IOSR Journal of Business and Management (IOSR-JBM)
e-ISSN: 2278-487X, p-ISSN: 2319-7668
PP 43-48
www.iosrjournals.org

Automation of Irrigation Monitoring Using Artificial Neural Network

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Abstract*: Water is an important resource in the earth for irrigation, so irrigation technique is essential for agriculture. In our country farmers are not following proper irrigation techniques. Currently, most of the irrigation scheduling systems and their corresponding automated tools are in fixed rate. Irrigation is not only essential for the improvement of irrigation system but also to save water resource for future purpose. Intelligent control system based on Artificial Neural Network is used for effective irrigation scheduling in paddy fields. The input parameters like air, temperature, soil moisture, radiations and humidity are modeled. Evapotranspiration and various growing stages of crops are considered and based on that the amount of water required for irrigation is estimated. Agriculture aims to provide good quality and high yield efficiently with less labor on limited lands. Taking advantages of industrial production methods and modern engineering techniques, facility agriculture makes a good use of the climate, soil and biological potential of fields to provide a controllable and suitable environment for plants so as to increase the productivity. Thus the prerequisite step of agriculture is monitoring the farming environment effectively. An agricultural environment monitoring system includes transmission, data acquisition and management. Sensors technologies provide convince opportunities to data acquisition. Profitable, optimal and sustainable use of our land and water resources is critical. Various types of sensors large in number can be deployed in the environment to collect environmental parameters and send them to the users through wireless data communication. However, a simple sensor cannot achieve the collection of various parameters of different crops on large farmlands. Remote sensors should be able to self-organized and to send data periodically to the control center. Using this existing Artificial neural network based intelligent control system, the water saving procedure in paddy field can be achieved*

Keywords*: Automated hardware,Artificial Neural Network, Irrigation scheduling, Evapotranspiration*.

I. Introduction

Our country is getting the benefits of rainfall during monsoon months. It is essential to provide irrigation for cultivation of crops during the rest of the eight months. So irrigation technique is necessary for cultivation of crops in less rainfall areas. India is an agricultural and populous country. In our country most of the people depend on agriculture in order to increase the level of agricultural products. So, extensive irrigation is necessary. Irrigation is the major problem in agriculture in the countries which are in developing stage. In any country which is like India where the income of people depends on agriculture directly or indirectly and the environmental conditions are isotropic still we are unable to use agriculture resources. The main causes are

- Unplanned usage of water resources by this way more water goes waste.
- low rainfall due to this more land not irrigated.
- By the drip system water supplied to plants zone only remaining area can't get water due to this large amount of water saved.

Automatic irrigation system can supply water to plants whenever they need water when power supply intervals. Here no need of turning ON/OFF valves. By this automatic irrigation system watering plants at exact time based on soil condition which will improves crop growth by taking minerals and water from soil when plants needed. The current work aims to sensor network based low cost soil moisture, temperature monitoring system to track the soil moisture and temperature in real time and there by allow water given to plants based on conditions of soil moisture, temperature and type of crop grown in soil. The sensors take the inputs like moisture, temperature and provide these inputs to the microcontroller. The microcontroller converts these inputs into its desired form with the program that is running on it and gives outputs in the mode of regulation of water flow according to the present input conditions. The sensors take the inputs like temperature, moisture and provide these inputs to the micro controller. The microcontroller converts these inputs into its desired form with the program that is running on it and gives outputs in the mode of regulation of water flow according to the present input conditions.

II. Background of The Work

2.1. Artificial Neural Network: A neural network is a processing device, either an algorithm, or an actual hardware. A neural network is sensitive based on their input and output because Information that flows through the network affects the structure of the ANN.

2.2 Controllers: It is an essential tool to supply water in the necessary quantity at right time A controller is an integral part of an irrigation system. To achieve high level of efficiency in water and energy and to sustain the agricultural production there are two types of controllers are used in irrigation system.

2.2.1 **Open loop controller**: This are also called non-feedback controllers. This type of controller is designed on following principles:

- It takes inputs and finds output for the system accordingly.
- This is most simple form of controller in which basic parameters and instructions are predefined. It does not have any feed-back to determine whether the desired output or goal is achieved or not such as:
- When to start watering/a task
- When to end watering /a task

Time delay intervals

During execution of set of instructions given above no measures are taken to check whether right amount of water is supplied or not using open loop-controller.

These controllers may have less cost, but they are not very good and they do not provide optimal (or a good) solution to irrigation problems.

Pseudo code

Step 1 Collect the details from field using sensors.

Step 2 Using **Evapotranspiration** model calculate the water requirement.

Step 3 With the help of ANN controller compare the output of the soil moisture with required Evapotranspiration model.

Step 4 Control the valves position

It is seen from above that control system consists of four interconnected stages.

1. **Input from Sensors:** In this stage different parameters like air humidity, temperature, wind speed, soil moisture and radiation are collected. The results of these parameters is passed to next stage as in input.
2. **Evapotranspiration Model:** This model converts inputs from four parameters into actual soil moisture
3. **Required Soil Moisture:** This block provides information about the amount of water required for proper growth of plants.
4. **Artificial Neural Network Controller:** In This stage comparison of required soil moisture with actual soil moisture and decision is made dynamically.

2.2.2 Closed loop controller: In this type of controller feedback of a necessary parameter is required to check right amount of water needed for irrigation They are based on pre-defined control concept and utilizing feedback from controlled object/system in some manner.

In order to make an optimal decision There are several parameters which play important role. Some of the fix parameters throughout the process. Such as:

- Leaf coverage
- Kind of soil
- Kind of plants
- Stage of growth etc.

Whereas some of them varies with time and should be measured during irrigation process. They are physical parameters such as:

- Radiation in the ground
- Soil humidity
- Air humidity
- Temperature

Whole irrigation process is mainly based upon physical parameters specified above. Amount of water being used for irrigation also changes since these parameters are physical and changes with time.

Closed loop control irrigation system exploited in this paper. The control unit continuously receives feedback from different sensors placed in the field. It enables control unit to update its data about important system parameters. The control unit decides how much water tap to open, in accordance with the data collected from sensors and predefined parameters(depending upon the crop, weather conditions etc.)

The major parameters that determine the irrigation process are:

- type of growth;
- Status of the growth (height, depth of roots);
- leaf coverage;
- kind of soil and saltiness;
- water budget (economy or normal irrigation).

Therefore, the input parameters that are used by the system are:

- soil (ground) humidity;
- temperature;
- radiation;
- wind speed;
- air humidity;
- salinity (amount of salt in the ground).

The output parameters are:

- Turning energy systems on/off (lights, heating, ventilation);
- opening/closing the valves for water and/or fertilizer, and adjusting their amounts in combination;
- Opening/closing walls and roofs of hothouses.

III. Architecture of Artificial Neural Network Based Irrigation Controller

Complete Irrigation System ingrained with ANN Controller. It is seen that control system consists of four interconnected stages.

- Input from Sensors: Different input parameters values like air humidity ,temperature, soil moisture, wind speed and radiation ,are collected. Then these parameters are passed to next stage as input.
- Required Soil Moisture: Information about the amount of water required for proper growth of plants is provided in this block.
- Evapotranspiration Model: this model converts inputs from four parameters into actual soil moisture
- ANN Controller: In This stage compares the actual soil moisture required with soil moisture and decision is made dynamically.

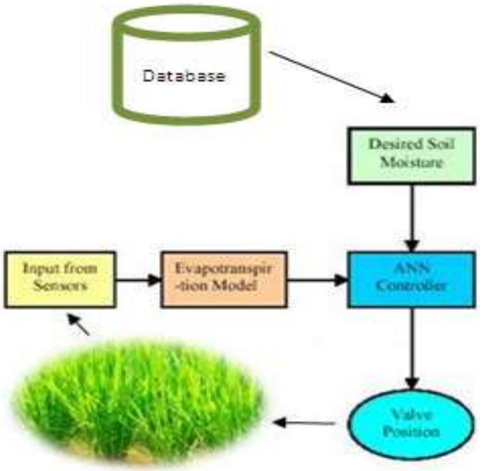

Figure-1 Block diagram for Irrigation control system

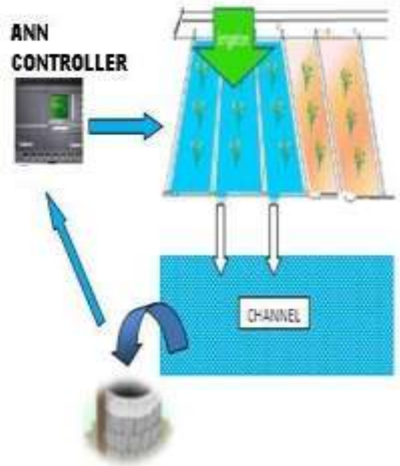

Figure -2 Functional Diagram for Irrigation Control System

3.1.Modeling of System Parameters: We use the modeling of input parameters from:

3.1.1. Inputs Parameters: There are four factors (Temperature, air humidity, wind speed and radiation) by which evapotranspiration is influenced.

3.1.2 Temperature: Variable acts as a continuous signal, but may show sharp changes in special places like deserts and so on therefore:
• A sine wave with amplitude of 5 ºC;
• A frequency of 0.2618 rad/h. This frequency is
• measured according to a time period of 24 h: 0.2168 rad/h = 2pi/T=2pi/24.
• A constant bias(offset) of 30 ºC;
This stimulus generates a wave which at its maximum can reach 35°C (midday) and at its minimum can reach +25°C (midnight). In this way, the temperature on any given day can be simulated by changing the bias that is attached to the variable. This diversion is obtained by uniform number generation.

3.1.3 Air humidity: It is modeled as:
- A sine wave with amplitude of 10%;
- Bias of 60% (constant);
- A frequency of 0.2618 rad/h.

3.1.4 Wind speed :
- A sine wave with amplitude of 1 Km/h;
- Bias of 3.5 Km/h (constant);
- A frequency of 0.2618 rad/h (Light Blue graph in Fig. 2) [10].

3.1.5 Radiation: It is modeled as maximum possible radiation at earth's surface (Rmax).
- A sine wave with amplitude of 2MJ/m2
- Bias of 112MJ/m;
- A frequency of 0.2618 rad/h.

3.2 Required Soil Moisture: It is solely dependent on the kind of plant, type of land, type of growth and type of soil. The required soil moisture is calculated according to the above mentioned factors.

3.3.Evapotranpiration Model: Penman-Monteith equation is a combination equation that has generally been accepted as a scientifically sound formulation for estimation of reference evapotranspiration (Eto). This equation is expressed as combined function of maximum and minimum temperature, vapor pressure, radiation and wind speed. After the Penman method is updated by FAO in May 1990, the Penman Monteith equation is written as the following:

$$Eto = \frac{0.408\Delta(Rn-G) + \gamma\, 900/(T+273)\, u2(e_s - e_a)}{\Delta + \gamma(1+0.34u2)} \quad \ldots\ldots(a)$$

$$\Delta = \frac{4098eo(T)}{(T+273.3)^2} \quad \ldots\ldots.(b)$$

$$e^o(T) = 0.6108 \exp(17.27T/T+273.3) \quad \ldots\ldots.(c)$$

$$\gamma = \frac{CpP}{\varepsilon\lambda} \bullet 10^{-3} = 0.001628 \bullet P/\lambda \quad \ldots\ldots(d)$$

Where:
ET0 = Reference evapotranspiration [mm day-1],
Rn = Net radiation at the crop surface [MJ m-2 day1],
G = Soil heat flux density [MJ m-2 day-1],
T = Mean daily air temperature at 2 m height [°C],
U_2 = Wind speed at 2 m height [m s 1],
e_s = Saturation vapor pressure[kPa],
e_a = Actual vapor pressure [kPa],
e_s-e_a = e^o(T)= Saturation vapor pressure deficit [kPa],
D = Slope vapor pressure curve [kPa °C-1],
g = Psychrometric constant [kPa °C 1].
P = Atmospheric pressure [kPa],

z = Elevation above sea level [m],
e°(T) = Saturation vapour pressure at the air temperature T [kPa],
λ = Latent heat of vaporization, 2.45 [MJ kg-1],
Cp = Specific heat at constant pressure, 1.013 10-3 [MJ kg-1 °C-1],
ε = Ratio molecular weight of water vapour/dry air = 0.622

3.4.Control Unit: The control unit consists of Artificial Neural Network based controller. This controller interfaces the required soil moisture and measured soil moisture. The main function of this stage is to keep the the required soil moisture close to the actual soil moisture. In order to optimized the whole system the output of this stage is control input for valve which supervises the amount of water which should be supplied. In the proposed method Dynamic Artificial Neural Network is used. Since Dynamic Networks have memory they are more powerful than static networks, they can be trained to learn sequential and time varying patterns. The controller has two inputs from evapotranspiration model i.e. calculated soil moisture and required soil moisture, and there is only one output of controller also called control input for Valve position. the Artificial Neural Network configuration is very simple and straight forward.

IV. Ann Controller Architecture

ANN Controller is implemented using the following;

- Topology: Distributed Time Delay Neural Network is used ;
- Training Function: Bayesian Regulation function is used for training.
- Performance: Sum squared error is taken as performance measure.
- Goal: The set goal is 0.0001.
- Learning Rate: The learning rate is set to 0.05. when the required soil moisture exceeds the measured soil moisture the valve is opened and it remains closed otherwise.

V. Simulation Results

It can be used as direct controller in cascade with the Evapotranspiration model once the neural network is trained. The control target is to bring the soil moisture as close as possible to required actual soil moisture and to optimize the resources like water and energy. For Soil moisture the ANN controller is noted for reference (Required). The Results of ANN controller is compared with ON/OFF controller implemented with the same evapotranspiration model. This is shown in figure 3-4.The important facts that can be extracted from the simulations are:

5.1 ON/OFF Controller: The legend of figure3 is:
• Yellow signal – Required Soil moisture
• Blue Signal-actual soil moisture.
• Light Red signal – valve out put.

1. The ON/OFF control based system is not stable because of the output of Continuous oscillation.
2. In ON/OFF controller the valve is opened and closed continuously at the extreme points(0 and 10).Due to this lot of energy and water is consumed which is undesirable.
3. In ON/OFF control based system, the actual soil moisture tracks the required soil moisture but there are continuous oscillations around the required soil moisture.

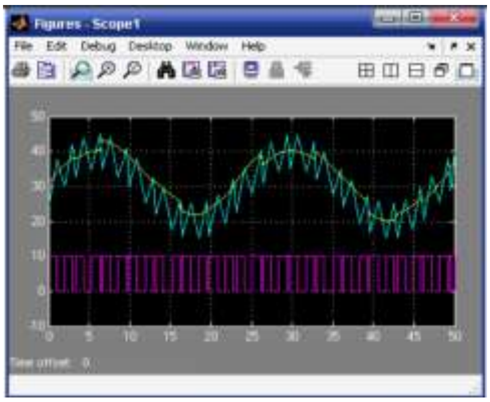

Figure-3: Simulation Results of ON/OFF control based System **Figure-4 :** Simulation Results of ANN based control System

5.2 ANN Controller: The legend of figure 4 is:
• Yellow signal-Required Soil moisture
• Light Red signal-Actual Soil moisture
• Green-Valve output.
The actual soil moisture tracks the required soil moisture without any oscillations.

1. The error(difference between required and actual soil moisture)is steady and reasonable (less than 2%)
2. In ANN controller the ON/OFF of the valve and energy system is very low and hence lot of energy and water can be saved.

The main goal of designing the cost-effective and result oriented Irrigation Control System has been achieved by using ANN Controller.

VI. Conclusion

Artificial Neural Network Controller has described a simple approach to Irrigation control problem .Water is one of nature's most important gifts to mankind, because of the increase in population food requirement for human being is also increasing. Over the past few decade usage of water for irrigation has increased. Water is polluted due to wastage and contaminants in the industries. Saving water is more important. This ultimate aim can be achieved by using the exiting Artificial Neural Network control system. It will provide a way to save flood water in the fields for future irrigation purpose. Irrigation has been the back bone of human civilization since man has started agriculture. In the present scenario on conservation of water is of high importance. Present work is attempts to save the natural resources available for human kind. we can control the flow of water and thereby reduce the wastage by continuously monitoring the status of the soil. ANN based systems can save lot of resources like energy, water and can provide optimized results to all type of agriculture areas.

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