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CONTROLLING WATER QUANTITY IN IRRIGATION SYSTEM USING LOW POWER SENSORS FOR SOIL AND WEATHER

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Abstract

The main purpose of this work is to present a new method to control the quantity of water used in irrigation. The challenge today is to create an automated irrigation system which in the same time can reduce the water's waste and is cost effective. Different parameters are important to measure in order to calculate the efficient quantity of water needed by plant. In this work, the proposed solution is the use of less power consumption and cheaper devices but still efficient enough for the system. The system is composed of three nodes to be used together; each node is composed from the TelosB mote and adequate sensors. The soil node will be used to detect the level of moisture and temperature in soil, the weather node to prevent the climatic changes and the last one is connected to an actuator so you can control the opening of the irrigation valve if necessary.

Keywords: *TelosB, Soil Node, Weather Node, Valve*

I. Introduction

Agriculture is an important sector for each country. It is the major source of income for every population. Besides providing foods and raw materials for manufacturing industries, it is a predominant occupation of working population.

One important part of agriculture system is the irrigation system. Today, crop irrigation uses more than 70% of the world's water. The use of water for irrigation is expected to be increasing in future because of the effects of climate change and the necessity to maintain a high quality of crop yield in despite of unpredictable drought periods.

Different factors can determine the effectiveness of the irrigation system such as the type of delivery system used and the climatic conditions. So, to have an effective irrigation system you need to get as much water to the plants, or into the soil, as possible. It may seem easy to do, but in fact, water loss from these systems can be up to 50% due to the evaporation cycle. On hot and sunny days, a good portion of water may never make it to the ground. So, the irrigation system should be able to detect when the plants are in need for water to open valves for irrigation.

II. Related Works

1. Surface irrigation

Surface irrigation is the most known irrigation method through the world. It is a combination of techniques for watering the soil. It has four major variations: Flooding, Bed or border, Basin method and Furrow method.[1]

1.1 Flooding Method

It consists of opening water channel in field so that water can flow freely in all directions and cover the surface of the land in a continuous sheet. It is the most inefficient method of irrigation as only about 20 percent of the water is actually used by plants and the rest is lost as a run off, seepage and evaporation.

Flooding method can be used on shallow soils and where system and operation costs are low. Despite this, flooding method has its disadvantages. Using this method led to an excessive loss of water and excessive soil erosion on step land. Also, the fertilizer is eroded from the soil.

1.2 Bed Method

The field is leveled and divided into small beds surrounded by bunds of 15 to 30 cm high. Small irrigation channels are provided between two adjacent rows of beds. This method is adaptable to most soil textures except sandy soils and is suitable for high value crops. Through the initial cost is high requires less labor and low maintenance cost.

1.3. Basin Method

A small bund of 15 to 22 cm high is formed around the stump of the tree at a distance of about 30 to 60 cm to keep soil dry. The height of the outer bund varies depending upon the depth of water proposed to retain. Basin irrigation also requires leveled land and not suitable for all types of soil. It is also efficient in the use of water but its initial cost is high.

1.4. Furrow Method

This irrigation method is used in the production of vegetables. The length of furrow is determined mostly by soil permeability. This technique makes plant to get water in its root zone and therefore plant is not in direct contact with water.

It is high water efficiency and can be used in any row crop. Also, it is not expensive to maintain and adapted to most soils. Despite all this, the drainage must be provided and it requires a skilled labor.

2. Drip irrigation

To keep water conservation move, we can move forward with drip irrigation. It is an efficient technique which is primarily used in hot tropical conditions .It conserves water and fertilizer .It allow water to drip slowly to the root of plants through valves, pipes, tubing etc. It is done with the help of narrow tubes which delivers water directly to the base of the plant. A study of land topography, soil, water conservation is needed to determine most suitable drip irrigation system.

Drip irrigation has many advantages; we can mention that the losses by drip irrigation and evaporation are minimized. Also, the system enables the application of water fertilizers at an optimum rate to the plant root system. Most important, the amount of water supplied to the soil is almost equal to the daily consumptive use, thus maintaining a low moisture tension in soil. Despite its efficiency, this method has an expensive price, which farmers cannot support.

3. Sprinkler irrigation

This method consists of application of water to soil in the form of spray, somewhat as rain. It is particularly useful for sandy soils because they absorb water too fast. Soils that are too shallow, too steep or rolling can be irrigated efficiently with sprinklers. In sprinkler irrigation, water is conveyed under pressure through pipes to the area to be irrigated.

It ensures uniform distribution of water and water losses are reduced to a minimum extent. Also, the amount of water can be controlled to meet the needs of crops.

But, the cost is very high. Wind interferes with the distribution pattern, reducing spread or increasing application rate near lateral pipe. Also, in case of damage the cost of operations and maintenance is very high.

III. New Proposition

Crop irrigation uses more than 70% of the world’s water, and thus, improving irrigation efficiency is important to be able to face the increasing demand for water and in the same time responding to plants need.

The best way to control irrigation system is the use of Wireless Sensors Networks (WSN) [2].The need for sensor systems in general is indispensable for improving competitiveness and for management of quality and quantity of crop. Sensors allow a periodical recording of the state (moisture, temperature, etc.) of the soil and the weather. Based on this knowledge decisions can be made automatically and on a scientific basis.

IV. Design of the proposed system

In this work, the proposed solution is the use of less power consumption and cheaper devices but still efficient enough for the system. The system is composed of three nodes to be used together.

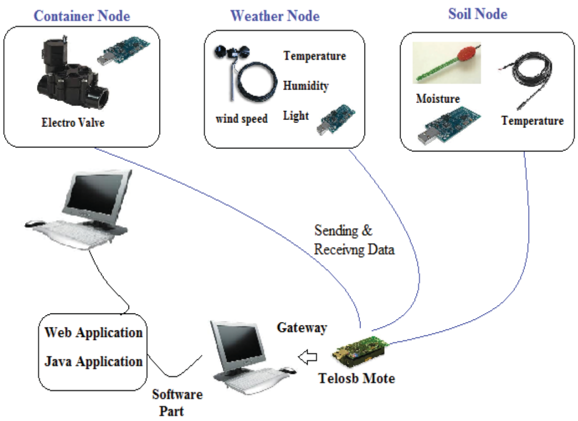

Figure1 : System Design

The system contains a node for soil, another one for weather and the last node is for the container. Each node is composed from a wireless sensors network called TelosB [3] and other additional sensors.

The system includes a Java application running on a PC that collects data from the sensor network and stores them in a MySQL[4] database. We prepared a web application for this project which is developed with PHP[5]/MySQL. So, the farmer can control his irrigation system in real time in home without going to the farm.

1. TelosB Mote

For our implementation, we used a TelosB mote which it is an ultra-low power wireless module for monitoring applications, eco-friendly product and rapid application prototyping. [6]

It is also a low power consumption device which it uses from only 2.1V to 3.6V.

Moreover, it is Zigbee compliant, small, and lightweight and when using energy saving protocols can be powered with two AA batteries for several weeks, even months. These characteristics make it ideal for our watering system as it can easily be deployed everywhere while being independent of power installations.

Figure2 : Telosb Mote

2. Base Station

A TelosB mote will be collected to the farmer computer. It will collect data from different other nodes plugged in field.

3. Soil Node

We try to measures two parameters: Soil moisture and soil temperature.

Measuring soil moisture is important to estimate the exact quantity of water needed for each plant in each field. So farmer can control water's supply properly avoiding wastes. Measuring temperature help farmer to know when he should open the water container to reduce it which is very important in hot and dry seasons.

The VH400 soil moisture sensor by Vegetronix[7] was used for soil monitoring. Because it measures the dielectric constant of the soil using transmission line techniques, it is insensitive to water salinity, and will not corrode over time. This sensor is small, rugged, and low power. Compared to other low cost sensor such as gypsum block sensors, VH400 offer a rapid response time.

Figure3: VH400 Vegetronix soil moisture sensor

For the supply voltage it needs at minimum 3.3 V which we can connect directly to the TelosB mote without any other external supply. It consists of a cable, which on one end has one prong and on the other end has 3 wires. The prongs are pushed inside the potting soil and the three wires of the other end are connected to the TelosB motes. The black wire is connected to the ADC channel pin as an output, the red wire is connected to the VCC pin and the bare wire is connected to the ground pin. We obtain voltage as an output. To have the appropriate values of soil moisture, we used the curve and the linear equation provided in the datasheet.

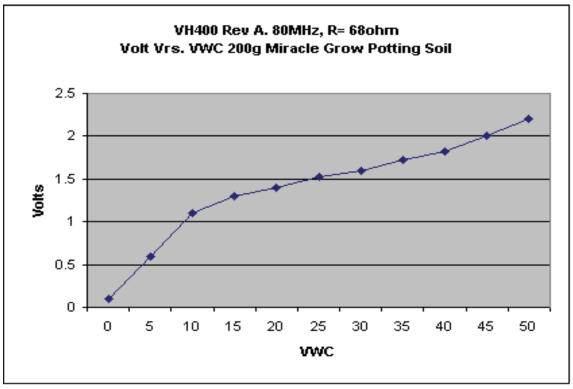

Figure4 : VH400 Rev A through Rev G VWC to Voltage curve for container with 200g of Miracle Grow Potting Soil.

For the soil temperature, we used the DS18B20. It is a digital temperature sensor by Maxim integrated. It provides 9-bit to 12-bit Celsius temperature measurements. It requires Only One Port Pin for communication. It can be powered with 3 V. It consists of three wires. The black wire is connected to the ground, the red is connected to the VCC and finally the white is connected to DAC channel pin.

Figure6:DS18B20 soil temperature sensor

The DS18B20 can be powered by an external supply on the VDD pin, or it can operate in “parasite power” mode, which allows the DS18B20 to function without a local external supply. When the DS18B20 is used in parasite power mode, the VDD pin must be connected to ground.

The DS18B20 output temperature data is calibrated in degrees centigrade. The temperature data is stored as a 16-bit sign-extended two’s complement number in the temperature register. The sign bits (S) indicate if the temperature is positive or negative: for positive numbers S = 0 and for negative numbers S = 1. If the DS18B20 is configured for 12-bit resolution, all bits in the temperature register will contain valid data. For 11-bit resolution, bit 0 is undefined. For 10-bit resolution, bits 1 and 0 are undefined, and for 9-bitresolution bits 2, 1 and 0 are undefined. Table 2 gives examples of digital output data and the corresponding temperature reading for 12-bit resolution conversions.

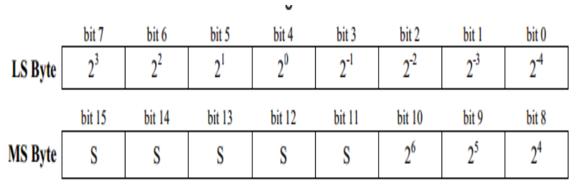

Figure5 : DS18B20 temperature register

TEMPERATURE	DIGITAL OUTPUT (Binary)	DIGITAL OUTPUT (Hex)
+125°C	0000 0111 1101 0000	07D0h
+85°C*	0000 0101 0101 0000	0550h
+25.0625°C	0000 0001 1001 0001	0191h
+10.125°C	0000 0000 1010 0010	00A2h
+0.5°C	0000 0000 0000 1000	0008h
0°C	0000 0000 0000 0000	0000h
-0.5°C	1111 1111 1111 1000	FFF8h
-10.125°C	1111 1111 0101 1110	FF5Eh
-25.0625°C	1111 1110 0110 1111	FE6Fh
-55°C	1111 1100 1001 0000	FC90h

*The power-on reset value of the temperature register is +85°C

Figure7 : Data & Temperature Relationship

4. Weather Node

This part is composed from specific TelosB mote which contain internal sensors for external weather. The mote can detect the temperature, solar radiation and air humidity. So to get more precision about weather changes that affect plant growth the mote is accomplished with a wind speed sensor. Using this sensor is helpful to detect if irrigation is good for this period or not because when the wind ‘speed is quiet high water will not persist in the soil.

For tis node we used the VORTEX[8] anemometer wind speed sensor. It is a rugged wind sensor which can handle speeds from 5 to over 125 mph. Reed switch/magnet provides one pulse per rotation.

Figure8: VORTEX wind speed sensor.

The Vortex Wind Sensor is supplied without any electronics. It includes the following major items:

- A high quality 3-cup rotor pressed on a stainless steel shaft.
- A rugged Delrin body with bronze and Rulon bushings.
- A flat aluminum mounting bracket with 2 holes.
- Reed switch and magnet providing one pulse per rotation.

The VORTEX sensor output is pulses, so we need to convert them to get the wind speed. The conversion is easy to make using the presented formula on the datasheet.

2.5 mph per Hz (1 Hz = 1 pulse/second)

5. Container Node

This part is the most important one in our system. It contains a TelosB mote with an actuator which will be used to open or close the water container in need. [9]

The container we have chosen is the CP/CPF Series from the Rain Bird Company. It a low power consumption device and it is powered with 24V for 50/60 Hz. So we need to use with it a relay to connect to the TelosB mote because this mote support 6V maximum. The relay is used for switching the amount of power with a small operating power.

Figure9: CP/CPF series actuator from the Rain Bird Company

The actuator offers superior performance in harsh water environments and has a reliable, non-clogging design. Its reverse Flow design reduces stress on diaphragm for dependable operation. Also it works with any standard sprinkler timer. The most important characteristics are energy efficient and low power encapsulated solenoid with captured plunger.

V. Evaluation

The hardware configuration of a telosb mote is shown in Table 1.

Table 1. Telosb specifications

Module	Specifications
Processor Performance	8 MHz TI MSP430 microcontroller, 16-bit RISC
Program Flash Memory	48 Kbytes
Measurement Serial Flash	1024 Kbytes
RAM	10 Kbytes
Configuration EEPROM	16 Kbytes
Serial Communications	UART
Analog to Digital Converter	12 bit ADC
Digital to Analog Converter	12 bit DAC
Other Interfaces	Digital I/O,I2C,SPI
Current Draw in Active and Sleep mode respectively.	1.8 mA, 5.1 μA
RF Transceiver	
Frequency band	2400 MHz to 2483.5 MHz
Transmit (TX) data rate	250 kbps

We used four types of nodes:

- one node contains the code of the base station ; which will collect data from other nodes,
- second node contains the code of soil node which will calculate the soil temperature and soil moisture values data,
- third node contains the code of the weather node which will send the weather parameters,
- The last node is used to activate or not the actuator depending on all collected data from previous nodes.

The program is written in nesC language in order to be supported by the tinyOS operating system.[10]

VI. Conclusion

This design uses a timed feedback control to measure the soil moisture and turn on the valve on demand, in regular intervals.

The design is still in a prototype stage. More tests need to be conducted before the efficiency, durability, and reliability can be demonstrated. Additionally, many improvements can be made to make the system more versatile, customizable, and user-friendly.

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