A Wireless Sensor Measurement Station for Agricultural Applications

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Fig. 1. Wireless acquisition station monitoring different ambient parameters of a young olive tree

***Abstract*—This work describes an application of wireless sensor network technologies for monitoring environmental parameters in agricultural applications. Each sensor node is a small wireless acquisition station composed by a Telos rev.b (Moteiv Corporation) mote and an in-house designed electronic board driving different sensors (soil moisture, leaf wetness, temperature, wind direction, wind speed). Sensor data are collected at the base-station node through a Matlab interface and processed in (soft) real-time. The distributed prototype wireless station was developed at the Automatic Control Laboratory of the University of Siena, Italy.**

I. Wireless ambient sensors

Ambient sensors networks are a cheap, easily deployable, low cost, and non invasive method to monitor ambient parameters in fields under cultivation, increasing the ability to conserve water and energy, optimize cereals yields, and avoid soil erosion and water pollution. Wireless sensor networks have been advocated in recent years for precision agriculture, where real-time data of the climatological and other environmental properties are sensed and relayed to a central repository [1], [2]. In this work, we describe an ambient sensor network where each wireless sensor node (see Figure 1) provides samples of up to five measurements of parameters that depend on atmospherical agents, namely: soil moisture, leaf wetness, ambient temperature, wind direction, and wind speed. The sensors reported in Table I were chosen to provide measurements of such parameters.

Sensor	Vendor
Soil moisture	Decagon Device $EC5$
Dielectric leaf wetness	Decagon Device LWS
Temperature	LM335
Anemometer	Davis 7911

TABLE I
Sensors used in each wireless acquisition station

An electronic board was designed to drive the sensors reported in Table I. The board is connected on the ADC expansion pins of the Telos mote, as depicted in Figure 2. Through specially tailored NesC software components for TinyOS2, each wireless node transmits the digitalized samples to the remote station located at a distance of about 40 m. As ambient parameters vary relatively slowly, samples are obtained every 30 minutes, which is adequate in most agricultural applications. To preserve battery energy, the logic described in the next section has been implemented.

II. Energy preservation logic

The following logic for preserving battery energy was implemented in the NesC program running on board of the sensor node. Samples are collected every 2 Hz during a period T_{on} (2min) when the node is awake with a consumption of 55mA at 3V. After T_{on} has elapsed, the node goes in standby for T_{off} (30min) with radio, sensors, and electronic board switched off, where the consumption is about 2.5mA (3V).

III. Acquisition program

The samples transmitted to the base station are processed by methods and conversion routines developed at the Automatic Control Laboratory designed around a Matlab Java object tool

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Fig. 2. Internal view of the sensor box, with electronic board and battery pack

(see Figure 3). The standard approach of relying on *Serial Forwarder* to collect data in the Matlab environment, such as the one applied in [3] for getting wireless magnetoresistive sensor data in TinyOS1.x+Matlab, is avoided here to simplify and make the real-time acquisition procedure more robust. After acquisition, noise is removed from data samples through a simple moving average filter.

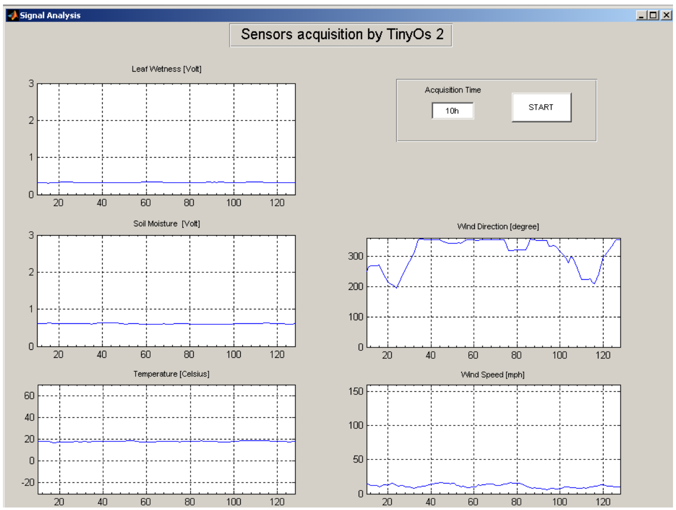

Fig. 3. Matlab acquisition tool for TinyOs2

IV. Implementation and Experiments

Several experiments have been carried out to test the wireless monitoring system in a small olive tree area. During the first set of experiments the nesC application was programmed to acquire ambient parameters from the five sensors, in order to assess the maximum distance between the base station and the mote connected to the sensors, which is about 70 m. Next, we introduced the logic for optimization of battery consumption described in Section II. An example of data obtained in this way is shown in Figure 4, where the graphs show the ambient parameters acquired from the sensors for 24 hours. Leaf wetness and soil moisture signals remained around a constant value, as no rain occurred during the acquisition. On the other hand, temperature decreased during the night and then increased again during daylight. Wind also changed direction several times.

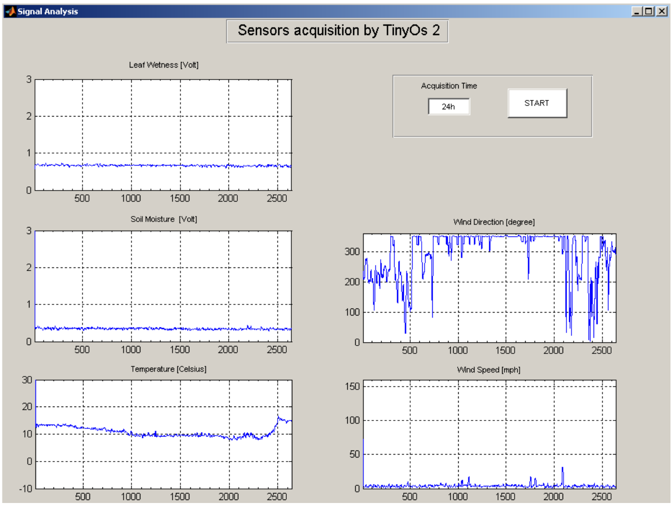

Fig. 4. Outdoor experiment

V. Conclusions

The wireless data acquisition station described in the poster proved to be a quite viable and reliable scheme for real-time monitoring of outdoor ambient parameters for agricultural applications. Several issues remain to be explored. Adaptive transmission schemes improving battery life by processing data locally on the Telos node should be investigated. The use of solar panels to largely increase the lifespan of the sensor nodes is currently under investigation.

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