Improved Durability of Soil Humidity Sensor for Agricultural IoT Environments

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***Abstract*—Soil humidity is the most important factor for plant growth. Therefore, the soil humidity sensor is an important part of smart farm application using agricultural IoT environments. Since soil humidity sensors are applied wet underground and the sensor consists of copper, rust eats away the copper surface of sensors. From rusting of sensors, wrong information of soil humidity can be collected on smart farm system based on agricultural IoT Environments. It makes that smart farm is not reliable. In this paper, we propose a new type of soil humidity sensor in order to extend life time.**

I. Introduction

The smart farm is a kind of farm automation system based on IoT technology. In 2015, the total area of smart farm or greenhouse system in Korea is 364ha, and it is 607% wider than in 2014 [1]. 80% farmers know the smart farm and 54.3% farmers have and intention to install smart farm [2]. The main feature of the smart farm is data monitoring and data of smart farm is collected using various sensors [3-5]. Among the various information of smart farm, a soil humidity is the most significant for plant growth and productivity [3]. A soil humidity sensor is vulnerable to moisture because its tips are copper which is easily corroded from soil and moisture. We found out this problem while developing a smart farm system.

To solve this problem, we propose a new type of soil humidity sensor which is last long and cheap with replaceable tips. The proposed sensor uses Korean chopsticks as tips with variable resistance.

II. Soil Humidity Sensor

We found a part where abnormal soil moisture values are collected during the process of developing a smart farm system [7]. Abnormal soil moisture data values are from corrosion of the soil moisture sensor. In order to check the corrosion speed of legacy soil humidity sensors, we tested the corrosion of legacy sensors. As a result, corrosion occurred rapidly in the working environment with voltage to measure soil humidity, as shown in Fig. 1. Corrosion occurred in both underwater environments and wet soil environments. However, sensors which did not collect data were not corroded. As shown in Fig. 2, corroded sensors measured unstable data, making the smart farm data unreliable. This means that the conventional soil moisture sensor can no longer be stably used for a long time.

To solve this problem, it is possible to coat the tip portion of the sensor with a material not corroded or to use a material which does not cause corrosion. In the case of the coating method, since only electrons smaller than the molecules of water can be transferred, the sensor to be coated has lower sensitivity. Therefore, we investigated materials that are resistant to corrosion but can be obtained easily and inexpensively in the surroundings. As a result, Korean steel chopsticks, vacuum chopsticks, stainless steel rod were selected as a candidate group and it was confirmed whether it could be used at the tip of the sensor. Korean chopsticks are made of compound metal and can be easily obtained at a price within 1 dollar. Furthermore, spoons and forks of similar material can be substituted. Fig. 3 shows the measurement of the humidity of the underwater environment using Korean chopsticks with various resistances. As the resistance value increased, it was confirmed that the data increased. In the case of a general soil moisture sensor, when it is 750, it is judged as an underwater environment. Therefore, it is possible to use soil moisture sensor with Korean chopsticks by using resistance. Based on this, we propose a soil moisture sensor with Korean chopsticks with a variable resistance driven by software. After replacing the tips, install the sensor in the underwater environment and design to fix and fix the appropriate resistance of the new tips via resistance setting. The minimum resistance value that stably maintains the value of 750 or more underwater environments is set to the sensor.

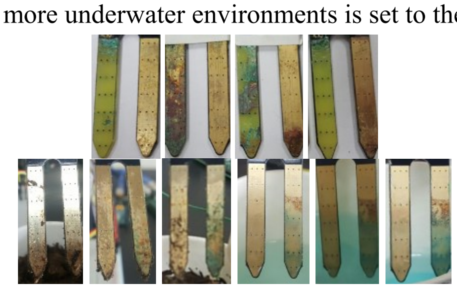

Fig. 1. Corrosive condition of legary soil humidity sensors. First row pictures are 2 months past. The first three pictures of second row are 5 days, 10 days and 20 days past under humid soil. The last three pictures are 5 days, 10 days and 20 days past under water.

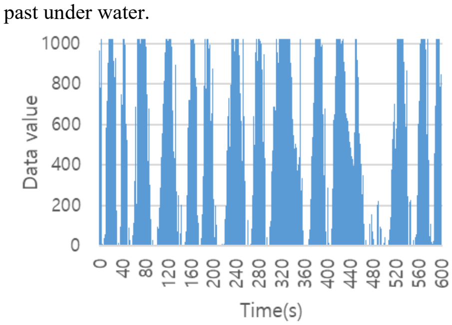

Fig. 2. Data graph of corroded soil humidity sensor.

This is research was Supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Science, ICT & Future Planning (NRF-2015R1C1A1A02036686)

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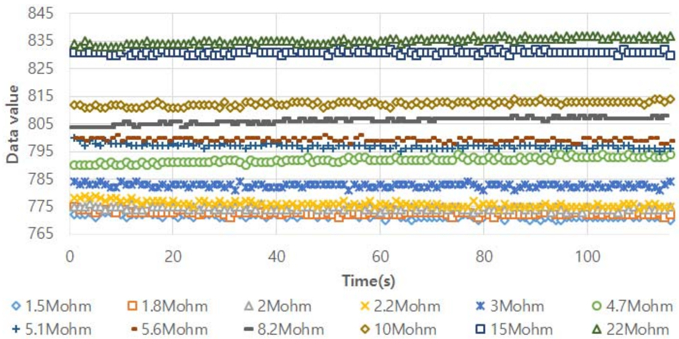

Fig. 3. Soil Humidity Data of the proposed sensor with Korean chopsticks by variable resistance in underwater.

III. Experimental Environment and Results

To confirm the performance of the proposed soil humidity sensor, we experiment comparing corrosion of sensors and automatic resistance setting function at tip replacement. We mounted on the proposed sensor using three material tips and set the appropriate resistance values automatically respectively. We collected data from two legacy soil humidity sensors and the three sensors set in this manner under wet soil environment and examined the extent of corrosion for total 5 sensors. For legacy soil sensors, FC-28 and SEN0114 models, which are commonly used soil moisture sensors, were used. For each of the three proposed sensors, we used Korean steel chopsticks and vacuum chopsticks, stainless steel rods, as a tip. We periodically supplied the same amount of water to the soil of the same environment for a total of 5 sensors and collected information on soil humidity every 1 second and checked the degree of corrosion at weekly intervals.

Fig. 4 shows the degree of corrosion of each sensor at 8th experimental week. In the case of the legacy sensors FC-28 and SEN0114, corrosion progressed on the sensor surface, whereas the proposed sensor confirmed that corrosion was not advanced at all. Fig. 5 describes collected data for one day at the 57th experimental day. It was confirmed that the soil humidity data pattern of the proposed sensor excluding the sensor using the stainless steel rod were not significantly different with data pattern of legacy sensors. However, the unstable data value of SEN0114 sensor is due to malfunction caused by corrosion progressing to a certain part.


Fig. 4. Tips change of soil humidity sensors at 8th experimental week.

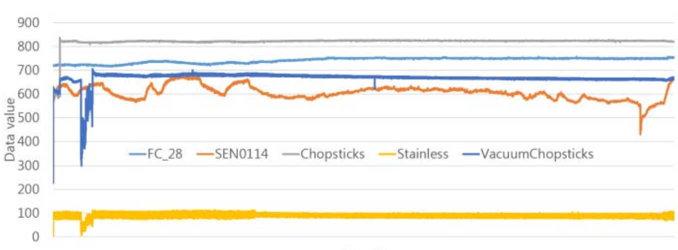

Fig. 5. Soil humidity data for one day at 57th experimental day.

Through experiments, we confirmed that the proposed soil humidity sensor is corrosive stronger than existing sensors, as well as being usable in actual environments. We confirmed that Korean chopsticks have the best sensing performance among the three material tips.

IV. Conclusion

The soil humidity sensor which is the core sensor of the smart farm is vulnerable to corrosion according to measurement principle and usage environment. This shortens the replacement cycle of the soil moisture sensor, which is an obstacle to the spread of smart farms. To solve these problems, we proposed a soil moisture sensor which is more resistant to corrosion than legacy sensors and which can be replaced with a material that can easily be seen in the surroundings. The proposed sensor prototype is implemented and confirmed that it can be normally used for a long time in an actual environment through comparison with legacy sensors. Corrosion did not occur in sensors providing experimental results up to the present, but if corrosion occurred, it showed that it can be used semi-permanently by exchanging tips. Through ongoing experiments and observations in the future, we plan to check the lifetime and drawback of the proposed sensor and solve this. In addition, we plan to find various tips such as spoons, forks, knives and the like having properties similar to those of Korean chopsticks and apply them to proposed sensors.

Reference

[1] Y. Kim, J. Park, and Y. Park, *An Analysis of the Current Status and Success Factors of Smart Farms,* Korea Rural Economic Institute, 2016.

[2] K. Kim, Y. Jeong, and D. Park, “The Implementation of Farm Management System based on IoT,” *in Proc. KICS Winter Conf.,* pp.366-367, Jan. 2016.

[3] J. Seo, M. Kang, Y. Kim, C. Sim, S. Joo, and C. Shin, “Implementation of Ubiquitous Greenhouse Management System Using Sensor Network,” *in J. of Korean Society for Internet Info.*, Vol. 9, No. 3, pp.129-139, Jun 2008.

[4] N. Yoo, G. Song, J. Yoo, S. Yang, C. Son, J. Koh, and W. Kim, “Design and Implementation of the Management System of Cultivation and Tracking for Agricultural Products using USN,” *in J. of KIISE : Comp. Prac. And Letters*, Vol. 15, No. 9, pp.661-674, Sep. 2009.

[5] S. Lee, T. Kim, T. Lee, and S. Lee, “Effect of Fertigation Concentration on Yield of Tomato and Salts Accumulation in Soils with Different EC Level Under PE Film House,” *in Korean J. of Env. Agri.*, Vol 25, No. 1, pp.64-70, 2006.

[6] J. Kim, S. Chung, D. Lee, Y. Cho, S. Jang, and J. Chol, “Calibration for Proper Usage of FDR Soil Moisture Sensors”, *in Horticulture Abstracts*, pp.52, Oct. 2014.

[7] Y. Jeong, K. An, S. Lee, M. Lee, and D. Seo, “A Proposal of Smart Farm Watering Automation System based on IoT and Pattern Learning,” in Proc. of 2017 Spring KIPS Conf., Vol. 23, No.1, pp.935-938, Apr. 2016.