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Machine Learning for Soil Fertility and Plant Nutrient Management using Back Propagation Neural Networks

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***Abstract* -** The objective of this paper is to analysis of main soil properties such as organic matter, essential plant nutrients, micronutrient that affects the growth of crops and find out the suitable relationship percentage among those properties using Supervised Learning, Back Propagation Neural Network. Although these parameters can be measured directly, their measurement is difficult and expensive. Back Propagation Networks(BPN) are trained with reference crops' growth properties available nutrient status and its ability to provide nutrients out of its own reserves and through external applications for crop production in both cases, BPN will find and suggest the correct correlation percentage among those properties. This machine learning system is divided into three steps, first sampling (Different soil with same number of properties with different parameters) second Back Propagation Algorithm and third Weight updating. The performance of the Back Propagation Neural network model will be evaluated using a test data set. Results will show that artificial neural network with certain number of neurons in hidden layer had better performance in predicting soil properties than multivariate regression. In conclusion, the result of this study showed that training is very important in increasing the model accuracy of one region and result in the form of a guide to recognizing soil properties relevant to plant growth and protection.

Key Words: *Neural network, Back Propagation Learning, Machine Learning, weights.*

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I. INTRODUCTION

India is an emerging economic power with vast human and natural resources, and a huge knowledge base. Ensuring food security is a key challenge facing our society. So to improve agricultural practices and the core of precision agriculture is to manage agricultural practices such as to accurately predicting responses of crop growth. Agriculture is the predominant occupation in India, accounting for about 52% of employment [1]. Agricultural soil quality includes the soil properties, particularly those related to organic matter such as N, C, pH, Mg Ca and K [2] and essential plant nutrients, K^+, Ca^{2+}, Mg^{2+} and NH^{4+} and detrimental elements, N^{a+}, H^+ and Al^{+3} [3]. Crop response to fertilization recommended micronutrient for plant growth are P, k, Mn, Zn and Cu [4].The native productive capacity of soil is dependent on basic chemical and physical properties and predictions are possible [5],[6]. So the main aim is to analysis, adjustment, and establishment of crops growth factors and soil properties' parameters.

An artificial neural network is a highly interconnected network of many simple processing units called neurons, which are analogous to the biological neurons in the human brain. The extraction of knowledge was computed manually using various statistical techniques but such techniques was time consuming [7]. Back Propagation Neural Networks are being counted as the wave of the future in computing. They are indeed self-learning mechanisms which don't require the traditional skills of a programmer. BPN able to enhance the ability to predict and competition between different species under changed environmental conditions and their potential applicability in other crops to grow as well [08]. This method capable to detect errors establishment of optimum or best possible solution, for classification and can be used to detect the components of organic mixtures both qualitatively and quantitatively including adaptive new characteristics [09],[10],[11],[12]. Using back-propagation learning algorithm, network error is reduced in a short time using differential adaptive learning rate [13].

II. BACK PROPAGATION NETWORK (BPN)

Back propagation, or propagation of error, is a common method of teaching artificial neural networks how to perform a given task. It was first described by Arthur E. Bryson and Yu-Chi Ho in 1969. An Artificial neural network is a powerful data-modeling tool that is able to capture and represent complex input/output relationships and this power wave is being counted for the future in computing. BPN able to compute and analysis a large number of data dividing into several small network and each network can be trained separately along with integration [14]. The Back Propagation learning algorithm is one of most important developments in neural net works (Bryson and Ho,1969; Werbos,1974; Lecun, 1985; Parker,1985; rumelhart,1986) [15]. This network has re-awakened the scientific and engineering community to the modeling and processing of quantitative phenomena. This algorithm is applied to multilayer feed-forward networks consisting of processing elements with continues differentiable activation functions. For a given set of input out pair, this algorithm provides a procedure for changing the weight in BPN to classify the given in put pattern correctly. The aim of the neural network is to train the net to achieve a balance between net's ability to respond (memorization) and its ability to give reasonable responses to the input that is similar but not identical to the one that is used in training (generalization). To this end, the advantage of unsupervised clustering over supervised learning is its adaptability. Different data sets taken from different soil can give different characteristics. While a supervised learning algorithm restricts and owing to its learning of specific feature values associated with known labels.

The training of the BPN is done in thee stages- the feed forward of the input training pattern, the calculation and back-propagation of the error and updation of weights. The commonly used activation function for BPN is binary sigmoidal and bipolar sigmoidal activation function because of following characteristics:

- Continuity
- Differentiability
- Non decreasing monotony

A. *Binary Sigmoidal Activation Function:*

$f(x) = 1 / (1+e^{-\lambda x})$, where λ is steepness parameter.

B. *Bipolar Sigmoidal Activation Function:*

$f(x) = (1- e^{-\lambda x}) / (1+e^{-\lambda x})$, where λ is steepness parameter.

C. *Steps*

- Sampling (Different soil with same no. of properties with different Parameters).
- Back Propagation Algorithm (Training Process)

The BPN algorithm completes after three phases Feed Forward Phase (Phase I), Back Propagation of error (Phase II), Weight and bias updation (phase III). Calculation of Net input on Hidden Layer and out put of the hidden unit by applying its activation functions is given by-

Feed Forward Phase I

$z_{inj} = v_{oj} + \sum x_i v_{ij}$ and $z_j = f(z_{inj})$

And send this out put signal from hidden unit to the input of out put layer.

The calculation of net input and put on output layer is given by-

$y_{ink} = w_{0k} + \sum z_j w_{jk}$ and $y_k = f(y_{ink})$

Back Propagation of error Phase II

Each output unit Y_k (k = 1 to m) receives a target pattern corresponding to the input training pattern and computes the error correction term.

$\partial_k = (t_k - Y_k) f'(y_{ink})$

On the basis of the calculated error correction term, update the change in weights and bias

$\Delta w_{jk} = \alpha \partial_k z_j$

$\Delta w_{0k} = \alpha \partial_k$, Where α is Learning rate.

Each hidden unit z_j (j=1 to p) sums it delta inputs from the output units and the term ∂_{inj} gets multiplied with the derivatives of $f(z_{inj})$

$\partial_{inj} = \sum \partial_k w_{jk}$ and $\partial_j = \partial_{inj} f'(z_{inj})$

On the basis of the calculated ∂_j, update the change in weights and bias:

$\Delta v_{ij} = \alpha \partial_j x_i$

$\Delta v_{0j} = \alpha \partial_j$

Weight and bias updation Phase III

Each input unit y_k,(k = 1 to m)

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$W_{jk(new)} = w_{jk(old)} + \Delta w_{jk}$

$W_{0k(new)} = w_{0k(old)} + \Delta w_{ok}$

Each hidden unit zj,(j=1 to p)

$V_{ij(new)} = v_{ij(old)} + \Delta v_{ij}$

$V_{0j(new)} = v_{0j(old)} + \Delta v_{0j}$

- Clustering of soil properties as a input and output pairs.

D. Algorithm Testing Steps:

1. Set the Activation Function.
2. Calculate the net input to hidden input.
3. Compute the out put of out layer.

E. Learning Factors of BPN:

1. Initialize Weight
2. Learning Rate
3. Number of training data set
4. Number of hidden layers and nodes.

III. BACK PROPAGATION NEURAL NETWORK ARCHITECTURE

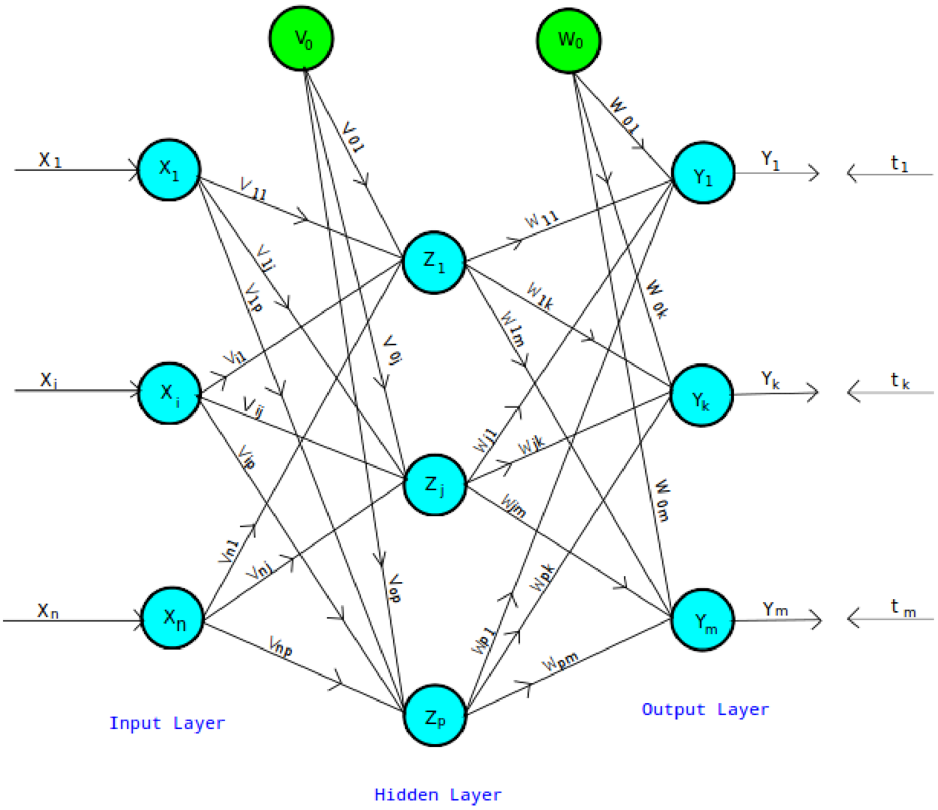

Fig: Architecture of a Back-Propagation Network

IV.MATLABE CODE

In this study, the training process will be performed by the commercial package MATLAB, which includes a number of training algorithms including the back propagation training algorithm. This is a gradient descent algorithm that has been used successfully and extensively in training feed forward neural networks.

```
%back propagation network, tacking random variables values
clear all;
clc;
disp('Back propagation Network');
```


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```
v=[0.7 -0.4;-0.2 0.3]
x=[0 1]
t=[1]
w=[0.5;0.1]
t1=0;
wb=-0.3
vb=[0.4 0.6]
alpha=0.25
e=1;
temp=0;
while (e<=3)
    e
    for i=1:2
        for j=1:2
            temp=temp+(v(j,i)*x(j));
        end
        zin(i)=temp+vb(i);
        temp1=e^(-zin(i));
        fz(i)=(1/(1+temp1));
        z(i)=fz(i);
        fdz(i)=fz(i)*(1-fz(i));
        temp=0;
    end

    for k=1
        for j=1:2
            temp=temp+z(j)*w(j,k);
        end
        yin(k)=temp+wb(k);
        fy(k)=(1/(1+(e^-yin(k))));
        y(k)=fy(k);
        temp=0;
    end

    for k=1
        fdy(k)=fy(k)*(1-fy(k));
        delk(k)=(t(k)-y(k))*fdy(k);
    end

    for k=1
        for j=1:2
            dw(j,k)=alpha*delk(k)*z(j);
        end
        dwb(k)=alpha*delk(k);
    end

    for j=1:2
        for k=1
            delin(j)=delk(k)*w(j,k);
        end
        delj(j)=delin(j)*fdz(j);
    end

    for i=1:2
        for j=1:2
            dv(i,j)=alpha*delj(j)*x(i);
        end
        dvb(i)=alpha*delj(i);
    end

    for k=1
        for j=1:2
            w(j,k)= w(j,k)+dw(j,k);
        end
        wb(k)=wb(k)+dwb(k);
    end
    w,wb

    for i=1:2
        for j=1:2
            v(i,j)=v(i,j)+dv(i,j);
        end
        vb(i)=vb(i)+dvb(i);
    end
    v,vb
    te(e)=e;
    e=e+1;
end
```


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V. RESULT ANALYSES

Instead of random values if real value of soil properties of examining field are taken and if they are compared with standard (desired or target) data set, then above algorithm and code will give the accurate updation needed for soil Compost.

VI. CONCLUSIONS

Results will show that the proposed correction method enables improving significantly Soil properties prediction accuracy and performs better than traditionally used methods consisting in automatic weight updation processing.

VII. FUTURE SCOPE: (IN NEXT PAPER)

Back-propagation network will be employed to develop a self trained function for predicting soil properties with parameters (variation).The performance of BPN can be evaluated by test data set. After so many clustering and trained network BPN can behave like automated system to predict crop growth rate for given soil properties.

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