2010 Jeju
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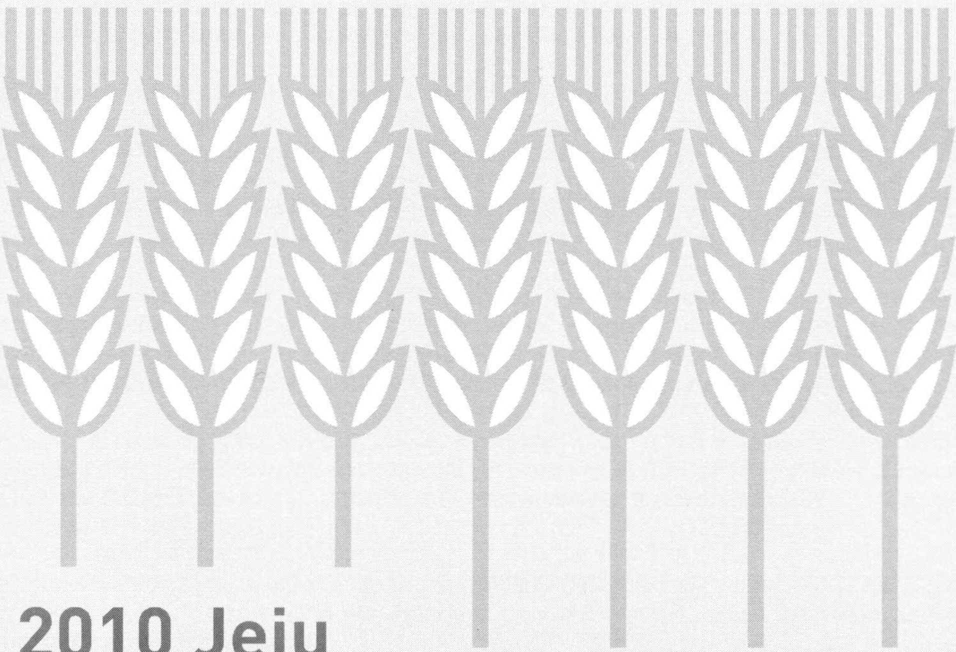

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October 27~29, 2010 ICC Jeju

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Development of Wireless Automated Irrigation Control System[1]

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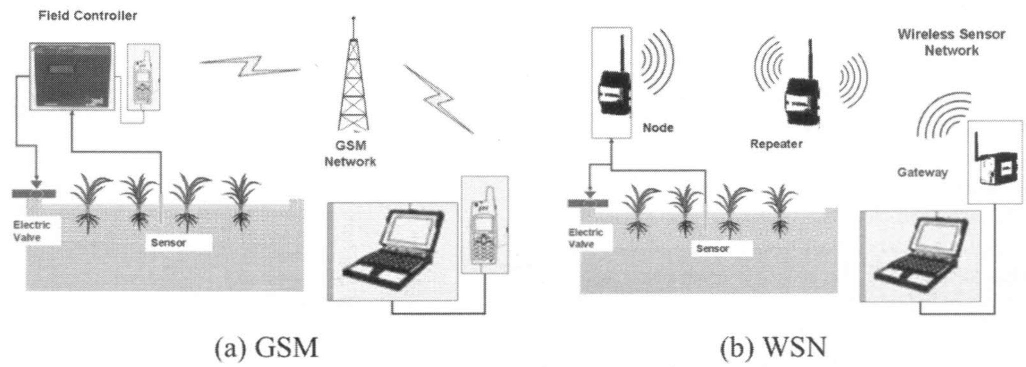
The aim of this research is to develop an automation system for irrigation to be implemented on existing irrigation facility. Implementations of this system are in the experimental production land for organic farming developed at IPB Campus, which uses piping system for water transmission and at experimental irrigation station. The system is also implemented in the research on modernization of irrigation in Indonesia, collaborated with Ministry of Public Works. The control system uses water level detection as input and operates the irrigation by using electric valve to open or close irrigation inlet.

There are two systems that are being developed for the implementation, both incorporating wireless communication technology. The first system used cellular based communication system (GSM) to provide long range irrigation control system (Fig. 1.a), and the second one used wireless sensor network system (Fig. 1.b) with much shorter range (up to 500 m from controller to control point device).



(a) GSM (b) WSN

Fig. 1. Wireless Irrigation Control System

In the first system, automation is made possible by using field controller to operate the valve that was programmed to act to keep water condition at the field as expected to provide suitable water condition, to record data from sensors and irrigation activity. Apart from the microcontroller a computer is prepared as main controller to monitor the control activity and regularly download data from the field controller. Additionally the computer can also send command to the microcontroller if changes should be made in the field controller. The communication between main controller and field controller is established by using cellular communication system, enabling flexible location of field controller implementation.

[1] Extended abstract prepared for INWEPF-PAWEES Joint Symposium, Jeju Island, Korea 2010.

The later system is similar to the first one, except that the wireless communication is made possible by using *Gateway* and *Nodes*. Computer, programmed as controller, communicate wirelessly to the Nodes attached with sensors and valves though Gateway. Nodes will collect data from sensors and will act to control the valves based on instruction sent from the computer. The instruction is the result of the control program that is run in the computer.

Both systems experience delays in response, starting from acquiring data, sending data to the computer, processing the data, sending control instruction and the movement of the valves. As the field is being irrigated, water level rises slowly and after irrigation the water decreases even slower. This cause the input signal sensed by the sensor varies slowly and thus the sampling resolution can be lowered to minutes scale for example, which in turn can be considered to adjust the system operation for lowering power consumption. Communication cost is also need to be considered in the GSM system, which is directly proportional to the length of connection time used in the operation. These issues suggest the need of efficiency in the connection.

Therefore, timer control was introduced in the development of the system. The timer control is also the solution for the open-close operation of the valve. Since the valve is an on-off device, it needs to be open for a certain time to discharge sufficient amount of water to maintain the water level. Fuzzy Control is used to adjust the timer, which then is called Fuzzy Timer Control (FTC) in this research. In summary, the control system gives output of 1. On/off of irrigation (or drainage) valve and 2. Length of operation time, which decide how long the valve will open or close and also how long until the computer connect to the field controller (in GSM case) again.

Table 1. Valve Operation U_{op}

Uop	Irrigation	Drainage
1	on	off
0	off	off
-1	off	on

Control signal Uk is the output of FTC, which relation between U_k, U_{op} and t_{op} is as follows.

$$U_k = U_{op} * t_{op} \qquad (1)$$

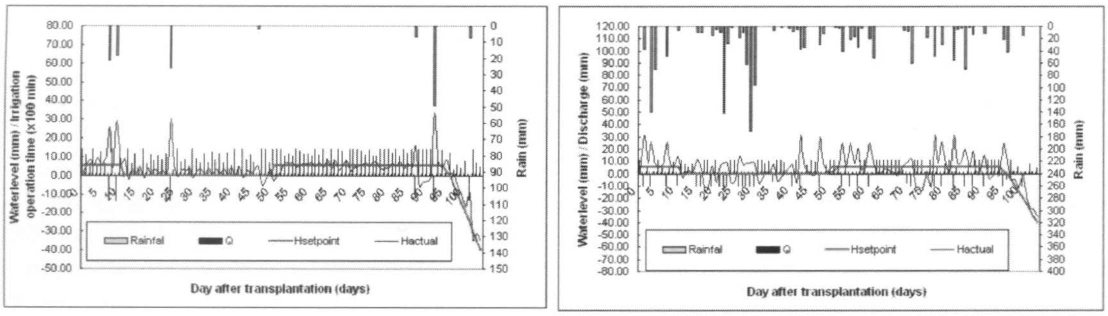
The result of the FTC is the sign (+/-) and operation time (Table1.). This system was used in simulation of water control, the simulation was based on water balance model

$$HP_t = HP_{t-1} + RF_t \pm Q_t - ET_t - P_t - RO_t \quad (2)$$

where ,

HP_t = water level/water table in the field at day t (mm)
HP_{t-1} = water level/water table in the field at day t-1 (mm)
Q_t = irrigation (+) or drainage (-) at day t (mm)
ET_t = Evapotranspiration (mm)
P_t = Percolation (mm)
RO_t = Surface run-off (mm)
t = time (day)

The results of the control system are as depicted in Fig. 2. Table 2 shows the behavior of FTC during the simulation. Here it is shown that the FTC works for controlling the irrigation as expected, but has limited performance in maintaining water level at a certain level, especially in the extreme case of rainfall or in a heavy rainy period.



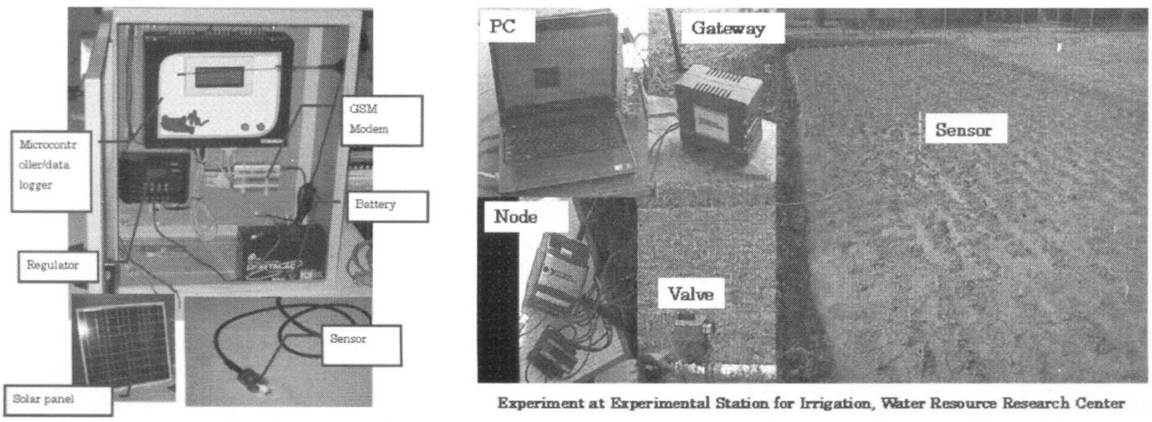
(a) Dry Season (b) Wet Season

Fig 2. Water balance simulation using FTC irrigation control

Table 2. Uk, top dan Qtotal of an example of simulated water level control operation

T (Day)	Uk	t_{op} (x100 min)	Irr	Drain	Q (mm)	Uk	t_{op} (x100 min)	Irr	Drain	Q (mm)
	Dry Season					Rainy Season				
0	1.00	14.40	1.00	0.00	14.09	1.00	14.40	1.00	0.00	11.07
1	0.79	11.41	1.00	0.00	11.16	-1.00	14.40	0.00	1.00	-11.07
2	0.43	6.13	1.00	0.00	6.00	0.49	7.11	1.00	0.00	5.47
3	1.00	14.40	1.00	0.00	14.09	-1.00	14.40	0.00	1.00	-11.07
4	0.39	5.66	1.00	0.00	5.54	0.10	1.48	1.00	0.00	1.14
5	0.90	12.89	1.00	0.00	12.61	1.00	14.40	1.00	0.00	11.07
50	1.00	14.40	1.00	0.00	14.09	1.00	14.40	1.00	0.00	11.07
51	1.00	14.40	1.00	0.00	14.09	1.00	14.40	1.00	0.00	11.07
52	1.00	14.40	1.00	0.00	14.09	0.45	6.54	1.00	0.00	5.03
53	0.76	10.97	1.00	0.00	10.73	-1.00	14.40	0.00	1.00	-11.07
54	0.83	11.97	1.00	0.00	11.71	0.93	13.42	1.00	0.00	10.32
55	0.76	10.89	1.00	0.00	10.65	-1.00	14.40	0.00	1.00	-11.07

The wireless control system for Irrigation has been tested in a short trial for the WSN system. The GSM system has not yet been tested because of some problems in the preparation of the experimental land. Fig. 3. shows the pictures of the two systems prepared for testing.



(a) (b)

Fig 3. Wireless control system prepared for research and education facility at IPB (a) and Experimental Station for Irrigation (b)