Predicting the Age of abalone Using Neural Networks

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Abstract

A neural network is an artificial representation of human brain that tries to simulate the learning process. The neural network is an array of interconnected processing elements, each of which can accept inputs, process them and produce single output. The input node describes the number of attributes and the output node describes the specification of category. The system provides the abalone (sea ear) datasets to implement the system. The system accepts the values of attributes which are used to determine rings of abalone. By adding 1.5 to resulted ring, the age of abalone is obtained. The system uses neural network to classify rings.

1. Introduction

The proposed system use eight attributes in input layer of neural network. The neural network has one hidden layer and directly connected to the output layer. The output layer produces the rings on the shell of abalone. By adding 1.5 to rings give age in years of abalone, that is mentioned in datasets. By adding 1.5 to rings, the system shows the age of abalone in years. [9].

The abalone is useful for abalone shell, because of shimmering shell for personal adornment items such as buttons and pendants. It is known as "mother of pearl". Abalone shell consists of a variety of elements including calcium, iron, magnesium, sodium and silicon and several chemical compounds including aspartic acid and glutamic acid. Abalone shell can be used in medicine for liver diseases.

The data set determines the age of abalone from physical measurements by cutting the shell through the cone, staining it and counting the number of rings through a microscope. This task is boring and time-consuming task. So, the system is useful in MRL (Marine Research Laboratory) because the system predict the age of abalone by entering the sex, length, diameter, whole weight, shucked weight, vicera weight and shell weight without cutting the shell through the cone, staining and counting the number of rings through a microscope. Knowing the age of abalone user determines the abalone is mature or immature or young.

Abalone is an edible mollusc. Endemic to Australia. It is considered a delicacy. It has a single, ear-shaped shell lined with mother of pearl. The foot of the abalone has a distinct black lip that gives this species its name. Belonging to the family of molluscs, abalones are large marine snails. Abalone is found along the rocky shores of Australia, south from mid New South Wales down and around to Western Australia. Abalone in shallow waters averages around 8cm, while shells found in deeper water grow to around 14cm. Growth rates vary seasonally and with location. Black lip abalone (H.rubra) can grow to at least 21cm in length. Mature males and females can easily be recognized by the differences in gonad colour [males = creamy white, females = usually green]. The gonad colour of female Black lip abalone changes quite regularly depending on the stage of maturation. Spent or developing ovaries are coloured a grey-blue or brown. A change from grey-green to olive green is evident as they approach maturity.

The maturity age and size of black lip abalone is 3 years and 70-110 mm. Black lip abalone found at temperatures of 15.0-16.0ºC.The spawning season and location of black lip abalone is October-January & March-June (SA) Generally Spring and Summer along the entire southern coast of Australia. The fertilization of black lip abalone is external. The fecundity (number of eggs measured in a single spawning) of black lip abalone species is 2.2-2.8 million eggs. The viable of fertilized eggs from black lip abalone are usually around 250 µm in diameter. The length of larva phase of black lip abalone is 4.5-6 days. The growth size of black lip abalone is 120-140mm and some are 200mm. Black lip will feed on a variety of algae, they prefer red algae. [10]

2. Neural Network

An artificial neural network (ANN), often just called a "Neural Network" (NN), is an interconnected group of artificial neurons that uses a mathematical model or computational model for information processing

based on a connectionist approach to computation. Neural Network consists of a (possibly large) number or simple neuron- like processing units, organized in layer. Neural Network has one or more hidden layers of sigmoid neurons followed by output layer linear neurons. Every unit in a layer is connected with all the units in the previous layer. These connections are not all equal; each connection may have a different strength or weight.

The weight on these connections encodes the knowledge of network. Knowledge is represented in a neural network by the pattern of connection among the processing elements and by the adjustable weight of these connections. Neural Network is motivated by their capability of learning. The operation of a processing element depends on the number of inputs to it that are currently activated on their weights. The weights or strengths of the links between neurons is where the functionally of the network resides. It basic structures shown in Figure 1;

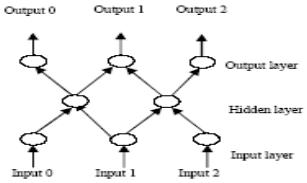

Figure 1.Architecture of Neural Network

2.1 Types of Neural Network

In general, there are three fundamentally different classes of network architectures: Single Layer Feed Forward Neural Network, Multilayer Feed Forward Neural Network and Recurrent Network.

2.1.1 Single Layer Feed Forward Neural Network

Single layer feed forward neural network is illustrated in Figure 2. This network is first and simplest type of artificial neural network and has an input layer of source nodes that projects onto an output layer of neurons, nodes, but not vice versa. The information moves forward, from the input nodes to the output nodes. There are no loops in the network. [1]

2.1.2 Multilayer of Feed Forward Neural Network

The second class of a feed forward neural network distinguishes itself by the presence of one or more hidden layers, whose computation nodes are correspondingly called hidden neurons of hidden units. The function of hidden neurons is to intervene between the external input and the network output in some useful manner. By adding one or more hidden layers, the network is enabled to extract higher order statistics. This input layer must be connected to a hidden layer. This hidden layer can then be connected to another hidden layer or directly to the output layer. There can be any number of hidden layers so long as at least one hidden layer is provided. In common use most neural networks will have only one hidden layer. It is very rare for a neural network to have more than two hidden layers.

The input layer to the neural network is the conduit through which the external environment presents a pattern to the neural network. The source nodes in the input layer of the network supply respective elements of the activation pattern (input vector), which constitute the inputs data applied to the neurons (computation nodes) in the second layer (i.e. the first hidden layer). The output of the second layer is used as inputs to the third layer, and so on for the rest of the network. Every input neuron should represent some independent variable that has an influence over the output of the neural network.

The output of the neurons in the output (final) layer of the network constitutes the overall response of the network to the activation pattern supplied by the source nodes in the input (first) layer. The output of the neural network is what actually presents a pattern to the external environment. What pattern is presented by the output layer can be directly traced back to the input layer. The number of output neurons should be directly related to the type of work that the neural network is to perform. [1]

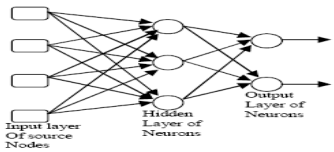

Figure 2. Fully connected Feed Forward Network

2.1.3 Recurrent Network

A recurrent neural network distinguishes itself from a feed-forward neural network in that it has at least one feedback loop. A recurrent network may consist of a single layer of neurons with each neuron feeding its output back to its inputs of all the other neurons. [1]

2.2 Weights

The weights used on the connections between different layers have significance in the working of the neural network and the characterization of a network. The following actions are possible in a neural network;

(1) Start with one set of weights and run the network. (No Training).
(2) Start with one set of weights, run the network , modify some or all the weights and run the network with new set of weights. Repeat this process until some predetermined goal is met (Training).

2.3 Back Propagation "BP" Process

The weights in the network are initialized to small random numbers (ranging from - 1.0 to 1.0 or -0.5 to 0.5). The net input to each unit in the hidden and output layers is computed as a linear combination of its inputs:

$$I_j = \sum i\ W_{ij}\ O_i + \theta_j \qquad \text{equation (1)}$$

where,
W_{ij} is the weight of the connection from unit i in the previous layer to unit j;
O_j is the output of unit i from the previous layer;
θ_j is the bias of the unit;
The bias acts as a threshold in that it serves to vary the activity of the unit. Each unit in the hidden and output layers takes its net input and then applies an activation function is;

$$O_j = 1/1+e^{-ij} \qquad \text{equation (2)}$$

2.4 Backpropagation Error

The error is propagated backwards by updating the weights and bias to reflect the error of the network's prediction. For a unit j in the output layer, the error is Err_j computed by:

$$Err_j = O_j(1 - O_j)\ (T_j - O_j) \qquad \text{equation (3)}$$

where,
O_j is the actual output of unit j
T_j is the true output
To compute the error of a hidden layer unit j is;

$$Err_j = O_j\ (1 - O_j) \sum_k Err_k\ W_{jk} \qquad \text{equation(4)}$$

where,
W_{ij} is the weight of the connection from unit j to a unit k in the next higher layer, and
Err_j is the error of unit k.
The weights and bias are updated to reflect the propagated errors. Weights are updated by the following equations;

$$\Delta W_{ij} = W_{ij} + (l) Err_j\ O_j \qquad \text{equation (5)}$$
$$W_{ij} = W_{ij} + \Delta W_{ij}$$

where,
l is the learning rate (having a value between 0.0 and 1.0)and the biases are updated by the following equation; [2]

$$\Delta \theta_j = \theta_j + (l)\ Err_j \qquad \text{equation (6)}$$
$$\theta_j = \theta_j + \Delta\theta_j$$

2.5 Back Propagation Algorithm

Input: The training samples, samples; the learning rate, l;
Output: A neural network trained to classify the samples.
Method:
(1) Initialize all weights and biases in network;
(2) While terminating condition is not satisfied {
(3) for each training sample ***x*** in samples {
(4) // Propagate the inputs forward :
(5) for each hidden or output layer unit j {
(6) $I_j = \sum_i W_{ij}\ O_j + \theta_j$; // compute the net input of unit j with respect to the layer, i
(7) $O_j = 1/1+e^{-ij}$; }// compute the output of each unit j
(8) // Backpropagate the errors:
(9) for each unit j in the output layer
(10) $Err_j = O_j\ (1 - O_j)(T_j - O_j)$; // compute the error
(11) for each unit j in the hidden layers, from the last to the hidden layer
(12) $Err_j = O_j\ (1 - O_j) \sum_j Err_j\ W_{jk}$; //compute the error withe respect to the next higher layer, k
(13) for each weight Wij in network {
(14) $W_{ij} = W_{ij} + (l) Err_j\ O_j$; // weight increment
(15) $W_{ij} = W_{ij} + \Delta W_{ij}$; } // weight update
(16) for each bias θj in network
(17) $\Delta\ \theta_j = (l)\ Err_j$; // bias increment
(18) $\theta_j = \theta_j + \Delta\theta_j$; } // bias update
(19) }}

2.6 Advantages of Neural Network

(1) NN provides high tolerance of noisy data (ability to classify patterns on which they have not been trained).
(2) NN can be used when you may have little knowledge of the relationships between attributes and classes. They are well -suited for continuous- valued inputs and outputs.
(3) NN can work successfully on real world data including handwritten character recognition, pathology, and laboratory medicine and training a computer to pronounce English text.
(4) NN technique can be used to speed up the computation process.
(5) Several techniques have been developed for extraction of rules from trained neural networks.
(6) NN are very useful for classification and prediction.

3. Proposed Classification System

3.1 Overview of the System

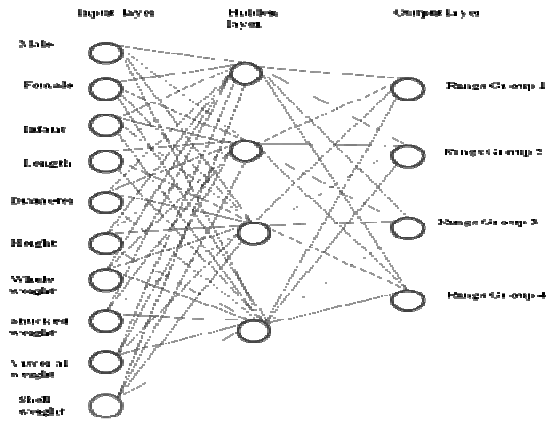

Figure 3. Neural Network Architecture of Proposed System

In the field of classification, there has been much research and method. The application of artificial Neural Network is proposed to meet the need of closely result. This system will represent the classification of rings of abalone based on their sex, length, height, whole weight, shucked weight, viscera weight, gut weight, shell weight. The attributes of abalone are fed to input stage of a Neural Network and the output is the specification of the category.

The input layer of network has ten input units. The network has one hidden layer and directly connected to the output layer. The output layer has four output units. The output layer produces the rings group. Generally, the rings of abalone are divided into four groups. The group1 is defined the rings of abalone is (3 to 7). The group 2 is defined the rings of abalone is (8 to 12). The group 3 is defined the rings of abalone is (13 to 17). The group 4 is defined the rings of abalone is (18 to 21). There are 837 records for group 1, 2645 records for group 2, 557 records for group 3 and 114 records for group 4 which are taken from datasets. After adding 1.5 to ring group 1, the age of abalone is from 4.5 to 8.5. After adding 1.5 to ring group 2, the age of abalone is from 9.5 to 13.5. After adding 1.5 to ring group 3, the age of abalone is from 14.5 to 18.5. After adding 1.5 to ring group 4, the age of abalone is from 19.5 to 22.5.

3.2 Classification Process

There are three steps in classification process. These are entering the attributes values, constructing neural network and adding 1.5 to result.

3.2.1 Entering the Attributes Values

Abalone data set contains eight attributes. There have one nominal attribute and seven continuous attributes. The attributes are-

Sex: M, F, and I (infant)
Length: Longest shell measurement
Diameter: perpendicular to length
Height: with meat in shell
Whole Weight: whole abalone
Shucked Weight: weight of meat
Viscera Weight: gut weight (after bleeding)
Shell Weight: after being dried

3.2.2 Constructing Neural Network

The eight attributes are used in input layer. In this system the neural network have one hidden layer and directly connected to the output layer. The output layer produces the rings on the shell of abalone.

3.2.3 Adding 1.5 to the result

The output from the neural network show the number rings on the shell and adding 1.5 to the result the system shows the age of abalone.

3.2.4 Sample Abalone Databases

Sex	M	M	F	M
length	0.455	0.35	0.53	0.44
Diameter	0.365	0.265	0.42	0.365
Height	0.095	0.09	0.135	0.125
Whole Weight	0.514	0.2255	0.677	0.516
Shucked Weight	0.2245	0.0995	0.2565	0.2155
Viscera Weight	0.101	0.0485	0.1415	0.114
Shell Weight	0.15	0.07	0.21	0.155
Rings +1.5 gives the age in years	15	7	9	10

Table 1.Sample Abalone Databases

3.2.5 System Overview

Over view of classification of process is as shown in Figure 4.

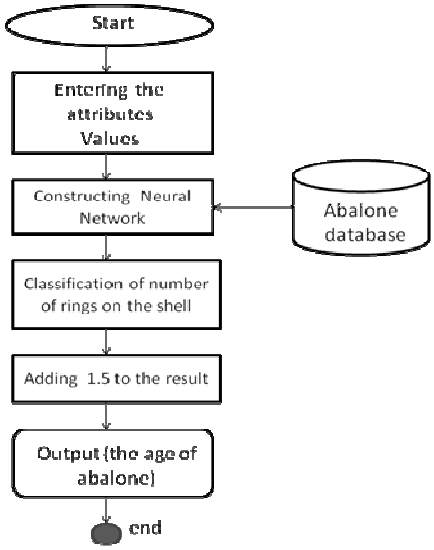

Figure 4. Classification Process

3.3 Process Flow of the System

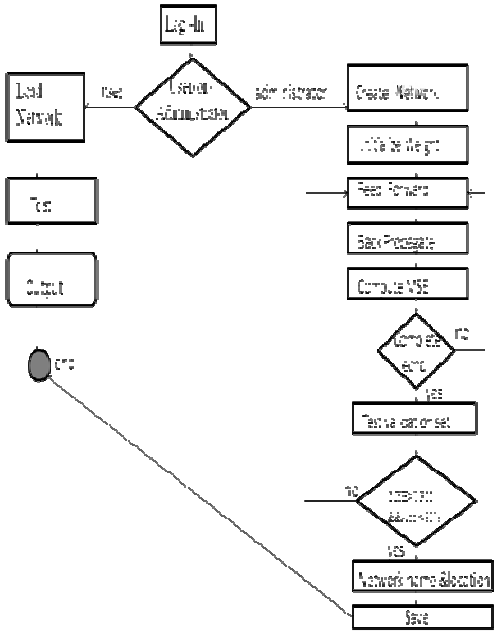

Figure 5. Process Flow of the System

3.3.1 Process Flow of the System

Firstly, user needs to login the system by using username and password. According to login information, two types of user can be identified. These are:

(1) Administrator and
(2) User

3.3.1.1 Administrator

If the user is administrator, the administrator can be created network. Initialize the network with the given structure with given hidden node and mean square error (MSE) to stop when load the training pattern into the network the training process each pattern. Entire set of pattern form training set is called an epcho. Epcho must be repeated until the MSE or required accuracy is satisfied. The weights are randomly initialized into network. The system used feed forward for each pattern in training process after random weight initialization , feed forward put the training input pattern into the network and error is calculate and error is back propagate, that process is continued for an epcho. If the entire echo does not meet the requirement of our system, not getting the required accuracy or MSE, the next epcho is runned. The system computes the backpropagation error and bias by applying back propagation algorithm. The administrator can test accuracy of network with validation set and testing set. And then network is saved.

3.3.1.2 User

If the user is normal user, the user cannot create network and user can load the network that is build by the administrator. The user can test accuracy with known input or unknown input.

4. Evaluation of Performance

The given database is divided into three partitioned. The first part is training and also contains 2327 records. The second part is validation and also contains 925 records. The third part is testing and also contains 925 records. The validation set is used for accuracy during program running. The test set is used for accuracy of unknown data. The system produce the maximum accuracy is 80%. The formula of accuracy is described below. The formula of accuracy is described below.

$$\text{Accuracy} = (\text{correct}/\text{size})*100$$

where **correct**= the number of correct answer and
size = all sample

For e.g. calculate accuracy for validation, validation contains 925 records, the size will be 925. The correct answer is 749. The accuracy will be 80.972. The accuracy is nearly 80%. The accuracy for test

can be calculated by this way. The other experiment uses this dataset with C4.5 algorithm [12]. The accuracy was 72.3. Another experiment uses this dataset with Case Based Reasoning [11]. The accuracy is depends on decision tree induction.

5. Conclusion

Abalone shell can be used in medicine for liver diseases and the production of personal adornment items. The proposed system will identify the age of Abalone by entering the attributes of it. By knowing the age of abalone, the researcher can decide it was ready for production of personal adornment items. And at the farm of abalone, the user can see how abalone is growing within duration by measuring whole weight. The proposed system can only be used for Abalone datasets. These datasets are collected from UCI machine learning repository. The system can be extended by using other classification method such as Fuzzy set, Naive Bayesian etc.

6. References

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