International Journal of Agriculture Sciences
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 11, Issue 5, 2019, pp.-7931-7933.
Available online at https://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

ADAPTIVE NEURO-FUZZY INFERENCE SYSTEM (ANFIS) MODEL TO PREDICT THE DISEASE SEVERITY OF RICE

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Received: February 18, 2019; Revised: March 11, 2019; Accepted: March 12, 2019; Published: March 15, 2019

Abstract: Rice is the important crop around the world. The rice crop is affected by various diseases. Among them the sheath rot disease is the most devasting disease and makes major challenge to the rice cultivation. This paper presents a model designed using Adaptive Neuro-Fuzzy Inference System (ANFIS) to diagnosis the disease severity in rice. ANFIS helps to determine the incompleteness in decision making made by human expert using the learning mechanism. Fuzzy inference system and neural network are combined in ANFIS, the input parameters are passed through input layer and output could be viewed through output layers. Training is involved with iterative adjustment of parameters of the ANFIS using hybrid learning process to diagnosis the disease severity of rice. ANFIS uses five layers, each layer has its own nodes. Layer1 has the input variables with membership function. Layer2 uses T-norm operator which uses AND operator. The rules are added and fired are assigned to layer3. Layer4 nodes are adaptive and consequent parts of the rules are performed. Single node that computes the overall output in layer5. With the input parameters Number of discoloured grains/panicle, Number of chaffy grains/panicle, Lesion Number/tiller, Lesion size (mm)-Length& width and Number of panicles infected/tiller, the algorithm is developed to diagnosis the disease severity. The proposed Fuzzy Prediction Model is effectively “hand crafted” to achieve the desired performance and also used for diagnosis disease severity.

Keywords: ANFIS, Hybrid neural network, Fuzzy Prediction Model, rice, disease severity

Citation: M. Kalpana, *et al*., (2019) Adaptive Neuro-Fuzzy Inference System (ANFIS) Model to Predict the Disease Severity of Rice. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 11, Issue 5, pp.- 7931-7933.

Introduction

Rice (*Oryza sativa*) is the food for all the parts of India. Many biological constraints play important role in crops and are affected by various disease which reduces production of crops. The rice crop has many biological constraints and affected by various diseases which reduces production in rice crop. Rice sheath rot disease is found in India and yield loss is up to 80%. Pathogen infects upper part of the leaf sheath which reduces the nutrients from foliage to panicle [1]. Agriculturalist faces problem in maintaining pathogens. However, most of the approaches using biological control of disease and microbes are beneficial for soil health [2-4], *Sarocladium oryzae*, in glasshouse condition. The results exposed promising antagonistic action by combination of strains was more efficient in reducing sheath rot disease in rice plants compared to individual strains under glasshouse conditions. The data of the study is under glass house condition, were sheath rot disease was taken to develop an Adaptive Neuro-Fuzzy Inference System. Fuzzy Logic is an emerging area in the field of agriculture to make decisions. Designed Fuzzy Expert System (FES) is used to make novel decision in the agriculture field. Fuzzy Expert System is used in many areas such as crop production and management to solve problems. Currently many FES has been developed in agriculture for diagnosis disease in rice, an important food crop around the worldwide [5]. ANFIS is an emerging area in the field of agriculture for prediction. Designed Fuzzy prediction Mechanism is used to make novel prediction in the agriculture field. ANFIS resembles that of neural network in which input values are mapped with input membership functions and output parameters are associated with output membership function to interpret the results for diagnosis of disease in rice crop. Roan, Chiang *et al*. [6] used concept of crisp sets, fuzzy sets provides more robust representations of the model of real-world objects. J-S. R Jang [7] used the concept called Adaptive Neuro-Fuzzy Inference System (ANFIS). It employs a NN approach to the design of a fuzzy inference system. B. Kosko [8] Learning and adaptation of the NNs makes this fuzzy system more systematic and less reliant on knowledge of experts. Serpen *et al*. [9] Probabilistic potential function neural network algorithm was developed. Haykin [10] the application of artificial intelligence approaches such as Neural Network (NN) and Fuzzy Logic (FL) do not require an explicit mathematical model and are suitable for nonlinear physiological systems. The advantage of the model is that it uses nonlinear input-output mapping, fault tolerance and adaptivity. ANFIS is used to predict the yield of crops with input parameters. The performance of the model is compared with SVM and ANN [11]. To predict the Disease Severity of rice Fuzzy prediction model is developed using ANFIS with the input parameters. The developed model is very useful for farmers as well as scientist to diagnosis the disease severity of rice. Designing of Prediction Model is organized with Fuzzification phase, Fuzzy Prediction Model and Defuzzification phase

Prediction model of rice

The Phase of Prediction model of rice is
Fuzzification phase
Fuzzy Prediction Model
Defuzzification phase

Fuzzification phase

Fuzzification is the process of converting crisp values into fuzzy input. Uncertainty is due to imprecision, vagueness, variables are fuzzy and represented by membership function.

Fuzzy Prediction Model

The Fuzzy Prediction Model can take fuzzy inputs, but the output produced is always a fuzzy set. With the crisp inputs and outputs, Fuzzy Prediction Model implements mapping from its input variable to output variable through a number of fuzzy if-then rules. Rice dataset is taken with for Number of discoloured grains/panicle (DG), Number of chaffy grains/panicle (CG), Lesion Number/tiller (LN), Lesion size (mm)-Length (LL) & Lesion size (mm)-width (LW) and Number of panicles infected / tiller (PI) are selected as the input fuzzy variables and Disease Severity (DS) as output fuzzy variable are adopted for Fuzzy Prediction Model. Adaptive network is the collection of all nodes and links. Hybrid learning method is used to learn the rules. Learning process is associated with input and output values. [Fig-1] indicates the architecture of fuzzy prediction model. Fuzzy prediction model has the following steps.

Step-1 Input the crisp values for Number of discoloured grains/panicle, Number of chaffy grains/panicle, Lesion Number/tiller, Lesion size (mm)-Length & Lesion size (mm)-width and Number of panicles infected / tiller.

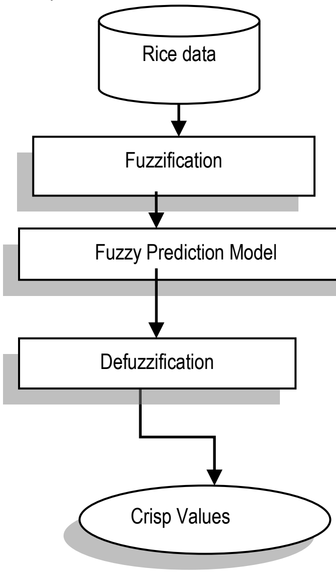

Fig-1 Architecture of the Fuzzy Prediction Model

Step-2 Set first order Sugeno fuzzy model, common rule set with fuzzy if-then rules.

Input the rule as {Rule 1,2…..k}

Step-3 ANFIS is executed by Sugeno method

Step-4 Layer 1-Every node is an adaptive node with node function.

$$O_i^{1,1} = \mu_{DG}(x), \ fori - 1,2,3$$
$$O_i^{1,2} = \mu_{CG}(x), \ fori - 1,2,3$$
$$O_i^{1,3} = \mu_{LN}(x), \ fori - 1,2,3$$
$$O_i^{1,4} = \mu_{LL}(x), \ fori - 1,2,3$$
$$O_i^{1,5} = \mu_{LW}(x), \ fori - 1,2,3$$
$$O_i^{1,6} = \mu_{PI}(x), \ fori - 1,2,3$$

Where x is input to node Number of discoloured grains/panicle, Number of chaffy grains/panicle, Lesion Number/tiller, Lesion size (mm)-Length & Lesion size (mm)-width and Number of panicles infected / tiller is a linguistic label associated with this node.

Step-4.1 Set the Gaussian function membership function for the fuzzy number

Step-5 In layer 2, multiplies the inputs from the nodes in layer 1 and generates the firing strength of the rules. T-norm operator that perform the AND operator is used.

Step-6 Layer 3 contains fixed nodes. The i^{th} node calculates the ration of the i^{th} rules firing strength to the sum of all rules firing strengths.

$$= \overline{w}_i = \frac{w_i}{\sum_{i=1}^{m} w_i}$$

Step-7 In Layer 4, the nodes in this layer are adaptive and perform the consequent of the rules

Step-8 There is a single node here that computes the overall output:

$$\sum_i \overline{w}_i f_i = \frac{\sum_i w_i f_i}{\sum_i w_i}$$

Step-9 Present the knowledge in human understandable form.

Defuzzification phase

Defuzzification process is conducted to convert aggregation result into crisp value for disease severity output. In this process the single number which represents the outcome of the fuzzy set evaluation. The final combined fuzzy conclusion is converted into a crisp value by using the weighted average method

Conclusions and Future Research

Fuzzy Prediction Model is used to diagnosis the disease severity of rice. The rice dataset is initially processed and the crisp values are converted into fuzzy values in the stage of fuzzification.

Application of research: The Fuzzy Prediction Model undergoes five layers to execute rules, to make a decision on disease severity of rice crop. Defuzzification process is conducted to convert the result into crisp value for rice database. In Future works the dataset is used to evaluate Fuzzy Prediction Model.

Research Category: Adaptive Neuro-Fuzzy Inference System

Abbreviations: FES: Fuzzy Expert System, ANFIS: Adaptive Neuro-Fuzzy Inference System, DG: Number of discoloured grains/panicle, CG: Number of chaffy grains/panicle, LN: Lesion Number/tiller, LL: Lesion size (mm)-Length, LW: Lesion size (mm)-width, PI: Number of panicles infected / tiller input fuzzy variables and DS: Disease Severity.

Acknowledgement / Funding: Authors are thankful to Tamil Nadu Agricultural University, Coimbatore, 641003, Tamil Nadu, India

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Research project name or number: Research station trials

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Tamil Nadu Agricultural University, Coimbatore, 641003, Tamil Nadu, India

Cultivar / Variety name: Rice (*Oryza sativa*)

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Ethical Committee Approval Number: Nil

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