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Prototype for Effective Utilization of Available Well Water Resource to Irrigate Multiple Agriculture Fields Effectively

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Abstract

Agriculture is one of the main sources of income in rural India. Farmers use their lands for cultivating different types of crops and the availability of water for irrigation is one of major factor that influence agriculture productivity. Fluctuates between surplus and almost no water depends entirely on the various monsoons that occur every year. Hence it is imperative to use water resources diligently and effectively. Well water is one of the main sources for irrigation and majority of agriculture fields in India are irrigated using it. Now the problem involved in using well water in about monitoring the flow of water from the well to fields. Huge quantity of well water is wasted due to the lack of availability of technology which measures the flow of water into the fields. In this work, we propose a wireless sensor networks prototype for effective utilization of well water for the irrigation. WSNs provide promising solution in the automation of irrigation process. Floating sensor is used in the prototype to sense the water level in the tank and soil moisture is monitored field condition. The prototypes automate the irrigation process by considering both water levels in tank and moisture requirement in fields. Experiments are carried out using three soil filled trays having different moisture level. Sensor is inserted into the field to measure moisture level. Motor is used to pump the water from water tank to field through water pipes. The system open/close water pipe vales by considering soil moisture in field. Motor is switch on/off by considering waters level in tank. System is experimented using 13 different scenarios and the results show that the proposed prototype is suitable for effective utilization of well water resources based on field conditions.

Keywords: Advanced RISC Machine (ARM), Wireless Sensor Networks (WSN), Global System for Mobile Communication (GSM), General Packet Radio Services (GPRS), Internet of Things (IOT).

INTRODUCTION

Well water is one of the main sources for irrigation in Tamil Nadu. Normally, a single well water resource is used to irrigate multiple agriculture fields. Farmers visit irrigation fields regularly to check well water level and field's moisture conditions. Based on availability of well water, water pumping motor is switched on to irrigate field with less moisture level. Farmer needs to wait until sufficient water flows in the respective field. This process is repeated until all the fields are irrigated.

Irrigation using WSNs made farmers work easy and their physical presence in field is not mandatory to perform irrigation process. Micro controllers are coded to control opening and closing of sinusoidal valve, switching on and off or irrigation motor. This is done based on water availability and field soil moisture requirement. Irrigation using WSNs helps in utilizing available well water resources to irrigate multiple agriculture fields effectively.

WSNs prototype for automatic controlling and remote accessing of irrigation motor is developed. The prototype sense soil moisture in the field and sends it to user mobile phone. Commands are sent from registered mobile phone to switch on/off irrigation motor. Many existing system considers water in well is always available. But in real time this may not be possible. In summer, water in well may dry out in middle of irrigation process. Therefore we need a wireless sensor network for effective utilization of well water to irrigate e agriculture fields effectively. Irrigation motor is switched off when well water is low. Again, the irrigation motor will be switched on, when natural springs releases sufficient water in well. This process repeats until all fields get irrigated.

LITERATURE REVIEW

Joaquin Gutierrez, et al., (2014) developed an automated irrigation system to optimize water usage in agriculture. In the system, soil-moistures and temperature sensors are placed in the root zone of the plants. Algorithm with temperature and soil moisture threshold values was programmed in microcontroller to control water flow. The algorithm first, identifies least significant byte in received packet. Second, soil moisture and temperature values are compared with programmed threshold values to activate irrigation pum. Third, algorithm records log data in memory and transfers it to a web server through GPRS module. Proposed system was tested in sage crop field and remarkable water savings is achieved compared to traditional irrigation practices. Results show that the proposed system has potential to be useful in water limited geographical areas. Limitation of the proposed system is that the availability of water is not taken into consideration in the irrigation process.

Similarly Jaichandran R, et al., (2013) and Ramya T, et al., (2015) also proposed automated irrigation system for switching on and off of irrigation motor based on field soil moisture condition, but the limitations of this system is that the water availability in an important parameter which is not taken into consideration.

Sukrithi et al., (2016) proposed a system for remote monitoring of water level in the tank using mobile phone and internet. Ultra sonic sensors are used to measure water level inside tank. Floating pad is mounted on the water in the tank and the ultra sonic sensor detects the distance of floating pad from the top of the tank and this is used to identify the availability of water in tank. Soil moisture sensor measures moisture in soil using two probes that acts as a resistor. The mobile phone is used to shut the water supply to irrigation field remotely. Switching on/off of motor has been automated. Proposed system can be installed to monitor moisture content of the soil continuously. Sprinklers are turned on automatically, when moisture of the soil goes below threshold level. The user can monitor irrigated process remotely using mobile application, without visiting the field. Proposed systems would make the farmers work extensively simple. Limitation of the proposed system is that the multiple fields are not taken into consideration.

Reshma S, et al., (2016) proposed automation in irrigation system using WSN and IOT. Major prototype used in the prototype includes: soil moisture sensor, temperature sensor, water level sensor, and relay, GSM, and GPRS module. Soil moisture sensors and temperature sensors are used in monitoring field condition and the data are sent to microcontroller. Water availability details are sensed by water level sensor and the details are sent to microcontroller. Sensed data send to user mobile phone and web site using GSM and GPRS module. Based on analysis, microcontroller sends signal to relay for switching on/off of motor. Limitation of this system is that the proposed system is experimented by considering only one field. But in real time, there may one than one field need to be irrigated using a single water source.

Shika et al., (2016) proposed automated irrigation system using three sensor nodes. Irrigation process is automated using the soil moisture values send from senor nodes. Mobile phones are used as remote control. Graphical user interfaces and databases for the prototype is developed using matlab and mysql.

This section reviews various WSNs model proposed for effective utilization of water resources in agriculture. In many WSNs models, sensors are used to measure soil moisture in field. Irrigation motor is controlled by microcontroller based on field soil moisture value. Mobile phones are used for information accessing and remote controlling. Limitations of many existing system is that Irrigation motor is switched on when soil moisture in field is low but availability of water in well is not taken into consideration. Due to this, irrigation motor may switch on even when sufficient water is not available in well particularly during summer season this may drain motor. Recently, WSNs models automated irrigation process by considering field soil moisture requirement and water availability. Such systems effectively utilize available water for irrigating multiple agriculture fields.

METHODOLOGY

Figure 1 illustrates methodology of the proposed prototype, in which floating sensor (FS) senses water level in water source and sends it to controller node for decision making. When water in well is below FS than the water status of the microcontroller is updated as “LOW” else as “SUFFICIENT”. Similarly soil moisture sensor senses soil moisture in field 1 (F1), field 2 (F2), and field 3 (F3) and sends it to microcontroller to for decision making. Each field soil moisture status is updated as either DRY//WET based on soil moisture sensor value from the field. “SWITCHING ON” or “SWITCHING OFF” of irrigation motor and “OPENING” or “CLOSING” of sinusoidal water pipe valves (V1, V2, V3) are controller by microcontroller based on values of soil moisture sensor and floating sensor. When the soil moisture value of the field is “DRY” and water status is “SUFFICIENT” then the irrigation motor will be “SWITCHED ON” and the corresponding sinusoidal water pipe vale will be “OPENED” to facilitate irrigation process. When soil moisture in the field reaches “NORMAL” or “HIGH” then irrigation motor will be “SWITCHED OFF” and the corresponding sinusoidal water pipe valve of the field will be “CLOSED”. During irrigation process, when water level reaches “LOW” then irrigation motor will “SWITCED OFF” and waits till water level reaches “SUFFICIENT” before switching on irrigation motor.

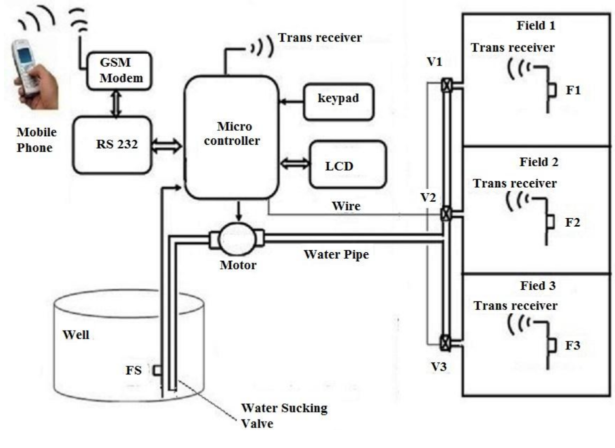

Figure 1: Methodology

Tables 1 illustrate the test cases of the prototype and are stated as follows.

Case1: water in well is sufficient and soil moisture in field1 (F1) field 2 (F2), and field 3(F3) is dry.

Case 2: water in well is sufficient and soil moisture in F1, F2 is dry and F3 is wet.

Case 3: water in well is sufficient and soil moisture in F1, F3 is dry and F2 is wet.

Case 4: water in well is sufficient and soil moisture in F1 is dry and F2 and F3 is wet.

Case 5: water in well is sufficient and soil moisture in F1 is wet and F2, F3 are dry

Case 6: water in well is sufficient and soil moisture in F1 and F3 are wet and F2 is dry.

Case 7: water in well is sufficient and soil moisture in F1 and F2 are wet and F3 is dry.

Case 8: water in well is sufficient and soil moisture in F1, F2 and F3.

Case 9: water in well is low and soil moisture in F1, F2 and F3 is dry.

Case 10: water in well is low and soil moisture in F1 is wet and F2, F3 is dry.

Case 11: water in well is low and soil moisture in F1, F3 is dry and F2 is wet.

Case 12: water in well is low and soil moisture in F1, F2 is dry and F3 is wet.

Case 13: water in well is low and soil moisture in F1, F2, and F3 is wet.

Soil moisture sensors in the fields send its output state as 1 to microcontroller if the corresponding field is wet else as 0. Floating sensor in well send its output state as 1 to microcontroller if the water in the well is sufficient else 0. Now based on the output put state of soil moisture sensors and floating sensor the microcontroller decides the states for the motor and sinusoidal valves. 1 is on state for the motor and 0 is off state for the motor. 1 is the open state sinusoidal valve and 0 is the closed state for sinusoidal valve. Table 1 illustrates various states for motor and sinusoidal vales (V1, V2, and V3) based on the states of floating sensor in well and soil moisture sensor in fields (F1, F2, and F3). In case 1, all the three fields are dry and require water for irrigation; therefore 3 flags (f1, f2, and f3-one flag for each field) are used. Initially all fields are dry therefore f1, f2, and f3 set to 0. On irrigation of each field its corresponding flag will be updated as 1.

Table 1: Test cases of Prototype

Cases	**FS State**	**Sensor State in Fields**			**Irrigation Motor state**	**Flag**			**Sinusoidal Valve state**		
		F1	**F2**	**F3**		**f1**	**f2**	**f3**	**V1**	**V2**	**V3**
1		0	0	0		0	0	0	1	0	0
						1	0	0	0	1	0
						1	1	0	0	0	1
						1	1	1	0	0	0
2		0	0	1					1	0	0
3	1	0	1	0	1				1	0	0
4		0	1	1					1	0	0
5		1	0	0					0	1	0
6		1	0	1					0	1	0
7		1	1	0					0	0	1
8		1	1	1					0	0	0
9		0	0	0					0	0	0
10	0	1	0	0					0	0	0
11		0	1	0	0				0	0	0
12		0	0	1					0	0	0
13		1	1	1					0	0	0

IMPLEMENTATION

Prototype is implemented using following tools specified as follows.

1) ARM LPC 2148 microcontrollers used to develop WSNs prototype have the following features: 512 KB flash memory, 40 KB static RAM, 60 MHz clock speed, power saving modes.
2) Soil moisture sensor is used for the measurement of soil moisture. It consists of two probes which act as a variable resistor. If more water is present in the soil, the conductivity between the pads increases and results in lower resistance. It is used in connection with controlling board consist mainly a buzzer module, comparator and digital and analog output ports.
3) Floating sensor detects water level in tank. These sensors have a permanent magnet in the float. When water in the tank raises to a threshold level the sensor get activate and sends control signal to the microcontroller for activating Irrigation motor switch.

4) Sinusoidal water pipe valve is used to control the flow of water. Opening and closing of the vale is controlled by the microcontroller.
5) Twenty five liter water tank is used as water source. Floating sensor and water sucking valve is fitted inside the cane.
6) Wireless transceivers used in WSNs prototype has following features: communication range is 100 meters in indoor urban environment and up to 1 mile in outdoor line of sight environment, and data rate is 250 kbps.
7) GSM module is used in prototype to send sensed data user to mobile phone.
8) keil micro (µ) vision development environment is used to program ARM microcontrollers using embedded C programming.
9) Philips LPC 2000 flash utility is used to flash program on-chip memory.
10) XCTU software is used to program, configure, and test XBee wireless Trans receivers. Terminal window in X-CTU displays ASCII and hexadecimal characters of transmitted data.

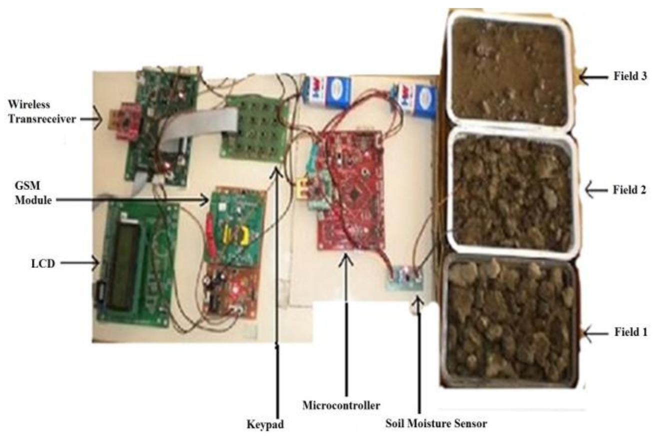

Figure 2 (a): Prototype for Monitoring Field Soil Moisture

Figure 2 (a) illustrates irrigation fields with different moisture condition using three trays. Tray 1 represents field 1 (Dry soil), tray 2 represents field 2 (soil with normal moisture), tray 3 field 3 (soil with high moisture). Sensors are inserted into the fields to measure soil moisture and their status is updated in microcontroller.

Figure 2 (b) illustrates controlling of water resource using 25 liter water tank. In the water tank floating sensor is fixed to measure water level. Water pipe is connected with water tank and water pumping motor is used to pump water from tank to the pipe. Water pipe has three sinusoidal valves. Each valve is allocated to one field (i.e., valve 1 is assigned to field 1, valve 2 is assigned to field 2, and valve 3 is assigned to field 3). Opening and closing of each valve is controlled by microcontroller based on the values from field and water tank.

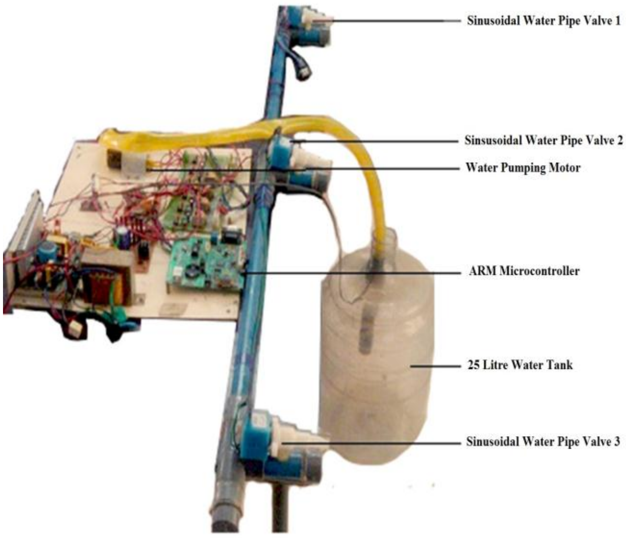

Figure 2 (b): Prototype for Controlling Water Source

RESULTS AND DISCUSSION

Experiments are conducted for the 13 cases in table 1 and the results are discussed as follows.

Case 1: water level is sufficient and all the three fields are dry and require water, hence valve associated with each field is opened using flags and are described as follows.

a. All three fields (F1, F2, and F3) are dry and f1, f2, f3 values are 0. V1 is opened and the irrigation motor is switched on and water flows to field 1.
b. F1 is wet and F2 and F3 are dry, therefore f1 is updated to 1 and f2, f3 remains to 0. V2 is opened and irrigation motor is switched on and water flows to field 2.
c. F1 and F2 are wet and F3 is dry, therefore f1 and f2 are updated as 1 and f3 remain to 0. V3 is opened and irrigation motor is switched on and water flows to field 3.
d. F1, F2, and F3 are wet; therefore f1, f2, and f3 are updated as 1. All valves are closed and irrigation motor is in off state.

Case 2: water level is sufficient, F1, F2 are dry and F3 is wet. V1 is opened and irrigation motor is switched on and water flows to field 1.

Case 3: water level is sufficient, F1, F3 are dry and F2 is wet. V1 is opened and irrigation motor is switched on and water flows to field 1.

Case 4: water level is sufficient, F1 is dry and F2, F3 is wet. V1 is opened and irrigation motor is switched on and water flows to field 1.

Case 5: water level is sufficient, F1 is wet and F2, F3 is dry. V2 is opened and irrigation motor is switched on and water flows to field 2.

Case 6: water level is sufficient, F1, F3 is wet and F2 is dry.V2 is opened and irrigation motor is switched on and water flows to field 2.

Case 7: water level is sufficient, F1, F2 is wet and F3 is dry. V3 is opened and irrigation motor is switched on and water flows to field 3.

Case 8: water level is sufficient, F1, F2, and F3 is wet. All valves are closed and irrigation motor is in off state.

Case 9 to 12: when water level is low, irrigation motor is in off state irrespective of field states.

CONCLUSION

A WSNs prototype is developed for effective utilization of available well water resources to irrigate agriculture fields effectively. The prototype is experimented using 3 trays filled with soil with different moisture level and soil moisture sensors inserted in it. Three sinusoidal water pipe valves are used to irrigate the trays. Each valve is allocated to one field (i.e., valve 1 is assigned to field 1, valve 2 is assigned to field 2, and valve 3 is assigned to field 3). 25 liter water tank is used as water source. Motor is used to pump the water from water tank to field through water pipe. The system open/close water pipe vales by considering soil moisture in field. Motor is switch on/off by considering waters level in tank. System is experimented under various scenario and the results show that the proposed prototype is suitable for effective utilization of water resources based on field conditions.

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