A WSN-BASED SOLUTION FOR PRECISION FARM PURPOSES

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1. INTRODUCTION

The growing demand of food resources, the rise of energy prices, and the climate changes have been recognized among the main causes of the food crisis that is recently affecting the whole planet [1]. In the framework of industrial agriculture, the dramatic increase of food prices brings back to mind the problem of the intensive exploitation of the natural resources. In order to define a suitable model of sustainable agriculture aimed at preserving the environment and the communities of the farmers as well as at enhancing the productivity, a modern approach consists into the exploitation of technologies and techniques for achieving, in production, economies of scale. Recently, an innovative strategy generally identified as "precision agriculture" has been proposed to cope with the problem of environmental sustainability. It is based on the observation, the impact assessment, and a timely strategic response to fine-scale variation of the parameters of agricultural production processes [2] in order to reduce the waste of natural resources and the use of fertilizing substances also holding or enhancing the yield of the tillage at the same time. In this area, a significant role is played by the Global Positioning System (GPS) [3] thanks to its features in terms of localization. Moreover, remote sensing techniques [4] have been employed to provide suitable and effective informations to the farmers in order to evaluate soil and environmental conditions starting from images collected by satellites or by the plane. However, the need of real-time data and the arising cost strongly suggest the use/integration of/with alternative strategies based on sensors located inside or nearby the tillage. Towards this end, Wireless Sensor Networks (WSNs) can play a relevant role because of their ability of providing real-time data collected by spatially distributed sensors [5]. More specifically, a WSN is a wireless network composed by a set of autonomous, low-power, and low-cost devices (called *nodes*) using sensors to cooperatively monitor physical quantities. WSNs have been already used for precision farm purposes especially for monitoring environmental parameters [6]. Such a paper describes an innovative solution based on a WSN for precision agriculture. With respect to state-of-the-art deployments, the proposed solution is based on totally autonomous sensor nodes characterized by multiple sensors to real-time collect in a distribute fashion data concerned with the temperature and the moisture of the subsoil, but also related to the tree, with the aim of defining a closed-loop control system for production/agriculture management. In the framework of the AGRIWSN project[1], the system is aimed at providing a substantial amount of information in order to assess the relationship between the irrigation and the quality of the tillage yield.

2. DEPLOYMENT OF THE NETWORK

The proposed system is composed by a WSN of 27 nodes, each one equipped with 5 soil moisture sensors, a subsoil thermometer, and a dendrometer in order to monitor the growth of the tree. Such sensors are connected to an input/output interface on a TinyNode 584[2] central unit. As detailed in Fig. 1, the power supply consists of a lead acid battery and a solar panel able to provide 250 *mA* at 7 *V*. In order to perform a real-time monitoring of the state of the network, each node also collects the data concerned with the voltage of the battery, the voltage of the solar panel, and the internal voltage as well as the temperature of the microcontroller. In addition to the voltage of the output signals of the sensors, the voltage of the feeding of the soil moisture sensors and of the dendrometer is gathered in order to real-time compensate the measured data.
The sensor nodes have been deployed on a 5000 m^2 large apple orchard and disposed in 3 different areas where different irrigation essays are carried out. In each area, the WSN nodes have been equally-spaced on a grid of size 30 m × 40 m. As

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[1] http://www.eledia.ing.unitn.it/html/index.php?module=Static_Docs&func=view&f=pages/nolang/agriwsn/index.htm
[2] http://www.tinynode.com/index.php?id=104

shown in Fig. 2, the soil moisture sensors have been located underground at different depth levels ($l_1 = -0.1\,m$, $l_2 = -0.2\,m$, $l_3 = -0.3\,m$, $l_4 = -0.5\,m$, and $l_5 = -0.8\,m$). Moreover, the thermometer has been located at -0.2 *m* in depth and the dendrometer has been applied to an apple tree randomly chosen among those close to the WSN node.
Data are continuously collected by the sensor nodes every 10 *min* and are then transmitted to a gateway node located in the farm 300 *m* far from the orchard and connected to a server station. The data gathered by the sensor nodes and from a permanent weather station are then organized in a database on a public web site. More in detail, data can be downloaded in raw format, their behavior with respect to time can be visualized, or the parameters can be presented linked to the location as in a geographic information system (GIS) as in Fig. 4.

3. CONCLUSIONS

This paper describes a WSN-based system for precision agriculture. Such an installation is characterized by totally autonomous nodes equipped with a set of multiple sensors to collect data concerned with environmental parameters as well as with the status of the apple trees. The preliminary validation of the network confirmed the effectiveness of such a system and the feasibility of the precision farming by means of WSN. The long run use of the system will certainly provide useful data and suggestions to complete a closed-loop solution for production management.

Figure 1 – Prototype of a WSN node

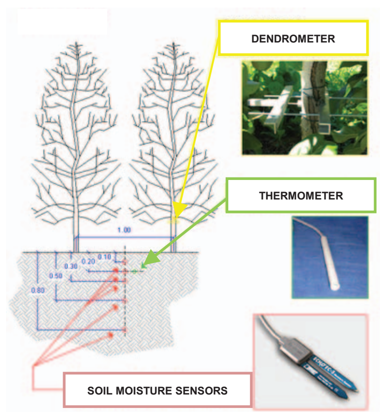

Figure 2 – Sensors positioning

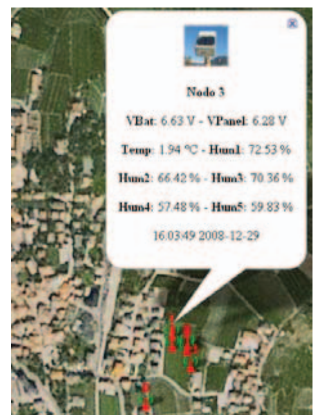

Figure 3 – GIS-like visualization of collected data

4. REFERENCES

[1] J. von Braun, “The food crisis isn't over,” *Nature*, vol. 456, Dec. 2008.

[2] Ciba Foundation Symposium, *Precision Agriculture: Spatial and Temporal Variability of Environmental Quality*, John Wiley & Sons, Chichester (England), 1997.

[3] D. Pfost, W. Casady, K. Shannon, *Precision Agriculture: Global Positioning System (GPS)*, WQ-452, University Extension, University of Missouri-System, Columbia, MO, 1998. http://muextension.missouri.edu/xplor/envqual/wq0452.htm.

[4] J. R. Jensen, *Remote Sensing of the Environment: An Earth Resource Perspective*, 2nd Ed., Upper Saddle River, NJ: Prentice Hall, 2007.

[5] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, “Wireless sensor networks: a survey,” *Computer Networks*, vol. 38, pp. 393-422, Mar 2002.

[6] A. Baggio, “Wireless sensor networks in precision agriculture,” *Workshop on Real-World Wireless Sensor Networks* (REALWSN05), Stockholm, Sweden, June 20-21, 2005.