A Robust Irrigation System with a Flow Sensor

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***Abstract*: An autonomous precision irrigation is drawing its attraction as it can reduce labor and water, and improve productivity in agriculture. This paper presents the design of a robust pump control system that can irrigate to a designated area with a fixed amount of water or run times. The system is able to turn off the pump in exceptional situations such as the absence of water. We experiment the implemented system with a drip-irrigated plant pot, showing the designed pump control algorithm works correctly.**

***Keywords* : Autonomous Irrigation, Flow Sensor, Solenoid Valve, Things Board, Water Pump**

I. INTRODUCTION

Water is the very important finite resource for the growth of plants. In Korea, water shortages occur frequently in summer because of the irregular precipitation distribution; in fact, Korea could be facing water crisis in the future. Furthermore, Korea's agricultural sector is at risk owing to the aging of rural populations, which is diminishing the stock of available farm labor [1]. Therefore, to reduce water and labor needs and improve sustainable agricultural productivity, a new system is needed. To this, an efficient, autonomous irrigation will be the answer. [2]. Smart irrigation management to maintain a balanced soil water content is crucial for the health and productivity of farm crops [3], and with smart irrigation, novice farmers can water as efficiently as the experienced farmers do. When an autonomous irrigation system is running, under the conditions of absence of water and pump running idle, it may fail due to overheating. Therefore, it is necessary to control the irrigation system to operate without failure even in exceptional situations. Researchers have studied several irrigation projects based on a water pump controller and the water level detection. The authors [4] used an ultrasonic sensor to detect water levels in water tanks. Getu et al [5] used a water level detection method for the purpose of filling a water tank. Ahn et al [6] used water level sensors in the water tank to implement an intelligent motor pump diagnosis system. Thus, the system informs the user of a low water level warning immediately when the water level drops. Two of the PLC GmbH's PLS-041A-6PPI level sensors were used to diagnose a pump by reading HIGH or LOW values. The disadvantages of the methods above are that it is not able to irrigate a fixed amount of water and also is difficult to install water level sensors in a water well. Our objective was to design a robust irrigation system using a flow sensor that automatically turns off the system when there is no water, and can irrigate the specified amount in a designated area. This method has the advantage that it can work in a water well instead of a water tank, and also prevent its failure due to idling. This paper consists of the following sections. In Section 2, we describe the architecture of the robust irrigation system; in Section 3, we presents the experimental environment and results. Finally, we presents the conclusions of the paper in Section 4..

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II. METHODOLOG

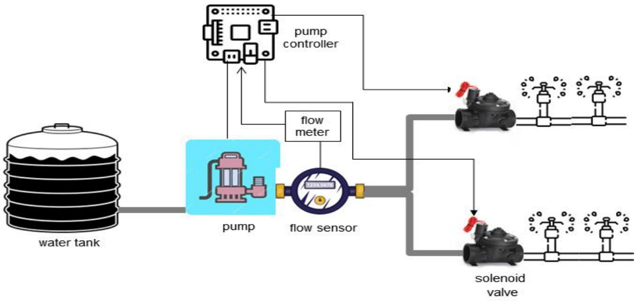

Fig. 1. A Robust Pump Control System Architecture

As Figure 1 shows, the flow sensor is placed in the pipe between the pump and the valve. And, the flow meter reads the measurement of the flow value when the pump is running.

When watering a specific zone, the pump controller turns on the solenoid valve and the pump. As the pump is operated, water is supplied from the water tank, and is discharged to the pump outlet. Then the amount of flow rate can be calculated by the flow sensor. If two zones are irrigated, both the pump and the two valves should be turned on. Thus the amount irrigated in each zone will be half the total amount. The pump controller turns on the power of the solenoid valve and pump when irrigation is performed in the designated area. Then the amount of flow rate can be calculated by the flow sensor. If two zones are irrigated, both the pump and the two valves should be turned on. Thus the amount irrigated in each zone will be half the total amount. Once water does not enter the pump, there will be little change in the value of the flow sensor. If there is no change in flow rate during the threshold time, it is judged that there is no water, the pump is automatically turned off.

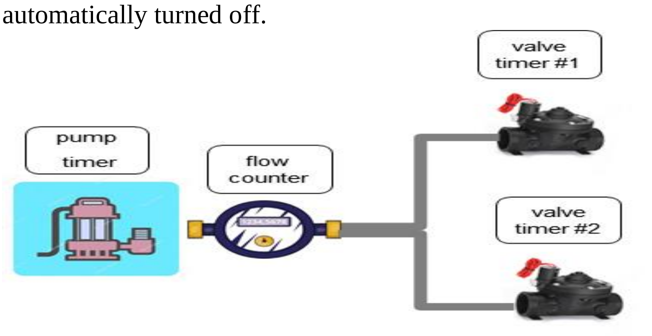

Fig. 2. Software architecture

Figure 2 shows the

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software view of our system. We design each pump and solenoid valve to have its own software timer to run under designated times. The operating rules for irrigation are as follows:

- Rule 1. If the valve time is set without setting the pump run time, it only records the valve time without opening the valve. When the pump is operated, then the valve is opened first and the pump is started.
- Rule 2. The valve timer starts when the pump starts to run. After the set time, the valve is automatically closed.
- Rule 3. If any of the valves are not open, the pump does not start. When, all are closed while the pump is running, the pump will automatically stop.
- Rule 4. When the pump is stopped, all valves are automatically closed.

III. RESULTS AND DISCUSSION

Table 1. Parts list

Hardware	Model
Pump controller	Raspberry Pi V3
Flow meter	Arduino Nano
Flow sensor	FS400A G1”
Solenoid valve	HUNTER PGV 1”
Relay	SSD YHD2415A

Fig. 3. A robust pump control system prototype

We constructed our system as show in Fig. 3, using the parts in Table 1. The Raspberry Pi acts as a gateway between a cloud server and a sensor network and also a controller to control both pump and valve. The flow meter reads the value of the flow sensor and transmits this value to the gateway using a serial communication method.

Fig. 4. A plant pot testbed

We conducted experiments on a plant pot of 70 x 40 x 50 cm with sandy soils and drip irrigation. Instead of a pump, the irrigation pipe connects to tap water and by operating the tap, cases where water was supplied and was not, were manually operated. When there is no water for 10 seconds, the valve is set to turn off. We implement an automatic irrigation using ThingsBoard, an open-source Internet of Things platform [1].

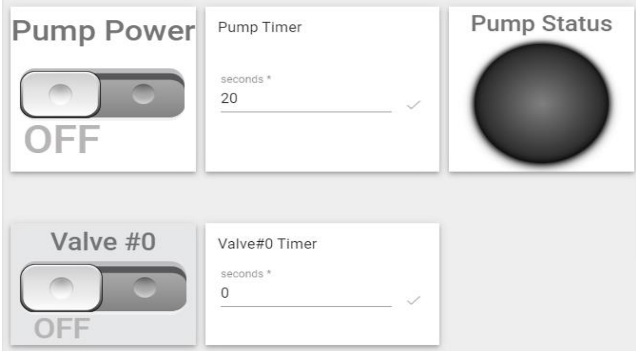

Fig. 5. Things Board dashboard to control each pump and solenoid valves

Fig. 5 shows the dashboard for our irrigation system. The dashboard has a timer and a power button for each pump and solenoid valves. The LED button indicates the current pump status and turns green when the pump is running.

```
pump on
pump off: duration end
pump off
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(a)

```
pump on
pump off: no water flow for 10 seconds
pump off
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(b)

Fig. 6. Examples of messages according to pump operation: (a) normal operation, (b) exceptional circumstances without water

Fig. 6 shows log messages when the system is running. Fig. 6(a) is a case in which the power of the pump is turned off after irrigation is normally performed during the designated time. 6(b) shows that the pump is turned off automatically because there is no water.

IV. CONCLUSION

With this paper, we aimed to present design and implementation of a robust water pump system that can adjust irrigation run times and the amount of irrigation water to specified zones. Also it is able to automatically shut down when there is no water. Applying the implemented system to a plant pot, we confirm that the system worked correctly. We believe this method can guarantee a robust irrigation system

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AUTHORS PROFILE

Byungsoon Kim, is working with Andong National University in South Korea as a professor since 2003. He received his PhD and MS degrees in computer science from Kyungpook National University and Sogang University, South Korea, respectively. His research interests include wireless sensor and actuator networks, and smart farming.