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Research Paper

WIRELESS SENSOR NETWORK UTILITY IN AGRICULTURAL RESOURCE MANAGEMENT THROUGH EMBEDDED SYSTEM

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ABSTRACT

Focus of recent advance technology is on maximum utilization of agricultural resources to improve the quality of the crop. Recommended doses of fertilizers for particular crop vary with time and environmental condition. Delivery of the water and fertilizer resources must be controlled efficiently according to meteorological parameters in order to improve product quality and production of the crop. Traditional drip irrigation can be integrated with water soluble fertilizers maintaining proper fertilizer-water-plant relationship. In this proposed Distributed Embedded System, selection of fertilizer, control of fertilizer doses and time scheduling for mixing with required quantity of water, all these tasks are managed properly, while maintaining sustainable environment for crop. Utility of the emerging Wireless Sensor Network (WSN) technology is used to monitor environmental field parameters and to control the usage of resources like fertilizers and water. Advance ZigBee based wireless communication system is implemented for task management and synchronization.

INTRODUCTION

In a tropical country like India, agriculture plays the important role in economy and development of the country. Now days, the farmers have been using fertilizing and irrigation technique in India through the manual control in which soil pollution by chemicals of fertilizers is major issue. The farmers even use either over head sprinklers or flood type irrigation system which leads more wastage of water and due to these methods soil gets saturated. Over watering also promotes infection and fungus in the valuable agricultural crops (Galande S.G. and G.H. Agrawal, 2013). Environmental sustainability demands rational use of water and fertilizers, economical benefit to the farmer is an additional advantage of savings of these agricultural resources. Use of advance technology in farming for which farmers need to switch from their conventional farming methods to Advance technology based methods (Patel N.R. *et al*., 2013).

Up to some extent, in some area farmers have adopted drip irrigation using wire based network operating pumping and other actuator tasks. Automatic irrigation and fertigation using embedded systems is an emerging field in agricultural technology. Wire based network have its own advantages and limitations. Considering present scenario of India, in large farm areas fertilizer storages, water tanks, mixing mechanisms, actuators etc are not arranged at a single place near to each other. Thus, wireless networks are more suggested in system designs. The mobility of the sensor and data collection unit is an additional advantage of wireless network.

Wireless sensor network introduction

In today's world, the development of Wireless Area Networks (WANs) makes wireless communications a current trend. However, the development of sensor techniques that are highly effective in transmitting and receiving data makes Wireless Sensor Networks (WSNs) a plausible platform of communications that is cheap and easy to deploy (Fatma Almajadub and Khaled Elleithy, 2014). There are so many types of communication protocols like ZigBee, Blue-Tooth, Wi-Fi etc are used in wireless sensor networks, among them most popular is ZigBee.

ZigBee is the simple technology that was designed with a cost less than other wireless personal networks which makes it more usable in the monitoring and controlling applications (Fatma Almajadub and Khaled Elleithy, 2014). ZigBee is reliable "hand-shacked" data transfer protocol suitable for Star, Mesh and Peer-to-Peer network topologies (P. Susmitha, V.Bhavya Reddy and Maninder Kaur, 2013). It follows IEEE 802.15.4 standard specifications for wireless communication on three license-free ISM frequency bands: 2.4000-2.4835 GHz, 868-870 MHz and 902-928 MHz for non commercial purpose (P. Susmitha, V.Bhavya Reddy and Maninder Kaur, 2013). ZigBee

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are embedded solutions providing wireless end point connectivity to devices, designed for high-throughput applications requiring low latency and predictable communication timing (V.Ramya, B.Palaniappan and Boby George, 2012). ZigBee modules are ideal for low-power, low-cost applications (Yunseop James Kim, Robert G. Evans and William M. Iversen, 2008). ZigBee modules interface to a host devices like microcontroller or computer through a logic-level asynchronous serial port. Through its serial port, the module can communicate with any logic and voltage compatible UART, or to a level translator to any serial device (V.Ramya, B.Palaniappan and Boby George, 2012). High fault tolerance, flexibility and autonomy are the advantages of Zigbee technology (Fatma Almajadub and Khaled Elleithy, 2014). In a network all ZigBee modules must be configured using a single PAN (Personal Area Network) identification, but each and every module will have unique MAC address. There are mainly three device types in a ZigBee network: Coordinator, Router and End devices (A.Tahir Ince, Onur Elma, Ugur S. Selamogullari, Hakan P. Partal, Bulent Vural, 2014). A ZigBee Coordinator starts the network, selecting the channel and PAN ID. Coordinator is responsible for handling out addresses, allowing routers and end devices to join the network, assists in routing data, can buffer wireless data packets for sleeping end device children, manages the other functions that define the network, secure it and keep it healthy. It cannot sleep; the coordinator must be powered all the time (Source: www, digi.com). A Router is a full-featured ZigBee node; can join existing network, send-receive and route information, can buffer wireless data packets for sleeping end device children. Router can allow other routers and end devices to join the network. It cannot sleep; must be powered all the time (Source: www, digi.com). An End Device is a reduced version of a router. The End Device can join the existing network and send and receive information, but cannot act as messenger between any other devices. End device always needs a router or the coordinator to be its parent device. An End Device can power itself down intermittently, saving energy by temporarily entering a non responsive sleep mode (source: www.digi.com). In my proposed system I have designed a network composed of one coordinator, multiple end devices and zero routers.

Proposed System

Architecture of the proposed fertilizer and water control system using WSN is shown in figure 1. The project develops an automatic irrigation system based on the environmental parameters like Temperature and Humidity. The data collection part of the system is automatic and the rest part which controls the actuators is also automatic in between human operator use knowledge based guidance. This is designed with the intention that knowledge based guidance can be utilized. Microcontroller based wireless sensor field at regular interval of time. Analogue values of these measured parameters are set in Zigbee frame format in digital form with the help of microcontroller. Then these data is sent over the wireless sensor network. Finally, data from the various nodes are collected at PC with attached WSN coordinator module. In order to observe collected parameter values console of XCTU software is used. This console updates the measured values of Temperature and Humidity at regular time interval. Using this periodical data and knowledge based guidance system; an operator can get decision support to send command from PC to respective actuator unit through wireless communication link established using zigbee. On the other side, control unit debug these commands and control the actuator accordingly. The actuator performs the given task as per predefined setup. Execution of these actuators helps the drip irrigation based fertilizer control system first, to select proper fertilizer type, dosage (proportion) and then mixes it with a predefined volume of water, then distributes the mixture to root zone of plant. In this proposed irrigation system, pumping and valves mechanisms can be controlled in order to distribute appropriate volume of mixtures and fulfill nutrient requirement of different crops in the field.

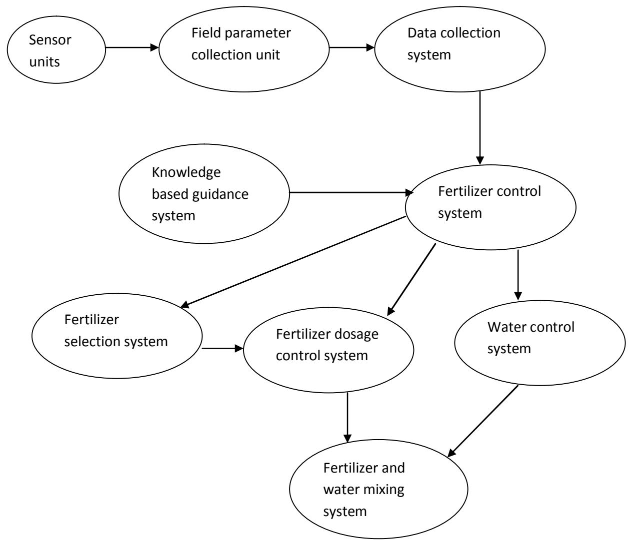

Figure 1 Proposed Fertilizer Control System

Proposed system divides in nine units and subsystems:

1. Sensor unit (environment interface segment)
2. Field parameter collection unit
3. Data collection system
4. Knowledge based guidance system
5. Fertilizer control system
6. Fertilizer selection system
7. Fertilizer doses control system
8. Water control system
9. Fertilizer and water mixing system

Sensor Unit. This is environmental interface segment of the system. Different environmental parameters like Temperature, humidity etc sensed by sensors. Seasonal variation in meteorological condition is monitored by this unit. Output of each sensor can be an analog value of a parameter.

Field Parameter Collection Unit. These analog signals are converted in to digital data using Analog to Digital Convertor (ADC). Microcontroller based node is used as field parameter collection unit. As per the requirement (area to be covered) of the application, it may be a single node or a network of multiple field nodes. Wireless sensor communication modules are attached and configured with each node.

Data Collection System. A coordinator module configured in network and attached with personal computer is established as data collection system. Here collected data may be observed in a console or can be recorded in storage system.

Knowledge Based Guidance System. Which kind of crop requires how much amount of water and which particular types of fertilizers in which proportion is required for the crop in respect to given environmental parameter values and type of soil, is subject of knowledge and experience. Based on this knowledge a guidance system can be implemented in order to help the operator to give appropriate commands over the actuators side. In this system partial portion of the knowledge can be converted in data format, but as a whole, it is experience based, so human interface is necessary.

Fertilizer Control System. This is a heart of the whole project. It is a one kind of decision support system. It compares wirelessly collected data of temperature and humidity with the data of knowledge based guidance system, Creates decision for selection of fertilizer, generates commands to control doses of the nutrients and decides for amount of water to be mixed.

Fertilizer Selection System. Different kind of crop requires different types of fertilizers. Selection of particular type of fertilizer may dependent on seasonal environmental parameters also. All these issues in this regard are managed by this subsystem. Actuator and their control drivers are partially included in this segment. The other actuators are parts of the following sub systems.

Fertilizer Doses Control System. Some actuator devices and their control drivers related to control the dose of fertilizer are included in this segment. Proportion of different kind of fertilizers is controlled in this unit. It works in accordance with the command given by Fertilizer Control System discussed in (5). It decides proportion of each type of fertilizer like Urea, Potash, and Nitrate, Phosphorous etc in gm/litter unit. Different type of valves motors and pumping mechanism are also part of this sub system, controlled by different actuators based on control and activation commands received from coordinating other sub control systems.

Water Control System. Total required volume of water is released in halves by setting ON/OFF (predefined) timings of the solenoid valve established at the outlet of water tank.

Fertilizer and Water Mixing System. As solubility timings are different for different fertilizer type, mixing system works according it. This can be s*et al*so as predefined timings.
This proposed system can be experimentally tested using ZigBee technology to establish communication between different sub-systems. The fertilizer control system handles network communication and synchronization of various tasks and performs as the coordinator. In the system, many tasks may be operated in different nodes at a time, which requires careful task management between all nodes. Most physical and mental tasks are operated by the embedded system, which is done by the human operator in traditional fertilizer spray/flood system. Knowledge based guidance of the human operator is directly interfaced with the Fertilizer Control System, is only human operational part of the system and it is also essential as all the knowledge-guidance is human experience, location and situation specific.

Experimental Work

ZigBee based communication to be used in proposed system has already been experimentally setup and tested with four LPC2148 microcontroller based circuit boards in laboratory. These are ARM7TDMI-S microcontrollers with 512 kB of on-chip flash memory and 32 kB of RAM with additional 8 kB RAM shared with USB Direct Memory Access. Out of four boards first board is used for the data collection (data of humidity and temperature) from the sensor side. More ADC channels provided configured for additional sensors to be added in future. A 16x2 LCD display is configured with this microcontroller board for monitoring these parameters. It is an optional provision for in-situ monitoring. Second board (actuator side) function as fertilizer selection and doses control system as these two systems are interrelated and generally established nearer to each other or may be at single location. The LED displays simulation of actuators. Third microcontroller circuit board (actuator side) is used for water control system and fourth board is implemented for mixing unit. A personal computer with ZigBee communication link performs the tasks of Fertilizer Control System, which is to be facilitated for limited human interface.

Humidity and Temperature sensor DHT22 is configured with an ADC channel of microcontroller LPC2148 is used to sense field parameters and this information is sent wirelessly to console window of personal computer, where ZigBee link established using XCTU software. Digi XBee S2C modules of ZigBee are used at sensor node as well as at actuator nodes in this experiment.

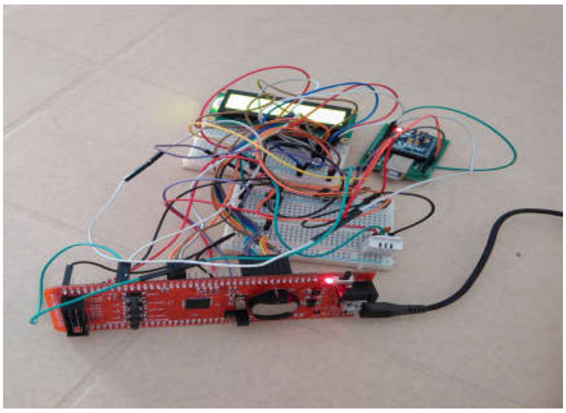

Figure 2 Prototype of Sensor and Field Parameter collection Unit

Operator compares received instantaneous values with stored values in his/her mind based on gained experience of the field location and condition. He/she sends command to remaining three boards to control actuators as predefined schedules shown in Table 1 and 2. The timings shown in the tables considered as an example. For example nutrient proportion N:P:K=3:1:2 is shown in table 1 of resource management schedule. The proportion of NPK nutrients can be varied according to knowledge based guidance.

Table 1 Resource Management Schedule

Circuit Board Number	Resource type	Operation/Related Actuator	Timing in seconds	Indicator
2	Fertilizer	Nitrate	45	LED-1
		phosphorus	15	LED-2
		Potash	30	LED-3
		Other nutrient/Filler	90	LED-4
3	Water	Solenoid Valve (cycle duration of 3 min)	Activation timing in seconds	
		First Minute (ON time)	10	
		Second Minute (ON time)	20	
		Third Minute (ON time)	30	

Table 2 Fertilizer Water Mixing Schedule

Circuit Board Number	Mixer related actuator	ON time	OFF time
4	Mixing Action (cycle of 1 hour)	20 Minutes	40 Minutes

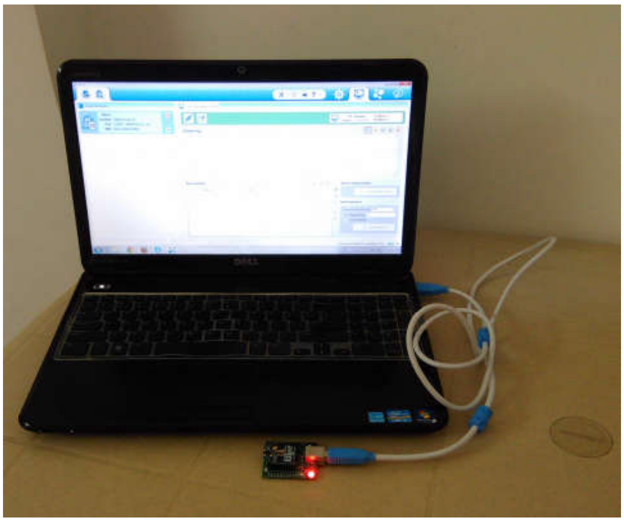

Figure 3 FCS with ZigBee

Figure 4 Visualization of an actuator as an LED operation.

Implementation sequence is shown in system function Flow-chart of figure 5. Initialize the microcontroller based wireless sensor network node by supplying appropriate power required by the node. This requirement can be fulfilled by solar energy operated power bank. As this node is activated, sensors will sense the temperature and humidity of the interfacing field area, where the node is set up. Analog data of these parameters are converted in to digital form and measured values are set in the ZigBee data frame format, finally it is transmitted through wireless network. At the coordinator end, this data is collected by personal computer at which ZigBee module is configured for coordination. Here data is observed in Xctu console window. As shown in functional flowchart this process repeats after every predetermined time period. We will get periodic readings of the parameters, which is useful for manual decision support to activate different actuators using knowledge based guidance. Actuators perform their tasks as per predefine set up. Through these actuators plant nutrients will be selected, proportion and dose will be predefined, mixed up with programmed water volume for predefined duration and irrigated at the roots of plants.

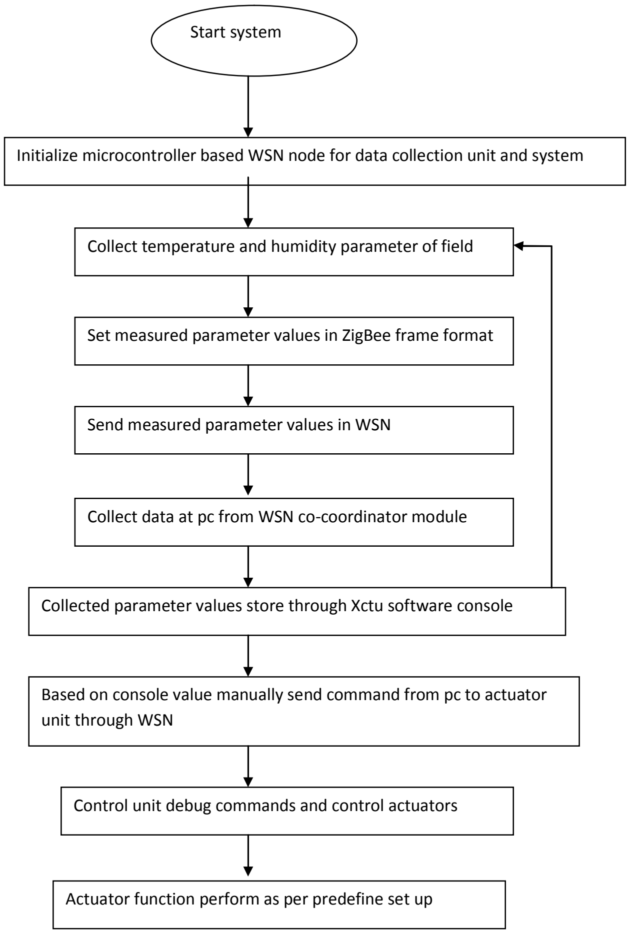

Figure 5 System function Flow-Chart

CONCLUSION

Embedded system for agricultural fertilizer control system offers a potential solution to support site and crop specific resource management that allows farmer to maximize their productivity while saving the soil from chemical pollution. The conventional fertilization and irrigation system is based on spray method and flow method are with huge human intervenes. The proposed system can be more efficient system with environment sustainability and minimum manual operations. Zigbee wireless communication keeps the field/farm wire-free allowing easy deployment and reducing complexity of the system. The system is scalable and allows different devices to be added with the minor change in the core system; Additional sensors for crop dependent parameter measurement can be configured as more ADCs are available at data collection unit. The work can be extended to include more actuators for other micronutrients and pesticides. GPS based mobile controlling of resources can also be considered as future extension of this research. One can develop a data-logger in order to create a data-base of temperature and humidity in order to establish meteorological parameters relationship with crop production and quantity.

References

FanishS. A., 2013. "Influence of drip fertigation on water productivity and profitability of maize". *African Journal* *of Agricultural*, vol. Vol. 8(28), no. July, pp. pp. 3757-3763, July 2013.

Fatma Almajadub, Khaled Elleithy, 2014 “Performance advancement of wireless sensor networks using low power techniques and efficient placement of nodes,” arXiv:1407.0091v1[cs.NI].

Vimal P, Priyanka.V., Rajyasree M, Santhiys Devi.P.T, Jagdeeshraj M., Suthanthira A., Vanitha N., 2014 "A Novel Approach for Automatic Irrigation and Fertigation Using Embedded System". *International Journal of VLSI and Embedded Systems-IJVES*, Vols. 05,, no. Article 03257, pp. 855-859, March.

V.Ramya, B.palniappan, Boby George, “Embedded system for automatic irrigation of Cardamom field using Xbee-PRO technology 2012*” International journal of computer applications*(IJCA), vol.53 no.14 pp.36-43

Guerbaoui M., El afou Y., Ed-dhhak A., Lachhab A., Bouchikhi B., "PC-BASED AUTOMATED DRIP IRRIGATION SYSTEM, 2013". *International Journal of Engineering Science and Technology* (IJEST), vol. 05, no. 01, pp. 221-225, January.

Yunseop (James) Kim, Robert G. Evans, William M. Iversen, “Remote sensing and control of an irrigation system using a distributed wireless sensor network” IEEE transactions on instrumentation and measurement, vol.57, no.7, July 2008.

Mahendran p.p., Yuvaraj M., C.Parameswari, A.Gurusamy, S.Krishnasamy, "Enhancing Growth, Yield and Quality of Banana through Subsurface Drip Fertigation, 2013. ". *International Journal of Chemical, Environmental & Biological Sciences* (IJCEBS), vol. 01, no. 02, pp. 391-395.

P. Susmitha, V.Bhavya Reddy, Maninder Kaur, “Low Power ZigBee Technology in Wireless Mesh Networks” *International Journal of Advanced Research in Electrical, Electronics and Information Engineering*”, Vol.2, Issue 2, February, 2013.

Beheram. S. , P.K. Mahapatra, R.B. Singansdhupe, D.K. Kundu, K. Kannan, K.G. Mandal, A. SINGH,2014. "Effect of Drip Fertigation on Yield, Water Use Efficiency and Water Productivity of Mint (Mentha arvensis L.)". *Journal of Agricultural Physics*, vol. 14, no. 01, pp. 37-41.

A.Tahir Ince, Onur Elma, Ugur S. Selamogullari, Hakan P. Partal, Bulent Vural, 2014 “Data Reliability and Latency Test for ZigBe-based Smart Home Energy Management Systems”, 7th International Ege Energy Symposium & Exhibition, June 18-20, 2014, Usak, Turkey.

Patel N.R., S.S.Thakare, D.S.Chaudhari, 2013."A Review of Different Parameter Monitoring Systems for Increasing Agricultural Yield". *International Journal of Innovative Technology and Exploring Engineering* (IJITEE), vol. 02, no. 04, pp. 65-67.

Galande. S.G., G. H. Agrawal, 2012. "Effects of Drip Irrigation, Embedded System and Fertilizers on Sugarcane," *International Journal of Engineering, Business and Enterprise Applications* (IJEBEA), aug-nov, pp. 5-8,.

Chanda C., S. Agarwal, Er. B.Persis Urbana Ivy, AP (SG), 2012"A Survey of Automated GSM Based Irrigation Systems". *International Journal of Emerging Technology and Advanced Engineering*, vol. 2, no. 10, pp. 370-373.

Galande S.G., G.H. Agrawal, 2013. "Embedded Controlled Drip Irrigation System". *International Journal of Emerging Trends & Technology in Computer Science* (IJETTCS), vol. 2, no. 5, pp. 37-41.

Samsuri S. F. M., A. Robiah, Hussein M., Abd. Rahman Abdul Rahim, "Wireless System for Monitoring Environmental variables of Rain Shelter, 2009". First International Conference on Computational Intelligence, Communication Systems and Networks,.

Lad H. J., V. G. Joshi ". Irrigation Control System using Distributed Embedded System,"1st International Conference on Contemporary Computing and Informatics (IC3I 2014), Mysore, IEEE: 978-1-4799-6629-5,pp. 1336-1339, November.

Mei N., Y. YUAN, 2012 "A Technical Framework for Designing Wireless Sensor Networks for Agricultural Monitoring in XinJiang Regions, 201". Second International Workshop on Education Technology and Computer Science.

Pandian S. L., Y. Charishma, V Parameswary, 2015. "Monitoring of Indian Agriculture using LPC2148". *International Journal of Computer Applications*, vol. 116, no. 16, pp. 14-1.

Indu G., S.R.N Reddy, 2012. "Innovative Gsm Bluetooth based Remote Controlled Embedded System for Irrigation," *International Journal of Computer Applications*, vol. 47, no. 13, pp. 1-7.

Lihong Z., S. Lei, H. Shufen, L. Weina, 2011. "Measurement and Control System of Soil Moisture of Large Greenhouse Group Based on Double CAN Bus". Third International Conference on Measuring Technology and Mechatronics Automation.

Hiteshkumar Lad, Vibhutikumar Joshi, Rameshchandra Makavana, “Natural Evaporation Type Salt Manufacturing Process Resource Management using Distributed Embedded System” *International Journal of Computer Applications*, vol. 117, no. 23, pp. 33-37.

www.digi.com/resources/documentation/digidocs (source: Digi International Inc.).

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