Development of calibration equations for capacitance sensors to enable accurate measurement of soil water content using IoT-based network

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ABSTRACT

Soil water content is one of the most important factors affecting crop development. Knowledge of soil water content (SWC) in agricultural fields help us manage water in a sustainable manner. There are several methods available to monitor SWC which includes labor intensive gravimetric method and different types of sensors. Although SWC sensors are helping the farmers to monitor SWC, they are very expensive and lack the spatial resolution, accuracy, and precision. For optimal design of sub-irrigation systems, it is very important to know the plant root zone water uptake pattern using miniature soil water sensors installed within the rootzone.

There is a need to test the accuracy, ease of use, and precision of different soil water sensors in Manitoba soils to enable remote monitoring. Raspberry Pi based data acquisition systems will be useful to collect, store, and transmit field data collected with different sensors. However, the commercial water content sensors lack the precision necessary for data collection in experimental plots. In this research, capacitance-based soil moisture sensors were connected to the Raspberry Pi to monitor soil water content in soil samples which were weighed periodically to obtain the gravimetric water content as the standard to compare.

The data presented in this study will compare the accuracy and precision of the capacitance sensors. A data collection, storage, and transmission protocol will be presented.

CONTACT

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References

- Arduino(2014a) Download the Arduino software. 28 Oct. 2014. <**http://arduino.cc/en/Main/Software**>.
- Cayanan, D.F., Dixon, M., Zheng, Y.(2008) Development of an automated irrigation system using wireless technology and root zone environment sensors. Acta Hort.797:167–172.

OBJECTIVES

- To find out soil moisture sensor probe's characteristics under laboratory conditions.
- To integrate the DF robot with raspberry-pi integrated system .
- To develop a calibration equation for DF Robot Sensors.

METHODS AND MATERIALS

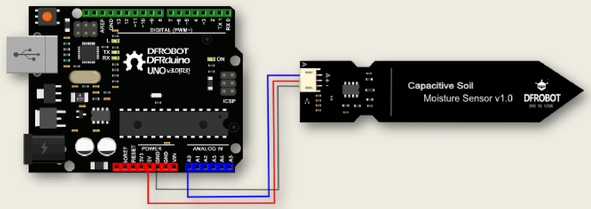

Figure 1. DF Robot Capacitive Soil Moisture Sensor

Figure 2. Soil Samples

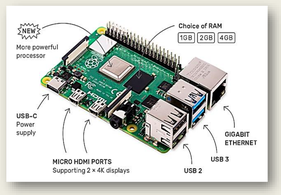

Figure 3. Raspberry Pi

Figure 4. GSM Module

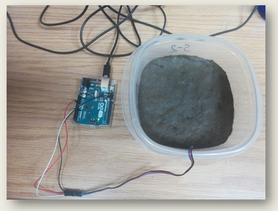

Figure 5. Lab Test

Figure 6. VNC Viewer

RESULTS

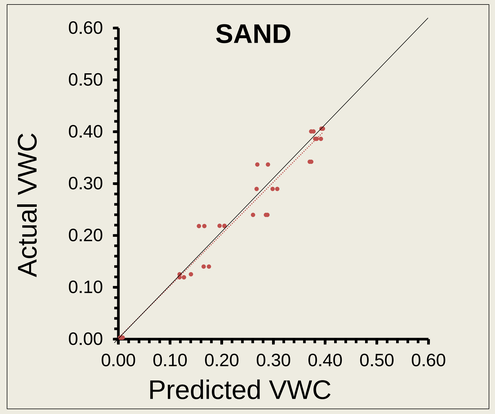

Chart 1. Standardization of DF robot sensor on sand

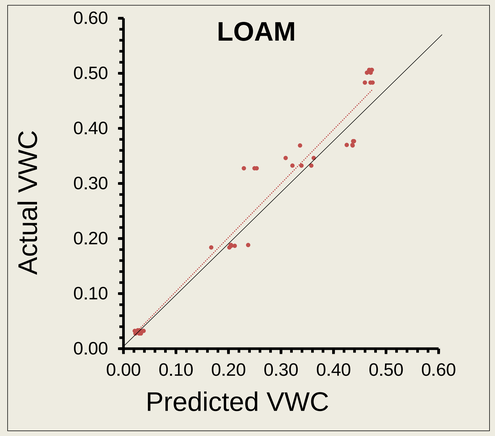

Chart 2. Standardization of DF robot sensor on Loam

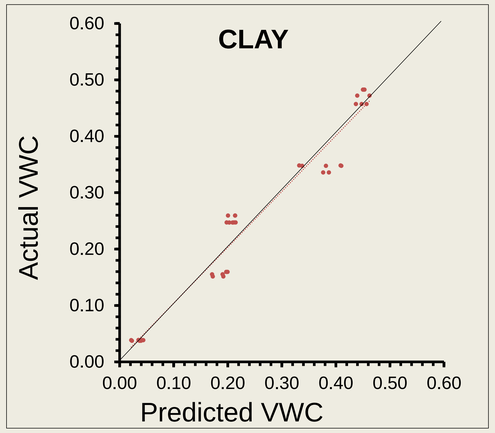

Chart 3. Standardization of DF robot sensor on Clay

CONCLUSIONS

- DF Robot performed with high 95% to 99% correlation to the actual volumetric water content.
- Installation of DF Robot is quite simple and easy to monitor via raspberry pi with Analog to Digital Converter (Arduino).
- Calibration equations were developed for three different soil types

RESULTS

Soil Type	Calibration Equation	R^2
SAND	$y = -6E\text{-}13x^3 + 3E\text{-}08x^2 - 0.0005x + 3.0813$	0.9598
LOAM	$y = -3E\text{-}13x^3 + 1E\text{-}08x^2 - 0.0003x + 1.9692$	0.9458
CLAY	$y = -8E\text{-}13x^3 + 4E\text{-}08x^2 - 0.0006x + 3.3594$	0.9465

Table 1. Calibration equations of three different soil types

DISCUSSION

- DF robot sensor probe should be penetrated deeply.
- Maximum errors can be neglected by controlling air gap occurs in between probe and the soil.
- Electronic circuits should not be exposed to moisture. Beeswax utilized to protect that.
- Probes are quite sensible of its depth of penetration because it affects accuracy of the data