

# Implementation & Simulation of Fuzzy Logic Controllers for Productivity and Fertility of Soil and Performance Evaluation of Triangular Membership Function

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**Abstract:** As soil is complex system and soil fertility represents crop productivity and soil productivity hence MIMO system is a necessity of fuzzy logic controller model design using simulation technique. Same model gives prediction of lots of problem and save development time. Modelling and simulation tools made a dynamic evolution in the design and control of prediction system. The basic requirements of prediction system are accuracy in result. The objective of this paper is to investigate the effect of triangular membership functions in the developed Simulink model of Mamdani model based fuzzy control for prediction of soil productivity. The built in membership functions of Matlab is selected for evaluation. The evaluation is done using the developed 207 fuzzy rules through the implementation in Matlab/Simulink model. The results of all soil parameter are analysed. The performances of triangular membership functions on mamdani model based fuzzy control starting currents are concerned for the developed model.

**Keywords:** Fuzzy logic control, Mamdani model, Simulink model, soil productivity

## I. INTRODUCTION

A model is an abstraction of a system, being able to reproduce replica of it for some application in which essential data are referred as state variables of the system. For any design of system modeling, the ultimate aim is to gain sufficient knowledge about the system of interest so as to provide more accurate predictions and better designs. Therefore, computer modeling and simulation popularity plays important role in the modern design practice in engineering and industry [1]. Complex analysis, computer modeling, simulation and fuzzy logic techniques are used for designing a prediction system in different application areas. Prediction support system and control system perform complex operation under imprecise environment. It predicts in diversified applications areas. Different computer models are developed for many applications in virtualized environment for real system. These models have high degree of accuracy and avoiding complexity. These models are used to determine different properties included in system models which attempts to find analytical solutions to problems. It enable the prediction of the behavior of the

system from a set of parameters and initial conditions [2]. Fuzzy set theory and concept of a linguistic variable was deriving values of variables and made its use for expanded application area. Fuzzy logic makes conversion of imprecise information to precise one, consists of capability to design rational decisions containing imperfect information. Uncertainty, imprecision, incompleteness, risk management, partial true and vice versa is an attribute of information in Fuzzy systems [3]. Fuzzy logic is capable of deriving precise and meaningful output without doing any measurement or calculation or computation as a part of soft computing.

Virtual model reproduce replica of some application in which essential data are referred to as state variables of the system [4]. The computer simulation techniques are used as a formal way to represent models for making empirical verifications. Simulations are used to analyze systems that are too complex and cannot solve with analytic methods such as calculus, standard probability and statistics, or queuing theory. An especially interesting feature of simulation is its ability to allow analyzing and comparing

certain scenarios quickly and efficiently for any design of system modeling [5].

Computer modeling and simulation is used to gain sufficient knowledge about the system of interest so as to provide more accurate predictions and better designs. Therefore, computer modeling and simulation popularity plays important role in the designing and modeling the application, prior to implementation in actual environment and arriving at particular conclusion [6].

Fuzzy inference systems (FIS) have been successfully applied as control system in different area such as automatic control, data classification, decision system, expert systems etc. Because of its multidisciplinary nature, FIS are associated with fuzzy rule-based systems, fuzzy expert systems, fuzzy modeling, fuzzy associative memory, fuzzy logic controllers, and simply fuzzy systems [7].

Fuzzy logic is used to provide way of importance of precision and the application of fuzzy set theory to many control problems. Concept of fuzzy logic is widely used in control system, precision system, and prediction system for design, development and decision making. Real system is very complex system hence prediction related yield and production is always done with uncertainties. Fuzzy logic design is the best approach to get precise, accurate result and conclusions [8].

## II. TRADITIONAL MODEL OF SOIL PRODUCTIVITY ESTIMATION

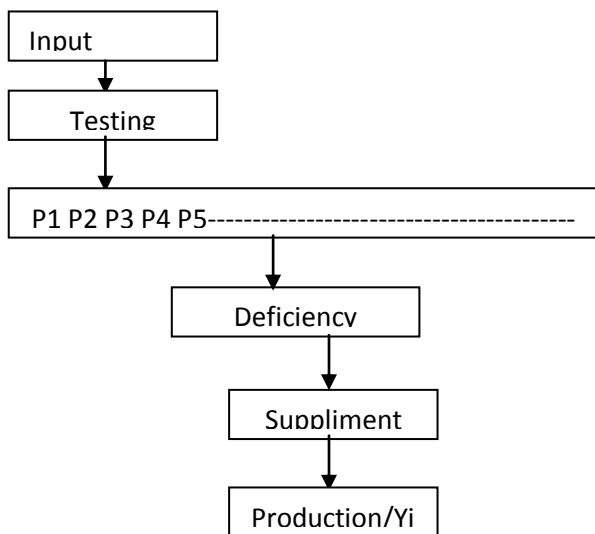


Figure 1: Traditional model of soil productivity

Lab analysis process is carried out for availability of nutrients in the soil. First the soil samples are collected from field for which testing carried out. Each macronutrient and micronutrient is measured with the help of analytical method separately. Availability of each nutrient level is

deciding the deficiency of nutrient level by comparing it with the standard value for profitable yield. These deficiencies are fulfilled by supplying fertilizer. This model gives idea about prediction of soil quality and draws one conclusion statement about yield but it is not accurate one because fertilizer is the combination of two or more nutrient, one nutrient become sufficient but other is either deficient.

### Traditional Productivity

Traditionally Soil fertility is calculated using Parker Formula [10] Fertility Index is also called as Nutrient index.

$$NI = ((N_i \times 1) + (N_m \times 2) + (N_h \times 3))/N_t \text{-----}1$$

Where,

Nt - Total number of samples analyzed in a given area,

Ni - Number of samples falling in low category of given nutrient,

Nm - Number of samples falling in medium category of given nutrient,

Nh - Number of samples falling in high category of given nutrient.

## III. FUZZY LOGIC CONTROL SCHEME

Fuzzy controllers are simple, low cost and can be designed without knowing the mathematical model of the process. Fuzzy logic is one of the successful applications of fuzzy set in which the variables are linguistic rather than the numeric variable. A fuzzy logic controller is based on a set of control rules called as the fuzzy rules among the linguistic variables. These rules are expressed in the form of conditional statements. The basic structure of our Fuzzy logic controller is shown in fig. The necessary inputs to the decision making unit block. The fuzzification unit converts the crisp variable into a linguistic format. The decision making unit decides in the linguistic format with the help of logical linguistic rules supplied by the rule base unit. The output of the decision making unit is given as input to the de-fuzzification unit and the linguistic format of the signal is converted back into the numeric form of data in the crisp form. Each fuzzy label has an associated membership function.

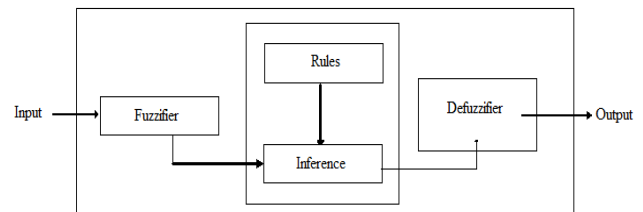


Figure 2: Standard Fuzzy Model[11]

#### IV DATA SAMPLING AND COLLECTION

A field study is carried out to collect information for assessing soil parameter. Soil parameters analysis is done on 902 soil samples collected from Krushi Vighan Kendra, Ghatkhed, Amravati. The values of C, N, P, K, Mg, C, Fe, Cu, Zn, B, Mo, Lime, Saline, CEC, Mn, OM and pH of soil sample collected for the year 2011-2012 and 2012-2013 and these soil parameters are considered as a dependent and independent parameter (as per expert knowledge) that have direct/indirect effects on productivity.

Macronutrients are elements required in larger quantities and micronutrients are elements required in smaller quantities. This division does not mean that one nutrient element is more important than another, just that they are required in different quantities and concentrations [9].

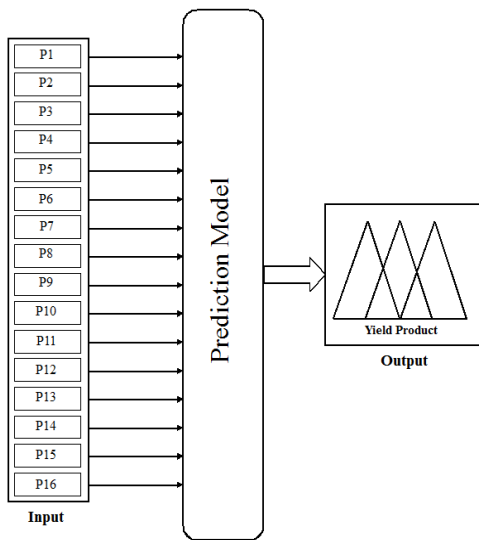


Figure 3: Architecture of FIS model

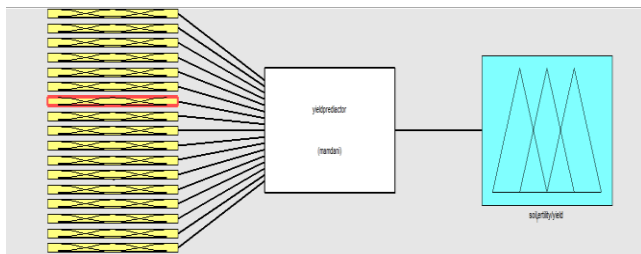


Figure: 4 FIS Model

The factors which are directly affecting the seeking goal, such variables are determined as input variables and result considered as the output variable.

The membership function is used to associate a grade to each linguistic term such as VVL, VL, L, N, H and VH. A membership function (MF) is a curve that defines how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 1 using triangular membership functions.

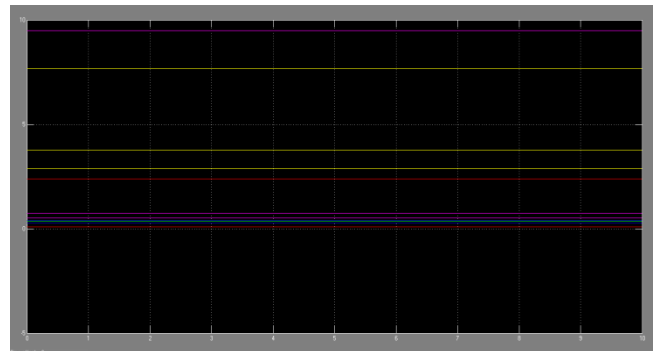
The Rule unit has several fuzzy rules that are defined by an expert. A single fuzzy if-then rule assumes the form “if x is A then y is B” where A and B are linguistic values defined by fuzzy sets on the ranges (universes of discourse) X and Y, respectively. Fuzzy logic with fuzzy rules has the potential to add human-like subjective reasoning capabilities to machine intelligences.

The inference unit applies the fuzzy values into the rules. After the fuzzy matching step, a fuzzy step is invoked for each of the relevant rules to produce a conclusion based on their matching degree. Defuzzification process produces a quantifiable result in fuzzy logic containing number of rules for transform a number of variables into a ‘fuzzy’ result, in terms of membership function in fuzzy sets. There are many different methods of defuzzification available, like center of gravity, mean of maxima etc. Defuzzification is the process of estimating the value of the dependent variable based on the resulting fuzzy set after applying the fuzzy inference rule.

#### V. SIMULINK MODEL

Fuzzy logic controller is developed using the fuzzy logic tool box available in Matlab / Simulink. Fuzzy logic controller employs all soil 17 parameter which is essential for prediction of soil fertility as input and soil productivity as output. The developed simulink model in MATLAB is shown in Fig 5.

Graph No 1 Responses of Mamdani model with Triangular membership function



#### VI. SIMULATION RESULTS AND DISCUSSIONS

The simulations are carried out in Matlab with Triangular & Trapezoidal membership functions for both models and Gaussian membership function for Sugeno model. The

response curves of voltage, stator current, rotor speed & torque v/s time are shown I Figs. 10-13. From the results, it is observed that the speed response takes less time to settle and the starting current is less in Sugeno model with Triangular & trapezoidal membership functions. For other membership functions the responses were not good.

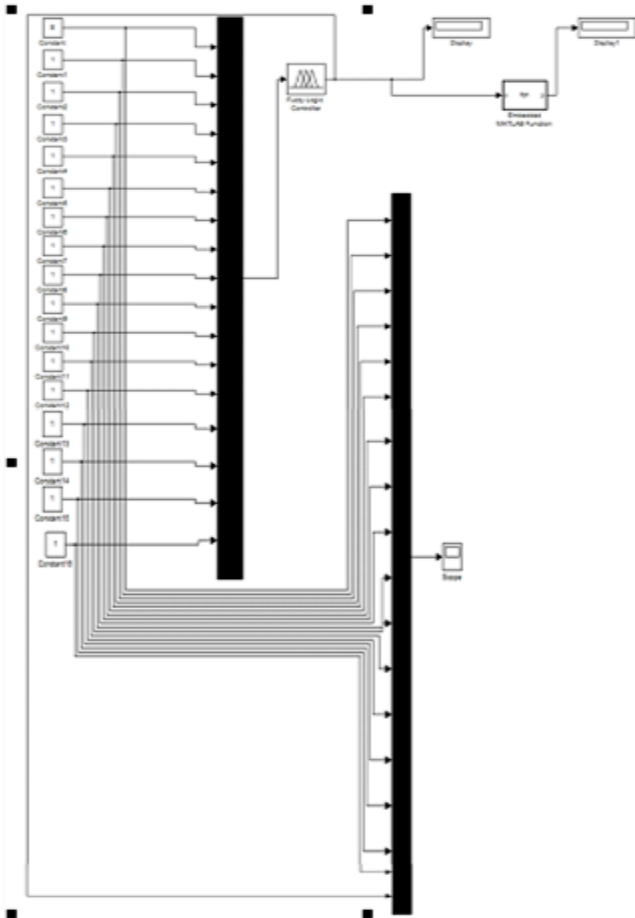


Figure 5: Simulink Model

1. FIS WIZARD STRUCTURE

The Fuzzy Logic Controller block automatically generates a hierarchical block diagram representation of developed FIS. This automatic model generation ability is Fuzzy Wizard. The block diagram representation only uses built-in Simulink blocks and, therefore, allows for efficient code generation.

To view the implementation of FIS, FIS Wizard sub system is used to see the implementation of FIS. This following figure shows part of the implementation (the entire model is too large to show in this document).The Fuzzy Logic Controller block uses built-in Simulink blocks to implement FIS. Although the models can grow complex, this representation is better is for efficient code generation.

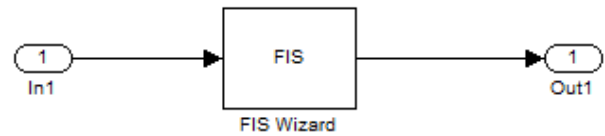


Figure 6: FIS Wizard Structure

Following figure shows sequence of rule firing and rule combination

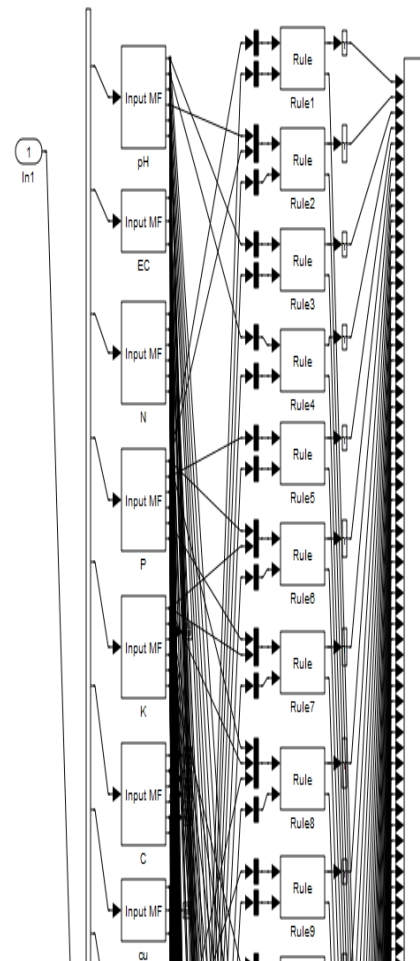


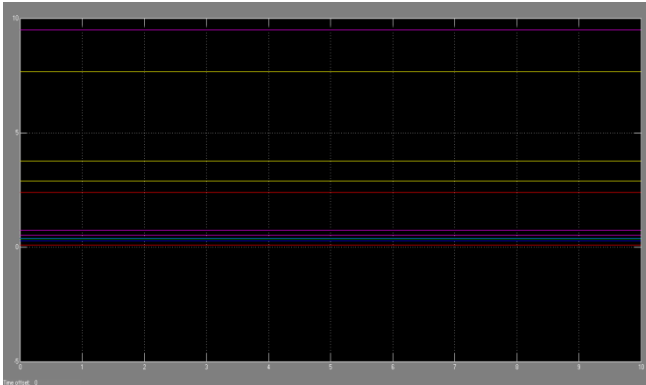
Figure 7: Sequence of Rule firing

1. SIMULINK ANALYSIS OF MODEL

Fuzzy logic controller is developed using the fuzzy logic tool box available in Matlab. Simulink Fuzzy logic controller employs all 17 soil parameter as inputs and productivity and fertility index is obtained as the output. Output is using a Scope block during a simulation. The developed Simulink model in MATLAB is shown below.

The simulations are carried out in Matlab with Triangular membership function. The response curves of all 17 parameter are shown Figs.

Graph No.2 Responses of Mamdani model with Triangular membership function



(Source: Compiled by Researcher)

It is observed that the all the parameters are in directly and positively related with productivity in Mamdani model with Triangular membership functions.

Simulink model of Mamdani system based fuzzy logic controller's is implemented for soil productivity analysis. Certain built in membership functions of Matlab is used for the simulation results of all 17 parameters and are analyzed.

## VII. CONCLUSION

Simulink model of model based fuzzy logic controllers are implemented for prediction of soil productivity.. Triangular built in membership functions of Matlab is selected for simulation. The simulation results of a soil parameters and working scernerio of model is analysed with the help of simuilink model and response of simulation is analysed.

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