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Classification using Artificial Neural Network Optimized with Bat Algorithm

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Abstract: ***In machine learning, there are two approaches: supervised and unsupervised learning. Classification is a technique which falls under the supervised learning. Out of many classification models, the most popularly used is the Artificial Neural Network. While neural networks work fine in classification and training a machine, the accuracy of the result might still be under question. To improve the accuracy and speed of result, the optimisation of artificial neural network is done. For this, ANN can be hybridised with a metaheuristic algorithm known as the Bat Algorithm. The benefits of optimising a neural network are mainly the improvement in accuracy of classification, interpretation of the data, reduction in cost and time consumption for getting accurate results etc. In present paper, a comparison between the results of an ANN-Backpropagation model and the proposed ANN-Bat model is done for medical diagnosis. The results were in the favour of the ANN-Bat approach which was significant in reducing the time taken to yield an output as well as the accuracy.***

Keywords: Artificial Neural Networks, Bat Algorithm, Back-propagation, Classification, Optimisation.

I. INTRODUCTION

Classification is one of the popular techniques of data mining [9]. It can be described as a process of building a model that depicts mapping between predicting attributes and class labels. Classification falls under the concept of supervised learning. For a supervised learning, class label of all the training tuple are provided [1].

Classification technique is used in many fields like marketing, medical diagnosis, performance prediction and credit analysis. Classification predict categorical label (discrete, ordered). Data classification involves two steps:

- The very first step in classification is known as the learning step. In this step, a classifier is built that describes an established set of data classes. Training takes place in this step and the classifier is built by a classification algorithm.
- For the second step, a classifier which was built in the first step is used for classification of unknown data. Because if training data is used for accuracy measure then classifier tends to over fit the data. The test set contains test tuple. These are selected randomly from any given data set. The classifier classifies the test set tuple and the ones that are correctly classified define the accuracy of the model. To determine the accuracy, a comparison is made between the classifier's class prediction that is learned and the class label that is associated with each test tuple. The tuple for which class labels are not known, they can be classified using this classifier. Datasets such as image dataset and text dataset can be classified using the classifier [1].

A. Artificial Neural Network:

Biology has been a great source of inspiration for many researchers. Artificial neural network (ANN) is also one of biological inspired technology and ANN models the human brain. Imitating the behaviour of the neurons of a brain, an ANN is designed as a connection of nodes, neurons, dendrites and synapses connected with the help of arcs, just like a biological nervous connection. A weight is associated with every arc. An activation function is applied on these arcs to adjust the weights after applying inputs to get a desired set of outputs. A neural network is basically an implementation of machine learning in the form a computing model. [2]

An artificial neural network is capable of performing perceptual and recognition tasks in lesser amount of time. A neural network exploits the non-linearity of a problem to define a set of desired inputs. Neural networks are important in realising a better way for classification in machine learning and finds application in various fields such as data mining, pattern recognition, forensics etc. [3].

An artificial neural network structure consists of basically 3 components, in the form of layers:

- Input Layer - Input layer bears the information that is fed into the network. This information is rather raw, initially.
- Hidden Layer – Hidden layer's basic job is to process the raw information received from the input layer into something that can be used by the output layer.ANN architecture can have one and more hidden layers.
- Output Layer: Information received from the hidden layer is fed to the output layer and it is processed to produce the desired results. [4].

There are the following types of artificial neural networks:

a) Feed-forward Neural Network: A feed-forward neural network is one the simplest neural network structures. It consists of an input layer where the data enters and comes out as the output from the output layer. The presence of hidden layers is optional. It uses an activation function for classification.

b) Back-propagation Neural Network: A back-propagation neural network is same as the feed-forward neural network except for one small change. Instead of the data passing through the network in only one direction, the data from the output layer is fed to the input layer based on an algorithm.

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c) Radial basis Neural Network: In this network, the distances between the points are under consideration. Out of many points, their distance from the common center is considered. This neural network consists of 2 layers.

d) Kohonen Self Organising Neural Network: A Kohonen map requires an input of arbitrary dimension to discrete map that are comprised of neurons. Later, this map should be trained so that it can create its own organisation of the training data.

B. Bat Algorithm

The metaheuristic algorithm used in this work is the Bat Algorithm. It was first introduced in the year 2010 by Yang. The complete working of the bat algorithm follows the echolocation characteristics of the Bat. These characteristics were deeply studied and used to come up with rules that form this algorithm [5]. There rules are as follows:

a) When bats fly in the night, in order to detect food or a prey, they use echolocation. This serves as the power with which they can differentiate between a prey, food or trivial background barriers in a natural way.

b) There are some fundamental parameters that a virtual bat should have:

v_i - velocity
x_i - position
f_i - frequency value
λ - wavelength
A_0 - loudness value
r - pulse emission.

Although all parameters are important but wavelength λ and pulse emission rate *r* are adjusted more frequently so as to locate the target.

c) The loudness in this case can vary but here we are considering the variation of loudness to be ranging from a large (positive) A_0 to a minimum constant value A_{min} [6, 14].

C. Movement of Bats

The movements of bats can be depicted with the help of basically three formulas. These are as follows mentioned as equation number "(1)", "(2)" and "(3)".

$$f_i = f_l + (f_h - f_l).\beta \quad (1)$$

$$v_i^t = v_i^{t-1} + (x_i^t - x_{gb}) \cdot f_i \quad (2)$$

$$x_i^t = x_i^{t-1} + v_i^t \quad (3)$$

Here, β is a random number between 0 and 1, *x* shows the best position among the *n* bats. Frequency (f_i) can vary for each problem, since [f_l, f_h] directly affect the value of f_i, are the search spaces of the sizes in the problem [6].

For the new location update, the following equation is used:

$$x_{new} = x_{old} + \epsilon A^t \quad (4)$$

Where x_{new} is the new position value of the bat and x_{old} is the previous position of the bat, ϵ is a random number between -1, 1 and A is the loudness value in iteration [6].

D. Pulse Emission and Loudness

The loudness and the pulse emission need to be updated in accordance with the iteration progresses. Once the bat finds its prey, the signal propagation rate r_i is generally increased although the decrease in loudness (A_i). Loudness and pulse emission are calculated by the equations as follows [6].

$$A_i^{t+1} = \alpha A_i^t \quad (5)$$

$$r^{t+1} = r_i^0[1 - \exp(-\gamma t)] \quad (6)$$

II. LITERATURE SURVEY

This section discusses the work done by various researchers that considered optimising the neural network by hybridising it with metaheuristic algorithms. Lubna and Halife [6] studied the functioning of bat algorithm for training an artificial neural network and how the weights in the ANN were optimised. The performance of this neural network was then tested in UCI data sets and results were compared with that of previous literatures where only the back-propagation algorithm was used for training the neural network. A neural modelling approach with a hybrid concept was presented by Yang et al. [7].

In the proposed approach, the training of a back-propagation neural network was done in order to map the underlying relationship. The genetic algorithm was also applied in order to improve the training efficiency and to optimise the input series in the same model along with the network topology. This neural network optimised with the help of a genetic algorithm was used on a landslide dynamic system. Results derived from this proved the efficiency of the hybrid method in terms of generalization and learning. Rajni Bala et al. [8] discussed various classification techniques that can be used with artificial neural networks in order to improve their performance. Artificial neural networks have a lot of advantages over other classification models but some hindrances always prevail. In order to overcome such hindrances, hybridisation techniques can be coupled with the artificial neural networks to make up for those setbacks.

A new bat algorithm was put forward by Xin-She Yang [9] to solve the optimisation problem. The algorithm was implemented and then a comparison was made with other algorithms such as Particle Swarm Optimisation and genetic algorithms. The implementation suggested that the bat algorithm worked better than the existing algorithms. The recent variants of the bat algorithm and detailed review on the bat algorithm were presented by Yang et al. [10]. He studied the areas which employed the use of bat algorithm and reviewed them to summarize briefly in this paper. Other than this, he also discussed the essence of the algorithm and the links between self-organisation and the algorithms. Topics that could be further researched were also discussed in this paper. An adaptation of Bat algorithm with artificial neural network was done by Mzelikahle et al. [11].

A Zimbabwean meteorological dataset was used to summarize and study to forecast climate with summarising and studying the results. From the proposed method, it was prevalent that the results showed an ability to reliably forecast climate for a period of 25 years. The proposed model was that of a BAT-ANN, a new improvement was over the classic ANN. For forecasting the weather, a java program was developed employing the BAT-ANN approach. Other than this, quantitative data was collected and BAT-ANN was adapted for analysis.

A comparison between Backpropagation artificial neural network, PSO neural network and a Bat algorithm optimized neural network was made by Golmaryami et al. [12] on stock price prediction.

The results showed that Bat algorithm adjusted the weight matrix more accurately than the other two used. The bat algorithm was evaluated along with its today's variants and was presented by Induja et al. [13]. Certain case studies involving Bat algorithm along with its various applications were widely selected and reviewed. The reviews and summaries based on these studies have been briefly put forward in [13].

III. EXPERIMENTAL RESULTS

The implementation of Bat optimised ANN is done using the Artificial Neural Network. One model consisted of ANN with Backpropagation algorithm and the second model is ANN with Bat algorithm. The dataset used in the study is of medical domain. The training and testing done with 70-30 partition i.e. 70 % data used for training the model and 30 % used for testing the model. The dataset consists of 50 images of bone x-ray which belongs to 3 different classes of osteoporosis i.e. normal bone, severe bone and non-severe bone. The images show either a case of osteoporosis which can be termed as a severe case or a non-severe case or a case of normal bone with no osteoporosis. The machine was first trained to learn the differences between the cases of osteoporosis. The bone images can be classified as Severe, Non-Severe or Normal cases of osteoporosis. In order to classify the test image, features selection was done over the image.

A. Classification using ANN Backpropagation Algorithm

In order to carry out the feature selection, various parameters were calculated for the input image. The image was first split into its constituent Gaussian and Segmented image. The "Fig.1" shows the constituent parts of the image that are split.

Now, the features selected for this image was depicted through a graph. Now classification is done using the ANN Backpropagation algorithm as shown in "Fig. 3". The image was classified as a case of osteoporosis bone which was a non-severe case and similarly other classes i.e. severe-case and normal can be show if found during classification.

Fig. 1. Input image divided into Gaussian and segmented image.

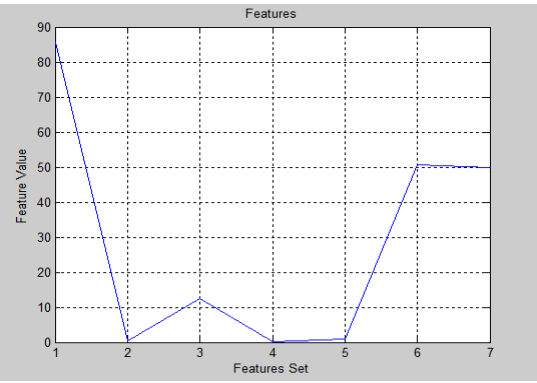

Fig. 2. Features selected from the input image.

B. Classification using ANN with Bat Algorithm

When the classification was applied on an image from the medical dataset discussed above, the features selected for the image is depicted through a graph in "Fig. 2". Interested reader may note that image for feature selection was same as shown for training sample in "Fig. 1". The graph shows the indexes of feature values vs. features set.

After selecting the relevant features, the classification of the image was done by applying bat algorithm on the weights of an artificial neural network in order to optimise them.

In classification of images it desired the output should be understandable by layman and therefore the output of classification process is simply showing the different categories in the experimental work. For example, in "Fig. 3" the input image got classified as a case of osteoporosis bone which was a non-severe case.

Both the algorithms, ANN-BAT and ANN-Backpropagation were applied on the osteoporosis dataset to classify the bone images of the dataset. The time elapsed and the accuracy of classification was recorded for both the algorithms. The comparison graphs for both have been shown in "Fig. 6" and "Fig. 7" respectively.

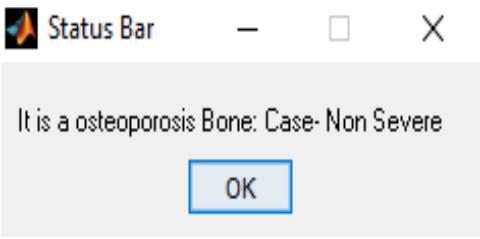

Fig. 3. Image classified as Non- severe.

C. TIME ELAPSED

The comparative analysis is done for time elapsed for the classification in both the models. ANN with bat algorithm took lesser time in classifying the image than

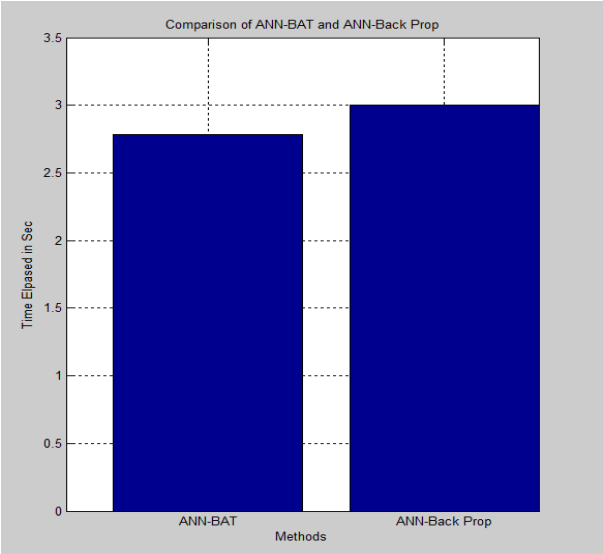

Fig. 4. Time elapsed for ANN-BAT and ANNBP.

the ANN with Backpropagation model. "Fig. 4" and "Fig. 6" show the comparison graph of time taken by both the models.

D. ACCURACY

In terms of accuracy of classification, the results of ANN-BAT algorithm were found to be more accurate than the AAN-Backpropagation algorithm. The "Fig. 5" shows the accuracy comparison graph of ANN-BAT and ANN-Backpropagation (ANNBP) algorithm.

E. COMPARISON OF RESULTS

The total time taken for classification of 3 different images in the data set was recorded for both the ANN models. Plots in figure 4 and 6 Shows the time taken for both the models and one can easily found the significance of the experiment done in the study. This benefit in terms

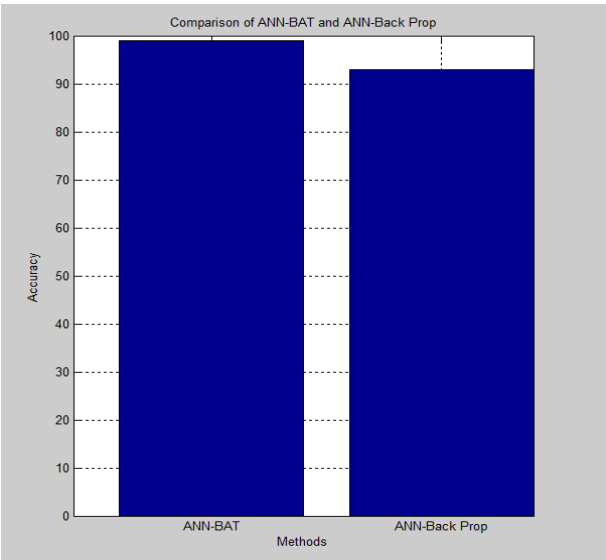

Fig. 5. Accuracies of ANN-BAT and ANNBP.

of time saving for building the model could enhance the confidence of researchers' tendency towards fast image based medical diagnosis system.

The ANN-BAT algorithm gives a total of 99% accuracy in classifying the images and the ANN-Backpropagation algorithm gives a total of 93% accuracy in classification as shown in "Fig. 5".

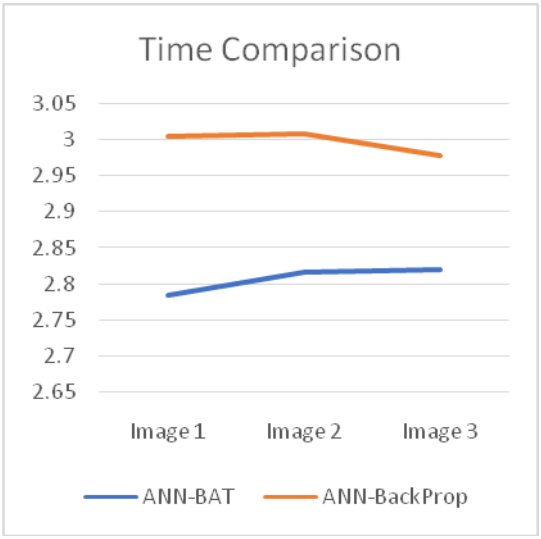

Fig. 6. Comparison of time for ANN-BAT and ANNBP.

The experiment's success is twofold as one can observe: (i) Time saved for building the classification model of neural network using BAT algorithm which proves itself a better metaheuristic for optimization. (ii) Accuracy improved significantly from 93 to 99% which is again a much demanded concern for researchers of machine learning and metaheuristic techniques.

IV. CONCLUSION

In terms of accuracy, the results were compared using a graph plot of the ANN-BAT and ANN-Backpropagation. It was prominent from the graph that the accuracy comparison of the result was going in the favour of ANN-BAT algorithm. The accuracy of ANN-BAT was found to be 99% which was more than that of the ANN-Backpropagation. The problems of slow convergence and getting stuck in local minima are greatly reduced with the proposed hybrid approach. The overall result show that classification algorithm perform better and yields more accurate results when weight optimisation is done using Bat algorithm. This hybridization can improve the overall accuracy of the classification process when using neural networks.

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