Fuzzy Logic System in Tomato Farming

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Abstract: *Fuzzy logic systems are used for checking the degrees of truth in real life events. Recent advancements in technologies especially in wireless technologies are giving new advancements in the field of agriculture. In this paper, we will study the uses of fuzzy logic systems with the help of some wireless technologies in efficient farming of tomato crop which is an important and profitable crop of India. This paper will explain the irrigation system as well as fertigation (Fertilizers given through irrigation) and circulating pesticides in the farm using a fuzzy logic control system. All required information is collected with the help of wireless sensors which is scientifically accurate. The use of advanced technologies lead to proper and efficient ways of using water, electricity and the other resources required for tomato farming. This paper can be considered as a research study which is done through literature, human experiences for developing an expert system in this particular area.*
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I. Introduction

Farmers now-a-days are trying to use various modern ways for farming. Implementing these methods in the farming obviously increases the long-term, site-specific, whole farm production, profitability, efficiency, productivity. There is a need of using more new, effective technologies and automations in the agricultural field, so it will ultimately be efficient and time saver.

In the field of agriculture, if the crops are not properly taken care off then it results in a very bad way and finally in a big loss. There is one term which is used often recently i.e. "Precision agriculture"[1]. This means all the work related to farms should be done precisely. All the things like water, fertilizers, pesticides which are like lifelines to any farm has to be given precisely and on time to time manner.

As of now, farmers are using certain techniques of irrigations and disease control in crops manually. While using these techniques, some delays can occur because of some unavoidable reasons then it affects the crop. For that reason, an automatic irrigation and disease control system based totally on sensing devices is required to reduce the manpower and to take appropriate decision which leads to the profit.

The wireless technology that is required for the system is widely used in many areas now a days and it is easily available in the markets on relatively cheap prices. It gives features like high speed data transfers, safe and reliable, flexibility, low cost etc. By implementing this technology in the farm, many things which are now requiring a considerable amount of man power can be handled automatically.

Tomato is an attractive crop [2] which grows in *Kharif* season (July to October), *Rabbi* (October to march) and also in summer season. It is cultivated throughout the country (Except Kerala). India is at 2nd place in world for cultivating tomatoes[10]. It is a large profit-giving crop but, it has to be taken care of properly in many ways. It is susceptible to many diseases and gets affected to the diseases very fast. So, we will see how to maintain ideal conditions for tomato crop as well as the ways to control the diseases in tomato crop.
The variables which are classified as Very Low, Low, Average, High and Very high are Linguistic Variables. These variables have values associated with them and are used while representation of fuzzy sets.

II. Literature Review

Previously, the research work is done in the area of irrigation control systems using fuzzy logic controllers and wireless sensors [3]. The study specifies various types of techniques for irrigation to be done in the farm [3]. Wireless sensors used in that particular technology are mainly used for collection of the information of soil in the farm. Collected information consists of –

- Effective rooting depth of mature crop.
- Available Water Storage Capacity (AWSC).
- Plant water use capabilities.
- Soil moisture content. Etc.

All information is provided to the fuzzy logic controller and then it makes the decision whether to irrigate water through farm or not.

As we can see, this research work [3] only specifies about the irrigation system for the farm. The crop needs many more resources than just water.

A drip irrigation system was proposed for farming with the use of wireless sensors and fuzzy logic systems [4]. The sensors contain the real-time data from the farm soil and send it to the hub and then the fuzzy logic controller decides when and for how much time the valves should be opened for dripping of water.

The whole system was powered by photovoltaic cells and communication link for monitoring the states of crops [3]. It is helpful in efficient use of both water and fertilizers. The system was proposed with the use of mobile technology in it [3].

III. Creating Ideal Conditions

- **Water storage capacity of soil**

Tomato crop has a requirement of **sandy loam** to grow. The water storage capacity can be measured by ES1100 Watermark sensor. It is a soil moisture and soil temperature sensor. It is possible to rate in which the soil gets dried.

Available Water Storage Capacity (AWSC) guide [5]

Soil Texture	AWSC[Inch of Water per Foot of Soil]	Linguistic variable
Sand	1	Sandy
Loamy Sand	1.2	Sandy
Sandy Loam	1.5	Sandy
Fine Sandy Loam	1.7	Loamy
Loam	2.1	Loamy
Silt Loam	2.5	Loamy
Clay Loam	2.4	Clay
Clay	2.4	Clay
Organic Soil	3	Clay

Table 1: Soil texture with Available Water Storage Capacity[3]

- **Temperature**

Ideal temperature for tomato crop is 18 degree Celsius to 30 degree Celsius. It can be measured by a sensor and that information can be sent for analysing [5].

Sensor reading	Level	Linguistic variable	Range
Temperature obtained by a sensor	10	Very cold	[0 5 10 15]
	20	Cold	[10 15 20 25]
	30	Normal	[20 25 30 35]
	40	Hot	[30 35 40 45]
	45	Very Hot	[40 45 50 50]

Table 2: Temperature classification[3]

- **Smoke detection**

Smoke detectors which are easily available in the market should be applied in the farm as tomato crop is susceptible to the smoke generated through any source. It badly affects the growth of leaves in plant.

- **pH of soil**

Tomatoes grow best in the soil with pH 6.0 to 6.8. It requires slightly acidic soil to grow [2]. Soil pH can be tested with many applications which are available in market.
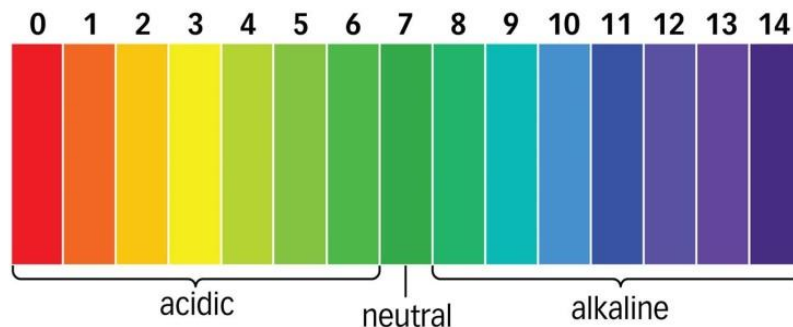

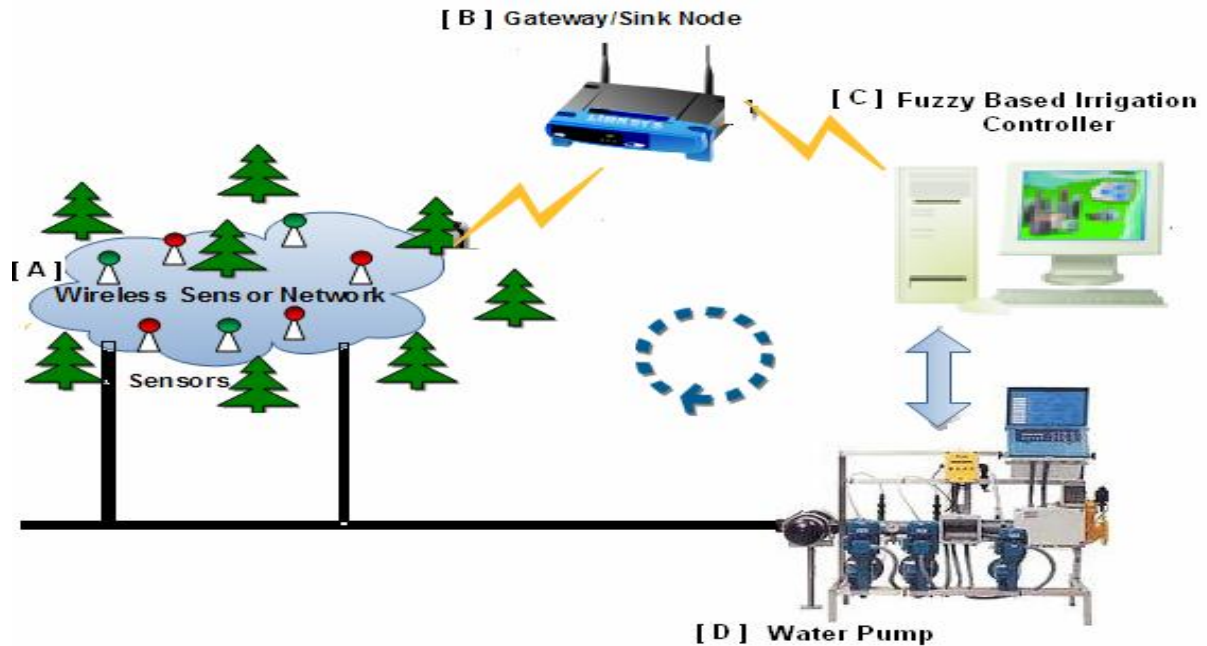**Fig 1:** pH Scale[7]

IV. Building A System

Fig 2: Structure of system[3]

V. Architecture Of System

As we can see in the image of the architecture of the system [5],

- **Farm** – The wireless sensors for all the parameters are distributed evenly for getting all the relevant data to send to the fuzzy controller.
- **Gateway** – The data sensed by the wireless sensors will be sent to the gateway, which will a router like device. The gateway node is directly connected to the fuzzy controller.
- **Fuzzy based controller** – It will accept the data which is sent by all the sensors from the farm. It will analyse it and according to rules specified in the system, it will send the signals to the respective machine. (Pump, sprinkler etc.).
- **Machine** – This will act according to the signals received from the fuzzy logic controller. The pump pipelines are distributed in the farms.

VI. Sensors In The System

There are various types of sensors available in market,

MEMSIC eKo Pro Series is a wireless agricultural and environmental sensing system for crop monitoring.
ES1100 Watermark Sensor (granular matrix sensor) is a soil moisture and soil temperature sensor.

ES1201 is a temperature/humidity sensor that measures the ambient relative humidity and air temperature.

Fig 3: Temperature / Humidity Sensors

Leaf wetness Sensor from **Decagon**   Tris compatible flat **pH sensor**

Fig 4: Leaf wetness sensor[8]   **Fig 5:** pH sensor[9]

Environment **temperature sensors**, **Smoke detectors** are also available in market.

VII.   Actions Taken If The Conditions Are Not Ideal

The system starts right after checking for the ideal conditions of the soil. If the conditions are not proper then the following measures are taken by the controller.

- **pH -** The pH sensor senses the pH of the soil and if the pH is more acidic than required then it can be raised by adding base into that which can be done through the automated irrigation system by using mixture of water and lime stones.

  When the sensor gets the information about pH being too acidic then it tries to control that, at the same time it will set the controller for giving water regularly in the farm after particular amount of time (1 or 2 days) for some time period. If the pH is more alkaline then we can make it acidic by using compost manure we can control the soil pH.

- **Soil temperature -** If the soil temperature is more than required then the sensor sends signals to the controller and then the timer is set into the controller for watering the soil regularly until the temperature is maintained. If the soil temperature is lower than nitrogen should be provided to the crop.

- **Formaldehyde -** If all the conditions are proper sensed by the sensors then a signal is sent to the controller for sprinkling formaldehyde into the farm field[6][2]. This task will be automated when all other factors are appropriate.

- **Water logging -** The wetness sensors will sense the soil and if it is wet for more amount of time then the water irrigation should be stopped.

After planting
- **NPK –**   Nitrogen, Phosphorous and Potassium are useful for increasing the durability, attractiveness and shine of the tomato fruit.

  If all the conditions are proper then Nitrogen, Phosphorous and Potassium should be circulated at proper time period throughout the tomato farming. All the conditions should be checked daily.

  NPK requirements –
    120 kg/hector
    60 kg/hector
    120 kg/hector

It can be mixed with water and then can be circulated in the farm through the distribution system.

- **Water irrigation -** If all the conditions are proper then the water should be irrigated to the farm after each 10th day. If the water is logged in the farm then the irrigation should be stopped. If the temperature drops to the ideal conditions then the irrigation should be stopped till the ideal conditions are maintained.

- **Zinc and Boron –** These two elements are essential for making fruit attractive [6] [2]. These elements are given as a mixture with water. At the time of 2nd or 3rd irrigation, these should be circulated in the farm.

- **Damping off -** Tomato crop gets affected by the disease called as 'Damping off'. This happens because of humid temperature and wet and cold soil [2]. To control this sensors keep watch on the conditions of soil and climate for particular amount of time**.**

- **Leaf curl –** Dimethoate is used to prevent leaf curl. It is caused by insects [2]. The insects can be controlled. It should be sprinkled on each 15th or 20th day. It should be sprinkled in concentration of 35ml / 1 litre.

- **Transportation of pollen grains -** If the temperature is increasing above certain level for 2 to 3 days the transportation of pollen grains is affected [6]. For successful transportation planofix (Indole acetic acid) can be sprinkled on the crops for maintaining the ideal conditions.
  If the soil is wet and the weather is humid for more than 2 days then the irrigation should be stopped and a message should be sent to a farmer. The controller should inform the distribution system to distribute the 'Bavistin'solution in the farm through dripping.

- **Leaf wetness –** After each watering or irrigation the wetness sensor checks the leaf and it should not be wet for long time otherwise it spreads diseases.

VIII. Algorithm For Sysetm To Maintain Proper Conditions

FOR CHECKING SOIL -
If AWSC sensor reading is less than 1.3 then   (Reading less than required condition)
    Take measures for making it equal to 1.5 (As we can't provide anything through our system).
    Suggestions – Grow root vegetables.
Else if AWSC sensor reading is greater than 1.7 then   (Reading more than required condition)
    Take measures for making conditions appropriate.
    Suggestions –Grow lettuce, chard, snap beans.
Else if AWSC sensor reading is greater than 1.3 and sensor reading is less than 1.7 then   (Required reading)
        If Temperature less than 18 and Temperature greater than 30 (for more than 15 days) then
            No appropriate conditions for crop.
        Else if Temperature greater than 18 and Temperature less than 30 (for more than 15 days) then
            Repeat the conditions for 20 days
            (This is the ideal condition, so check this IDEAL TEMPERATURE condition for 20 days instead of 15 days to make sure that the environmental conditions are steady)

If pHreading less than 6.0 then
        Add lime powder through the irrigation system into the farm. Circulate water regularly in the farm till the pH reaches to required rating.
Else if pHreading greater than 6.8 then
        Circulate Sulphur from the irrigation system into the farm till the pH reaches to required rating.
Else if pHreading greater than 6.0 or pHreading less than 6.8 then
        The conditions are appropriate for tomato crop farming.
Check the conditions of pH after <u>each 2 days for 20 times.</u>

    AFTER FARMING -
Check dailyCount for 120 days   (Looping structure)
        Check hoursCount for 5 hours   (Looping structure)
                If loggingSensor = true then
                    Stop irrigation immediately until the sensor sends "No" signal.
                    SIGNAL="Stop";
                Else
                SIGNAL="Continue";
                Increase the hoursCount by 1
                If SIGNAL is "Continue" then
        IfpHreading less than 6.0 then
                Add lime powder through the irrigation system into the farm. Circulate water regularly in the farm till pH reaches to required rating.
        Else if pHreading greater than 6.8 then
                Circulate Sulphur from the irrigation system into the farm till pH reaches to required rating.
        Else if pHreading greater than 6.0 or pHreading less than 6.8 then
        Conditions are good.
        FLAG=1

(As tomato is known as very sensitive crop, the temperature conditions are different before farming and after farming. Therefore, though earlier it is mentioned that Ideal soil temperature is 18 degrees to 30 degrees, after farming the soil temperature should be between 19 degrees to 21 degrees)

If soilTemperature less than 19 then
> Store the record in the database with a count.

Else if soilTemperature greater than 21 then
> Circulate nitrogen fertilizer through water in the farm.
> Store the record in the database with a count.

Else if soilTemperature greater than equals to 19 and soilTemperature less than equals to 21 then
> Conditions are good.

Else
> **Inform farmer by a message.**

If temperatureHumidity greater than requirement then
> Irrigate hydrogen peroxide solution from water.
> HumidityCount++;

If humidityCount greater than 2 then
> **Inform farmer by a message.**
> Sprinkle planofix on the crops.

Increase the dailyCount by 1
If (dailyCount/15) =0 then
> SPRINKLE FORMALDEHYDE ON THE FARM
> (Formaldehyde will be sprinkled on each 15th day on the crop)
> IRRIGATION CONTROL -

Check for (dayCount%10=0) till 120 days   (Each 10th day till 120 days)
> Water should be irrigated with proper amount (As mentioned earlier in point VII) of NPK fertilizers in it.

> **Check for minuteCount till 60 minutes**
> > **If dayCount=3 then**
> > A mixture of zinc and boron should be given through the water.
> > **If dayCount%2 equals to 0 then**
> > Sprinkle Dimethoate into the farm.
> > **Increase minutesCount by 1;**
> **Until minuteCount less than equals to 60;**

dayCount++;
Until dayCount less than equals to 120;

IX. Conclusion

Crop irrigation and fertigation are the most important factors in the farming. It is very necessary to find out the proper requirements for the crop and take measures according to that. In the case of tomato crop, it is quite hard to maintain the crop as it is very susceptible for the environmental factors. So, if proper care is not taken of the crop then the profit making crop can turn into a disaster.

There are some problems with which farmers deal with regularly are, water shortage and adequate amount of fertilizers. If the proper scientific measures are taken and analyzed, on the basis of temperature, soil humidity, soil moisture, environmental conditions, we can achieve a way higher yield.

In the points which are discussed above, there are still some limitations regarding the solid materials which are required to be distributed in the farm because at present there is no mechanism present for it. The materials which are liquid and the materials which are soluble in water can be flown very easily in the farm and certainly there are some factors in which a machine actually can't do anything but just inform farmers.

Thus, we conclude that, by using the proposed ideas, we can achieve the following advantages - Increasing Irrigation Efficiency, reducing the labor cost, saving water and electricity.

Regarding all these limitations, there is a future scope to work on all the limitations present.

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