SenSprout: Inkjet-Printed Soil Moisture and Leaf Wetness Sensor

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ABSTRACT
In this paper we show a low cost and environmentally friendly fabrication for an agricultural sensing application. An antenna, a soil moisture sensor, and a leaf wetness sensor are inkjet-printed on paper substrate. A microprocessor attached to the paper substrate is capable of detecting the capacitance change on the surface of the sensor, and report the data over the wireless communication interface. This sensing system is useful to optimize irrigation systems.

Author Keywords Inkjet-printing, Energy Harvesting

ACM Classification Keywords C.3 [SPECIAL-PURPOSE AND APPLICATION-BASED SYSTEMS]: Microprocessor/microcomputer applications

General Terms Design, Experimentation

INTRODUCTION
Water is essential for the growth of plants. Even though droughts inhibit the growth of plants, overwatering can also stress the plants and make them more susceptible to disease and blight. Thus, irrigation optimization has been one of the most important challenges for modern agriculture. In this paper, we present a low-cost, inkjet-printed sensor that makes it possible to densely monitor soil moisture and detect rainfall or frost over a wireless link. Different from existing sensors, electrodes and antennas are printed on paper substrate that degrades in the soil due to bacteria after the growing season. This is important for keeping the manufacturing cost low and eliminating the need to collect the densely deployed sensors over vast fields.

DESIGN AND FABRICATION PROCESS
Figure 1 illustrates the concept of SenSprout As previously mentioned, sensor electrodes and an antenna are printed using a Dimatix DMP-2800 inkjet printer. Different from typical printed circuit board fabrication processes using etching, the necessary amount of silver nano-particle ink is directly printed onto the paper surface. Sintering is performed in an oven at a constant temperature of 120°C for 4 hours after printing. The sintering process increases the conductivity of the metal. A chemical coating can be applied to the paper surface to increase durability.

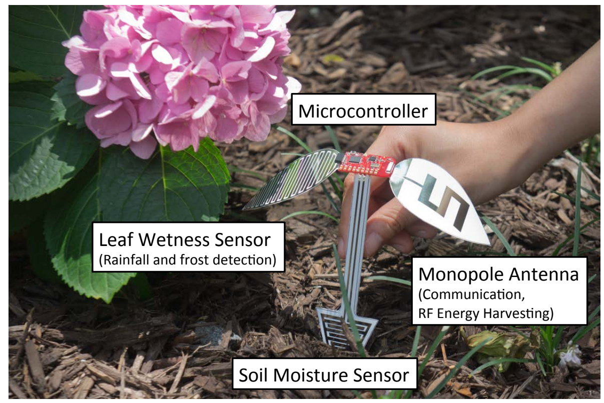

Figure 1. Prototype of the inkjet-printed sensor SenSprout.

Soil moisture can be detected by monitoring the change of capacitance of the electrodes embedded in the soil. The dielectric property (permittivity) of liquid water is approximately 80, while that of dry soil is about 4. Because capacitance increases proportionally to the permittivity, the amount of water in the soil can be determined. Different from [1], we directly measure the change of capacitance by forming a RC circuit with a microprocessor (Texas Instruments MSP430). Rainfall and frost can also be monitored using the same method because permittivity of air, water and ice are 1, 3.2, and 80, respectively.

The monopole antenna covers 2.4-2.5GHz where IEEE 802.15.4 is used. The antenna can be used for wireless communication as well as wireless power transmission or ambient radio frequency energy harvesting[2]. Because used batteries can contaminate the soil when physically damaged, it may be preferable to use a capacitor to store the electrical energy sent over wireless power transmission methods.

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REFERENCES

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