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Design of wireless sensor network for monitoring of soil quality parameters

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Abstract

Design of wireless sensor network for monitoring of soil quality parameters (temperature, humidity, conductivity and acidity) is proposed in the study. The structure, panels and block - diagrams of graphical user interface in the software LabView are developed. Web-based mobile system for wireless measurement of temperature, humidity, conductivity and acidity based on Arduino modules is proposed. The devices are configured and appropriate software for the operation of wireless sensor modules is written.

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Keywords: wireless sensor network, soil quality parameters, LabView

1. Introduction

Precision farming is a new technology that allows manufacturers to adequate manage the land depending on spatially differentiated information. It is an innovative, technological and information based intelligent approach to identifying, analyzing and managing the variables to obtain profitable production with optimum production and conservation. Precision farming has great potential in developing economic and environmental benefits, which translates into reducing the use of water, fertilizers, chemicals, labor and equipment.

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Increasing electricity prices, together with high technological requirements and the need for lowering production costs require the development and optimization of Information Technologies -advising systems for measuring and monitoring the parameters of the land.

The benefits arising from the application of wireless sensor technologies (Baggio, 2005; Losilla et al., 2007; Zhang et al., 2004) in precision agriculture come from precision in the amount of irrigation (H.E.L. de Lima et al., 2010), fertilizer use only in necessary areas and controlling the quantities of fertilizer. Other advantages of wireless sensor networks are (Buratti et al., 2009):

- possible to monitor parameters for long periods of time;
- directly and accurately monitor the status and parameters of the cultivated lands and the opportunity to intervene in emergency situations;
- remotely decision-making;
- analysis and storage of information;
- the ability to create graphical user interface for system monitoring;
- permit accurate assessment of new methods and techniques for processing the earth's surface.

For the establishment and operation of a wireless sensor network required placement of sensors at key locations so as to cover the whole area.

Studies on the positioning of sensors in building a wireless sensor network marked significant progress in the last decade. In scientific studies have examined the positioning of sensors in terms of data transmission, and various regular distributions of sensors in the form of a square, triangle and hexagon network.

In precision farming requires full coverage of the surveyed area. On the other hand, the number of sensors should be as low as possible, since more than one sensor would imply a high final value for construction of the network. It is possible and a higher impact on the environment. It is require minimal energy consumption of the network. This means minimal cost for maintenance of the network. Sometimes batteries that operate the network are expensive and sometimes expensive their replacement, especially when it comes to hard to reach areas and others.

Reducing the number of sensors results in an increase of the energy network. On the other hand, in order to reduce the energy of the network it is necessary to add sensors. Therefore, the aim is to determine the balance between the number of sensors and energy consumption in view of the basic parameters based on the number of messages transmission time information, the total number of packets sent and the amount of loss of information.

2. Materials and Methods

2.1. Wireless sensor network topology.

The Wireless sensor netowrk topology is based on ZigBee protocol for network communication. ZigBee standard supports various network topologies: point to point (point - to - point), point-to-multipoint (point- to -multipoint), stellate (star), tree (tree) and cellular (mesh). The latter has the ability to dynamically change the route between the devices on the network based on the availability of intermediate routing devices - units. There are three types of network ZigBee nodes: coordinator - obligatory at least one of each ZigBee network and initializes the formation of the network and performs a function as its coordinator (managing node); it can work as a router after setting the network; router - associated with ZigBee coordinator or another ZigBee router; involved in the transmission of information between nodes in the network. Regardless of their purpose devices in ZigBee network usually have: synchronous and asynchronous communication interfaces, analog - digital converters, digital inputs and outputs general. Through its diverse peripherals ZigBee modules are various applications for controlling production processes, periodically measuring the parameters of physical and electrical parameters and others. [25].

The coordinator creates a ZigBee network and its route map, administers various nodes in the network, monitor network parameters and provides basic maintenance. It connects via multifunctional development platform through an asynchronous serial interface (UART). Coordinator module provides access through radio channel development platform to individual routers and measuring sensors in the ZigBee network. Through it enters the measurement information from all the measurement sensors connected to a ZigBee network nodes.

Routers perform the interconnection between devices in the network. They are responsible for periodically extracting information from associated measuring sensors to their periphery and retention of information collected until transmission and a coordinator module [26].

Each topology has its own set of challenges, advantages and disadvantages.

To realize the system is selected Mesh topology. This is a multi-hop system in which all wireless sensor nodes are identical. They act as a router, communicate, transmit data to and from other nodes in the network. Standard XMesh configuration is presented on Fig. 1.

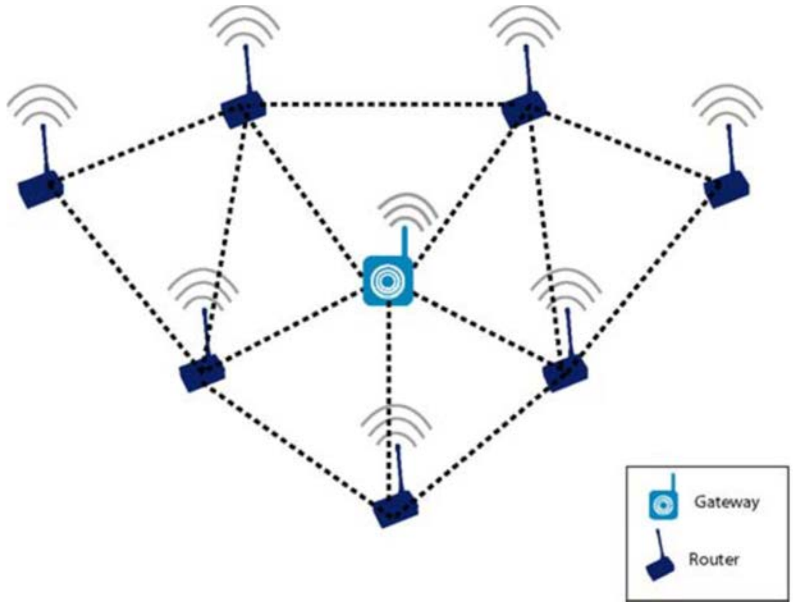

Fig. 1. Standard Xmesh topology

Its main advantages are:
- direct exchange of data between nodes;
- a high degree of reliability;
- if a path fails, can be found bypass route network and will not lose performance.

2.2. Graphical user interface structure

The graphical user interface (GUI) aims to manage both initialization of the ZigBee network and the flow of information received from the sensors. Through its programs providing web-based platform makes checking the reliability of data, sorts the data obtained, recorded them in a database and presents them to the user in an appropriate form. Thereby providing the user with access to chronologically recorded data with the respective interconnections between them.

By appropriately designed graphic or web interface development platform provides the data recorded by the adjacent peripherals (monitor, projector) or remotely via local or global network.

The main task of the GUI is to provide the user for review, preparation of reports, construction of statistical graphs and tables of data recorded by the system.

Development of the GUI is based on software LabView.

The front panel of the developed virtual instrument of mobile system based on wireless measurement the main soil quality parameters are shown on Fig. 2.

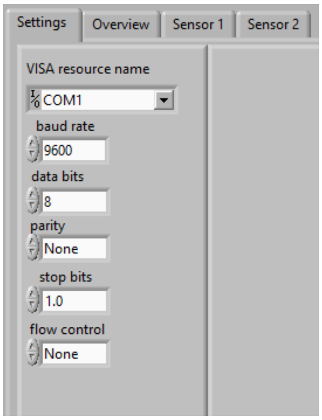

Fig. 2. Front panel of the GUI

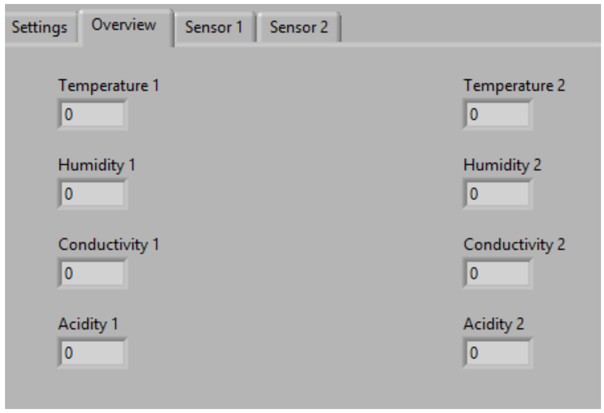

Fig. 3. Submenu "Overview" of the GUI

The front panel (Fig. 2) is divided into four submenus. The left side of the front panel shows the main menu to select the COM port to which will be connected the base station, the speed of data transmission and other parameters specific for each device. The next submenu is "Overview" (Fig. 3) – for visualization of the temperature, humidity, conductivity and acidity values.

The submenu "Sensor 1" (Fig. 5) is used for visualization of the temperature, humidity, conductivity and acidity values using bar daigrams and to show the history of the values for time range defined from the user. Different color are used for visualization of the main parameters.

The part of the developed block – diagram is represent on Fig. 4.

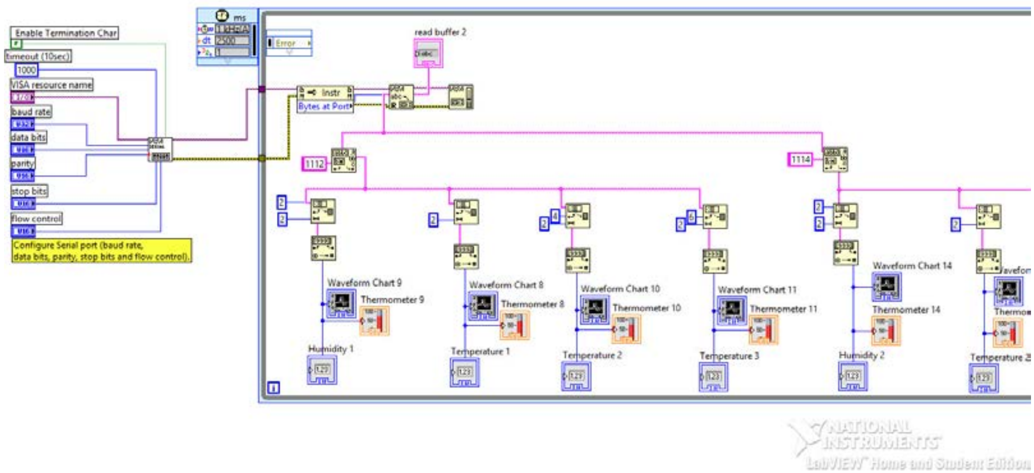

Fig. 4. Block - diagram of the GUI

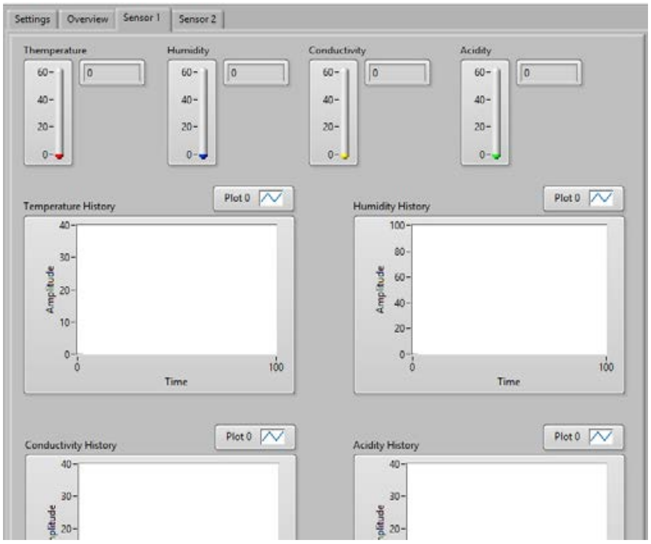

Fig. 5. Submenu “Sensor 1” of the GUI

2.3. Hardware design

Development of the wireless mobile system for measuring and monitoring of the main quality soil parameters is based on Arduino modules. There are used modules with wireless communication, for measuring temperature, humidity, conductivity and acidity of the soil and module - a base station connected to a portable laptop for receiving, processing and storing information from wireless sensor modules.

Arduino platform is based on input-output board and a development environment that uses language processing. Arduino board is equipped with a powerful ATmega microcontrollers and usually serves as the "brain" of the robot and interactive projects. Arduino can "feel" the world around him using various sensors and respond to changes in the environment.

Base station is a device connected to a PC which acts as a transceiver for centralized service group end subscriber wireless sensor devices. The base station consists of the following elements: Arduino Uno, Arduino Xbee Wireless Proto shield and radio module XBee 60mW with PCB antenna - Series 1 (802.15.4) (Fig. 6.).

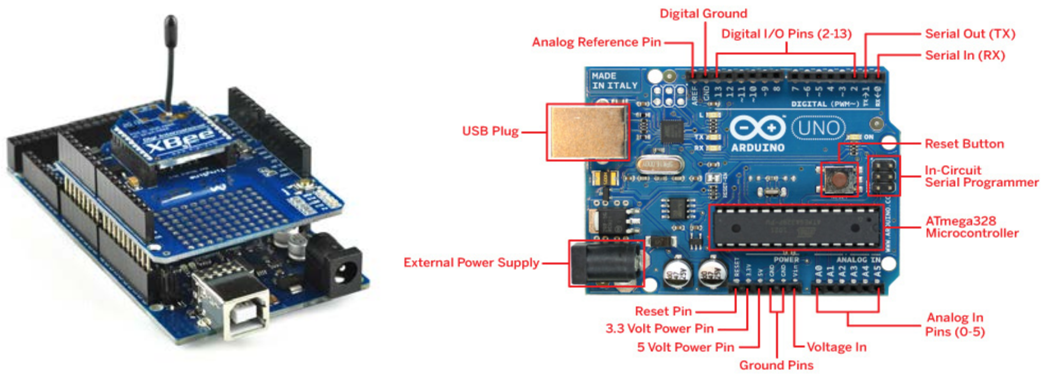

Fig. 6. The base station

Arduino Uno is a microcontroller development board with ATmega328P AVR microcontroller. There are 14 digital input-output (I / O) ports, 6 analog inputs, 16 MHz quartz resonator, four LEDs (one user connected on 13 digital I / O port and three that indicate the work of the board: ON, Tx and Rx), USB connector, power connector, reset button and ICSP connector. Six of digital I / O port can be used as PWM (PWM) outputs. Connection to a PC is done via USB cable USB A - USB B.

Sensors for measurement of the main soil parameters are shown on Fig. 7.

Fig. 7. Sensors for measurement of the main soil parameters

A high level simulation environment, which provides a fast and easy way for routing performance evaluations will be used for optimization of the network topology. PROWLER is a probabilistic network simulator developed with various radio models and a CSMA MAC layer (Simon et al., 2003).

The developed mobile system (Fig. 8) is tested in the laboratory.

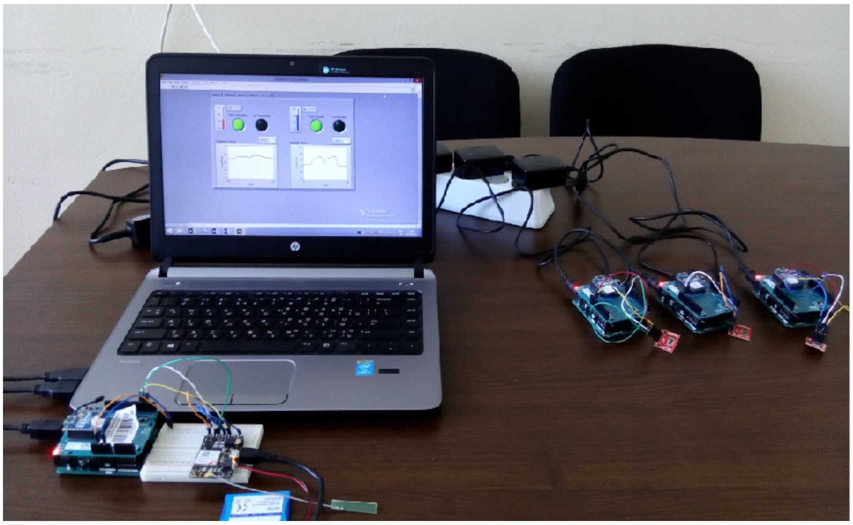

Fig. 8. Developed mobile system

3. Conclusions

This paper implemented a wireless sensor network system for soil main quality parameters monitoring.

An analysis of the published results in the study area indicates that there is a problem with choosing an appropriate management technology for monitoring of soil quality parameters. This requires solving specific tasks in this study.

The structure, panels and block - diagrams of graphical user interface in the software LabView are developed.

Web-based mobile system for wireless measurement of temperature, humidity, conductivity and acidity based on Arduino modules is developed. The devices are configured and appropriate software for the operation of wireless sensor modules is written.

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