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Rice yield prediction using adaptive Neuro-fuzzy inference system (ANFIS)

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Abstract
In agriculture yield prediction is toughest task around the globe. The agriculture yield depends on various factors such as water, weather, soil characteristics, crop rotation, pest, disease etc., This paper presents a model designed using Adaptive Neuro-Fuzzy Inference System (ANFIS) to predict the yield of 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 yield of rice. ANFIS uses five layers, each layer has its own nodes. Layer1 has the input variables with membership function. T-norm operator that perform the AND operator can be used in layer2. The sum of all rules firing strengths are assigned in layer3. The nodes in layer4 are adaptive and perform the consequent of the rules. Single node that computes the overall output in layer5. With the input parameters Leaf Folder pest incidence(LFI), Sheath Blight disease (SB), Number of Tillers Hill(NH), No. of grains per panicle(GP) and 1000 grain weight(GW) the algorithm is developed to predict the yield of rice. The proposed Fuzzy Prediction Model is effectively "hand crafted" to achieve the desired performance and also used for rice yield prediction.

Keywords: ANFIS, hybrid neural network, fuzzy prediction model, rice

Introduction
Rice (*Oryza sativa*) is the food for all the parts of India. 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. Adaptive Neuro Fuzzy Inference like that of neural network, which maps inputs through input membership functions and associated parameters, and then through output membership functions and associated parameters to outputs, can be used to interpret the input/output result for diagnosis of yield of rice.
Roan, Chiang *et al.* [1] used concept of crisp sets, fuzzy sets provides more robust representations of the model of real-world objects. J-S. R Jang [2] 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 [3] Learning and adaptation of the NNs makes this fuzzy system more systematic and less reliant on knowledge of experts. Serpen *et al.* [4] Probabilistic potential function neural network algorithm was developed. Haykin [5] 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. Moreover, they offer several advantages such as nonlinear input-output mapping, adaptivity and fault tolerance. ANFIS is used for predicting the yield of crops by considering all the essential input parameters which plays important role in the growth and crop yield. The performance of the model is compared with SVM and ANN. [6]. To predict the yield 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 yield of rice. Designing of Prediction Model is organized in Section 2 with Fuzzification phase, Fuzzy Prediction Model and Defuzzification phase

Prediction model of rice

The Phase of Prediction model of rice is

1. Fuzzification phase
2. Fuzzy Prediction Model
3. Defuzzification phase

Fuzzification phase

The conversion from crisp to fuzzy input is known as fuzzification. If the form of uncertainty happens to arise because of imprecision, ambiguity, or vagueness, the variable is probably fuzzy and can be represented by a membership function.

Fuzzy Prediction Model

The Fuzzy Prediction Model can take fuzzy inputs, but the output produced is always a fuzzy sets. 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 Leaf Folder Incidence, Shealth Blight, Number of Tillers Hill, No. of grains per panicle and 1000 grain weight are selected as the input fuzzy variables and Grain Yield per Plant as output fuzzy variable are adopted for Fuzzy Prediction Model. An adaptive network is network of nodes and directional links. Associated with the network is a learning rule – hybrid method. Networks are learning a relationship between inputs and outputs. The Architecture of the Fuzzy Prediction Model using ANFIS is shown in figure 1. The circular nodes represent nodes that are fixed whereas the square nodes are nodes that have parameters to be learnt. Fuzzy Prediction Model is executed with the following step

Step1: Input the crisp values for Leaf Folder Incidence, Shealth Blight, Number of Tillers Hill, No. of grains per panicle and 1000 grain weight.

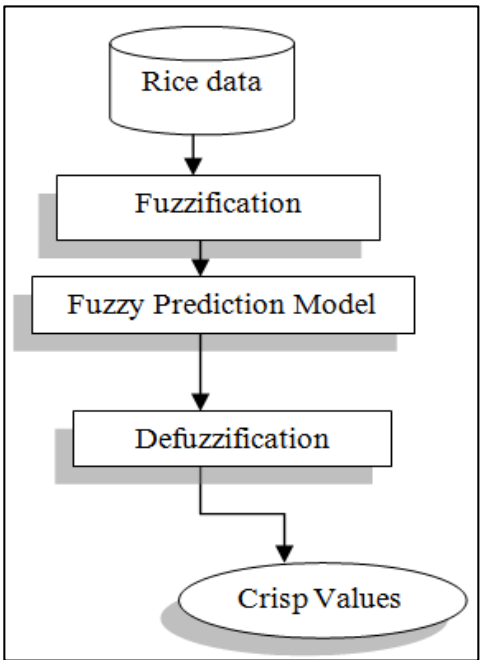

Fig 1: Architecture of the Fuzzy Prediction Model

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.

$$O_i^{1,1} = \mu_{LFI}(x),\ fori - 1,2,3$$

$$O_i^{1,2} = \mu_{SB}(x),\ fori - 1,2,3$$

$$O_i^{1,3} = \mu_{NH}(x),\ fori - 1,2,3$$

$$O_i^{1,4} = \mu_{GP}(x),\ fori - 1,2,3$$

$$O_i^{1,5} = \mu_{GW}(x),\ fori - 1,2,3$$

Where x is input to node and Leaf Folder Incidence, Shealth Blight, Number of Tillers Hill, No. of grains per panicle and 1000 grain weight 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 num 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 predict the yield of rice. The rice dataset is initially processed and the crisp values are converted into fuzzy values in the stage of fuzzification. The Fuzzy Prediction Model undergoes five layers to execute rules, to make a decision on yield prediction. 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

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