www.ijramr.com

ISSN : 2350-0743

International Journal of Recent Advances in Multidisciplinary Research

Vol. 04, Issue 11, pp.3066-3070, November, 2017

RESEARCH ARTICLE

DETECTION OF MALIGNANT MELANOMA USINGARTIFICIAL NEURAL NETWORKS TRAINED WITH PARTICLE SWARM OPTIMIZATION ALGORITHM

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ARTICLE INFO

Article History:
Received 09th August, 2017
Received in revised form
28th September, 2017
Accepted 04th October, 2017
Published online 30th November, 2017

Keywords:
Artificial Neural Networks,
Back Propagation, SIFT, SURF,
Particle swarm optimization algorithm,
Malignant melanoma and
Benign melanoma.

ABSTRACT

Malignant Melanoma is a type of cancerous cell which occurs in the skin and it is known as the deadliest form of all skin cancers. They sometimes develop from a mole with increase in size, irregular edges,change in color, itchiness or skin breakdown. If detected early, malignant melanoma can be treated successfully. In this paper, detection of the malignant melanoma is done by artificial neural network trained with particle swarm optimization algorithm. The features of the image are extracted using SIFT (Scale invariant feature transform) and SURF (Speeded Up Robust Features) techniques. Once the dominant characteristics are identified it is fed into the ANN(Artificial Neural Networks) for classification of the tumor images as malignant or benign. Simulation results indicate that the neural network trained with particle swarm optimization algorithm provides a good accuracy in the classification.

INTRODUCTION

The diagnosis of skin tumors can be easily done based on two main characteristics of the skin ie the physical feature and color of the skin which can be categorized into several categories of skin cancer (Friedman, 1991). These days, dermatologists should perform a biopsy to assess whether the tumor is malignant or benign. As the procedure is very costly, different alternatives have been used for early detection which is inexpensive compared to the biopsy (Friedman, 1991). In this study we use color images of skin tumor which goes through a process of an image processing and then stored into the artificial neural network for determining if the pigment is malignant or benign. Malignant melanoma cells produce dark protective layer which accounts for cancer in the shades of tan, brown and black which is varied according to each case. Melanoma is able to spread so early detection and treatment is very necessary (Stoecker, 1992).

Malignant melanoma can be described by looking for these four factors:

- Asymmetry
- Border Irregularity
- Color
- Diameter

The cancerous cells are irregular in their symmetry and border.

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These are the main factors that can be easily noticed by the naked eye. The color of cell is not uniform which also contributes into a great factor for determination of the cancerous cell. The diameter of the pigment shouldn't be greater than 6mm which can be also determined if looked and measured carefully (Gori, 1992). This paper uses ANN to detect malignant melanoma. The ANN consists of 3 layers. The first layer is for the input variables which are the features extracted by the SIFT and SURF from the input image. The hidden layer contains five neurons which is chosen empirically. The final layer which is the output layer comprises of one output neuron for the classes in which the data will be classified. In this paper the classes are malignant and benign cancer. The transfer function which is used is the hyperbolic tangent sigmoid function. The dataset is divided into three sections which are training dataset (60% of original dataset), cross- validation dataset (20% of original dataset) and testing dataset (20% of the original dataset). The performance of the network is evaluated by calculating the mean square error (MSE).

Basic Features of ANN

Multilayer Perceptron: Multilayer ANN or MLP has a layered architecture consisting of interconnected neurons. It generally has three layers namely input layer, hidden layer and output layer, the neurons in each layer are connected with other neurons in the neighboring layers (Wilamowski, 1999). The result of a neuron depends on the connecting weights, these results acts as the input in the consecutive layer showing a direction for information processing. As a result MLP is also recognized as a feed-forward neural network. MLP is trained using the training dataset which helps the model to learn about the data on which it has to operate which means it helps the model to learn about the problem for which it is used.

Activation Function: In an ANN in every neuron the input signal is translated to an output signal using a function called as activation function. Activation function can be broadly classified into three classes: linear, threshold or sigmoidal (Ludermir, 2006). Linear function gives a resulting signal in the neuron which is in direct proportion with the activity level of the neuron. The threshold function gives an output signal which stays constant till a certain level, then the output changes to a new level which stays constant until the activity level drops below the threshold. The Sigmoid function gives an output whose value changes continuously with the changes in the activity level although the variation is non-linear. It consist of two functions-Hyperbolic whose values varies from -1 to +1 and Logistic function whose value rages from 0 to +1. Sigmoidal transfer function is the most frequently used activation function.

Training Methods: The interconnections between the neurons is formed by the process of learning or training. Learning algorithm tells how the weights are to be adjusted so that the interconnections which are formed provides the best result. At first these weights are chosen at random but are then adjusted using the optimization techniques such that the result reaches at minimum value for the cost function.

Optimization Algorithms in training ANN

When we run a neural network it gives results which may or may not match with the expected output in such cases it is important to reduce the error and get a more accurate output. This process is called as optimization of neural network (Amali, 2015). In this process a value of algorithm is found which gives the least error and minimizes the cost function. Optimization leads to a result which is more precise and makes best use of resources like memory and time as well as greatly increases the quality of the output.There are a number of optimization techniques which are used such as Genetic Algorithm, Simulated Annealing and Gradient Descent. These large number of techniques often creates a dilemma of which algorithm is the best. There is no definite answer for it but researchers are working to find the best one. This paper compares the performance of optimization techniques- Back Propagation and Particle Swarm Optimization.

Back-Propagation

Back-propagation algorithm is a supervised learning algorithm. At first the input layer is fed with the corresponding inputs which are then multiplied with the weights of the respective interconnections between input and hidden layer and the product is passed on to the hidden layer. Inside the hidden layer the sum of the output from the input layer is calculated and a non-linear function processes that sum (El Adawy, 2002). Finally, output from the hidden layer is given to the output layer by multiplying it with the weights of the respective interconnections between hidden layer and output layer, the output layer processes this product and gives the final output of the model. The model for back-propagation neural network is shown in Figure-1. The output from ANN is compared to the desired output and the error is calculated in the form of mean square error. This error is then fed back to ANN and the weights are adjusted accordingly to minimize the error in each subsequent iteration. The specifications of the ANN used in this paper is shown in Table-1.

Table 1. Specifications for the Back-propagation neural network (BP)

Sigmoid	Activation function used in the hidden layer
5	Neurons present at the hidden layer
Fmincg	Minimizing the cost function

After training ANN, the network is given test data in order to assess its performance. The networks which are trained properly give accurate result when presented with inputs which are not seen by the network before.

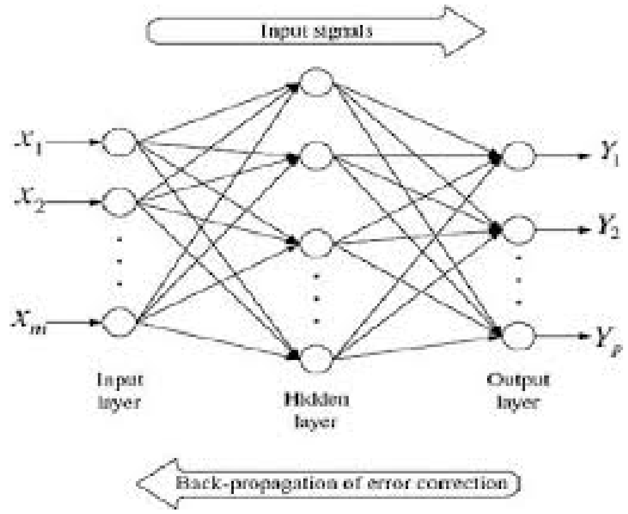

Fig. 1. Back propagation model

Particle Swarm Optimization

PSO is a technique used for optimization whose basis is the movement and intelligence of swarms. There are a number of particles in swarm which move around the search space to look for the optimal solution (Noel, 2012). Every particle in the swarm behaves like a point present in the N-dimensional space which change their movements after carefully considering their own experiences as well as the experiences of the other particles present in the swarm. Every particle keeps track of the coordinates in the solution space which relates it to the optimal solution found so far by it. Pbest denotes the personal best value of each particle and Gbest is the global best which is defined as the best value obtained by the particles in the neighborhood of the particle under consideration (Amali, 2015). The location of each particle is subject to change and depends on following factors - distance between the current position and gbest, current positions, current distance between the current position and pbest and current velocities (Muthiah-Nakarajan, 2016). This information is given in (1)

$$V_i^{k+1} = wV_i^k + c_1rand_1(\ldots.)x\ (pbest_i\text{-}s_i^k) + c_2rand_2(\ldots.)x(gbest\text{-}s_i^k) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where,

rand: uniformly distributed random number between 0 and 1
v_i^k: velocity of particle i at iteration k
w: weighting function
s_i^k: current position of particle i at iteration k
gbest: gbest of the group and

w=wMax-[(wMax-wMain)xiter]/maxIter

Where,
wMin: final weight
wMax: initial weight
maxIter: maximum number of iteration
iter: current iteration number and
s_i^{k+1} is given as:
$s_i^{k+1} = s_i^k + v_i^{k+1}$

Specifications of ANN with PSO are given in Table 2.

Table 2. Specification of (ANN +PSO)

20	The initial population
2.05	c1 , c2
-1,1	xmin, xmax
2000	The number of iteration

Proposed Model

We employ the SIFT (Scale invariant feature transform) techniqueto detect and describe the local features in images. We use this feature to determine key features like asymmetry, border irregularity, inconsistent color and the diameter scaling greater than 6mm. SIFT is used to identify the features which can be extracted from the training image which is even detectable in scale, noise and illumination. SIFT is employed as it exhibits highest matching accuracies. The algorithm used for this paper is shown in Figure 1.

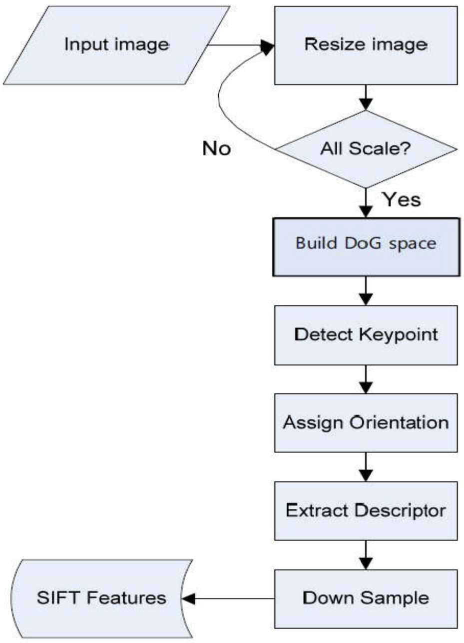

Fig.1. Scale Invariant Feature Transform

The dataset contains malignant melanoma and benign images which are then converted into matrix form and feed into the neural network by using which is trained with backpropogation and the particle swarm optimization algorithm. 60% samples are used for training the neural network, 40% for validation testing.Flowchart of the algorithm for the artificial neural network is illustrated in Figure 2:

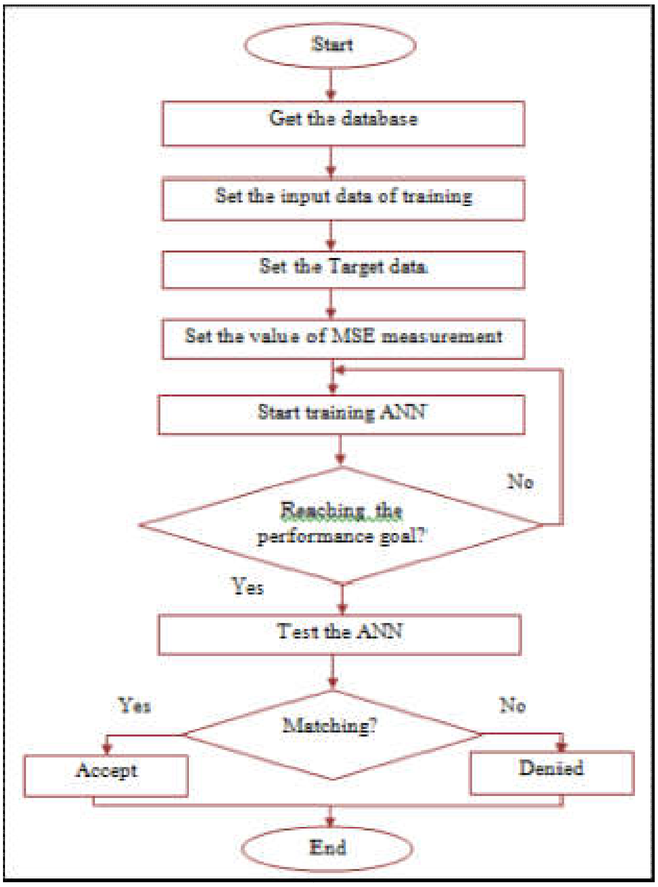

Fig.2. Artificial Neural Network Flow Chart

RESULTS AND DISUSSION

The Neural network is trained with the sample images from each group. The sample image of malignant melanoma and benign are showcased in Figure 3 and Figure 4. The neural network trained with backpropogation provided a 70% accuracy whereas the neural network trained with the PSO algorithm gave a 80% accuracy.

Fig.3. Malignant Melanoma Skin Cancer image

Fig.4. Benign Melanoma Skin Cancer image

Validation testing result is provided in Figure 4. The neural network and the confusion matrix is given in Figures 6 and 7. The mean square error and the accuracy is tabulated in Table 3.

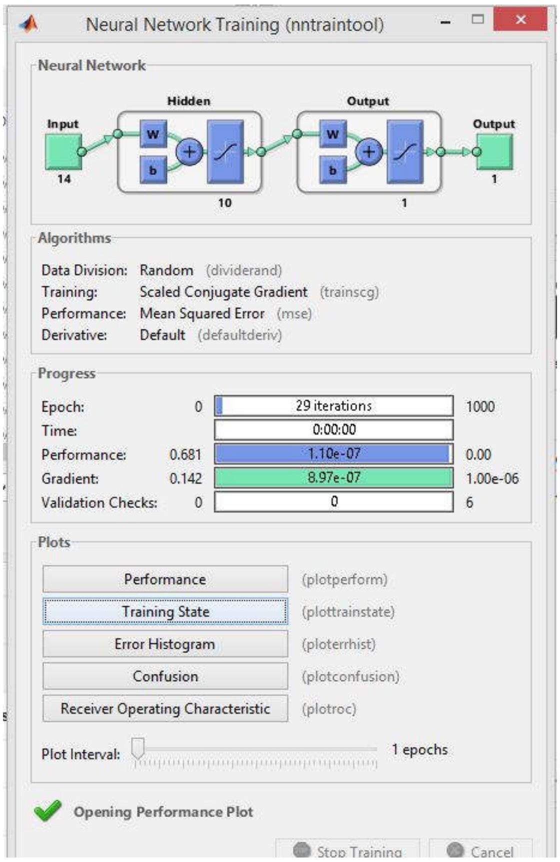

Fig.5. The representation of the neural network and the progress

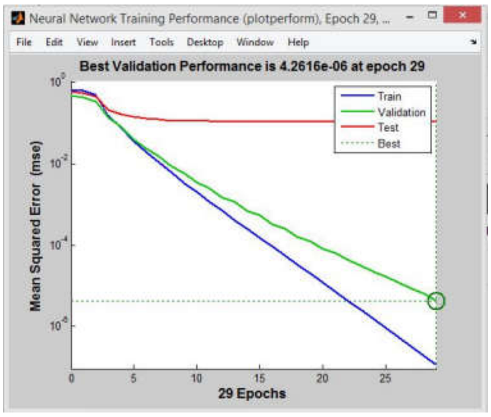

Fig.6. The Best Validation Performance of the neural network

Fig.7. The Confusion Matrix of the neutral network

Table 3. Comparison of the mean square error

Optimization Technique	MSE	Accuracy
Back-Propagation	0.257622	70%
PSO	0.08919	80%

Conclusion

The study shows that the detection of the imaged based melanoma malignant cancerous cell is efficient using artificial network. The ANN was trained with backpropogation and the PSO algorithm. Results show that the ANN trained with the PSO algorithm performs better than the ANN trained with the backpropogation algorithm. By using the SIFT and the SURF for extracting the features, the dimension of the feature vector was reduced thereby reducing the search space. Since the PSO algorithm is stochastic, it escapes the local minima and converges to the global minimum thereby giving a good accuracy compared to backpropogation. Improving accuracy with hybrid algorithms that combine deterministic and stochastic approaches will be considered for future work.

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