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GREENHOUSE MICROCLIMATE REAL-TIME MONITORING BASED ON WIRELESS SENSOR NETWORK AND GIS

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Abstract: The usage of greenhouse with controlled microclimate represents an important way to increase the production of fruits and vegetables considering the plants needs and has recently become one of the hottest topics in precision agriculture. In order to know and to control the greenhouse microclimate smart sensing nodes with wireless communication capabilities represents the solution. As one of promissory protocol associated with wireless sensor network can be mentioned the ZigBee due to its low cost, low power consumption, extended ranges and architecture flexibility. In the present work a sensing and control sensing nodes with ZigBee communication capabilities are considered, while the microclimate is monitored using a set of solid state sensors for temperature, relative humidity, light intensity and CO_2 concentration considering this parameters with important role in plants growing. Every sensor node uses energy from a solar cell through a battery charger circuit considering also the powering of the sensing and control node during the night periods. The data from ZigBee network nodes are sent to Wireless-Ethernet gateway connected to a computer that runs a LabVIEW application that perform primary processing and web geographic information system that provides information about the greenhouse microclimate. Elements related power harvesting for implemented wireless sensor network, as so as a set of experimental results are included in the present work.

Keywords: air quality, greenhouse microclimate, ZigBee sensor network, geographic information system, power harvesting

1. INTRODUCTION

One of the most basic and thus critical and priority problems of humankind is food. Water and food shortage affect a huge percentage of the 7 billion people that inhabit Earth in 2011. The intensification of greenhouse horticulture is a commonly occurring trend in many regions around the world, including the Netherlands, Australia, Canada, Iberian Peninsula, the U.S., and the U.K. The main incentive for this clustering is the reduction of production costs by sharing infrastructure such as energy, water and gas facilities. This intensification leads into increasing greenhouses' scale and the creation of 'greenhouse parks' where greenhouses are clustered on a single site [1], where technology is required to enhance the culture management. While the size of these structures increases, the use of Geographical Information Systems (GIS) [2] brings the ability to visualize and manage all the geo-referenced data produced by wireless sensing nodes monitoring the greenhouses materializing the precision agriculture concept. To practice precision agriculture, is mainly related to air and soil relevant parameters monitoring that express the greenhouse microclimate that play important role in the crop growth. Thus microclimate real-time distributed monitoring system based on sensor network technology and GIS can be considered as an optimal tool for obtaining the informations regarding greenhouse microclimate.

In the present work was designed and implemented a wireless sensor network based on IEEE 802.15.4 (ZigBee) to acquire real-time climate data in a cultivate area from a greenhouse, taking into account plant growth parameters such as relative humidity, temperature, light intensity and CO2 concentration. As reported research in the area can be mentioned wireless microclimate sensor for tracking of the critical environment [3][4], long range wireless sensor system for long-term microclimate monitoring [5]. Sensor network architectures for air quality and water quality monitoring were reported also by our group and corresponds to field measurement of water quality using Wi-Fi networking technology [6][7] including also GIS [8][9] or refers the usage of wireless networks for indoor air quality monitoring [10][11]. Using the NI wireless sensor network (WSN) technology, including configurable WSN nodes and WSN gateway as so as the NI LabVIEW Wireless Sensor Network Module as a geographic information system the implemented distributed monitoring system assure accurate monitoring of greenhouse microclimate of wide monitoring areas. Farmers can access in real-time the microclimate data using a browser installed on mobile devices such as tablet computer that access the GIS server pages which receive the data from sensing nodes through a WSN gateway.

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5. CONCLUSIONS AND FINAL WORK

This paper presents the design and implementation of greenhouse micro-climate real-time monitoring based on

ZigBee wireless sensing network and a geographic information system. The system was installed and tested in laboratory indoor conditions but also in a greenhouse. The laboratory tests were necessary in order to estimate the reliability of the system including the solar panel and battery circuit charger associated for each node. Elements of intelligent modelling of multivariable characteristics were included in the work considering the necessity to improve the accuracy of the RH and CO_2 measurement channels which characteristics are dependent by temperature which is an external factor. Power harvesting tests were also done and new results were included in the final form of the article.

Referring software the work presents a web based geographic information system design and implementation, which is characterized by high flexibility and the capacity to be adapted to new monitoring scenario.

As the future work we are planning to include on the WSN node level new measurement channels such as soil moisture and soil temperature to help irrigation.

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