Development of a Multi-function Water Depth Sensor in the Irrigated Paddy Fields for Water Resource Management and Precision Agriculture

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Water resource management is one of the most critical issues in the worldwide area. Taiwan area is lack of water resources due to that the main rainfall is concentrated in summer seasons and the water storages in rivers and dams are also difficult. In Taiwan, the water consumptions for agricultural purposes are around 71% of the total water use, and the water use for irrigated paddy fields is close 72% of the agricultural water use. Therefore, the water use for irrigated paddy fields is around 50% of the total water use in Taiwan. Similar water consumptions situations were also found in Japan and some southeast Asian countries. A systematic, real-time and optimal management for the water use in irrigated paddy fields is the most critical issue in the water resource management in Taiwan. The Internet of Things (IoT) connects the physical devices, software, appliances and sensors, which is able to inter-operate within the existing internal infrastructure, which provides the opportunities for more effective, precise and economic benefit of water resource management. Moreover, the Precision Agriculture is a farming management concept based on observing, measuring and responding to inter and intra-field variability in crops to optimize the yields while preserving resources, which was considered as one of the key components of the third wave of modern agricultural revolutions. Indeed, the Precision Agriculture is one of the implementations of the IoT. However, one the most critical points for these applications of IoT is to develop a useable and multi-function sensor.

This research focuses on the development of a multi-function water depth sensor for the irrigated paddy fields based on the concept of continuous conductivity measurements in different depths of the water in the irrigated paddy fields. According to the experimental results, the conductivity profiles can precisely indicate the depths of water level in the irrigated paddy fields. Moreover, a wireless sensor network system (WNS) will also be constructed to detect and collect the conductivity data from different sensors located in different fields and water channels. This information can be used to optimize the water use for the irrigated paddy fields by cooperating a water gate to control the water flow into the field, resulting the saving of water resource for paddy fields. Then a systematic and real-time using the concepts of IoT for the optimal management of the water use of irrigated paddy fields can be constructed.

Additionally, the fertilizer substances (for example the nitrogen, phosphate, potash) drawn in the paddy fields will alter the measured conductivities in the fields. This proposed multi-function water depth sensor based on the continuous conductivity measurements can indicate the approximate concentrations of the fertilizer substances in the fields. A series of tests were also conducted using the proposed water depth sensor to measure the conductivities of the samples which were added different concentrations of chemical fertilizers into the collected water from the real paddy field. A linear relationship was found between the measured conductivities and the concentrations fertilizer (presented by ammonia nitrogen) added in the samples. This finding indicates that this proposed depth sensor can also measure the approximate concentrations of the fertilizer substances in the fields, and provides the multiple information in the paddy field. On the other hand, this proposed sensor can be used as an early warning when the irrigation water was polluted by the discharged wastewater, especially form the industrial

wastewater.

Both of the peasants and the governor of the water use of irrigation system can connect to the on-line sensor system. The governor can use this information from the system to optimal the water use for paddy fields even for the other agricultural purposes, and also provide a basis for the development of the Precision Agriculture. The peasants can also more effectively manger the water depth in their paddy fields by using a cell phone to connect to this on-line sensor system.

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