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Research Paper

FUZZIGATION

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The present scenario, where water and power are endangered, it is most unwise to be lavish in these resources. Whilst Irrigation is also a vital part in Indian economy, we must ensure to meet both ends. Manual labor in the irrigation fields is tiresome and not to mention the inequality in the distribution of water to the plants. Inevitably an automated system for irrigation is a wiser and a frugal solution. We propose system working on Fuzzy logic. Fuzzy logic in short is the opposite of Boolean logic. The former can take a wide range of values between the two absolute values '0' and '1'. Parameter refers to the water level in a field sector. The parameters are arranged in sets namely Fuzzy sets in which the parameters are arranged in highest priority manner. It can be implemented using a Microcontroller and making efficient use of the parameters. This system is more optimal than conventional systems that seed water at periodic intervals. With this we get a lucid view regarding water content required by plants on a relative scale. We can drastically minimize water consumption by regulating the watering quantity and duration and also avoiding the need for manual labor.

Keywords: Diffculties of irrigation, Fuzzy logic interface, Fuzzification, Defuzzification, Fuzzy interference system

INTRODUCTION

Civilization began with agriculture. When our nomadic ancestors began to settle and grow their own food, human society was forever changed. With the invent of technique of agriculture, gradually they moved from forests and hilly areas to plains. Not only did villages, towns and cities begin to flourish, but so did knowledge, the arts and the technological services. Human communities, no matter how sophisticated, could not ignore the importance of agriculture. Agriculture is the major source of income for about three-fourth of India's rural population. Agriculture not only provides food but also raw materials for manufacturing industries like textiles, sugar, vegetable oil, etc. Irrigation is the artificial method of application of water to the land or soil. In countries like India, the monsoons are uncertain. So irrigation is necessary to protect the crops.

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IMPORTANCE OF IRRIGATION IN AGRICULTURE

For vegetative growth and development, plants require water within reach of their roots, of adequate quantity, in appropriate quantity and at the right time. In Irrigated agriculture, water taken up by crops is partly or totally provided through human intervention. Irrigation water is drawn from a water source (like river, lake, etc.,) and led to the field through appropriate conveyance infrastructure. To satisfy their requirements, Irrigated crops benefit from both more or less unreliable rainfall and from irrigation water. According to FAO forecasts, the share of irrigation in world crop production is expected to increase in the next decades. In particular, in developing countries, the area equipped for irrigation is expected to expand by the year 2030. This mean that 20% of total land with irrigation potential but not yet equipped will be brought under irrigation, and that 60% of all land with irrigation potential will be in use by 2030.

According to the impact of irrigation on available water resources, the volume of water about to be extracted is considerably greater than the actual volume of water required by the plants. Water use efficiency is an indicator often used to express the level of performance of water use in irrigation systems from the source to crop; it is the ratio between estimated plant water requirements and the actual water withdrawal. On average, it is estimated that overall water use efficiency of irrigation in developing countries is about 38%.

Improving irrigation efficiency is a slow and difficult process that depends in large part on the local water scarcity situation. Irrigation water withdrawal in developing countries is expect to grow by about 14% from the current 2130 km^3 per year to 2420 km^3 in 2030. Harvested irrigated area is expected to increase by 33% from 257 million ha in 1998 to 341 million ha in 2030. The disproportionate increase in harvested area is explained by expected improvements in irrigation efficiency.

While some countries have reached extreme levels of water use for agriculture, irrigation still represents relatively small part of total water resources of developing countries. The projected increase in water withdrawal will not significantly alter the overall picture. There are already water shortages in East/North Africa and in many parts of Asia. Of the ninety three developing countries surveyed by FAO, 10 are already using more than 40% of their renewable water resources for irrigation, a threshold used to flag the level at which countries are usually forced to make difficult choices between their agricultural and urban water sectors. Another 8 countries were using more than 20%, a threshold that can be used to indicate impending water scarcity. By 2030, South Asia will have reached the 40% level and North Africa not less than 58%. However, Sub-Saharan Africa, Latin America and East Asia in 2030 is likely to remain far below the critical threshold.

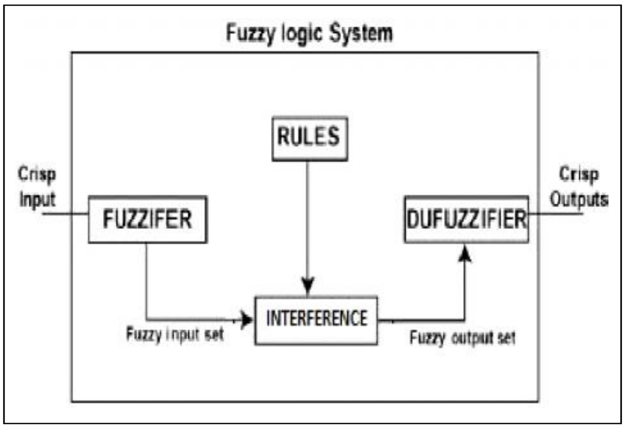
Plants have widely differing water needs depending on origin and type. Plants from arid areas of the world require less water than the plants that grow in areas that receive rainfall. The practice of crop irrigation reflects the fact that water is a key resource limiting agricultural productivity. About 97% of water taken up by plants is lost to the atmosphere.

Evapotranspiration is the term that accounts for the movement of water to air. In the irrigation system, plants take varying amount of water at different stages of plant growth. Unless adequate and timely supply of water is assured, the physiological activities taking place are bound to be adversely affected.

FUZZY LOGIC THEORY

Fuzzy Logic Control (FLC) system is based on fuzzy set theory. This set theory is advanced version of Crisp a set or does not belong to a set. But fuzzy set supports a flexible sense of membership of elements to a set. Many degree of membership between 0 and 1 are allowed. The membership function is associated with a fuzzy set in such a way that the function maps every element on the universal of discourse or the reference set, as it may said, to the interval (0,1). In crisp logic, the truth values acquired by propositions or predicates are two-valued, namely TRUE or FALSE, which is numerically equivalent to 0, 1. However, in fuzzy logic, truth values are multi valued such as absolutely true, partially true, absolutely false and so on.

In general, a Fuzzy Logic System maps crispy inputs into crisp outputs and this mapping can be expressed quantitatively as $y = f(x)$. Fuzzy Logic System contains three components: Fuzzy rules, interference engine and defuzzifier.



A fuzzy logic system contains sets used to categories input data (fuzzification), decision rules that are applied to each set and a way of generating an output from the rules.

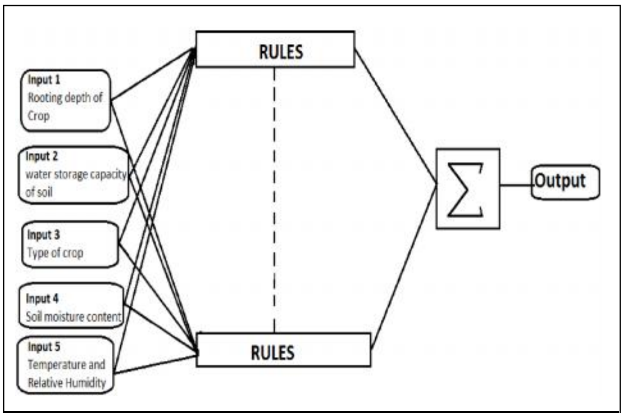
DESIGN OF FUZZY INTERFERENCE SYSTEM

To ensure proper design and operation of an irrigation system the following parameters should be considered.

1. Rooting depth of the crop
2. Water storage capacities of soil
3. Type of crop
4. Soil moisture content

ENVIRONMENT TEMPERATURE AND RELATIVE HUMIDITY

Fuzzy interference is the process of formulating the mapping from a given input to an output using fuzzy logic. The mapping then provides a basis from which decisions can be made or patterns discerned.



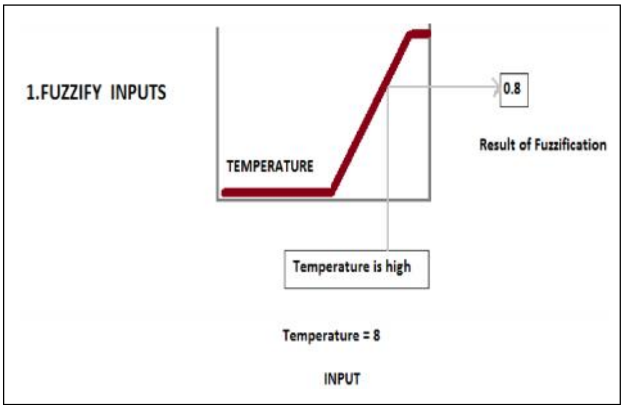
Note: Inputs are Crisp Numbers; All rules are Evaluated parallel Using fuzzy logic; Results are combined.

Information flows from left to right, from five inputs to a single output. The parallel nature of the rules is one of the important aspect of fuzzy logic systems. Instead of sharp switching between modes based on breakpoints, logic flows smoothly from regions where the system's behaviour is dominated by either one rule or other.

Here we divide a field into number of sectors, depending on the size and shape for easy implementation method. From the various sectors of the field, using sensors, we get inputs for the Fuzzy Interference System. These rules need not be same in all places. Rules differ from places to places,either tropic or temperate, type of soil, either red soil or black soil, type of water, either river or sea. Here to design a Fuzzy Interference System, we consider only two rules for instance, Soil moisture and Environment temperature.

Fuzzify Inputs

The first step is to take the inputs and determine the degree of membership function. The input is always a crisp numerical value limited to the universe of discourse of the input variable (i.e., the interval is between 0 and 10) and the output is a fuzzy degree of membership in the qualifying linguistic sets (always between 0 and 1).



In this manner, each input is fuzzified over all the qualifying membership functions required by the rules.

Apply Fuzzy Operator

After the inputs are fuzzified, you know the degree to which each part of the antecedent is satisfied for each rule. If the antecedent of a given rule has more than one part, the fuzzy operator is applied to obtain one number that represents the result of the antecedent for that rule. This number is then applied to the output function. The input to the fuzzy operator is two or more membership values from fuzzifed input variables. The output is a single truth table.

In logical operations, any number of well-defined methods can fill in for the AND operation and the OR operation. In the toolbox, two built-in AND methods are supported: min (minimum) and prod (product). Two built-in OR methods are also supported: max (maximum) and the probabilistic OR method (probor). The probor is calculated according to the equation,

$$Probor(a, b) = a + b - ab$$

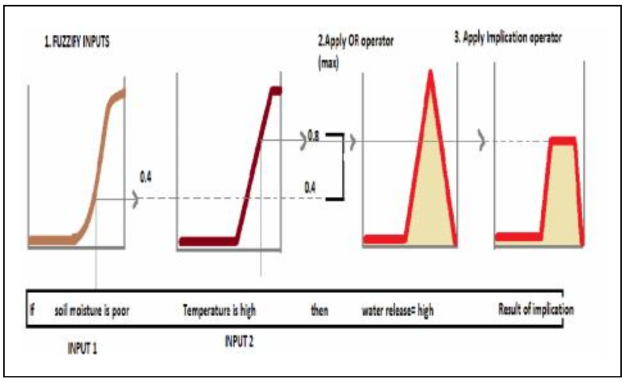
In addition to these built-in methods, we can create our own methods for AND and OR by writing any function.

The following figure shows the OR operator max at work, evaluating the antecedent, the two different pieces of the antecedent (soil moisture is poor and temperature is high) yielded the fuzzy membership values 0.4 and 0.8 respectively. The fuzzy OR operator simply selects the maximum of two values, 0.8. The probor would still result in 0.8.

Apply Implication Method

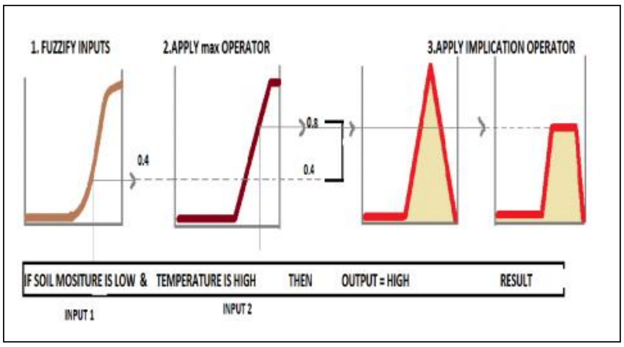
Before applying the implication method, you must determine the rules weight. Every rule has a weight (a number between 0 and 1), which is applied to the number given by the antecedent. After proper weighting has been assigned to each rule, the implication method is implemented. A consequent is a fuzzy set represented by a membership function.

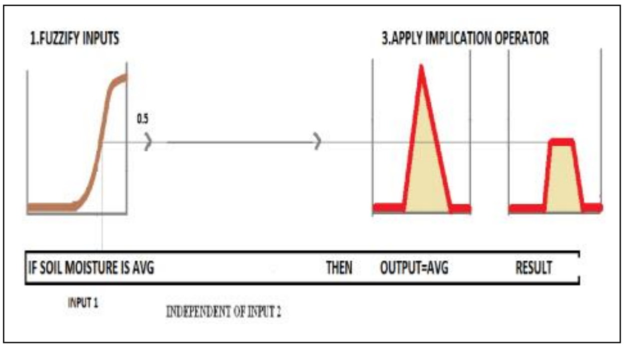
The consequent is reshaped using a function associated with the antecedent. The input for the implication process is a single number given by the antecedent, and the output is a fuzzy set. Implication is implemented for each rule.

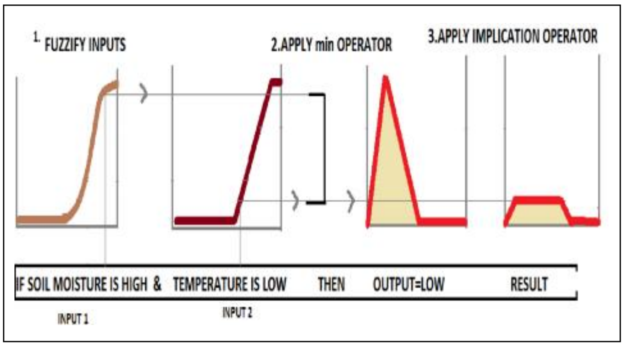


Aggregate All Outputs

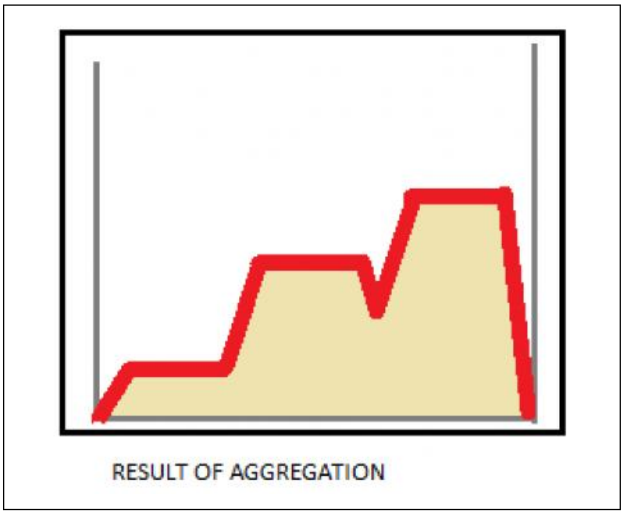
Because decisions are based on the testing of the rules in Fuzzy Interface System, the rules must be combined in some manner in order to make a decision. Aggregation is the process by which the fuzzy sets that represent the outputs of each rule are combined into a single fuzzy set. The Aggregation only occurs for each output variable, just prior to the defuzzification. The input of the Aggregation process is the list of truncated output functions returned by the implication process for each rule. The output of the aggregation process is one fuzzy set for each output variable. As long as the Aggregation method is commutative, the order in which the rules are executed is unimportant.







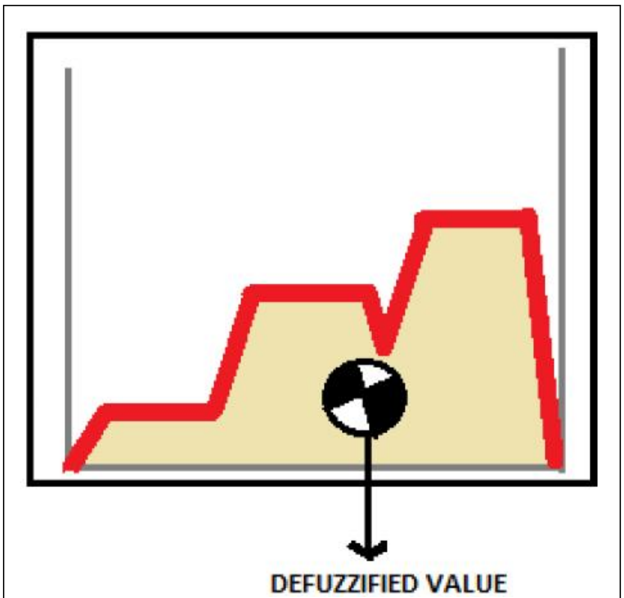
Now, the result of aggregation would be,



Defuzzify

The input for the defuzzification process is a fuzzy set (the aggregate output fuzzy set) and the output is a single number. As much as fuzziness helps the rule evaluation during the intermediate steps, the final desired output for each variable is generally single number. However, the aggregate of a fuzzy set encompasses a range of output values, and so must be defuzzified in order to resolve a single output value from the set.

The most popular defuzzification method is the centroid calculation, which returns the centre area under the curve. The other built-in methods are Centroid, Bisector, middle of maximum (average of the maximum value of output set), largest of maximum, smallest of maximum.



This defuzzified value indicates the water requirement of crops considering all the rules. The motor will pump the only this amount of water. Here,the Fuzzy Interference system is designed in such a way to pump water considering all the requirements of crops. This defuzzified value varies from one sector to another sector in a field. Provided proper management of fields and ensuring no leakages in valves, using this Fuzzy Interference System, Water Use Efficiency indicator can be improved.

CONCLUSION

Crop irrigation control is the most important concern in the domain of agriculture. Shortage of water globally is also emphasizing the need of systems that not only control the crop irrigation but also provide the intelligent way to provide water to places where it is needed and in the required quantity. By monitoring soil moisture, Leaf wetness, Temperature, Relative Humidity, Plant Root Depth, Sand Texture, Water Storage Capacities of soil, Plant water use capabilities, we can make efficient use of water resources and also in achieving high yield. The above paper presented here brings out the potential advantages of applying Fuzzy Logic Technique for Irrigation system. Thus we conclude that, by using the proposed technique, we get the following advantages- Increasing Irrigation Efficiency, Reducing the labour cost, Saving water and electricity.

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