**
Mody University,
Lakshmangarh, Rajasthan,
India

**Suneet Gupta**
Asst. Prof. Mody University,
Lakshmangarh, Rajasthan,
India

**Correspondence:**
**Jasleen Kaur**
Mody University,
Lakshmangarh, Rajasthan,
India

# Multimodality assessment of PET/CT scan images

**Jasleen Kaur, Suneet Gupta**

**Abstract**
Interpretation of medical images is often difficult and time consuming, even for experienced physicians. The aid of image analysis and machine learning can make this process easier. Assessment of the combined Positron Emission Tomography and Computed Tomography scan images done through multiple modes via the application of image enhancement, morphological operations, noise reduction, segmentation, feature extraction, training and testing of the neural network, can yield various important aspects, properties and attributes of these images, thus spanning the scope of this new medical modality.

**Keywords:** PET/CT, Artificial neural network, Back Propagation Algorithm, Feature Extraction, Pattern Recognition

## 1. Introduction
Medical diagnosis is a critical field to deal with, especially nowadays with increasing number of patient's and diseases. Hence, there is a crucial requirement to predict correct analysis. A review of the medical diagnosis is needed to be given by the learning physicians, which turns into a tedious task when an expert is not available full time to guide them [1]. Hence, there is a need of a decision support system which could give results of a certain medical diagnosis and to which learning physicians could match their predictions. An artificial neural network using pattern recognition can be used to extract specific or unique features from the given input which later trains and tests the system [2].

## 2. Artificial Neural Network
An artificial neural network is a type of learning system that is inspired by biological neural network. It consists of interconnected elements called neurons, that perform computations in parallel with a transfer function [2].
A Neural Network is a massively parallel distributed processor made up of simple processing units which have natural propensity for storing experiential knowledge and making it available for use. It resembles to the brain in two aspects:

- Knowledge is acquired by the network from its environment through a learning process.
- Interneuron connection strength is used to store acquired knowledge.

Neural Networks basically aim at mimicking the structure and functioning of the human brain, to create intelligent behavior [3]. Here, each node performs some simple computation and each connection conveys a signal from one node to another labeled by a number called connection strength.

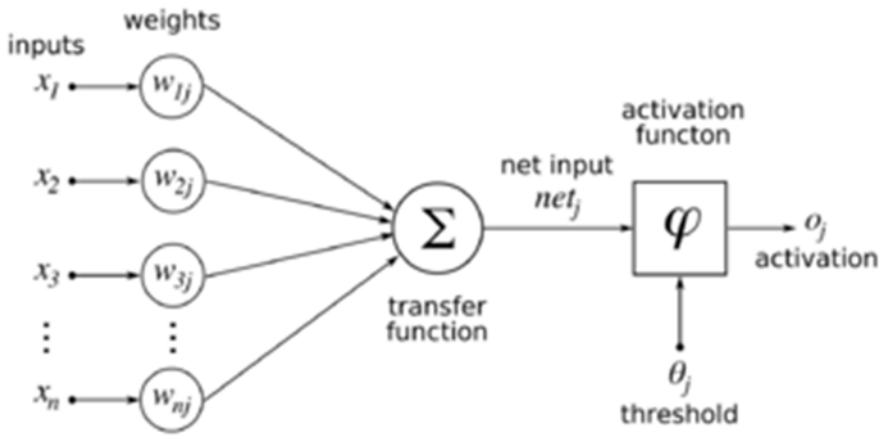


**Fig 1:** A Simple Neuron Model

### 3. Back Propagation Algorithm

Multimodality assessment of PET/CT scan images is a multiclass problem making use of multi-layer feed forward architecture including an input layer, output layer and few hidden layers [4]-[6]. The architecture makes use of back propagation algorithm. Back-Propagation Neural Network (BPNN) is the most popular and oldest supervised learning multilayer feed-forward neural network algorithm proposed by Rumelhart, Hinton and Williams.

Input vectors and the corresponding target vectors are used to train a network until it can approximate a function, associate input vectors with specific output vectors, or classify input vectors in an appropriate way as defined by the user. Networks with bias, a sigmoid layer, and a linear output layer are capable of approximating any function with a finite number of discontinuities [7].

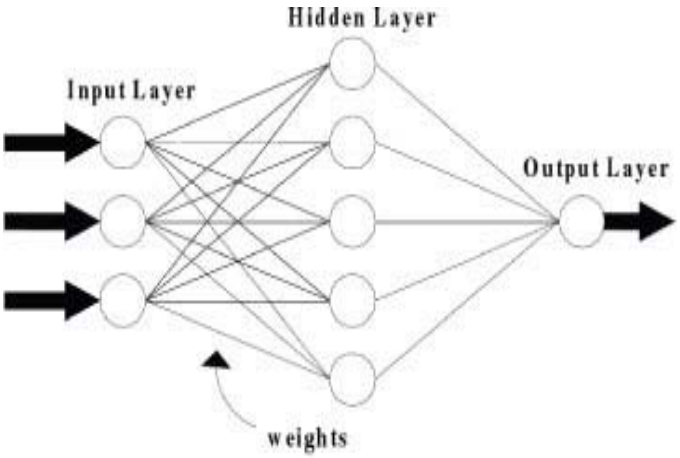


**Fig 2:** ANN Model Architecture

### 4. Methodology

#### 4.1. INPUT:

A database of patient's PET/CT scans is collected which is the first and most crucial stage behind developing a decision support system. The images must be of the same format and should be attached to the supporting front-end. This system is being developed with the help of MATLAB.

#### 4.2. PRE-PROCESSING

**(i) Image Enhancement:**

Image enhancement is basically improving the interpretability or perception of information in images for human viewers and providing better input for other automated image processing techniques. The main objective of image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observer [8]. Various techniques have been applied on the input data that can enhance the PET/CT scan images without spoiling them. These various techniques are as follows:

- Image normalization
- Image sharpening
- Filtering
- Morphological operations

**(ii) Noise Removal**

Another important factor is noise removal from the input images. Extracting out and hence, removing different kinds of noise present in the data can vastly help in improving the data quality as well as the output to be obtained later. For the purpose of noise removal, median filter has been used since it was found to be the most suitable and gave the best results in this case.

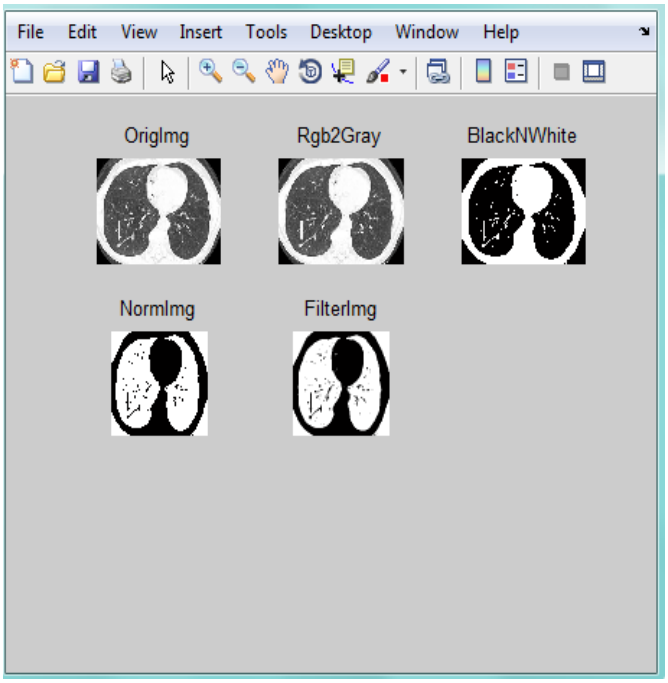


**Fig 3:** Pre-Processing Stages of input image

**(iii) Segmentation:**

The purpose of segmentation of the concerned region in the PET/CT image is to achieve a better orientation in the image. Thresholding is a simple, but yet useful, method for segmentation in the area of image analysis [9]-[10]. It is a spatial domain method that operates directly on the pixels of the image, scanning them one by one. The expression for thresholding can be written as:

$$g(x, y) = 1, \text{ if } f(x, y) > T$$
$$0, \text{ if } f(x, y) <= T$$

f(x, y) = grey-level input image
g(x, y) = output image
(x, y) = pixel position
T = threshold value

giving a binary image where pixels labeled as 1 are object points and 0 are background
points.

Therefore, a method of global thresholding has been applied which seperates out the region of interest.

#### 4.3. Feature Extraction & Pattern Recognition:

The concept of pattern recognition is to train a system from samples, which consist of an arrangement of descriptors, often called features. A feature describes some property of the pattern and a pattern class is a collection of patterns grouped together by something they have in common. Two or more classes can be used, but in general a high number of pattern classes give a more complex problem [11]-[12]. The goal of feature extraction and pattern recognition is to build a system that automatically can assign an unknown pattern to the right pattern class.

Single-level 2D wavelet decomposition with Symlet *sym4* wavelet has been used. The method computes approximation coefficients and detailed coefficients of images. It extracts 6 geometrical features like mean, median, standard deviation, minimum, maximum, and variance for these approximation and detailed coefficients.

1) *Low Pass Approximation:* - Is a one or two dimensional wavelet analysis function.
2) *Horizontal Detail Image*: - For an Input Image the Horizontal Points of image are displayed in this portion.
3) *Vertical Detail Image*: - For an Input Image the Vertical Points of image are displayed in this portion.
4) *Diagonal Detail Image:* - For an Input Image the Diagonal Points of image are displayed in this portion.

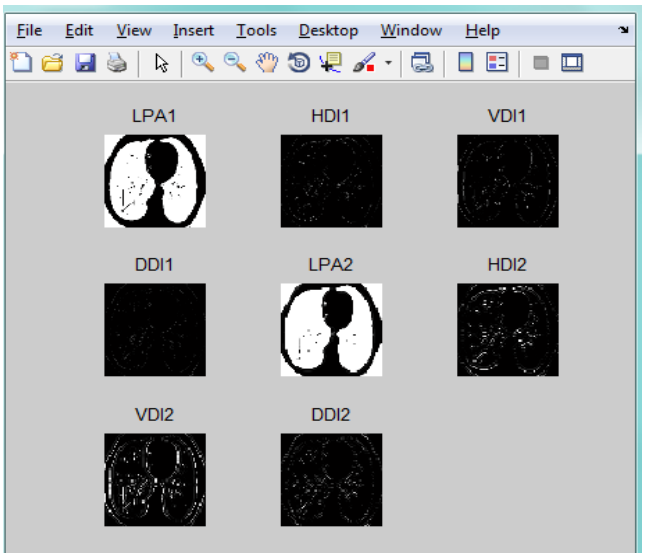


**Fig 4:** Output of Feature Extraction & Pattern Recognition process with different detail images

### 4.4. Training & Testing Of Neural Network

The neural network divides the input data into three sets as training set, validation set and testing set [13]-[14]. With the given input of 55 images, the system trained itself with 49 images, then, validated and tested itself with the remaining images and hence, generating an output.

## 5. Experimental Results

The trained and thus, tested neural network shows a recognition rate of 89.1%, where 49 out of 55 images were correctly trained and recognized.

The output figures below show the performance phases of the system:

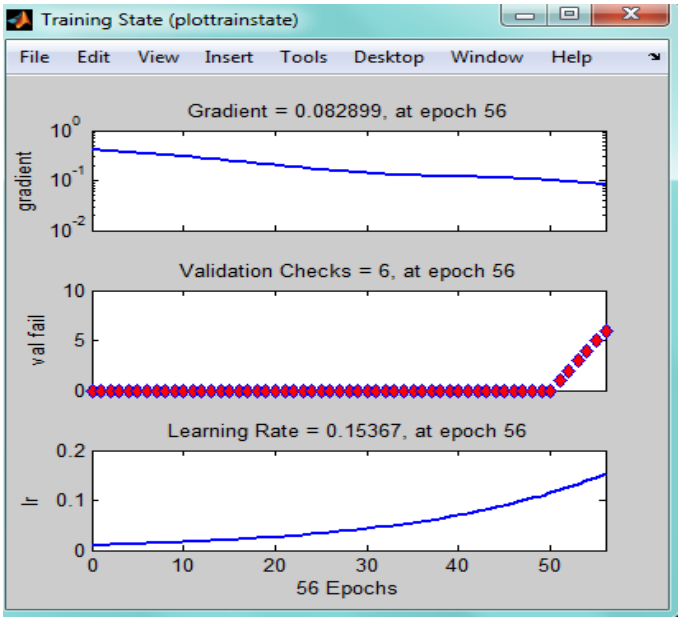


**Fig 5:** Training plot for system

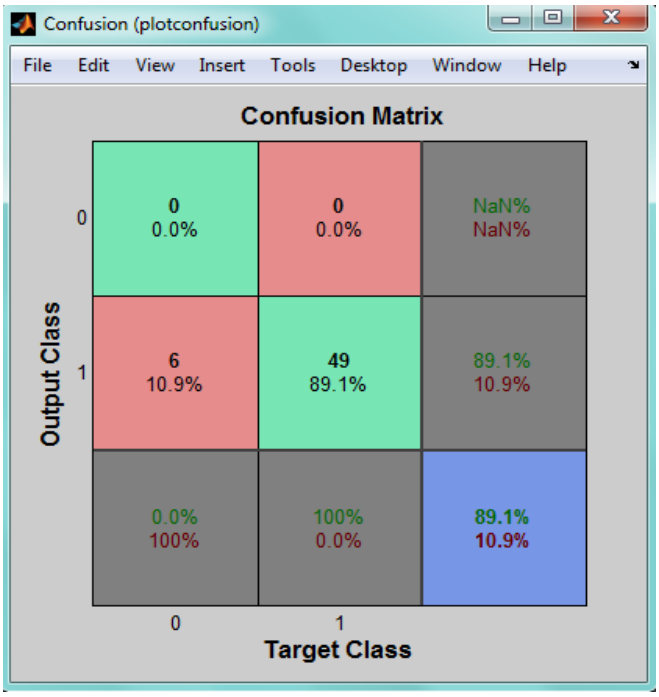


**Fig 6:** Confusion Matrix with recognition rate of 89.1%

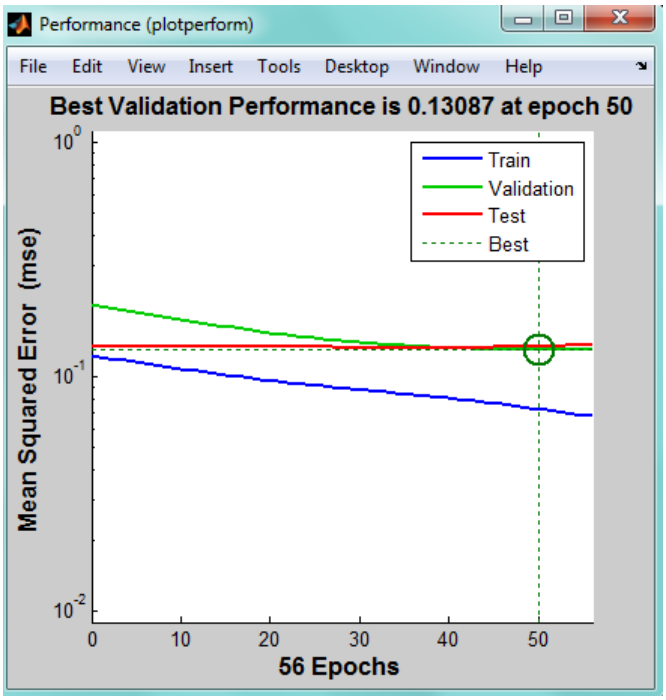


**Fig 7:** Performance plot for system

## 6. Conclusion & Future Work

The experimental results illustrate that Artificial Neural Network can successfully be applied to various sectors of biomedical digital image processing. A decision support system based on PET/CT scan images, with such a success recognition rate made with the baseline of MATLAB and ANN can prove out to be a really useful system in the field of biomedical.

System enhancement can be gained by altering the pre-processing and neural network models used. This system can also be developed with the use of support vector machines which might yield better results. Various other sagittal views of the input data may also be considered which could benefit the work by taking into account new features and hence, patterns.

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