Low-Cost Green Stormwater Infrastructure Monitoring: Results from the Field

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Abstract

In this poster, the design and implementation of low-cost instrumentation for green stormwater infrastructure (GSI) monitoring is discussed. As the use of GSI increases, monitoring becomes more and more critical to prove efficacy of the sites, inform future designs, and guide maintenance. This can be expensive and difficult, especially in the case of existing sites that need to be retrofitted.

As part of Philadelphia's Green City, Clean Waters initiative, GSI sites are being installed throughout the city of Philadelphia. The Villanova Urban Stormwater Partnership (VUSP), the Villanova Center for Nonlinear Dynamics and Control (CENDAC), and Philadelphia Water (PWD) have partnered to study the effectiveness of these sites through extensive monitoring of select GSI installations. To accomplish this task, low-cost computing hardware is being leveraged to develop highly reliable, yet inexpensive instrumentation (data logging, sensor interfaces, telemetry, etc.) In the following, work being done in parallel at VU and PWD is presented with a focus on soil moisture monitoring.

Background

In the broader instrumentation community, there is a great interest in the use of emerging low-cost, yet highly functional computer hardware and sensing technologies to augment (or replace) higher-cost equivalents. This, and the open-access nature of these products, has spurred an explosion of useful devices. These developments have a potential to significantly impact the area of GSI monitoring and has generated interest in this community.

There are a number of important design aspects that must be considered, including:

- Power supply and recharge capability (e.g., solar)
- Telemetry (e.g., GSM, Wi-Fi, radio signal)
- Waterproofing and security in the urban environment
- Ease of installation and maintenance.

Villanova University

The goals of the work being done at Villanova are as follows:

- Develop low-cost data loggers for GSI monitoring
- Minimize power consumption
- Create on platform with possibility to be adapted for multiple types of sensors, and various improvements

Morris Leeds Tree Trench

Fig. 1: The Tree Trench Site at Morris Leeds Middle School

As part of this work, 5 tree pits at Morris Leeds Middle School (shown in Fig. 1) have been instrumented with soil moisture sensors and low-cost data logging units. Some information about the system is below:

- Logger uses an Arduino Uno and a Raspberry Pi.
- Sensors used are Stevens Hydra Probe II.
- Cost is around $100.

Fig. 2: Stevens Hydra Probe II soil moisture meter

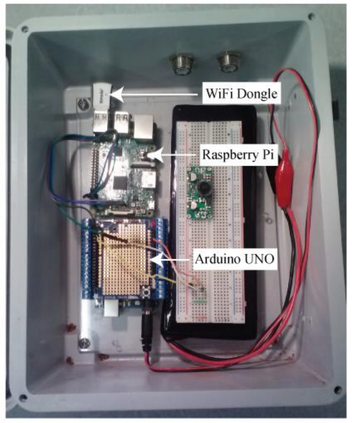

Fig. 3: Data Logger Hardware

Example Data is shown below (horiz. ticks are 1 day apart):

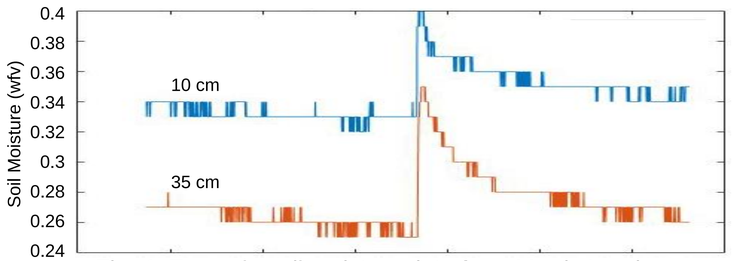

Fig. 4: Example soil moisture data from Morris Leeds.

Philadelphia Water

Philadelphia Water began exploring low-cost sensor technology in 2013 by collaborating with civic hackers and coders to create an environmentally based STEM program (greenSTEM). PWD continues to identify GSI monitoring needs and develop technologies to collect and communicate data, working in tandem with Villanova University.

Kemble Park

Kemble Park, a large GSI site with two rain gardens and a connecting swale, is costly to maintain. Watering is mandated if no rain occurs for 4 consecutive days while vegetation is establishing. Data collection helps ensure watering occurs only when needed and avoids costly overwatering.

In order to inform the maintenance crew, a sensor unit has been designed to communicate soil moisture data to the maintenance group remotely by using the 2G cell phone network and a cloud network to store and display data online:

- Uses Adafruit Fona board to enable 2G communication.
- Sends an alert email when moisture levels fall below certain thresholds.
- Unit costs around $150.

Fig. 4: PWD Data Logger "El Chapo"

Example data is shown below:

Acknowledgments

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