CHAPTER 5

ARTIFICIAL NEURAL NETWORK APPROACH

In the proposed method of Artificial Neural Networks, there are two types of classifier has been performed such as Single Layer Artificial Neural Network Classifier and Optimized Multilayer with Back Propagation Algorithm for detecting the skin Melanocytes. These two methods are giving best result of Melanocytes classification. But the Optimized Multilayer with Back Propagation Algorithm is performed better than the Single Layer Artificial Neural Network Classifier and also it’s reducing the mis - classification rate of result in Single Layer Artificial Neural Network Classifier.

5.1 Reason for selecting Artificial Neural Networks

In our research work, Artificial Neural Network (ANN) is choosing as a classifier for skin Melanocytes Classification because of its architecture. For the mathematical point of view Artificial Neural Network is a dynamic system and also it is able to model as a set of coupled differential equations. The major advantage of using Artificial Neural Networks is characteristics such as Neuro computing, Learning, Adaptability, Robustness, Fault tolerance, Asynchronous. The number of parameters is played a vital part of performance of ANN classifier. These parameters are increasing the percentage rate of accuracy. Basic parameters of ANN classifier is number of Layers involved in the networks, number of neurons performed for each layer, number of iteration, adaptability degree, selecting the non linearity function, learning algorithm and learning momentum, immunity of noise and so on... [117]

5.2 Working principles

The network consists of collection nodes which are interconnected each other in the distributed manner that helps to obtain the output from the given inputs. The network works according to the concept of the brain functions and activities which is done by using three different layers such as input, hidden and output layer [118]. The input layer obtains input from the previous feature extraction step, which is passed to the next hidden layer via the connected links.
In addition to this network consists of collection of weights and bias value that helps to calculate the output value with effective manner. In hidden layer, the received inputs are process and fed into the output layer in which the output is calculated as,

\[
Net\ output = \sum_{i=1}^{N} x_i * w_i + b \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \quad (5.1)
\]

At the time of output estimation process, the network trains the features using the training algorithm in this work, the Levenberg-Marquardt learning algorithm has been utilized for updating the weights and bias value which is done the equation

\[
x_{k+1} = x_k - [f^T f + \mu I]^{-1} f^T \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \quad (5.2)
\]

This training process produces the related output for all the features present in the neural networks. In the testing phase, the query template feature is compared to the output of the neural network, when it replies 0 the template is normal else it has been considered as the skin cancer related features. According to the concept of the traditional Artificial Neural Network working process in this work, Single Layer Artificial Neural Network and Multi Layer Neural Network has been used for making the effective skin cancer classification process.

5.3 Delta Learning Rule

One of the effective functions of the learning rule is minimizing the error rate while examining the extracted features [119]. The delta learning rule that mostly uses the gradient descent learning process which helps to update the weights present in the Single Layer Artificial Neural Networks. Then the delta rule of the neuron weights has been defined as,

\[
\Delta w_{ji} = \alpha(t_j - y_j)g'(h_j)x_i \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \quad (5.3)
\]

Where,

- \( \alpha \) represents as the learning rate,
- \( g(x) \) is the activation function of neuron
- \( t_j \) is the target output value
- \( h_j \) weighted sum of the neuron input value
Then the weighted sum of the input neuron value is obtained as follows,

\[ h_j = \sum x_i w_{ji} \]  \hspace{1cm} \text{(5.4)}

\[ y_j = g(h_j) \]  \hspace{1cm} \text{(5.5)}

Then delta rule has been simplified as,

\[ \Delta w_{ji} = \alpha (t_j - y_j)x_i \]  \hspace{1cm} \text{(5.6)}

According to the above process, the delta rule is applied to the network for minimizing the error rate with effective manner. The minimized error rate also improves the recognition rate while analyzing the extracted features. In our research work, Delta learning rule has used in process of classification.

5.4 Single Layer Artificial Neural Network Classifier

The single layer neural network also called as the single layer perceptron that has single output nodes [120]. The extracted features are fed into the input layer then the output value is calculated by multiplying the input value with weight, which is obtained the equation

\[ y_j = \sum x_i w_l + b_l \]  \hspace{1cm} \text{(5.7)}

\( y_j \) is the output value of the network
\( x_i \) is the input value of the neurons
\( w_l \) is the weighted value of each neuron
\( b \) is the bias value.
The estimated output value is compared with the threshold value, if it is below to 0 or 1 then the activation function is applied to the network for continue the recognition process else it has been updated continuously for eliminating the error value. During this process, each neuron has been trained with the help of the delta rule for avoiding the error rate.

5.5 Classification using Single Layer Artificial Neural Network Classifier

According to this principle, first Artificial Neural Networks skin Melanocytes is recognized classifier designed named as Single Layer Artificial Neural Network. It consist a single hidden layer and using the Tan h function as the learning function while examining the input values. Along with the learning function, the output value is calculated. During the net output calculation, the neural network is trained by using the Levenberg-Marquardt learning algorithm which updates the weights and bias as defined as [121],

$$X_{k+1} = X_k - [J^T] + [\mu I]^{-1} Te \hspace{1cm} \text{(5.8)}$$

This training process produces the related output for all the features present in the neural networks. In the testing phase, the query template feature is compared to the output of the neural network, when it replies 0 the template is normal or abnormal features. Thus the process successfully utilizes the learning momentum as 0.3 and the skin features are classified with minimum time and computational cost. At time of feature classification process, the network utilizes the Tan h as the learning function which is defined as Fig 5.1. The choice of learning momentum and also the activation function basically random selection only. In Single Layer Artificial Neural Network classifier has the two phases such as Training phase and the testing phase. In the time of preprocessing every images are employed the filtering, noise removing, edges are detected and finally the essential features are extracted and also the four optimum features are identified such as Asymmetry, Border Irregularity, Color change, Diameter These features are involved to the classification as the input value.
In the stage of training, the classifier trained with sample dataset. The training period classifier analyzes the feature of Melanocytes and makes a pattern for the testing. The testing stage new input features are compared to the pattern and its produce the output. After the classification process established for Melanocytes, the classifier produces the output as ‘0’ or ‘1’. Here ‘1’ represents as Melanoma and ‘0’ represents as non-Melanoma represents. The results of Single Layer Artificial Neural Network are shown in Table 5.1.

Figure 5.1: Tan h learning function
## Table. 5.1 Single Layer Artificial Neural Network Classifier Results

<table>
<thead>
<tr>
<th>S.No</th>
<th>Input Images</th>
<th>Input ABCD Features</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Asymmetry</td>
<td>Border irregularity</td>
</tr>
<tr>
<td>1</td>
<td><img src="1" alt="Image" /></td>
<td>5.5223</td>
<td>0.4857</td>
</tr>
<tr>
<td>2</td>
<td><img src="2" alt="Image" /></td>
<td>5.5365</td>
<td>0.4674</td>
</tr>
<tr>
<td>3</td>
<td><img src="3" alt="Image" /></td>
<td>3.5239</td>
<td>0.7705</td>
</tr>
<tr>
<td>4</td>
<td><img src="4" alt="Image" /></td>
<td>2.562</td>
<td>0.7212</td>
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<tr>
<td>5</td>
<td><img src="5" alt="Image" /></td>
<td>5.321</td>
<td>0.654</td>
</tr>
<tr>
<td>6</td>
<td><img src="6" alt="Image" /></td>
<td>4.355</td>
<td>0.753</td>
</tr>
<tr>
<td>7</td>
<td><img src="7" alt="Image" /></td>
<td>3.987</td>
<td>0.652</td>
</tr>
</tbody>
</table>
The effectiveness of Single Layer Artificial Neural Network Classifier is tested by running the algorithm in MATLABRa2013 tool and the efficiency is determined by using the following Performance Metrics viz., Mean Square Error (MSE), Sensitivity, Specificity and Accuracy.

5.6 Performance Metrics and Results of Single Layer Artificial Neural Network

The four performance metrics viz., Mean Square Error, Sensitivity, Specificity and Accuracy which are used in this chapter for performance analysis is explained in this sub section.

5.6.1 Mean Square Error (MSE):

Mean Square Error is used for calculating the error amount by the pixel values of the image. It will be calculated by the equ (5.90)

\[
MSE = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} (f(i, j) - f'(i, j))^2
\]

In eqn (5.9) represented as the original image and denoted as the noise estimated image. M is the height of the image and N is the width of the image. Mean Square Error of Single Layer Artificial Neural Network Classifier is 0.321.

5.6.2 Sensitivity

Sensitivity is a measure, it is used to how the proposed system correctly classifies the skin cancer with efficient manner. The sensitivity is measured by ratio between True Positive and True Positive plus False Negative. The sensitivity rate of Single Layer Artificial Neural Network is 79.5%.

5.6.3 Specificity

Specificity is a kind of measure, how the proposed system correctly identifies the negative classifiers during the skin Melanocytes recognition process. The Specificity is measured by ratio between True Negative and True Negative plus False Positive. Finally the Specificity rate of Single Layer Artificial Neural Network is 59.5%.
6.4 Accuracy

Accuracy is a statistical measure which is used to analyze how well the binary classifier recognizes the skin cancer with optimized way. In addition, the accuracy is the proportion of the true results that include both true positives and true negatives among the total number of cases examined. Then the accuracy value also determined by the sensitivity and specificity values which are defined as,

\[ Accuracy = (Sensitivity)(Prevalence) + (Specificity)(1 - Prevalence) \]

\[ ... (5.10) \]

The efficiency of the Single Layer Artificial Neural Network Classifier based skin cancer recognition system is analyzed. Derived features are that is fed into the Single Layer Artificial Neural Network Classifier for recognizing the skin Melanocytes. The performance of Single Layer Artificial Neural Network (SLANN) Classifier is stated in the Table 5.2 and the Fig 5.2.

<table>
<thead>
<tr>
<th>Performance Metrics</th>
<th>Single Layer Artificial Neural Network Classifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>79.5%</td>
</tr>
<tr>
<td>Specificity</td>
<td>59.5%</td>
</tr>
<tr>
<td>Accuracy</td>
<td>84.23%</td>
</tr>
</tbody>
</table>
The Single Layer Artificial Neural Network capable of learning the linear separable patterns in effective manner and the accuracy of SLANN classifier is considerable but the Single Layer Artificial Neural Network consumes high misclassification error rate which leads to reducing the efficiency of the system. So, the need of improving the efficiency of the system, move on to the next classifier named as Optimized Multilayer Artificial Neural Network with Back Propagation Algorithm.

### 5.7. Multi-Layer Artificial Neural Network

The Multi Layer Neural Network also called as the Multi Layer Perceptron which consists of three different layers namely, input layer, hidden layer and output layer [122]. The input layer consumes the input from the feature extraction process which is passed to the hidden layer along with the weights value. Each node in the network uses the non-linear activation function while classifying the input values. Then the non-linear activation function successfully firing each neuron that helps to match the exact output [123]. In addition to the activation function, the network uses the learning function for minimizing the error rate. Then the learning process is done by using the gradient descent value, which is calculated as,
Based on the equation, the weights values are continuously updated in the Multi Layer Network for minimizing the error rate with successful manner. The Multi Layer Neural Network examines the each input with effective way and provides the approximation solution for input. In addition to this, the effective learning rule process has been explained as follows for achieving the better results.

5.7.1 Back Propagation Algorithm

The Back Propagation Algorithm was developed in the year of 1974 and it has been usually used algorithm [124]. BPN algorithm mainly divides the two sessions training session and testing session. Pair of patterns given in to the network, one is input pattern and another one is target pattern. The input patterns are the responsible for the output pattern and the error signal occurred will be by the difference between the actual pattern and output pattern. Error signals are basically depend on the weights. If the weights get the new value then the error will be reduced. Before using the BPNN some of the parameters required such as set of training, input and target, learning rate, methods to be used for updating the weight, non linearity function, initial weight values. Generally sigmoid function used in the BPNN. [117]

5.7.2 Steps performed in Back propagation Algorithm

Step 1: Initialize the weights using small random values

Step 2: All the input neurons obtain the input signal and that signals are transmit to all hidden units.

Step 3: Every hidden neurons are sums its weighted input signals and applying the activation function then transfer that signal to output units.

Step4: Each output neurons sums its weighted input signals and relate its activation function to compute the output signal.

Step5: Each output neuron compares the target pattern corresponding to an input type, error value term is calculated as

$$\Delta w_{ji}(n) = -\eta \frac{\delta E(n)}{\delta v_i(n)} y_i(n) \quad \ldots \ldots \ldots \ldots (5.11)$$
\[ \delta_j = \delta_{inj} f'(Z_{inj}) \]  
\hfill (5.12)

Step 6: Weight and Bias of every output neuron updating.

The weight correction term is

\[ \Delta W_{jk} = \alpha \delta_k Z_j \]  
\hfill (5.13)

The bias correction term is

\[ \Delta W_{ok} = \alpha \delta_k \]  
\hfill (5.14)

Step 7: Examining the condition to terminate, When the error reduction and iteration count etc..[125]

5.7.3 Informal Description of Back Propagation Algorithm

The description of Back Propagation algorithm has seven major steps. These steps are involved the training phase. First the weight value should be initialize to the network and it’s basically selected by random. The second stage is each input neurons get input signals and transmitted to the hidden unit. The neurons are added to its weight and also applying to the activation function. After the activation function process established the signals are transmitted to the output units. Each output neurons are added its weighted input signals and applies its activation function for calculating the output signals.

Every output neuron compares to the target pattern corresponding to the input pattern and difference between the desired outputs and the target output value is referring as error value. Updating the weight of output neurons for reduce the error value and also get the target output. The iteration will be processed up to eradicate the error.
5.8 Optimized Multilayer with Back Propagation Algorithm (OMLBPN)

The research purpose is efficiency improvement and also reduces the misclassification rate so that the new classifier has been designed. First the classifier structured with the minimum parameters and it’s used for the classification of skin Melanocytes. Back propagation algorithms are used for this classification. It will be modified with the help of different kinds of parameter such as activation function, learning rate, and count of hidden layers. The classifier alters by the number by steps. Each step has the improvement and also gives better result. Finally the output of the every stage has been compared and identified the better one.

The modified classifier named as the Optimized Multi Layer with Back Propagation Algorithm is used for classifying the skin Melanocytes as well as to overcome the drawback of Single Layer Artificial Neural Network. It is trained with the help of the Delta learning rule along with one input layer, output layer, and hidden layers will be increased one by one. The layer utilizes the Taylor series for making the template examination process [126]. Then the Taylor series defined as follows,

$$D(x) = D + \frac{\partial \mu^r}{\partial x} x + \frac{1}{2} x^T \frac{\partial^2 D}{\partial x^2} x \quad \text{............... (5.15)}$$

The input layer receives the input from the trained features which has relevant weighted value and a bias value. By using these values the output the hidden neuron is estimated as,

$$Z_{ini} = v_{oi} + \sum x_i v_{ij} \quad \text{............... (5.16)}$$

In the eqn (5.16), $v_{ij}$ is the connected weighted value, $x_i$ is the input values of the network

After estimating the hidden value which is fed into the output layer for computing the final output that is calculated as ,

$$y_{in} = w_{ok} + \sum z_i + w_{jk} \quad \text{............... (5.17)}$$
In the eqn (5.17), \( w_{ok} \) is the weighted value

Based on the weighted value and bias value and final output is estimated with activation function. The first stage of our classifier designed with two hidden layers, learning momentum is 0.3 and the Tan h activation function. This stage of classifier gives somewhat improvement of accuracy. Second stage, need to test increasing the hidden layers. So the classifier gets the three hidden layers with same learning rate and activation function (0.3 and Tan h) as used in the second stage. After the alignment of classifier the features are fed in to the classifier and obtained the output at every time.

Next the classifier increased the one more hidden layer i.e four hidden layer with same learning rate and activation function. In the time of increasing the hidden layer the performance of the classifier would be down compared to the three hidden layers. So, in that case get the conclude of hidden layers. As compared to four hidden layer three hidden only gives the better results. Now our classifier fixed with the three hidden layer and here after the balance two parameters are only altered for getting the good results.

Now the three hidden layer worked with another activation function log value. This activation function and three hidden layer works with all three selected learning momentum such as 0.3, 0.2 and 0.1. Here also the results are estimated and also analyzed. Next the activation function is changed as the sigmoid function and classifier works with three hidden layers and also the three kinds of learning momentum 0.3, 0.2, and 0.1. The randomized selection of learning momentum is involved to the classifier. Moreover decreasing range of learning momentum rate will increase the accuracy as well as number of iteration also increased.

Based on the weighted value and bias value the final output is estimated and the sigmoid activation function is used for determining the skin cancer-related features. Then the sigmoid activation function is calculated as,

\[
f(x) = \frac{1}{(1+\exp(-x))} \quad \ldots \ldots \ldots (5.18)
\]
Figure 5.3. Structure of Optimized Multi Layer Back Propagation Neural Network

The Typical structure of Optimized Multi Layer with Back Propagation Algorithm is shown in the Fig 5.3. After computing the output value by using the sigmoid function which is compared with the target function. The matching process used to determine the error value then the error value is calculated as,

$$\delta_x = (t_k - y_k) \times f'(y_{in}) \ldots \ldots \ldots \ldots \ldots (5.19)$$

In the eqn, every value of hidden node error value is estimated as,

$$\delta_i = \delta_{inl} \times f'(z_{inl}) \ldots \ldots \ldots \ldots \ldots (5.20)$$

In the eqn (5.20) the computed error has been transmitted to the input
layer which helps to minimize the error rate for further feature classification process. Then the computed error has been minimized with the help of the weights and bias value updating process which is done by as ,

\[ v_{oi}(new) = v_{oi}(old) + \Delta v_{oi} \quad \ldots \ldots (5.21) \]

\[ v_{ij}(new) = v_{ij}(old) + \Delta v_{ij} \quad \ldots \ldots (5.22) \]

The above-updated value is weight value between the input layer and the hidden layer. Further, the weights between the hidden layer and output value is estimated as,

\[ w_{ok}(new) = w_{ok}(old) + \Delta w_{ok} \quad \ldots \ldots (5.23) \]

\[ w_{jk}(new) = w_{jk}(old) + \Delta w_{jk} \quad \ldots \ldots (5.24) \]

This process is repeated continuously until to eliminate the error value while matching the skin cancer with testing feature. The optimum features are fed into the classifier and the process of the classifier established finally the output is obtained. Based on the Optimized Multi Layer with Back Propagation Artificial Neural Network, the given input has been classified and the obtained results are shown in the following Table 5.3
Table 5.3 Optimized Multi Layer Back Propagation Neural Network Classifier Results

<table>
<thead>
<tr>
<th>S.No</th>
<th>Input Images</th>
<th>Input ABCD Features</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Asymmetry</td>
</tr>
<tr>
<td>1</td>
<td><img src="image1.png" alt="Image 1" /></td>
<td>5.5223</td>
</tr>
<tr>
<td>2</td>
<td><img src="image2.png" alt="Image 2" /></td>
<td>5.5365</td>
</tr>
<tr>
<td>3</td>
<td><img src="image3.png" alt="Image 3" /></td>
<td>3.5239</td>
</tr>
<tr>
<td>4</td>
<td><img src="image4.png" alt="Image 4" /></td>
<td>2.562</td>
</tr>
<tr>
<td>5</td>
<td><img src="image5.png" alt="Image 5" /></td>
<td>5.321</td>
</tr>
<tr>
<td>6</td>
<td><img src="image6.png" alt="Image 6" /></td>
<td>4.355</td>
</tr>
<tr>
<td>7</td>
<td><img src="image7.png" alt="Image 7" /></td>
<td>3.987</td>
</tr>
</tbody>
</table>
Then the Optimized Multilayer with Back Propagation Algorithm (OMLBPN) Classifier based result has been representing in the Table 5.4. The efficiency of the proposed Optimized Multilayer with Back Propagation Algorithm (OMLBPN) Classifier based skin cancer recognition system is analyzed using the skin images which are collected from the International Skin Imaging Collaboration data set using MATLABRa2013 tool. Mean Square Error (MSE) of OMLBPNN Classifier is 0.234. The performance of OMLBPNN Classifier is stated in the Table 5.5.

<table>
<thead>
<tr>
<th>Classifiers</th>
<th>Number of Hidden Layer(s)</th>
<th>Activation Function</th>
<th>Learning Momentum</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>OMLBPNN</td>
<td>2</td>
<td>Tan h</td>
<td>0.3</td>
<td>80.56</td>
<td>60.78</td>
<td>84.73</td>
</tr>
<tr>
<td>OMLBPNN</td>
<td>3</td>
<td>Tan h</td>
<td>0.3</td>
<td>80.76</td>
<td>62.38</td>
<td>84.85</td>
</tr>
<tr>
<td>OMLBPNN</td>
<td>4</td>
<td>Tan h</td>
<td>0.3</td>
<td>78.35</td>
<td>70.22</td>
<td>79.22</td>
</tr>
<tr>
<td>OMLBPNN</td>
<td>3</td>
<td>Log value</td>
<td>0.3</td>
<td>81.73</td>
<td>69.89</td>
<td>83.32</td>
</tr>
<tr>
<td>OMLBPNN</td>
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<td>Log value</td>
<td>0.2</td>
<td>81.86</td>
<td>69.64</td>
<td>83.65</td>
</tr>
<tr>
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<td>Log value</td>
<td>0.1</td>
<td>82.11</td>
<td>69.50</td>
<td>84.78</td>
</tr>
<tr>
<td>OMLBPNN</td>
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<td>Sigmoid</td>
<td>0.3</td>
<td>82.85</td>
<td>68.75</td>
<td>86.78</td>
</tr>
<tr>
<td>OMLBPNN</td>
<td>3</td>
<td>Sigmoid</td>
<td>0.2</td>
<td>83.46</td>
<td>67.93</td>
<td>86.89</td>
</tr>
<tr>
<td>OMLBPNN</td>
<td>3</td>
<td>sigmoid</td>
<td>0.1</td>
<td>84.32</td>
<td>67.57</td>
<td>87.73</td>
</tr>
</tbody>
</table>
The Table 5.5 shows the classification result which is shown in by using the sensitivity, specificity and accuracy of the OMLBPNN classifier on skin cancer dataset. The results are graphically represented in Fig 5.4. Performance matrices are evaluated as well as done in the Single Layer Artificial Neural Network such as Sensitivity, Specificity, Accuracy.

Table 5.5 Optimized Multi Layer Back Propagation Neural Network

<table>
<thead>
<tr>
<th>Performance Metrics</th>
<th>OMLBPNN Classifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>83 %</td>
</tr>
<tr>
<td>Specificity</td>
<td>66.5%</td>
</tr>
<tr>
<td>Accuracy</td>
<td>87.73%</td>
</tr>
</tbody>
</table>

Table 5.6 Classification Results

<table>
<thead>
<tr>
<th>Classifiers</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Layer Artificial Neural networks</td>
<td>80.43</td>
<td>60.54</td>
<td>84.23</td>
</tr>
<tr>
<td>Optimized Multilayer with Back</td>
<td>84.32</td>
<td>67.57</td>
<td>87.73</td>
</tr>
<tr>
<td>Propagation Algorithm</td>
<td></td>
<td></td>
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</tbody>
</table>
According to the Fig 5.4, and Table 5.6, it clearly shows that the Optimized Multilayer with Back Propagation Algorithm (OMLBPN) Classifier successfully analyze each features and classifies the results with higher accuracy when compared to the traditional artificial neural networks and Single Layer Neural Network.

![Figure 5.4 OMLBPN Classification Accuracy](image)

**Figure 5.4 OMLBPN Classification Accuracy**