Title
CON1: Development of the Soil Pylon System for Observing Subterranean Processes

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Publication Date
2005

Development of the Soil Pylon System for Observing Subterranean Processes

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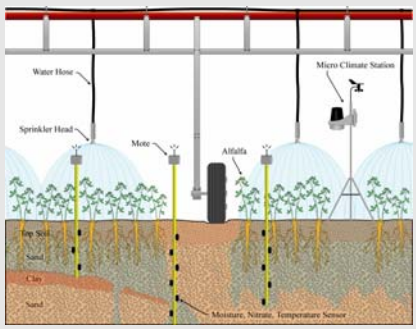
Introduction: Modular Wireless Sensor Networks for Soils

Wireless sensor arrays for observing soil properties would be extremely useful in support of many precision agriculture, environmental monitoring, and terrestrial habitat observation applications. This effort describes the fabrication and functionality of CENS's aggregate subterranean sensing stations referred to as soil pylons. The specific system described here includes the following sensing modalities: soil moisture, temperature, above-ground precipitation/irrigation rate and aqueous nitrate concentrations. This pylon is being deployed in the context of an wastewater recycling/precision agriculture application. Individual pylons are controlled by motes (MICA2) which report to and are reconfigurable by a central "base-station" (Stargate). Data are transmitted to a database (MySQL) where they are easily accessible by physically based process simulation and system control agorithms.

Problem Description: Designing and testing a robust yet easily deployable soil sensing array

Simulation and Control Models

- **Description of the transport and fate of nitrate in the unsaturated zone requires *flow, temperature, and nitrate simulation models***
- **Soil is homogenous fine to medium sand; flow expected to be mainly vertical (one dimension)**
- **Irrigation must be scheduled with simulation models and *data feedback from the pylons* to control pivot operation, thus optimizing discharge of nitrate-laden wastewater**



drawing by Jason Fisher

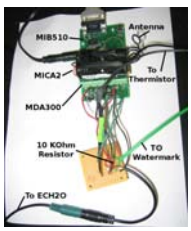
Sensor Network System

- **A *Multi-level sensing station (pylon)* for temperature, moisture, and nitrate was deployed at a test site in Palmdale, CA**
- **The *pylon measures temperature, moisture, and nitrate* in its one-dimensional setting**
- **Pylons will *communicate with other nearby pylons* to delineate water balance and nitrate concentration distribution in time and space.**
- **Data is captured at a base-station and relayed to a database**

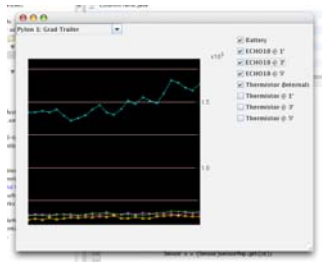
Solution: The CENS soil pylon - An integrated soil sensing and feedback-control system

Pylon Components and Lab Prototype System

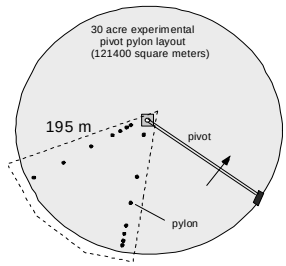
- **Central "base-station" provides mote control:**
  - **Sampling rates**
  - **Data transmission rates**
  - **Energy management.**
- **Motes (using an MDA300 sensor interface board) acquire sensors' readings of the environment**



- **Sensors take samples at user-specificed intervals or adaptively as determined by auto-reconfiguration algorithms (in development)**
- **Current sensor suite:**
  - **Local rain gauge sensors monitor spatially distributed irrigation rates**
  - **Soil moisture sensors monitor local water content to support the observations of water infiltration and redistribution**
  - **Thermistors monitor temperature (local air and below-ground gradient) to support energy balance in evapotranspiration calculations**
  - **Commercially available vs. CENS-fabricated nitrate sensors *(in-situ* test bed system for CENS Sensor Group)**
- **Measurements are propagated through the networ, to the "base-station," where they are forwarded to a central database.**
- **Master solar panels maintain 12 V battery (Stargate); Heliomotes' panels maintain two 1.5v batteries on Motes**



Raw data streaming from Merced test bed for thermistors and soil moisture sensors.



Birds-eye view of pivot coverage area.

Palmdale Field Test Bed

- **Each pylon services a geospatial "zone"**
- **Using current and historical data, we can optimal pylon placement, minimize cost, and maximize our coverage area**

Clockwise from upper right: Irrigation pivot, "Base-station", Main solar panel, Initial Palmdale soil pylon;