International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 04 | Apr-2018 www.irjet.net p-ISSN: 2395-0072

Application of Fuzzy logic in water irrigation system

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Abstract - *In order to satisfy the food demand of the ever increasing population of our planet, it is utmost necessary to do vital in the field of agriculture. Artificial intelligence and fuzzy logic is seen more and more as a solution implemented in an intelligent drip irrigation system. It optimizes the supply of water to the agricultural crops using fuzzy logic. The crux of this paper is to design and simulate the fuzzy logic controller and simulate using MATLAB (Matrix Laboratory) the water irrigation issue. This study outlines the trends and the development of the agricultural sector with implementation of expert systems, fuzzy logic and artificial intelligence. We study how symbolic logic will solve agricultural problems and develop a sensible system using computer science, mathematical logic and artificial intelligence*

Key Words: **Fuzzy logic, Intelligent drip irrigation system, MATLAB, Agriculture, Computer science**.

1. INTRODUCTION

Today, India has the second largest farm outputs, still faces major uncertainties in this domain. For a sustainable, sufficient and healthy farm output, the uncertainties regarding temperature, humidity, climate etc. needs to be faced. Here, we solve the dilemma of "When should I water the fields? " and "How long should I water the fields? " using expert systems, keeping in mind the uncertain parameters. When the farmers start the irrigation cycle too early or run the irrigation cycle for too long they supply excessive water more than the requirement to the crops and damage them. This is called over-watering. Likewise, starting the irrigation system for a very short time and/or too late is called under-watering. Over-watering and under-watering can cause reduced yields, poor crop quality, damages the land and affects the farmers majorly. Another issue related to water irrigation system is, Evapotranspiration (ET). ET is a process in which the soil moisture is evaporated from the land to the atmosphere and by transpiration of the plants. Thus, soil moisture in an important factor taken into consideration for irrigation system. Temperature around the soil also plays a major role in Evapotranspiration. For building a smart water irrigation system we need to tackle these uncertain situations. Many expert systems have been developed in the agricultural sector aiming at maximizing the yields and tackling the uncertain situations.

In 1965, Sir Lotfi A. Zadeh proposed an idea to tackle uncertainty in any situations, which is 'set membership' to make decisions i. e. FUZZY SET THEORY. Lotfi Zadeh proposed the set membership idea to make suitable decisions when uncertainty occurs. [1] Fuzzy logic (FL) has emerged as a crucial branch of skilled system that has established to provide solutions to real world issues that had remained unsolvable otherwise. Fuzzy system is used to model human experience and human decision-making behavior. In fuzzy logic, the input–output relation is expressed by using a set of linguistic rules or relational expressions. A fuzzy logic mainly consists of four parts a fuzzifier, a de-fuzzifier, an inference system and a rule base. The input data to a fuzzy system are usually crisp, so the process of fuzzification is required to convert the crisp value into a suitable set of linguistic value which is needed by the inference engine. Fuzzy set theory and fuzzy logic provide powerful tool to represent and process human knowledge in the form of fuzzy "IF-THEN" rules. In this paper, I have used Fuzzy logic, simulated using MATLAB, to tackle the issues for a sustainable, effective agricultural growth to meet the demands of the future.

2. LITERATURE SURVEY

In the paper titled "Design and Development of Fuzzy Expert System for Integrated Disease Management in Finger Millets" , an expert system is made using fuzzy logic which figures out the diseases based on the symptoms and appearances. Due to diseases and pests that attack the crop, a loss of 8-10% overall occurs throughout the year for a particular crop cultivation. Therefore, Integrated Pest Management (IPM) , a program to control the pests is important. IPM is designed to maintain environmental sustainability and the economic viability of the production system. It aims at reducing the pest population, diseases and unhealthy conditions of the crop in order to maximize the agricultural yield. In this study they tackle the diseases by recommending the treatment level required, but they do not specifically target a particular crop disease or a particular type of pest. Sometimes, the experience of the farmer or agricultural scholar works more than the fuzzification and de-fuzzification. [2]

The paper titled "Uncertainty in future irrigation water demand and risk of crop failure for maize in Europe" [3] aims to investigate which aspects of modeling crop water use, soil water extraction, soil evaporation, soil water balance and root growth contributes most to the variability in estimates of maize crop water use and the risk of crop failure, and demonstrate the resulting uncertainty in a climate change impact study for Europe. This study focuses only on the Europe cultivation. Keeping in mind such climatic and crop water irrigation uncertainties we have devised fuzzy logic to tackle the irrigation issue.

3. FUZZY LOGIC

The word fuzzy means vague or indistinct. Fuzzy control system aims at producing acceptable but definite output in response to incomplete, vague input. In contrast to, fuzzy

logic system, a convectional logic system understands a precise input and produces a definite output as true or false, which is equivalent to our yes or no. Lotfi Zadeh, the inventor of fuzzy logic explains fuzzy logic as a human decision making system, which includes a range of possibilities between a yes and no, i. e. CERTAINLY YES, POSSIBLY YES, CANNOT SAY, POSSIBLY NO, CERTAINLY NO. Fuzzy logic is an approach to computing, which supports 'degrees of truth' instead of the standard 'True or False' (0 or 1) Boolean logic on which the trendy computer is predicted

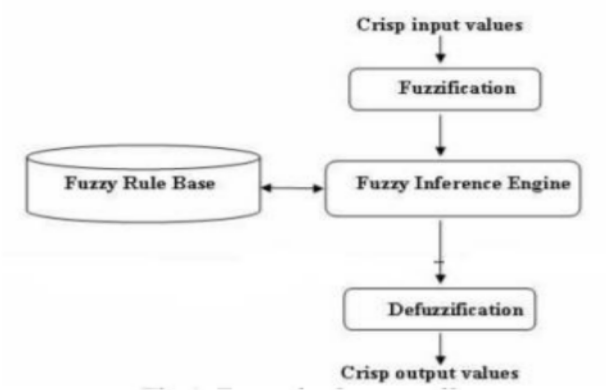

Fig -1 : Block Diagram of Fuzzy Logic

Fuzzy logic is extensively used to control the uncertain inputs for which a control output is required. There are 3 important blocks of a fuzzy logic control system:

- **Fuzzification:** It is the process of converting crisp input into linguistic variables.
- **Fussy Inference Engine**: FIS will use a collection of fuzzy 'if-then' rules that determine how the system will react to different conditions. These 'if-then' rules are given to the FIS by fuzzy rule base. There are two types of FIS namely, Mamdani & Sugeno.
- **Defuzzification**: It is process of transferring fuzzy date into crisp value which can be further utilized for input to another system.

3.1 Problem Statement

In agriculture, water irrigation has become one of the major issues hindering the agriculture yields. Evapotranspiration is also a factor responsible for water irrigation issue. Evapotranspiration (EP) is the combined method through which soil wetness is lost into the atmosphere through evaporation and plants taking water out of the soil and transpiring it to the atmosphere. ET is typically a calculated value that takes into consideration factors like recent rainfall, relative humidity, radiation, and a crop coefficient that accounts for the plant size and stage of growth. The calculated ET can offer the cultivator an estimate on what quantity of water the soil is losing because of ET. Once he is aware of what quantity of soil moisture he is losing he will confirm how long he must irrigate to replace the lost soil wetness. Depending on the various parameters, we have a devised a fuzzy system which will open the water valve for sufficient and optimum amount of water to reach the crops, in order to avoid underwater and overwater in the farms. [4]

3.2 Application of Fuzzy logic In Water Irrigation System

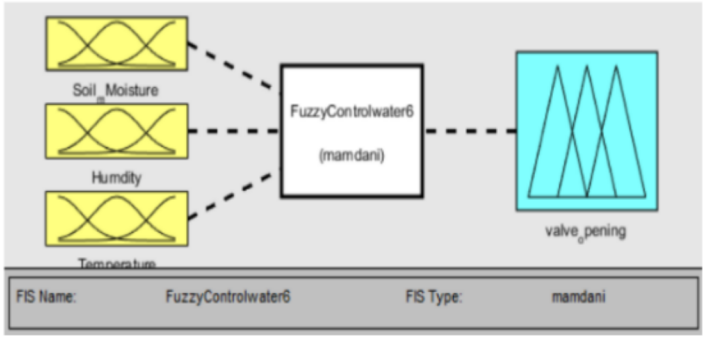

Fig – 2: Irrigation System using Fuzzy Inference System

Input to the fuzzy system will be:

Soil moisture: The moisture content of the soil is an important factor to be noted before watering the crops, if the crops are already moist, supplying more water can overwater the crops. This can damage the crops. Evapotranspiration, soil water extraction, soil water balance, root growth all are the factors considered in the soil moisture input. Hence, this factor is selected. It is measured in centibar

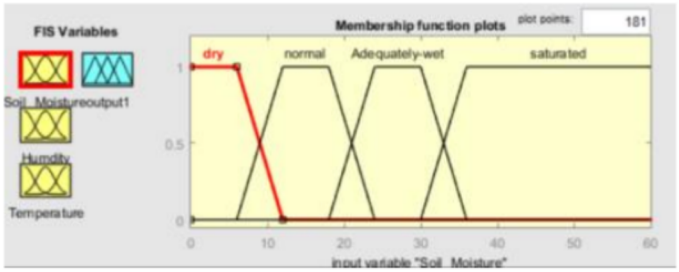

Fig -2 : Membership function plot for soil moisture

Relative humidity: Most plants grow best with relative humidity of over 50% though several plants can tolerate humidness levels below 25%. Relative Humidity is expressed as percentage of moisture in the air around the soil surface

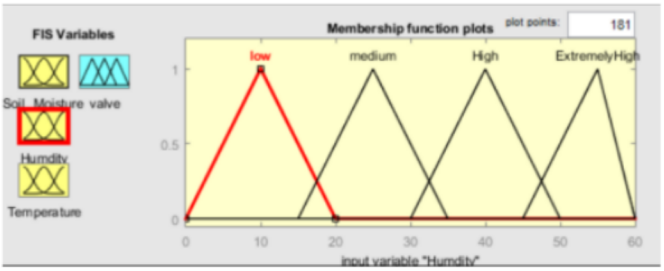

Fig -3 : Membership function plot for relative humidity

Temperature around the soil: For a wide variety of seeds, there are various temperatures that are optimal for germination of the seeds. If the temperature around the soil is high, the soil moisture will evaporate, the water balance gets affected. Thus in the fuzzy logic control, Temperature is an important factor to be considered while watering the yields. Temperature is expressed as degree C.

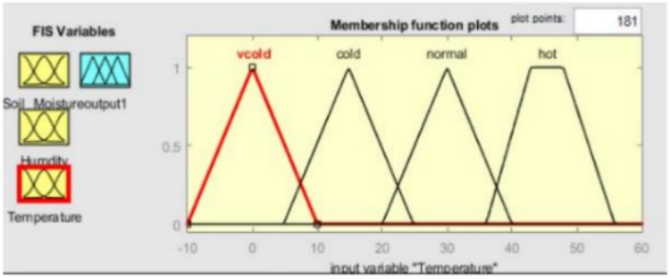

Fig -4 : Membership function plot for temperature

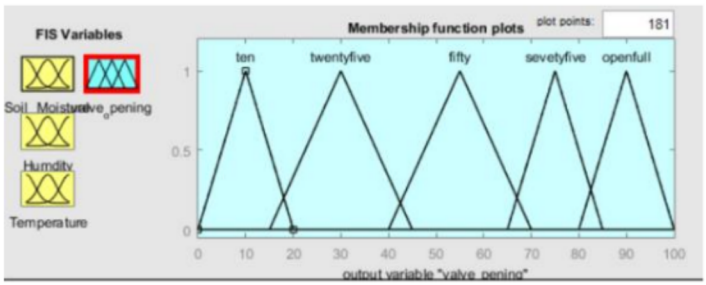

Fig -5: Membership function plot for output

Table -1: Input and output of fuzzy system

INPUT	Measured as	Range	Linguistic Variable
Soil Moisture	Centibars	[0 60]	Dry Normal Adequately wet Saturated
Relative Humidity	%	[0 60]	Low Medium High Extremely high
Temperature	Degree C	[-10 0 60]	Very Cold Cold Normal Hot
OUTPUT	Measured as	Range	Linguistic Variable
Valve opening	%	[0 10 25 50 75 100]	10% open 25% open 50% open 75% open 100% open

3.2.1 MATLAB inference system

Fuzzy inference is the method of formulating input/output mappings using mathematical logic. Fuzzy logic Toolbox™, software package provides command-line functions and an app for creating Mamdani and Sugeno fuzzy systems. Mamdani is the most typically seen fuzzy methodology. Mamdani is the most suitable model when encoding expert's opinion during which their consequences are expressed as variables. Mamdani methodology finds the centroid of a two-dimensional function.[5]

The FIS handles five parts of the fuzzy inference namely, FIS editor, membership function editor, rule editor, rule viewer and surface viewer. FIS editor is used to define the number of inputs and outputs. Soil moisture, relative humidity and temperature are defined in the FIS editor. The membership function editor is used to define the membership functions, providing a range with an associated linguistic variable. We use Mamdani-type Inference. The rule editor is used to add rules, delete rules. Based on the inputs and the membership function, fuzzy if-then rules can be defined. Examples of the rules are:

IF soil moisture and humidity is high and temperature is low, **THEN** valve opens 10%

IF soil moisture and humidity is low and temperature is high, **THEN** valve opens 90%

Fig -6: Rule base editor

After summing up the rules, a defuzzification step is required to obtain the crisp value. The crisp value is then given to the actuator for which the valve will open to water the crops. The output is measured as the percentage of the valve opening.

3.3 Results

As shown in the figure, when the soil moisture content is medium, 30-35 centibars, humidity and temperature is also medium, then the valve opens only 50%

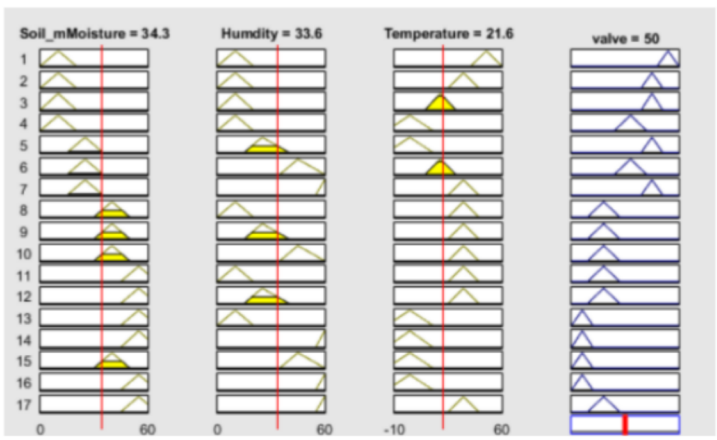

Fig -7 Rule view (50% valve open)

When the soil moisture content is very low, 3-5 centibars, humidity is also very low and the temperature is high, around 50 degree C, then the valve is 90% open.

To compensate for the evaporation of water taking place in the soil due to high temperature, soil dryness the valve is 90% open

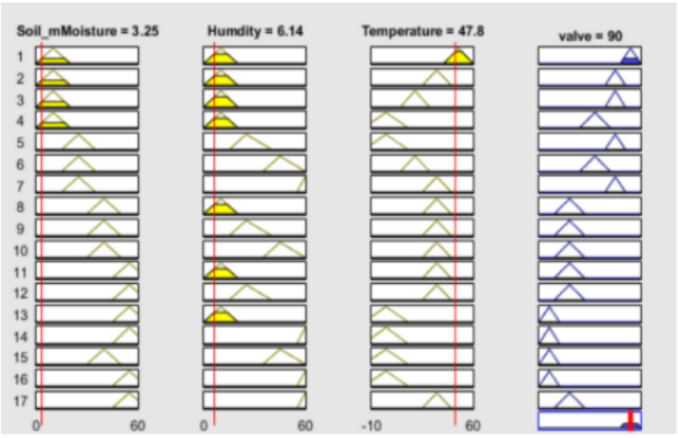

Fig -8: Rule view (90% valve open)

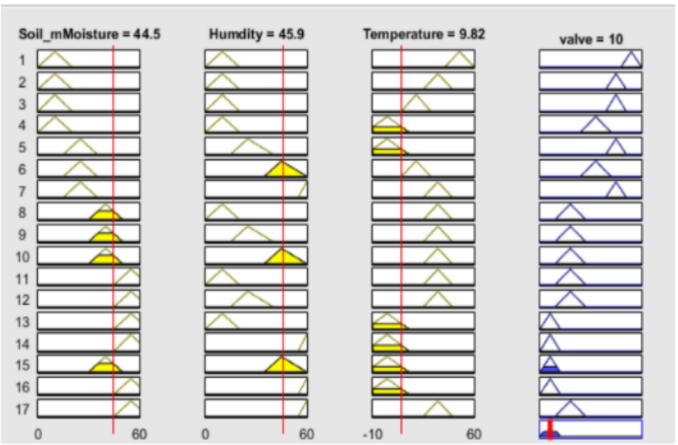

Fig -9: Rule view (10% valve open)

4. FUTURISTIC APPROACH

Efficiency and productivity can increase within the next years as 'precision agriculture' grows larger and farms become smarter and additional connected. Agricultureal drones facilitate already farmers to scan fields, monitor crops and seeds or analyze plant health. Farm activities will become rather more effective once drone information, IOT(Internet of Things) and computer vision technologies work to optimize methods. The utilization of cognitive technologies in agriculture might help to determine the simplest crop alternative or the best hybrid seed selection for a crop combine adapted to numerous objectives , conditions and better suited for farm's want. Several operations are going to be done remotely, processes are going to be automatic , risks can be identified and problems can be resolved before occuring. Farmers are going to be able to take additional saftey measures and speedy selections in the near future, the correct mixture of skills can probably increase technology and agricultural skills. [6]

5. CONCLUSION

Expert system are often of great help to the farmers as well as the researchers.Their potency of diagnosing the proper time to irrigate will enhance the productivity and cut back the losses. The contribution of expert sytem within the field of agriculture are growing hugely. With the advancement of technology especially, the expert systems designed will be of great use to the farmers in tackling the issues that arise at numerous stages of growth. Expert systems and decision support systems are widely utilized in delveloped countries. This paper throws light on the use of fuzzy logic that solves the dilemma of WHEN and HOW long to irrigate the field. By taking the factors to be considered before irrigating are taken as input to the fuzzy system i. e. soil moisture, relative humidity, temperature. These inputs are given to the Fuzzy Inference System which decides the actual amount of valve to open for sufficient amount of water for an optimum output.

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