TOWARDS FOOD SECURITY THROUGH ARTIFICIAL NEURAL NETWORK

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Abstract

The detection of plant disease is a very important factor to prevent serious outbreak. The Outbreak of disease in paddy plant could cause severe losses in yield leading to insecurity of food security. To achieve automatic diagnosis of paddy disease this research aims to develop a system for detection of Blast disease in paddy leaf. The disease identification is achieved through Image Processing technique and Back Propagation Neural Network. Features of images are extracted through binning pixels into eight Attribute Bins. Training of Neural Network is achieved by feed forwarding these features to neural network. The error generated is back propagated in order to adjust the weights of neural network. Images of the diseased leaves are identified with accuracy. Thus fast and accurate diagnosis of paddy disease could timely control outbreak leading the path towards ensuring food security. This research could be enhanced through implementation of Deep Learning Neural Network, further contributing the Smart Agriculture.

Keywords: Food security, Paddy disease, Back Propagation Neural Network, Deep learning, Smart Agriculture.

1. Introduction

Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.(The State of Food Insecurity in the World 2001.Rome.FAO, UN. 2002)

Food security is also recognized as being more than just providing people with enough calories to live on, but ensuring people have enough nutrients for optimal health too. Among the many food people eat worldwide, rice is the most important human food, eaten by more than half of the world's population every day. In Asia alone, where 90% of rice is consumed, ensuring there is enough affordable rice for everyone, or rice security, is equivalent to food security. Likewise, in Africa and Latin America, rice is becoming a more important staple too (International Rice Research Institute, Rice Knowledge Bank).

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Food Security for the world could be achieved by assuring good yield of rice through paddy disease prevention and treatment which would be only possible by timely detection of diseases. In order to control the disease, fast and accurate diagnosis of plant disease should be conducted, effectively. The prevalence of plant disease should be well known and disease prediction should be caused out. Image Recognition of Paddy disease and automatic classification of disease severity is achieved by using Image Processing Technologies. The research aims at creating system for detection and classification of paddy disease with implementation of Image Processing and Back Propagations Neural Network with precision.

1.1. Relevance of Research

Many people in Asia rely heavily on rice for most or their entire calorie needs because they cannot afford or do not have access to nutritious food such as fruits, vegetables, and foods from animal sources (e.g., meat, dairy products, and eggs). As a result, lack of iron, zinc, and vitamin A has become prevalent micronutrient deficiencies in rice-consuming countries. The cost of these deficiencies in terms of lives and quality of life lost is enormous, with women and children being the ones at most risk. Two billion people suffer from micronutrient malnutrition. They

get enough macronutrients (carbohydrates, protein, and fat) from their diet, but not enough micronutrients (vitamins and minerals) that are essential to good health. Not having enough vitamins and minerals can result in more frequent and severe illness and complications during pregnancy, childbirth, infancy, and childhood.

Even a small increase in the micronutrient content of rice grains could have a significant impact on human health as rice is the dominant cereal crop in most of the Asian countries. Rice is the staple food for more than half of the world's population (including many of those living in poverty).Undoubtedly, healthier rice (paddy) ensures that people who mostly depend on rice get more nutrients into their diet to reduce malnutrition as healthy rice varieties have the potential to reach many people because rice is already widely grown and eaten. Hence paddy disease control through precise detection diagnosis and treatment is very essential towards achieving food security.

To ensure food security, paddy plant disease is to be controlled timely and effectively. Recognition and diagnosis of paddy disease relies on visual identification by agricultural technicians that requires high professional knowledge with rich experience. Besides disease diagnosis through pathogen detection requires satisfactory laboratory and molecule biological techniques which is both time consuming and costly.

A simple and fast plant disease identification method with high accuracy is a path towards ensuring food security by achieving a healthy yield in desired quantities. This Research is focused on Paddy disease recognition on the basis of Image processing techniques and Back Propagation Networks.

1.2. Related Work

To achieve automatic diagnosis of plant diseases, (Wang, et al., 2012) used two kinds of grape diseases and two kinds of wheat diseases. The image recognition of these diseases was conducted based on image processing and pattern recognition. Back propagation (BP) networks were used as to classify these diseases. His research used PCA (Principle Component Analysis) to reduced features and maintains accuracy 97.14%.

(Kurniawati et al.,2009) proposed a method of paddy disease diagnosis. Their research used automatic

threshold and Otsu method for image processing and production rule technique to recognize paddy disease with accuracy of 94.7 percent.

(Bhong and Pawar,2016) presented a paper for detection of disease in cotton plant leaf. The paper provides method to detect cotton leaf disease using image processing technique in which K-means clustering algorithm used for segmentation and color feature extracted was sent to neural network for recognition gaining 89.56% accuracy using Euclidean distance.

Similarly a research carried out by (Verma, 2014) has implemented a Back Propagation algorithm to classify image. The classification is based on comparison of performance of existing machine learning algorithm like naïve bays classifier, decision tree lazy classifier and other back propagation. They were of the conclusion that Back propagation is one of the best solutions for disease detection through image processing at the accuracy of 97.02 percent.

The survey on plant leaf disease classification carried out by (Kumar and Kaur, 2015) provides an overview on different image processing and classification technique such as PCA, SVM, and Neural Network. Their survey demonstrated that Back Propagation has very impressive result in classification and is an easy way to implement non-linear technique for training neural network.

A study conducted by (Kahar et al., 2015) presented an integrated method for recognizing disease on paddy plant leaves and provided the user with recommendation on how to overcome and control the diseases. The method of disease recognition used in this study is a neuro-fuzzy expert system. The method combines the learning capabilities of Artificial Neural Network with human like knowledge representation and fuzzy logic system and rule based expert system. The prototype developed to assist Malaysian Paddy farmer and paddy researcher. Here the accuracy result is 74.21%.

2. Research Methodology

The research methodology been followed is shown as
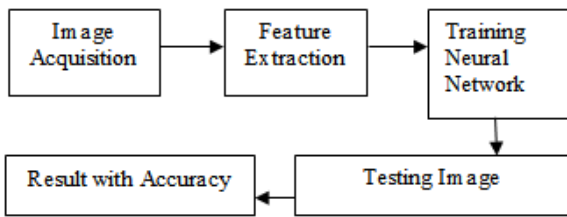
in figure below.

Fig. 1. System Architecture

2.1 Image Acquisition

The images used to train and test the Neural Network for this research are obtained from the International Rice Research Institute (IRRI).

2.2 Feature Extraction

To train the images features of images are to be extracted. In this research, feature extraction is done using the concept of binning each pixels of the image into eight attribute bins. Binning pixels is popular method in image processing for pattern recognition. Image is composed of number of pixels. Each pixel can be represented as the intensity of Red, Green and Blue(R, G, B) as shown in Table 1 below.

2.3 Training Neural Network

The extracted features of the images are set as an input to train the neural network. Training of neural network is accomplished through feed forward propagation and Back Propagation of error and adjustment of weights. In forward propagion, the bin features as an input is propagated through network. The initial weights that connect the nodes are chosen in random. The input layer and hidden layer contain Eight Nodes. While propagating in forward direction the neurons are activated using sigmoid activation function and output is generated. The difference of target output and actual output is set as error. This error is propagated backward to network and weights are adjusted till the mean square error is minimum i.e. 0.0001.

The Back Propagation Neural Network algorithm used for this system is as follows.

Step 1: initialize the weights of input layer and hidden layer to small random variable.

Step 2: Feed inputs to the network.

Step 3: Forward propagation using sigmoid activation function.

$$F(x) = \frac{1}{1+e^{-input}} \qquad (1)$$

Step 4: Calculate error, the difference between the actual output and the target output.

Step 5: Adjust the weights of output layer and hidden layer propagating the error backward

Weight (new) = Weight (old) + learning rate *error * output of hidden layer * Output of output layer * (1- output of output layer).(2)

Step 6: Repeat through step 2

Step 7: Test for stopping (mean square error is 0.0001)

Momentum and Adaptive Learning Rate are been considered to accelerate the convergence of the Back Propagation.

Table 1: Binning Pixels into Attribute Bin

Red low	Red high	Green low	Green high	Blue low	Blue high	Attribute Bin
0	127	0	127	0	127	1
0	127	0	127	127	255	2
0	127	127	255	0	127	3
0	127	127	255	127	255	4
127	255	0	127	0	127	5
127	255	0	127	127	255	6
127	255	127	255	0	127	7
127	255	127	255	127	255	8

2.3.1. Training Back propagation Neural Network with Momentum

Setting parameter of Momentum prevents the system from converging to a local minimum point and helps to increase system's convergence speed. High momentum parameter creates a risk of overshooting the minimum that leads to system instability. Low momentum coefficient cannot reliably avoid local minima that slow the training ofthe system.

Making weight changes equal to the sum of a fraction of the last weight change and the new change suggested by the gradient descent BP rule.

W (new) = W (old) + learning rate * error * output of hidden layer * output of output layer * (1- output of outer layer) + momentum constant * W (old-1).   (3)

Where, momentum constant of value 0.95

2.3.2. Learning with Adaptive Learning Rate

To accelerate the convergence and avoid the danger of instability we can apply two heuristics
1. If the change of the sum of squared errors has the same algebraic sign for several consequent epochs then the learning rate parameter should be increased.
2. If the algebraic sign of the change of the sum of squared error alternates for several consequent epochs, then the learning rate parameter should be decreased.
Adapting the learning rate requires some changes in the back propagation algorithm.
•If the sum of the squared errors at the current epoch exceeds the previous value by more than a predefined ratio (typically 1.04) the learning rate parameter is decreased typically multiplying by 0.7) and new weight and threshold are calculated.
•If the error is less than the previous one the learning rate is increased (typically multiplying by 1.05).

2.4. Testing of Image

For testing the defected image, the bin values are extracted through feature extraction process. These features are set as input to the neural network for forward propagation. The output of neural network is matched to the target value. The target value of the Blast disease for the system is 0.85.Finally accuracy of the disease is calculated with respect to the target output and actual output.

3. Simulation Results and Discussions

As been explained in methodology, simulation is performed for the effectiveness of research work to approach food security through detecting the disease in paddy leaf.Training session proceeds training the neural network by selecting the images. Eighteen images are selected for training. The selected images are of Blast Disease. Training session started with extraction of features from the images. Features are the Binning attributes of those images. The extracted feature is shown in the Table 2 below.

Table 2: Attribute Bins of 18 images for Training

Feature id	Disease name	binl	bin2	bin3	bin4	bin5	bin6	bin7	bin8
1209	Blast	0.161664	0	0.244447	0	0.121335	0	0.472554	0
1210	Blast	0.063196	0	0.306628	0	0.081743	0	0.548433	0
1211	Blast	0.670879	0	0.133105	0	0.045221	0	0.150796	0
1212	Blast	0.218085	0	0.053254	0	0.084091	0	0.64457	0
1213	Blast	0.232447	0	0.561558	0	0.038702	0	0.167293	0
1214	Blast	0.269465	0	0.00529	0	0.060155	0	0.66509	0
1215	Blast	0.053807	0	0.205062	0	0.075167	0	0.665963	0
1216	Blast	0.175203	0	0.143791	0	0.066745	0	0.614261	0
1217	Blast	0.041892	0	0.082579	0	0.016383	0	0.859146	0
1218	Blast	0.044453	0	0.002405	0	0.096509	0	0.856633	0
1219	Blast	0.045181	0	0.138895	0	0.076554	0	0.739369	0
1220	Blast	0.646218	0	0.087002	0	0.078854	0	0.187925	0
1221	Blast	0.174089	0	0.144104	0	0.066968	0	0.614839	0
1222	Blast	0.041239	0	0.073564	0	0.015908	0	0.869289	0
1223	Blast	0.230451	0	0.150533	0	0.15865	0	0.460366	0
1224	Blast	0.074354	0	0.27722	0	0.149017	0	0.499408	0
1225	Blast	0.042106	0	0.083867	0	0.016521	0	0.857505	0
1226	Blast	0.090608	0	0.629504	0	0.023472	0	0.256416	0

These features are set as input to neural network with

eight input and hidden neurons respectively; We set the target value for blast disease as 0.85. During training these features are feed as input to neural network, forward propagation is done through the use of activation function. The initial weight of hidden layer is set as random value to minimize error to 0.0001 network back propagates with Number of epochs. With constant learning rate 0.2 Weights are adjusted. Adjusted weights are shown in Table 3 below.

3.1 Training with Momentum

To accelerate training of network, learning rate with momentum factors is considered. The convergence is obtained by 109 epochs with Momentum value 0.95. Figure 2 shows the completion of training network using momentum. The convergence is obtained by 109 epochs. Here Mean square error significantly lowered at epochs 13.

Table 3: Adjusted weight of hidden neuron

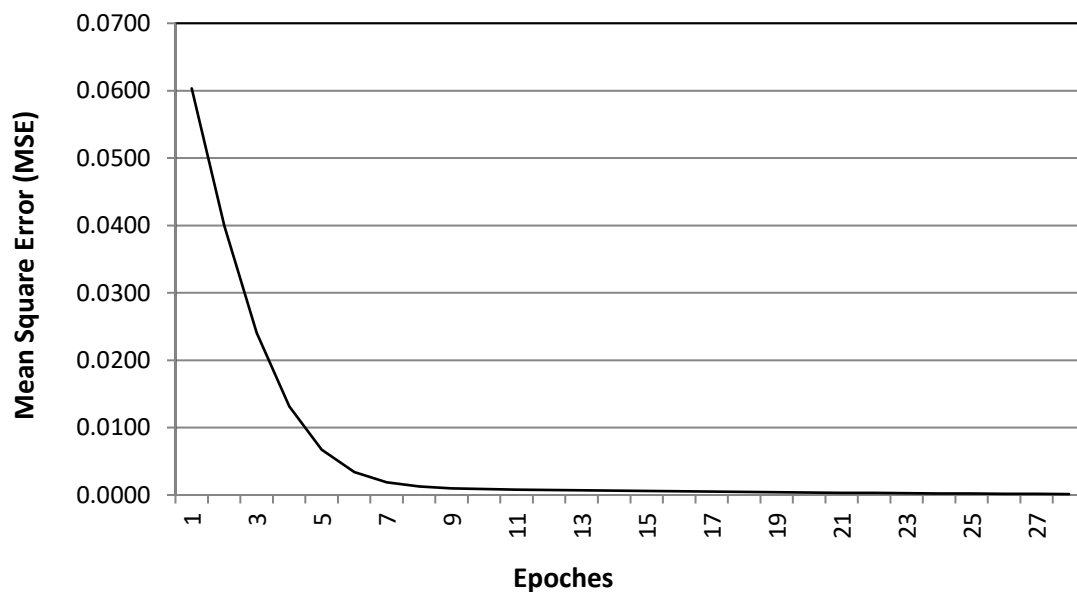| W1	W2	W3	W4	W5	W6	W7	W8
0.48	0.27	0.20	0.26	0.39	0.62	0.06	0.69
0.55	0.17	0.53	0.49	0.76	0.59	0.19	0.20
0.52	0.32	0.24	0.22	0.42	0.65	0.13	0.72
0.55	0.17	0.53	0.49	0.76	0.59	0.19	0.20
0.56	0.35	0.28	0.18	0.47	0.69	0.14	0.76
0.55	0.17	0.53	0.49	0.76	0.59	0.19	0.20
0.28	0.07	6.55	0.46	0.19	0.43	0.14	0.51
0.55	0.17	0.53	0.49	0.76	0.59	0.19	0.20

Fig. 2. Learning rate with momentum

3.1. Training with Adaptive Learning Rate

Considering adaptive learning rate, convergence is obtained at 41 epochs as in Figure 3 below.

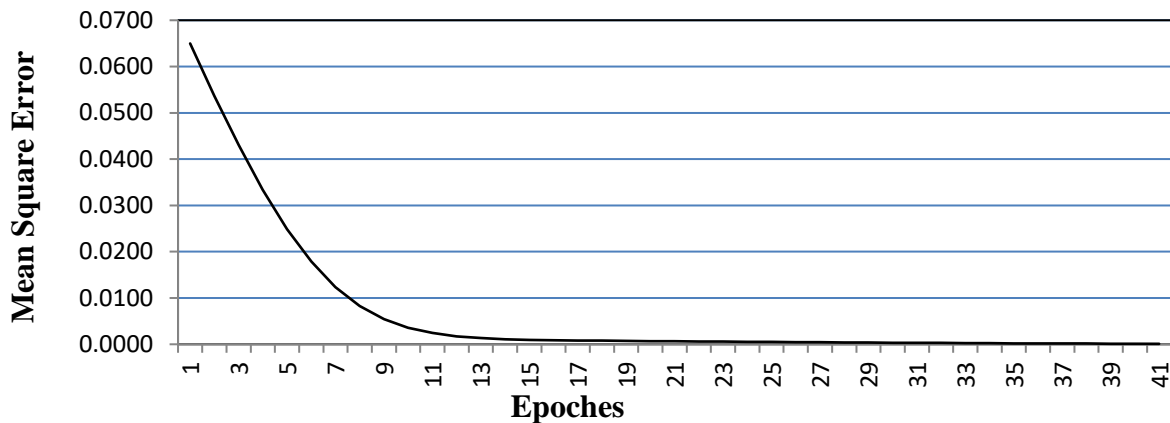Fig. 3. Adaptive learning rate

3.2. Test session

Detection of disease is processed through taking the infected sample image. This image is different from trained images.
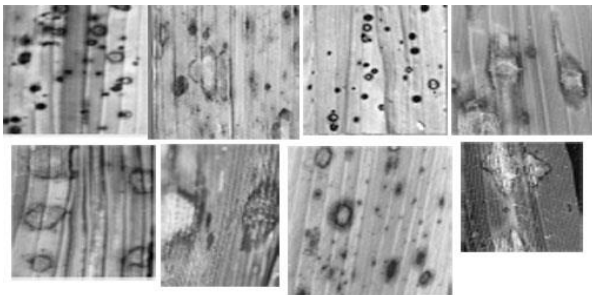

Fig. 4. Images of Infected Leaves for Test session (source:www.knowledgebank.irri.org/blast – leaf - collar)

The sample image is set for test session. Its feature is extracted through binning pixels into eight attribute bin.Those features are feed as an input to the trained network for forward propagation. The output of the network which is 0.84427 is matched to the target value 0.85 which been set for the blast disease. The simulation match output value with target value. The accuracy is calculated by taking ratio of output value to target value displaying percentage matched to the target disease. We considered 50 different images for testing the system.

4. Validations

The validation of system is done on the basis of ratio between correct sample images to total sample images,27 images that is not used for the testing and training session are been considered. 21 images are correctly classified with 77.77% accuracy of the system. The images other than paddy plant are irrelevant for the system.

5. Conclusion and Recommendations

Freedom from Hunger is the key to Human existence. This research aims to contribute in ensuring the freedom by enhancing food security. Rice being the staple food for more than 90% of the world population, the diseases detection of paddy would pave way for the prevention and treatment thereby improving the yield. The improved yield would than ensure food security.

This research work supports achievement of food security emphasizing protection of paddy plant through recognition of disease. The recognition is conducted using image processing technique and Back Propagation Algorithm. Neural network is trained to identify the paddy disease based on extracted Bin attributes from diseased images. The network contains eight input neurons, eight hidden neurons and an output neuron. Training proceeds through forward propagation of features with Back propagation of error for weights adjustment. The research specifically uses Back Propagation algorithm for disease detection. Since Back Propagation is the basis for Deep Learning Neural Network. This opens up opportunities for further enhancement by implementing Deep Learning Neural Network, promoting Smart Agriculture since Digital farming makes agriculture sustainable.

References

[1] International Rice Research Institute, Rice Knowledge Bank.

[2] Haiguang Wang, et al. (2012). Image Recognition of Plant Disease Based on Back Propagation Network, 5th International Congress on Image and Signal Processing (CISP).

[3] Nunik Noviana Kurniawati, et al. (2009). Investigation on Image Processing Technique for Diagnosing Paddy Diseases, International computational Conference of Soft Computing and Pattern Recognition.

[4] Vijay S. Bhong, B.V. Pawar. (2016). Study and Analysis of Cotton Leaf Disease Detection Using Image Processing, International Journal Of Advanced Research in Science, Engineering and Technology.

[5] KesariVerma. (2014). Image Classification using Back Propagation Algorithm, Journal of computer Science and Software Application.

[6] Surender Kumar, Rupinder Kaur. (2015). Plant Disease Detection Using Image Processing- A Review, International Journal of Computer Application.

[7] Mohd Adzhar A. Kahar, Sofianita Mutalib, Shuzlina A. Rahman. (2015). Early Detection and Classification of Paddy Diseases with Neural Networks and Fuzzy Logic Recent Advances in Mathematical and Computational Method.

[8] Richard Spellman. Artificial Intelligence. retrieved from http://www.cs.plu.edu/courses/csce330/notes.htm

[9] Rafael C. Gonzalez, Richard Elwood. (2011). Digital Image Processing, Pearson Education in South Asia.

[10] K. Muthukannan1, P. Latha, R. PonSelvi, P. Nisha. Classification of diseased Plan Leaves Using Neural Network Algorithms", ISSN 1819-6608 ARPN Journal of Engineering and Applied Sciences.

[11] Agrawal Dharmesh. (2012). Design and Implementation of Intelligence System.

[12] Sanjay B. Dhaygude, Nitin P. Kumbhar. Agricultural Plant Leaf Disease Detection Using Image Processing, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering.

[13] Jayme Garcia Ama Barbed. (2013). Digital Image Processing Technique for Detecting, quantifying and Classifying Plant Disease,A Springer Open Journal.

[14] Approach for Automatic Diagnosis of Coronary Artery Disease in Nuclear Medicine., IEEE transaction on Nuclear Science Vol 5.1.

[15] Food and Agriculture Organization, Rome Declaration on Food Security and World Food Summit Plan of Action, 1996.

[16] FAO, WFP, IFAD,The State of Food Insecurity in the World, 2013.

[17] Management of Rice Blast in Nepal retrieved from http://www.knowledgebank.irri.org.

[18] Food Security and Nutrition Monitoring System, South Sudan-Aug/Sept 2015 retrieved from www.wfp.org on 3 December 2015.

[19] Kiran, R. Gavhale, UjwallaGawande. (2016). An Overview of the Research on Plant Leaves Disease detection using Image Processing Technique, IOSR Journal of Computer Engineering (IOSR-JCE) e-ISSN: 2278-0661, p- ISSN: 2278-8727Volume 16, Issue 1, PP 10-16.

[20] Ananthi, S. V. Varthini. (2012). Detection and Classification Of Plant Leaf Diseases International Journal of Research in Engineering &Applied Sciences, Volume 2, and Issue 2, ISSN: 2249-3905

[21] H. Al-Hiary, S. Bani-Ah Mad, M. Reyalat, M. BraikAnd Z. ALrahamneh, Fast and Accurate Detection and Classification of Plant Diseases, IJCA, 2011, 17(1), 31-38, IEEE-2010.

[22] S. Russel, P. Norvig. (2003). Artificial Intelligence, A Modern Approach, Pearson Education, Second Edition, First Indian Reprint.

[23] E. Rich, K. Knight. (2006). Artificial Intelligence, Tata McGraw-Hill.