Irrigation System Controller using Artificial Neural Network

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Abstract— Irrigation structures are as old as guy itself seeing that agriculture is the career of civilized humanity. To irrigate huge regions of vegetation is a laborious task. In order to conquer this hassle many irrigation scheduling techniques have been developed which might be in particular based on tracking the soil, crop and weather conditions. Irrigation scheduling engrossed when to irrigate and what sort of water to be implemented. The coronary heart of a computerized irrigation machine (constant charge or variable fee) is its control unit: as it controls irrigation time and water flow. Intelligent control primarily based irrigation is necessitated to maximize the efficiency and manufacturing. Existing technologies vary from water stability or take a look at book technique to state-of-the-art sensor-based totally systems. Most of the irrigation structures use ON/OFF controllers. These controllers cannot supply greatest effects for varying time delays and varying gadget parameters. This paper offers Artificial Neural Network (ANN) based shrewd manipulate gadget for effective irrigation scheduling. The proposed Artificial Neural Network (ANN) based controller is prototyped using MATLAB. The input parameters like air temperature, soil moisture, radiations and humidity are modeled. Then the usage of appropriate technique, ecological situations, evapotranspiration and kind of crop, the amount of water needed for irrigation is anticipated and then related effects are simulated.

Keywords: Irrigation System Controller, Artificial Neural Network (ANN)

I. INTRODUCTION

A. *Objective*

This automatic irrigation device senses the moisture content of the soil and automatically switches the pump whilst the energy is on. When soil is going dry pump will begin watering. The intention of the implementation is to reduce water use and automated irrigation can be used for store time and occasional energy monitor tool.

1) *Overview of the System*

Agriculture has, at some point of History, performed a main function in human society’s endeavors to be self-sufficient in meals. Irrigation is a vital thing of crop manufacturing in lots of regions of the sector. In cotton for example, recent research has shown that proper timing of irrigation is a crucial production factor and that delaying irrigation can result in losses of between USD 62/ha and USDv300/ha. Irrigation water use represents a widespread opportunity for residential water savings. Automation of irrigation gadgets has the capacity to offer maximum water use efficiency through monitoring soil moistures at most beneficial degree. The manage unit is the pivotal block of the whole irrigation machine. It controls the float of water and consequently enables the grower to collect optimized outcomes.

B. *Artificial Neural Network*

Artificial neural networks or connectionist systems are computing structures vaguely inspired by using the biological neural networks that represent animal brains. Such structures "examine" to carry out duties with the aid of thinking about examples, normally without being programmed with challenge-particular policies. Wikipedia

C. *Pseudo Code*

1) Step 1: Getting inputs from the sensors.
2) Step 2: Using Evapotranspiration model calculate the water requirement.
3) Step 3: With the help of an artificial neural network controller compare the output of the soil moisture with the required Evapotranspiration model.
4) Step 4: Control the taps or valves.

D. *Types of Controllers*

1) *Open Loop Controllers*

The open loop controllers also called as non-feedback controllers. The manipulate motion from the controller is unbiased of the "technique output", that's the system variable that is being managed. It simply takes an input and gives the output based on the system accordingly. This is the simple form of controller because the parameter and instruction are pre-defined or determined before the process. The sample parameters are such as:

– Start time of the task
– End time of the task
– Time delay intervals

No measures are taken when we execute the above instruction to check whether the amount of water supplied was right or not. These controllers are not provide a good solution for the problem.

2) *Closed Loop Controllers*

Open loop controllers are using or utilizing the feed-back from the controlled system. These controllers are based on predefined control concept. Feedback is necessary for this type of controllers and calculating the right amount water is needed for the irrigation. There are many parameters which plays a major role in irrigation. Some of the parameters are constant and some parameters are varying based on time, whether and during the irrigation process.

a) Constant parameters are:
– Type of soil
– Type of plants
– Stage of growth and etc.

b) Varying parameters are:
– Humidity of soil
– Humidity of air
– Temperature
– Radiation
– Whether condition

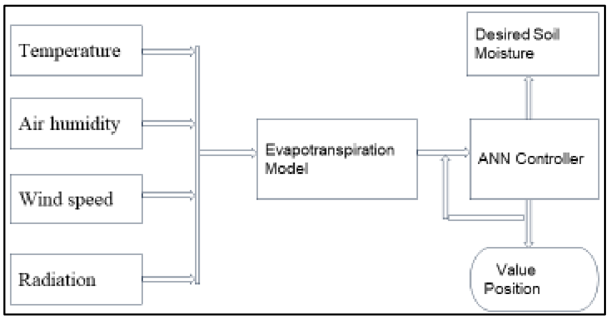

Fig. 1: Block Diagram

The irrigation system is mainly based on the above parameters. These parameters are changed based on time and the amount of water needed to the irrigation system is also changed. The control system in this paper is based on a closed loop controller. The system receives an input from the sensors on the field. Based on the data from the sensor the control unit decides the amount of time to be tap open.

II. DESIGN OF ANN BASED CONTROLLER

Figure 1 shows the complete block diagram of automated irrigation system using artificial neural network based controller. This controller consists of four stages.

– Input from sensors

In this stage the different parameters like air humidity, temperature, soil moisture, wind speed and radiation are collected. These parameters are given to the next stage as input.

– Evapotranspiration Model

This block converts four input parameters into actual soil moisture (details in coming section).

– Required Soil Moisture

This block provides information about the amount of water required for proper growth of plants.

– ANN Controller

This stage compares the required soil moisture with actual soil moisture and decision is made dynamically.

A. Modeling of System Parameters

We use the modeling of input parameters from [10]

1) Inputs Parameters

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

2) Temperature

This variable should be defined as a continuous signal (normally as a sine wave which simulated the day and night temperature changes), 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;

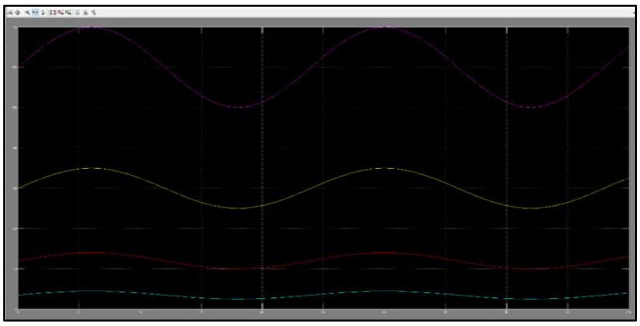

Fig. 2: Input Parameters Graphical Representation

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 (Yellow graph in figure 2).

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 (Orange graph in Fig. 2).
- 2.1.4 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].

4) Radiation

- A sine wave with amplitude of 2MJ/m2
- Bias of 112MJ/m;
- A frequency of 0.2618 rad/h.

B. Evapotranspiration Model

Penman-Monteith equation is a combination equation that has generally been accepted as a scientifically sound formulation for estimation of reference evapotranspiration. This equation is expressed as combined function of radiation, maximum and minimum temperature, vapor pressure, and wind speed.

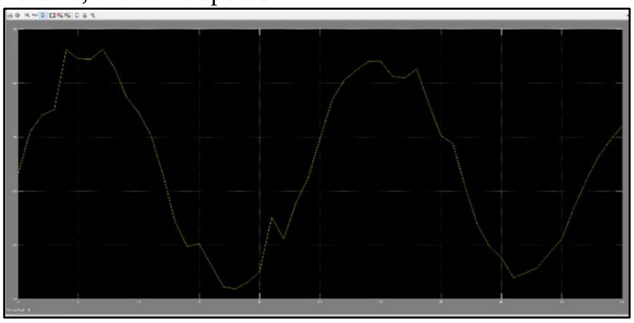

Fig. 3: Soil Moisture Graphical Representation

After the Penman method is updated by FAO in May 1990, the Penman Monteith equation is written as the following:

$$Eto = \frac{0.408\Delta(R_n-G) + \gamma \frac{900}{T+273} u_2(e_s - e_a)}{\Delta + \gamma(1+0.34u2)} \quad (a)$$

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

$$e^o(T)=0.6108 \exp\left(\frac{17.27T}{T+273.3}\right) \quad (c)$$

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

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],
- U2 = Wind speed at 2 m height [m s 1],
- es = Saturation vapor pressure[kPa],
- ea = Actual vapor pressure [kPa],
- es-ea = 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 kg1 °C-1],
- ε = Ratio molecular weight of water vapour/dry air=0.622

III. ANN CONTROLLER ARCHITECTURE

ANN Controller is implemented using the following:

A. Topology

Distributed Time Delay Neural Network is used

B. Training Function

Bayesian Regulation function is used for training.

C. Performance

Sum squared error is taken as performance measure.

D. Goal

The set goal is 0.0001.

E. Learning Rate

The learning rate is set to0.05.

In this configuration the valve is opened when the required soil moisture exceeds the measured soil moisture and it remains closed otherwise.

IV. SIMULATION RESULTS

Once the neural network is trained, it can be used as direct controller in cascade with the Evapotranspiration model. The control target is to bring the actual soil moisture as close as possible to required soil moisture and to optimize the resources like water and energy.

A. On/Off Controller

The legends of figure 6 are:

- Yellow: Required signal Soil moisture
- Blue: actual Signal soil moisture.
- Light Red signal: valve output.

1) 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.
2) The Continuous oscillation at the output shows that the ON/OFF control based system is not stable. 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 are consumed which is undesirable.

B. ANN Controller

The legends of figure 5 are:

- Yellow signal: Required Soil moisture
- Light: Actual Red Soil signal 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 than2%)
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.

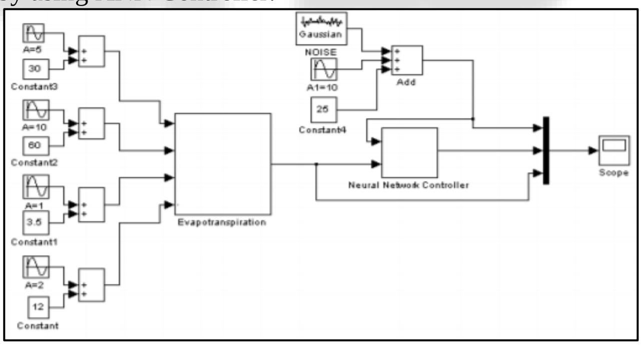

Fig. 4: Control System with Evapotranspiration Model

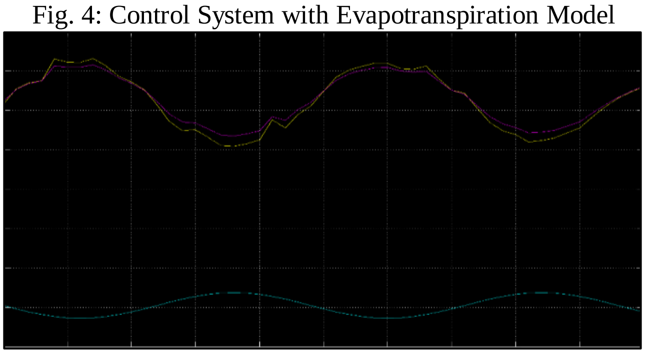

Fig. 5: Simulation Results of ANN Based Control System

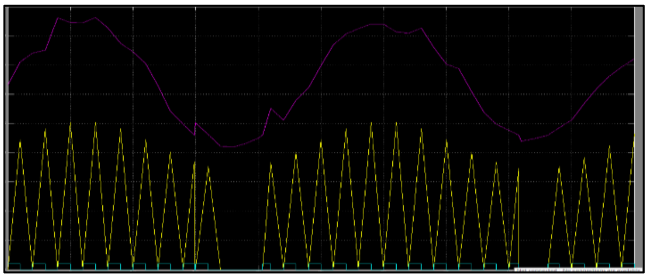

Fig. 6: Simulation Results Of ON/OFF Based Control System

V. CONCLUSION

This paper has described a simple method to Irrigation control problem using Artificial Neural Network Controller. The proposed system is as compared with ON/OFF controller and it's far proven that ON/OFF Controller primarily based System fails miserably due to its barriers. On the other hand ANN based approach has led to viable implementation of higher and extra green control. These controllers do not require a prior information of device and feature inherent potential to evolve to the changing conditions in contrast to traditional methods. It is noteworthy that ANN based totally structures can save lot of sources (electricity and water) and may offer optimized results to all sort of agriculture regions. In future we plan to do away with some idealizations used in this paper (which includes input parameters), and could make use of real facts. We also plan for hardware implementation of contemporary paintings.

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