A Novel for Unmaned Irrigation Based on WSN Architecture

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Abstract

In this project an embedded system is proposed for automatic control of irrigation. This project has wireless sensor network (moisture sensor, PH sensor, PIR sensor, Temperature sensor) for real-time sensing and control of an irrigation system.This system provides uniformand required level of water for the agricultural farm and it avoids water wastage.At the same time, the pest and diseases have increased and insects cause major kinds of damage to growing crops. It directs injury to the plant, which eats leaves or fruit, or roots. Most vegetable crops are subject to pest damage.So protection from insect attack to the crop is essential for better production.

1. Introduction

In this project, a lot of water is saved from being wasted. A wireless sensor network (WSN) is used for a temperature measurement and humidity measurement then send to the 8051 microcontroller.

The irrigation system is used only when there is not sufficient moisture in the soil and the microcontroller decides when the pump should be turned on/off and in turn saves a lot time and water for the farmers. Our project is based on embedded system. An embedded system is nothing but some combination of computer hardware and software, either fixed in capability or programmable, that is specifically designed for a particular kind of application device.

The Microcontroller based automated irrigation system consists of moisture sensors, analog to digital converter, microcontroller, relay driver, solenoid valve, solar panel and a battery. This system can be used in the areas where electrical power is difficult to obtain. The development of WSNs based on microcontrollers and communication technologies can improve the current methods of monitoring to support the response appropriately in real time for a wide range of applications. The system proposes Remote Monitoring and control Systems based on GSM. GSM network is a medium for transmitting the remote signal and communication takes place between monitoring centre and remote monitoring station. The central monitoring station performs real time control, alarm and data processing and also manages database.

2. Proposed System

To overcome the drawbacks of existing system like high cost, difficult in maintenance and more wired connection. We introduce a new system which will have wireless connection between transmitter and receiver. We introduce a new design of embedded web server making use of GSM network technology in paper. Compared to wired link web server system, this system is characterized by having no wires between the transmitter and receiver. These systems have lower cost and having more flexibility of the GSM.

In proposed system, the system consists of moisture level sensors, 8051 microcontroller, relays and insect avoidance kit. At the field station, the sensors which are buried inside the soil send the signal to the microcontroller. The microcontroller converts the analog signal to digital values. This value is compared with a value representing the minimum allowable value below this minimum value, a signal is sent to turn on the corresponding Relay to allow water flow into the farm and vice-versa. This is helpful to carried out the irrigation whenever required as well as to save energy and well crops health. Every procedure in scheduling is controlled by the program inside the microcontroller.

3. Block Diagram

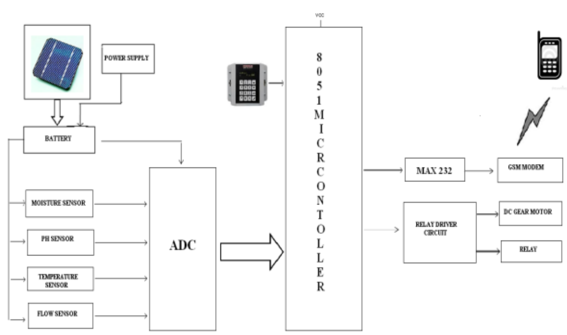

FIG 2.1

Moisture Sensor

It measures the water content in soil. The dielectric constant can be thought of as the soil's ability to transmit electricity. The dielectric constant of soil increases as the water content of the soil increases. This response is due to the fact that the dielectric constant of water is much larger than the other soil components, including air. Thus, measurement of the dielectric constant gives a predictable estimation of water content.

Temperature Sensor

This are specially designed to measure the hotness or coolness of an object. Temperature sensor is a device which senses variations in temperature across it. LM35 is a basic temperature sensor that can be used for experimental purpose. It give the readings in centigrade (degree Celsius)

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since its output voltage is linearly proportional to temperature. It uses the fact that as temperature increases, the voltage across diode increases at known rate (actually the drop across base-emitter junction of transistor).

Flow Sensor

A flow sensor is a device for sensing the rate of fluid flow. Flow measurement is the quantification of bulk fluid movement. Flow can be measured in a variety of ways. Positive-displacement flow meters accumulate a fixed volume of fluid and then count the number of times the volume is filled to measure flow. Other flow measurement methods rely on forces produced by the flowing stream as it overcomes a known constriction, to indirectly calculate flow. Flow may be measured by measuring the velocity of fluid over a known area.

ADC

An analog-to-digital converter (ADC, A/D, or A to D) is a device that converts a continuous physical quantity (usually voltage) to a digital number that represents the quantity's amplitude. The analog signal is not processed in microcontroller so it converted into digital form. It converts an input analog voltage or current to a digital number proportional to the magnitude of the voltage or current.

8051 Microcontroller

8051 is an 8-bit family of microcontroller developed by Intel in the year 1981. This is one of the most popular family of microcontroller being used all across the world. This microcontroller was also referred as “system on a chip” because it has 128 bytes of RAM, 4Kbytes of ROM, 2 Timers, 1 Serial port, and four ports on a single chip. The CPU can work for only 8bits of data at a time because 8051 is an 8-bit processor. In case the data is larger than 8 bits then it has to be broken into parts so that the CPU can process conveniently. Most manufacturers have put 4Kbytes of ROM even though the quantity of ROM can be exceeded up to 64 K bytes.

MAX 232

The MAX232 is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals. The drivers provide RS-232 voltage level outputs (approx. ± 7.5 V) from a single + 5 V supply via on-chip charge pumps and external capacitors.

GSM Modem

A GSM modem is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone.When a GSM modem is connected to a computer, this allows the computer to use the GSM modem to communicate over the mobile network. While these GSM modems are most frequently used to provide mobile internet connectivity, many of them can also be used for sending and receiving SMS and MMS messages.

Commands

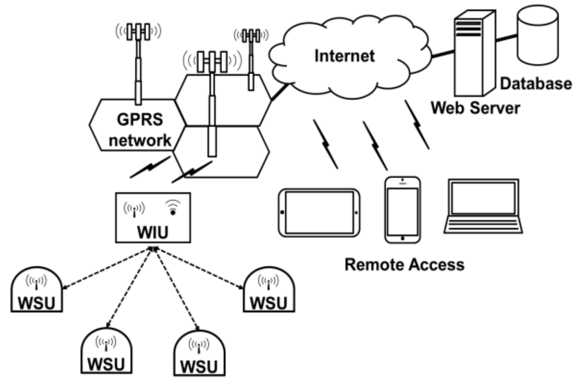
Command	Description
ATD+17637853600	Initiate Call
ATA	Answer to this incoming call
ATH	Disconnect call

Relay

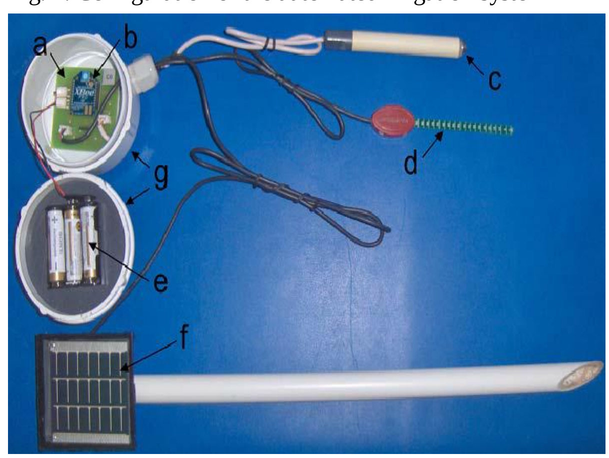
Relays are electromechanical devices that use an electromagnet to operate a pair of movable contacts from an open position to a closed position. The advantage of relays is that it takes a relatively small amount of power to operate the relay coil, but the relay itself can be used to control motors, heaters, lamps or AC circuits which themselves can draw a lot more electrical power.

Automated Irrigation System

The automated irrigation system hereby reported, consisted of two components



Wireless sensor units (WSUs) and a wireless information unit (WIU), linked by radio transceivers that allowed the transfer of soil moisture and temperature data, implementing a WSN that uses ZigBee technology. The WIU has also a GPRS module to transmit the data to a web
Fig. 1. Configuration of the automated irrigation system



WSUs and a WIU, based on microcontroller, ZigBee, and GPRS technologies and WSU
(a) Electronic component PCB
(b) Radio modem ZigBee
(c) Temperature sensor
(d) Moisture sensor
(e) Rechargeable batteries
(f) Photovoltaic cell
(g) Polyvinyl chloride container.

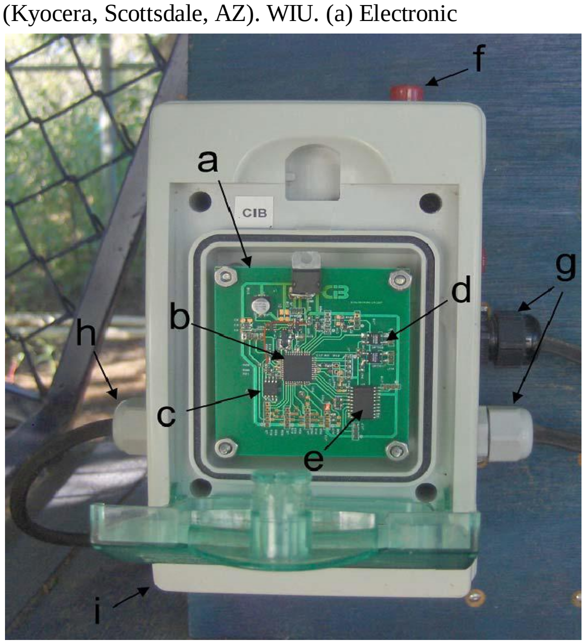
Server via the public mobile network. The information can be remotely monitored online through a graphical application through Internet access devices.

A. Wireless Sensor Unit

A WSU is comprised of a RF transceiver, sensors, a microcontroller, and power sources. Several WSUs can be deployed in-field to configure a distributed sensor network for the automated irrigation system. Each unit is based on the microcontroller 8051 (Microchip Technologies, Chandler, AZ) that controls the radio modem XBeePro S2 (Digi International, Eden Prairie, MN) and processes information from the soil-moisture sensor VH400 (Vegetronix, Sandy, UT), and the temperature sensor DS1822 (Maxim Integrated, San Jose, CA). These components are powered by rechargeable AA 2000-mAh Ni-MH Cycle Energy batteries (SONY, Australia). The charge is maintained by a photovoltaic panel MPT4.8-75 (Power Film Solar, Ames, IN) to achieve full energy autonomy. The microcontroller, radio modem, rechargeable batteries, and electronic components were encapsulated in a waterproof Polyvinyl chloride (PVC) container. These components were selected to minimize the power consumption for the proposed application.

B. Wireless Information Unit

The soil moisture and temperature data from each WSU are received, identified, recorded, and analyzed in the WIU. The WIU consists of a master microcontroller 8051 ,an XBee radio modem, a GPRS module MTSMC-G2-SP (Multi Tech Systems, Mounds View, MN), an RS-232 interfaceMAX3235E (Maxim Integrated, San Jose, CA), two electronic relays, two 12 V dc 1100 GPH Livewell pumps (Rule-Industries, Gloucester, MA) for driving the water of the tanks, and a deep cycle 12 V at 100-Ah rechargeable batteryL-24M/DC-140 (LTH, Mexico), which is recharged by a solar panel KC130TM of 12 V at 130 W (Kyocera, Scottsdale, AZ). WIU. (a) Electronic



through a PWM charge controller SCI-120.

All the WIU electronic components were encapsulated in waterproof PVC box. The WIU can be located up to 1500-m line-of-sight from the WSUs placed in the field.

1) **Master Microcontroller:** The functionality of the WIU is based on the microcontroller, which is programmed to perform diverse tasks. The first task of the program is to download from a web server the date and time through the GPRS module. The WIU is ready to transmit via XBee the date and time for each WSU once powered. Then, the microcontroller receives the information package transmitted by each WSU that conform the WSN. These data are processed by the algorithm that first identifies the least significant byte of a unique 64-bit address encapsulated in the package received. Second, the soil moisture and temperature data are compared with programmed values of minimum soil moisture and maximum soil temperature to activate the irrigation pumps for a desired period. Third, the algorithm also records a log file with the data in a solid state memory 24FC1025 (Microchip Technologies, Chandler, AZ) with a capacity of 128 kB. Each log is 12-B long, including soil moisture and temperature, the battery voltage, the WSU ID, the date, and time generated by the internal RTCC. If irrigation is provided, the program also stores a register with the duration of irrigation, the date, and time. Finally, these data and a greenhouse ID are also transmitted.

2) GPRS Module: The MTSMC-G2-SP is a cellular modem embedded in a 64-pins universal socket that offers standards based quad-band GSM/GPRS Class 10 performance. This GPRS modem includes an embedded transmission control protocol/Internet protocol stack to bring Internet connectivity, a UFL antenna connector and subscriber identity module (SIM) socket. The module is capable of transfer speeds up to 115.2 K b/s and can be interfaced directly to a UAR Tor microcontroller using AT commands. It also includes an onboard LED to display network status. The GPRS was powered to 5 V regulated by UA7805 (Texas Instruments, Dallas, TX) and operated at 9600 Bd through a serial port of the master microcontroller and connected to a PCB antenna. The power consumption is 0.56 W at 5 V.

In each connection, the microcontroller sends AT commands to the GPRS module; it inquires the received signal strength indication, which must be greater than −89 dBm to guarantee a good connection. In addition, it establishes the communication with the URL of the web server to upload and download data. If the received signal strength is poor, then all data are stored into the solid-state memory of the WIU and the system try to establish the connection each hour.

3) **Watering Module:** The irrigation is performed by controlling the two pumps through 40-A electromagnetic relays connected with the microcontroller via two optical (Clare, Beverly. MA). The pumps have a power consumption of 48 W each and were fed by a 5000-l water tank. Four different irrigation actions (IA) are implemented in the WIU algorithm:

1. Fixed duration for manual irrigation with the push button.
2. Scheduled date and time irrigations through the web page for any desired time.
3. Automated irrigation with a fixed duration, if at least one soil moisture sensor value of the WSN drops below the programmed threshold level.

4. Automated irrigation with a fixed duration, if at least one soil temperature sensor value of the WSN exceeds the Programmed threshold level.

4. Irrigation System Operation

The WSU-57 unit was used measure the soil moisture and temperature in the area (bed 23) where the traditional irrigation practices were employed. The other three units (WSU-54, 55, and 56) were located in beds 1, 2, and 12 to operate the automated irrigation system with their corresponding soil moisture and temperature sensors situated at a depth of 10 cm. Gathered data of the WSUs, in the web application of the automated irrigation system: soil temperatures, soil moisture, and water supplied (vertical bars indicate automated and scheduled irrigation). In the root zone of the plants. These three units allowed data redundancy to ensure irrigation control. The algorithm considered the values from the WSU-54, 55, and 56, if one reached the threshold values the automated irrigation was performed. The pumping rate provided 10 ml/min/drip hole, which was measured in the automated irrigation zone in six different drip holes. In accordance with the organic producer's experience, a minimum value of 5% VWC for the soil was established as the moisture threshold level and 30 °C as the temperature threshold level for the automated irrigation modes (IA-3 andIA-4, respectively). Initially, the scheduled irrigation (IA-2) of 35 min/week was used during the first six weeks. A fterthat, the scheduled irrigation was set at 35 min three times per week. Sage cultivation finalized after 136 days. During the cultivation, several automated irrigation periods were carried out by the system because of the soil-moisture (IA-3) or temperature (IA-4) levels, regardless of the scheduled irrigation (IA-2). All data were uploaded each hour to the web server for remote supervision. The vertical bars indicate automated irrigation periods triggered by temperature when soil temperature was above the threshold value (30 °C). When the temperature was above 30 °C, the irrigation system was activated for 5 min according to IA-4, whereas the soil moisture remained above the threshold level.

5. Conclusion

The automated irrigation system implemented was found to be feasible and cost effective for optimizing water resources for agricultural production. This irrigation system allows cultivation in places with water scarcity thereby improving sustainability. The automated irrigation system developed proves that the use of water can be diminished for a given amount of fresh biomass production. The use of solar power in this irrigation system is pertinent and significantly important for organic crops and other agricultural products that are geographically isolated, where the investment in electric power supply would be expensive. The irrigation system can be adjusted to a variety of specific crop needs and requires minimum maintenance. The modular configuration of the automated irrigation system allows it to be scaled up for larger greenhouses or open fields. In addition, other applications such as temperature monitoring in compost production can be easily implemented. The Internet controlled duplex communication system provides a powerful decisionmakingdevice concept for adaptation to several cultivation scenarios. Furthermore, the Internet link allows the supervision through mobile telecommunication devices, such as a smartphone. esides the monetary savings in water use, the importance of the preservation of this natural resource justify the use of this kind of irrigation systems.

References

[1] X. Wang, W. Yang, A. Wheaton, N. Cooley, B. Moran, Efficient registration of optical and IR images for automatic plant water stress assessment, Comput. Electron. Agricult., 74(2), 2010, 230–237

[2] Y. Erdem, L. Arin, T. Erdem, S. Polat, M. Deveci, H. Okursoy, H. T. Gültas, Crop water stress index for assessing irrigation scheduling of drip irrigated broccoli (Brassica oleracea L. var. italica), A gricult Water Manag., 98(1), 2010, 148–156

[3] S. A. O'Shaughnessy, S. R. Evett, Canopy temperature based system effectively schedules and controls center pivot irrigation of cotton, Agricult. Water Manag., 97(9), 2010, 1310–1316

[4] S. L. Davis, M. D. Dukes, Irrigation scheduling performance by evapotranspiration-based controllers, Agricult. Water Manag., 98(1), 2010, 19–28

[5] J. M. Blonquist, Jr., S. B. Jones, D. A. Robinson, Precise irrigation scheduling for turf grass using a subsurface electromagnetic soil moisturesensor, Agricult. Water Manag., 84(1–2), 2006, 153–165

[6] O. M. Grant, M. J. Davies, H. Longbottom, C. J. Atkinson, Irrigation scheduling and irrigation systems: Optimising irrigation efficiency for container ornamental shrubs, Irrigation Sci., 27(2), 2009, 139–153

[7] Y. Kim, R. G. Evans, W. M. Iversen, Remote sensing and control of an irrigation system using a distributed wireless sensor network, IEEE Trans. Instrum. Meas., 57(7), 2008, 1379–1387

[8] Y. Kim, R. G. Evans, Software design for wireless sensor-basedsite-specific irrigation," Comput. Electron. Agricult., 66(2), 2009, 159–165

[9] D. K. Fisher, H. A. Kebede, A low-cost microcontroller-based system to monitor crop temperature and water status, Comput. Electron. Agricult., 74(1), 2010, 168–173

[10] Y. Kim, J. D. Jabro, R. G. Evans, Wireless lysimeters for realtimeonline soil water monitoring, Irrigation Sci., 29(5), 2011, 423–430
[11] O. Mirabella, M. Brischetto, A hybrid wired/wireless networking infrastructure for greenhouse management, IEEE Trans. Instrum. Meas., 60(2), 2011, 398–407
[12] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, E. Cayirci, A survey on sensor networks, IEEE Commun. Mag., 40(8), 104–112, 2002
[13] J. Yick, B. Mukherjee, D. Ghosal, Wireless sensor network survey,"Comput. Netw., 52(12), 2008, 2292–2330
[14] M. Winkler, K.-D. Tuchs, K. Hughes, G. Barclay, Theoretical and practical aspects of military wireless sensor networks, J. Telecommun. Inf. Technol., 2, 2008, 37–45
[15] M. P. Durisic, Z. Tafa, G. Dimic, V. Milutinovic, A survey of military applications of wireless sensor networks, MECO, 2012, 196–199
[16] M. C. Rodríguez-Sánchez, S. Borromeo, J. A. Hernández-Tamames, Wireless sensor networks for conservation and monitoring culturalassets, IEEE Sensors J., 11(6), 2011, 1382–1389
[17] G. López, V. Custodio, J. I. Moreno, LOBIN: E-textile and wireless-sensor-network-based platform for healthcare monitoring infuture hospital environments, IEEE Trans. Inf. Technol. Biomed. 14(6), 2010, 1446–1458
[18] J. M. Corchado, J. Bajo, D. I. Tapia, A. Abraham, Using heterogeneous wireless sensor networks in a telemonitoring system for healthcare, IEEE Trans. Inf. Technol. Biomed., 14(2), 2010, 234–240
[19] G. X. Lee, K. S. Low, T. Taher, Unrestrained measurement of arm motion based on a wearable wireless sensor network, IEEE Trans. Instrum. Meas., 59(5), 2010, 1309–1317
[20] D.-M. Han, J.-H. Lim, Smart home energy management system using IEEE 802.15.4 and ZigBee, IEEE Trans. Consum. Electron., 56(3), 2010, 1403–1410
[21] C. Gomez, J. Paradells, Wireless home automation networks: A survey of architectures and technologies," IEEE Commun. Mag., 48(6), 2010, 92–101
[22] M. Bertocco, G. Gamba, A. Sona, S. Vitturi, Experimental characterization of wireless sensor networks for industrial applications, IEEE Trans. Instrum. Meas., 57(8), 2008, 1537–1546
[23] V. C. Gungor, G. P. Hancke, Industrial wireless sensor networks: Challenges, design principles, and technical approaches, IEEE Trans. Ind. Electron., 56(10), 2009, 4258–4265
[24] L. Hou, N. W. Bergmann, Novel industrial wireless sensor networks for machine condition monitoring and fault diagnosis, IEEE Trans. Instrum. Meas., 61(10), , 2012, 2787–2798
[25] P. Mariño, F. P. Fontan, M. A. Dominguez, S. Otero, An experimental ad-hoc WSN for the instrumentation of biological models, IEEE Trans. In strum. Meas., 59(11), 2010, 2936–2948