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LOW COST WIRELESS DATA ACQUISITION SYSTEM FOR MULTISENSOR APPLICATIONS

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ABSTRACT

Automated irrigation systems for agriculture purposes are becoming increasingly important and popular due to the scarcity of water resources and increasing demands of food production. Data acquisition is one of the most important aspects in the automated systems in agriculture sector. This paper presents a low cost wireless system for data acquisition. Sensor nodes and frame format of the sensor data are built using an Atmega328 microcontroller. X-Bee offers the wireless connectivity between the sensor nodes and co-ordinator node build using an ATmega2560, which is in turn communicated to the LabVIEW using serial a communication (VISA). The sensor nodes, capable of acquiring information about multiple parameters related to the status of the farm field, are installed at the farm site and data from each sensor node are processed and stored in a spread sheet format with date and time stamp for each sensor. The design considerations and test results of this data acquisition system monitoring the sensor parameters 24x7 with user defined interval are presented in this paper.

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INTRODUCTION

Various laboratories mug the need of erecting their own purpose- made experimental DAS systems. Indeed, this is the natural quality of precise research, in which innovative and strange phenomena entail the novel experimental set-ups. While several instruments are too multifaceted to be developed in-house and require practiced support and convenient tools from engineering, numerous are graceful enough to be realized in restricted industrial capabilities offered within the investigating groups and from campus support staff. In recent years, the scientific community has revealed open-source electronic platform (Arduino) for monitoring and controlling the experimental hardware (Joel and Sáiz, 2014). In this framework, the term data acquisition is often applied to a variety of developments, ranging from analog to digital signals of numerous types and from the acquisition from a simple motion sensor to the acquisition from a complex pulse train (Martín *et al.,* 2014). Data acquisition (DAQ) is the process by which physical phenomena from the real world are transformed into electrical signals that are measured and converted into a digital format for processing, analysis, and storage by a computer (Park and Mackay, 2003). An arduino and X-Bee based system is economical and vastly scalable equally in terms of the type of sensors and the number of sensor nodes that make it well suitable for a wide range of applications associated with the environmental monitoring (Ferdoush and Li, 2014). Processing data and displaying numerical values are some of the most important engineering aspects. Microcontrollers, such as Arduino, are important tools for analyzing data wirelessly with a variety of wireless modules. Kadi *et al.,* 2013 implemented the Arduino and WiFi network analysis however, they were not able to send any data wirelessly nor they stored at all (Kadi *et al.,* 2013). In data acquisition, the time synchronization of ADC channels play a key role to take data for multichannel sensor data acquisition (Włodarczyk *et al.,* 2014). Joel et al used the open source python based software (Instrumentino) having data logging facility wherein arduino and the component panel allows the user to directly control and monitor the system components with wired network (Joel and Sáiz, 2014). While the open source data acquisition card (open DAQ) was employed by Martín et al working on his own software platform in python GUI, communication with computer via USB cable (Martín *et al.,* 2014). The Arduino , raspberry pi and internet server facilities were employed by Ferdoush et al for monitoring humidity parameters; the main drawback of such systems is data logging success dependent on the internet network (Ferdoush and Li, 2014). Włodarczyk et al devised a time synchronized ADC triggering method using GPS and time synchronization of ADC for data acquisition (Włodarczyk *et al.,* 2016), however, use of GPS may cause some network problems associated with the satellite synchronization leading the system to wait state until the data from the GPS are further decoded and processed. In certain cases, there will be a range of problems occurred for the devices in remote areas and in underground areas. The Lab VIEW has facility of time synchronization (separate function of Get Time Stamp) which may be used for synchronization of ADC triggering effectively without using GPS. A LabVIEW based battery operated system and its data logging and storing was pointed out by Jamaluddin *et al.,* 2013. But the system being wired, may cause faults due to the entire communication for data acquisition or rarer and tyre the connection. A GSM/GPRS and LabVIEW based data acquisition system with internet connectivity and SMS facility was developed by Ionel *et al.,* 2012 however, the system takes time for checking authority person data from various locations and network transmission dependent upon the internet facility which is quite a major issue for the remote locations where internet facility and mobile network are serious problems.

Understanding these key ideas for the autonomous data acquisition, developed system consists of the microcontrollers that convert the data of any analog sensor into digital one and beyond that it must have facility of connecting the digital sensors and communication from a sensor node to computer wirelessly using X-Bee device. At the coordinator node it also consists of microcontroller which is communicating or receiving the data from sensor nodes. This coordinator node again communicates to the LabVIEW which is a prominent tool for Virtual Instrumentation having capability to process, store and easy to make GUI platform. The developed LabVIEW GUI can be converted into .exe file which helps the user to use at any place with minimum system configuration (http://www.ni.com/labview). The advancements in electronics and integrated circuit technology have offered a new platform in the DAQ system that a microcontroller based DAQ system is very trendy previous and still being used since of its low-cost, wide resources available and can be modified easily for other applications .Wired systems are problematic, the haziness of wires may cause some errors or some incorrect communication in agriculture or in any system monitoring the parameters using multiple sensors. This necessitates to develop a multisensor wireless data acquisition system to monitor various field parameters such as soil moisture, soil temperature, humidity, light intensity, etc. To set up a low cost wireless data acquisition scheme, ATmega328 microcontroller (i.e. Arduino uno) is used and a GUI is developed in LabVIEW [Fig 1(a, b)]. In the context, wireless device X-Bee is used for collecting the data from different sensor nodes in the farms without any disturbance. This paper highlights the actual programming steps to build a wireless data acquisition system and GUI development in LabVIEW. The acquired data can not only be displayed but also stored for future reference.

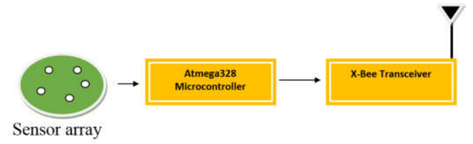

Fig 1 a) Sensor node block diagram.

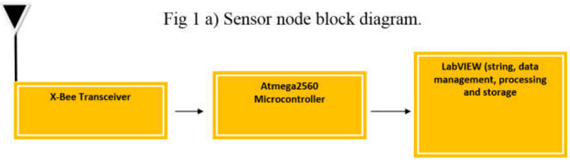

Fig 1 b) Co-ordinator node block diagram.

The tools and techniques

Building frame format for DAQ system

The required sensors were interfaced to ATmega328 microcontroller which is a 8- bit high performance microcontroller having 6 channel 10 bit analog to digital converter. The sensors were connected to ADC channels of ATmega328 ; each sensor data is converted into digital form to recognize data of each sensor. Thus the frame format is prepared that gives an individual ID to each sensor data and sends serially to wireless device (X-Bee). The purpose of giving ID to each sensor is that the data can be easily processed and stored.

The frame output is,

Usensor1dataVsensor2dataWsensor3dataXsensor4dataYsensor5dataZsensor6………

Where U, V, W, X, Y and Z are frame id’s of different sensor data which are 10bit per sensor. These frames send the data serially to X-Bee at sensor node which is further communicated to the X-Bee co-ordinator node.

The proposed algorithm

We propose the following algorithm (Fig. 2a).

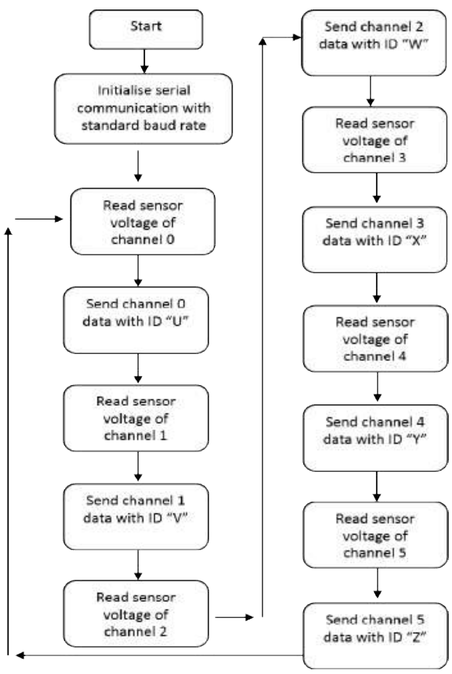

Fig. 2a. Algorithm for generating frame format.

The sensor node and Co-ordinator node connections

The sensor node connections to X-Bee and sensor array are shown in Fig.2b.

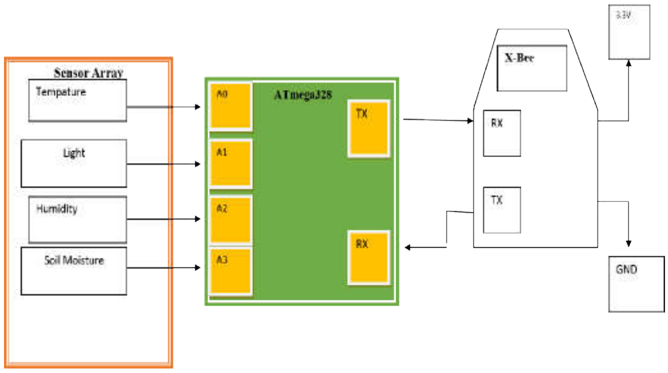

Fig. 2b. Sensor node connections to X-Bee and sensor array

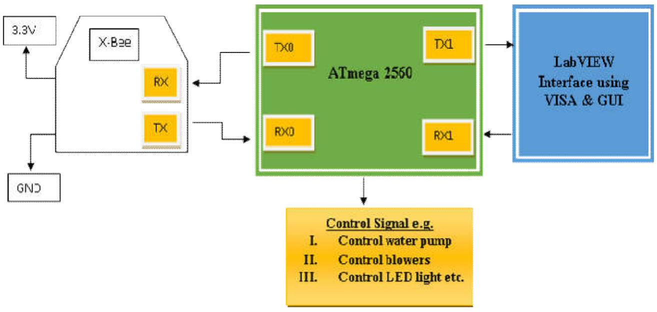

Fig 2c. Co-ordinator node connections to X-Bee and LabVIEW

Making DAQ system wireless, X-Bee S2 is used which is IEEE 802.14.5 ZigBee Protocol. Fig.2 c) co-ordinator node connections to LabVIEW. To configure the X-Bee X-CTU software, the sensor node is configured as ZIGBEE ROUTER AT/ SENSOR AT and co-ordinator node is configured as ZIGBEE COORDINATOR AT with the same PAN ID. The data from arduino is send to X-Bee ZIGBEE ROUTER AT/ SENSOR AT to X-Bee CO-ORDINATOR NODE AT.

String, data management, processing and storage in labview & GUI development

At sensor node ATmega328 is having 10bit 6channel ADC. Data produced by the microcontroller are 60 bit and six frame ID's are added in sensor data which are 48 bit the total 108 bit data i.e. 15 bytes data are produced by a sensor node and send wirelessly using X-Bee sensor device to co-ordinator node. Once data are available at the co-ordinator node, ATmega328 microcontroller sends it serially to LabVIEW using virtual instrument software architecture (VISA). To setup a VISA, VISA configure serial port, VISA close and VISA read operations in LabVIEW are carried out. At co-ordinator node X-Bee transceiver receives all the data regarding sensors connected to the sensor nodes which is predefined frame or string followed by algorithm shown in fig.2a.This frame or sting is 15 bytes long having different ID's which are now separated and only data are processed, displayed and stored in a spreadsheet format with sample number, date, time and relevant parameters given by the sensors using LabVIEW. The string operation in LabVIEW is as:

- Search/split string
- Search and replace string
- Decimal string to number and
- Data processing using formula node.

After processing the data, parameters of the sensor data are stored in the spread sheet format and also displayed in table format. We can store the 24x7 data in spread sheet and table formats which is the prominent feature of the frame/scheme. To achieve this following operations were used:

- Table (Silver)
- While loop
- Shift register
- Insert into array
- Format into string
- Build array
- Write to spreadsheet file
- Get date/time in seconds and
- Get date/time string.

Simulation, test results and GUI

Test procedure

To work with data acquisition system precisely we have to ensure that the sensor node is properly installed or not. After successfully installing the sensor node, ensure that coordinator node is properly connected to PC or Laptop via USB, open the data acquisition GUI; select the VISA source name (i.e. serial communication terminal). Further select the baud rate for the serial communication, ensure that the baud rate of coordinator node and baud rate of LabVIEW GUI is same. Give the file path properly in such a way that all the data from sensor node are stored and displayed properly in LabVIEW GUI. After successful communication of coordinator node and LabVIEW, data from sensor node is displayed in GUI and saved in a spread sheet format. The following figures (fig.3a,b,c,d) and G-code shows GUI interface for multisensor wireless DAQ system.

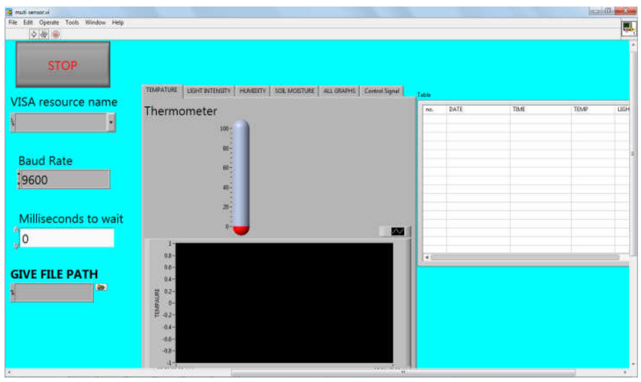

Fig 3a. GUI for multisensor wireless DAQ

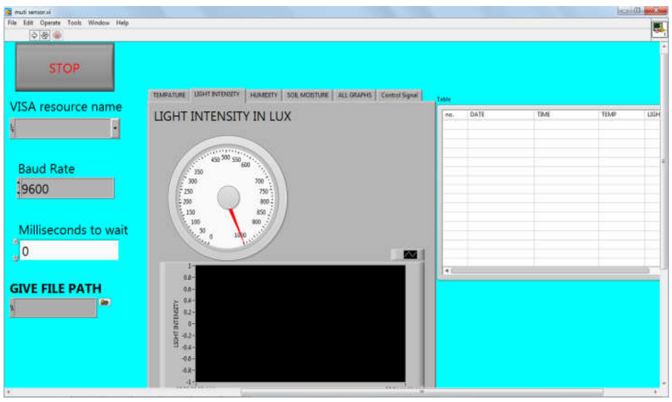

Fig. 3b. GUI for multisensor wireless DAQ

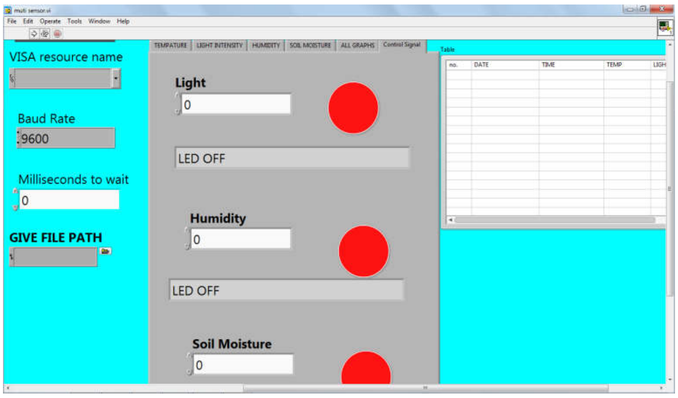

Fig. 3c. GUI for control signal of wireless DAQ

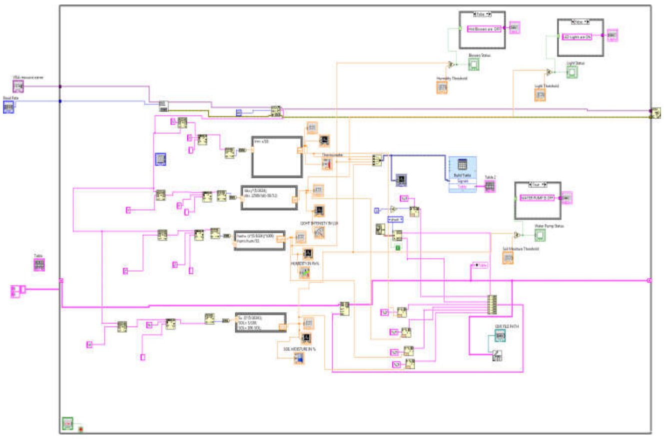

Fig. 3d. G-Code for multisensor wireless DAQ

Conclusion

The developed GUI application can run with a wireless network of X-Bee and in some cases, user can also access and acquire the information from the same GUI from internet connectivity anywhere. The LabVIEW application was veteran on a portable computer with a 2.40 GHz CPU, 4 GB DDR. The developed DAQ system is successfully used for a specific application or can be modified easily for any applications of our interest and easy to scale for sensor number. The use of time stamp leads to good time synchronization between ADC channels selectivity. All data from sensors are saved in spared sheet format for a given interval of time. Data collection ability of developed DAQ system is 24x7 pre specified time interval.

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