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A Watering Controller System in Mixed Garden Based on Temperature and Moisture by Case Base Reasoning Technique via Wireless Network

Thammakorn Krongtripop[1*] Putthiphong Kirdpipat[2] and Witaya Srigul[1]

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Abstract

The purpose of research is to construct paper watering controller system in mixed garden based on temperature and moisture by Case Base Reasoning (CBR) technique via wireless network. The hardware design is an embedded system under Arduino Uno R3 microcontroller which interfaces with sensor and transducer. This microcontroller is able to control temperature and supply the water to vegetable if all information from sensor and transducer are corresponding to the type of vegetable and other parameters in CBR system. The theory of CBR is capable of classifying all data and sequence of all data such as type of vegetable, the appropriate temperature and soil moisture in order to control the watering system. Our system has also communication between all sensor nodes and server computer via Xbee wireless modules which may reduce wire installation. As the experiments, we tested our watering system with Chinese morning glory thereby comparing with the watering systems by using the timer and worker respectively. The results show that CBR method can enhance the growth of Chinese morning glory more than those of other methods. We observe thataverage height of Chinese morning glory in CBR method is greater than the watering

[1] *Faculty of Engineering and Architecture, Rajamangala University of Technology Isan, Nakhon Ratchasima*
[2] *Faculty of Engineering, Rajamangala University of Technology Krungthep, Bangkok*
[*] *Corresponding Author E - mail Address: Thammakorn@rmuti.ac.th*

systems by using the timer and worker approximately 16.51 percents and 20.82 percents respectively. This CBR method may also support all gardeners due to their flexibility and convenience to various mixed vegetable gardeners.

Keywords: Arduino Uno R3; Sensor Node; Watering System; Case Base Reasoning; Chinese Morning Glory

Introduction

Nowadays, water shortage in the north-eastern part of Thailand is becoming a national issue saw many years ago [1]. This is because in summer season the weather is so hot and the rain doesn't fall which causes the rivers to dry out the water. Farmers and gardener grow rice and some vegetables but they get low agricultural outputs. The produce is usually not enough for consumers and there are also high prices. Previously, gardeners used workers to water all vegetables in the mixed garden. After the electronic technology was developed gardener use timer system to control watering system. It has been observed that those of watering systems may not be suitable and there are some restrictions. For example, the watering systems by worker and timer may not consider the requirement of each vegetable in mixed garden. This means that the worker or timer system will supply the water according to the function or time period only. Sometimes the vegetables may not require the water but worker or timer system will control and supply the water to vegetables. This is also a cause of water shortage in summer season. In agriculture research, several articles have proposed various scenarios such as [2] - [3] the monitoring systems (soil moisture and temperature). Those applications are under microcontrollers which apply Xbee wireless modules to communicate between sensor nodes and master nodes. The objectives of those papers have been proposed for data acquisitions. However, those methods may not peruse the watering systems. Mahamai, P. et al. [4] have proposed automatic watering using solar PV tracking to the longan. This application is suitable for areas without electricity system. The research in [5] proposed an automatic watering system via wireless network based on Arduino Uno R3 microcontroller and Xbee wireless module. The concept of this work proposed the measurement of soil moisture to control the watering of vegetable. In addition, the satisfaction of user and maximum transmission range of wireless communication are also considered. Some researchers have proposed microcontrollers based irrigation systems for solving a serious problem of food in India [6] - [7]. Nevertheless, those of previous researches [4] - [7] did not peruse all factors such as

type of vegetable, temperature and soil moisture. Those methods might not be flexible for mixed gardens if there are various vegetables. We consider that those of all factors may also improve the growing up of vegetables and provide more agricultural outputs. A watering system of various vegetables in mixed garden should be modified. This is because each vegetable may require a different soil moisture and temperature for improving the growing up. A watering system may depend on all those factors.

In this paper, we present a watering controller system in mixed garden based on temperature and moisture by Case Base Reasoning (CBR) technique via wireless network. The Case Base Reasoning is a method which may apply to several researches. However, a watering system in crap production based on Case Based Reasoning may not be found but there is in fish farming [8]. Our research, applies the sensor and transducer thereby interfacing with Arduino Uno R3 microcontroller which sends all information to server computer via wireless network. The decision of Case Base Reasoning in server computer will classify all data such as type of vegetable, temperature and soil moisture. The result of decision will be replying to sensor node in order to control the solenoid valve, cooling pad and heating if the humidity and temperature of vegetable are not suitable. By this reason, the growing up of vegetable may be improved.

Case Based Reasoning

Case Base Reasoning (CBR) [9] - [10] is an expert system that uses old knowledge in the past to solve a new problem. This concept looks like the idea of human. The first step of CBR method investigates the problem in the system thereby comparing new problem and old problem as shown in Figure 1. This first step is called retrieve process. The similarity of those problems will be reused to solve problems. Otherwise, the system will revise for testing and repairing the case. Then, the retain process will be learned case. Normally, it comprised of retrieve, reuse, revise and retrain processes. The advantage of CBR method may apply in the medical, engineering, finance and education.

Our work is a watering system in mixed garden which consists of several vegetables and there are various parameters to control in each vegetable such as soil moisture and temperature. So that, this research is able to apply CBR technique in mixed garden because each vegetable may require different parameters in order to control the watering system to many vegetables in mixed garden. The database of this concept may require all case bases that contain more old cases or old problems for retrieving and solving based on various conditions of each vegetable in the watering system.

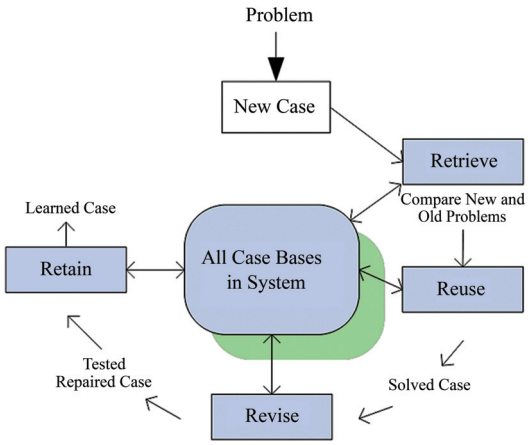

Figure 1 Case Base Reasoning

Hardware Design

The system design is based on star topology that composes of several sensor nodes and one server computer as shown in Figure 2. Each sensor node is a Micro-Controller Unit (MCU) which gets several inputs from temperature sensor and soil moisture sensor. It also interfaces via Xbee wireless module which reduces wire installation to server computer. The relay module is used for controlling soil moisture, heating and cooling pad. The solar cell charger supports the power system if the main electricity system has a problem.

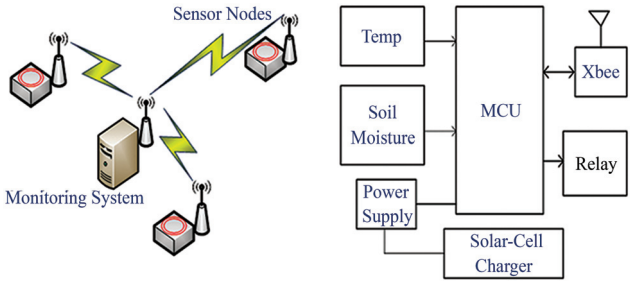

Figure 2 The structure of the watering system in mixed garden

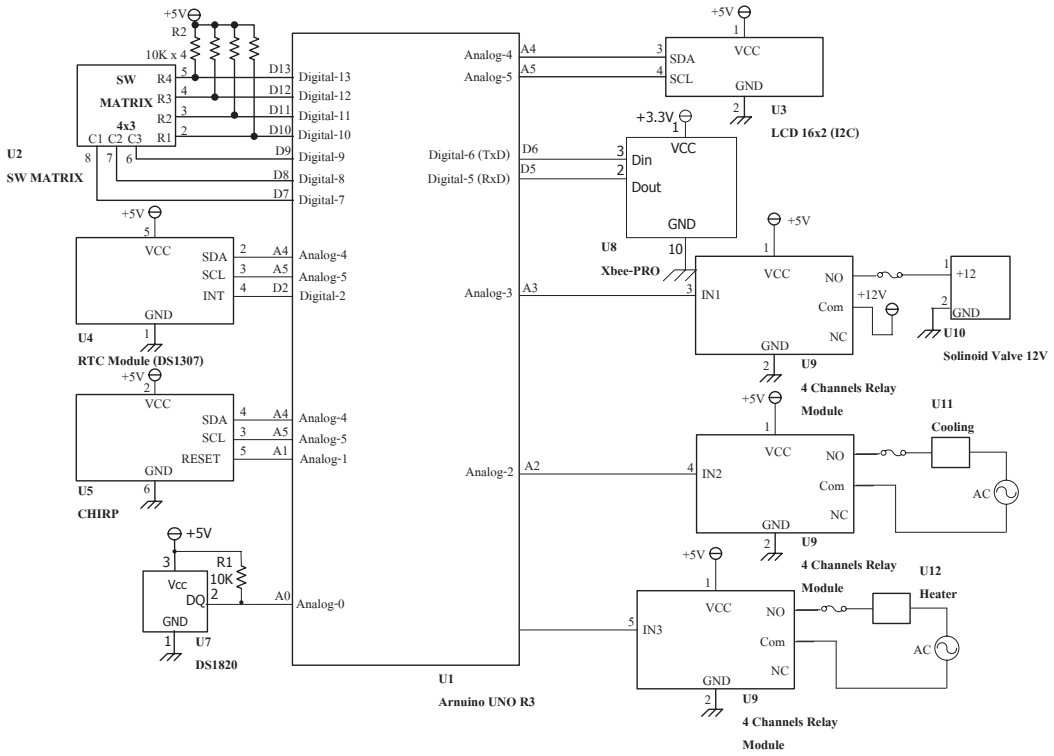

Figure 3 Sensor node

Figure 3 depicts a more detail hardware circuit. Arduino Uno R3 [11] is a microcontroller that interfaces with matrix switch for data entry. The DS1307 [12] is a real time clock which is displayed on LCD. The chirp module is soil moisture sensor and DS1820 [13] is a temperature sensor. There are four channels of relay in order to control many outputs. The first output is a solenoid valve which supplies the water to the soil. The other relays are used for controlling temperature by heating and cooling. The Xbee module [14] is a wireless communicator to server computer.

The Necessary Parameter in Agriculture

Many parameters may be important to the growing up of all vegetables in the agriculture. All gardeners should know and control those of parameters like temperature and soil moisture in the agriculture. Because each vegetable may require a different appropriate value. The gardeners may get more agricultural outputs if they control those of appropriate parameters. We have some examples of those parameters in each vegetable [15] as shown in Table 1.

Table 1 Appropriate of each parameter in agriculture

Type of Vegetable	Temperature	Soil Moisture
Chinese Morning Glory	25 - 35 ºC	Much
Chinese Kale	25 - 30 ºC	Moderate
Chinese Cabbage	20 - 25 ºC	Much
Asparagus	20 - 30 ºC	Moderate

All parameters of Case Base Reasoning may be related to hardware control i.e., the status of solenoid vale to control soil moisture and temperature (Cooling pad and Heating). We have some examples in our system as shown in Table 2.

Table 2 All parameters which are related to the status of hardware

Type of Vegetable	Moisture	Temp (Min)	Temp (Max)	Solenoid Valve	Status
Chinese Morning Glory	Little	0 ºC	24 ºC	On	Heating-On
	Quite a little	25 ºC	35 ºC	On	-
	Moderate	36 ºC	50 ºC	On	Cooling-On
	Rather	-	-	On	-
	Much	-	-	Off	-
Chinese Kale	Little	0 ºC	24 ºC	On	Heating-On
	Quite a little	25 ºC	30 ºC	On	-
	Moderate	31 ºC	50 ºC	Off	Cooling-On
	Rather	-	-	Off	-
	Much	-	-	Off	-
Chinese Cabbage	Little	0 ºC	19 ºC	On	Heating-On
	Quite a little	20 ºC	25 ºC	On	-
	Moderate	26 ºC	50 ºC	On	Cooling-On
	Rather	-	-	On	-
	Much	-	-	Off	-
Asparagus	Little	0 ºC	19 ºC	On	Heating-On
	Quite a little	20 ºC	30 ºC	On	-
	Moderate	31 ºC	50 ºC	Off	Cooling-On
	Rather	-	-	Off	-
	Much	-	-	Off	-

Software Development

We also develop all software by using Visual C# [16] which has several functions in the main program such as plant function, writing function, reading function, status function and connecting function. The plant function is used for adding, editing and erasing the type of vegetable. The writing function is able to send all information to control the sensor node i.e., operation mode, type of plant and the values of temperature and humidity. The reading function can check the operation of sensor node like the values of temperature and humidity, operation mode and plant. The status function shows the operation status of sensor node such as control mode, temperature, humidity, soil moisture, the increasing and decreasing of temperatures. The connecting function connects the wireless module which can assign the port and speed of communication. However, algorithm of Case Base Reasoning has more significant than the others. The basic concept of solution for a new problem is comparing the similarity between new problem and old problem in CBR system such as type of vegetable, temperature and soil moisture. The example of searching is shown as follows:

If the type of vegetable is correct then...
  If the temp is low, then increase temp (Heating)
  If the temp is high, then decrease temp (Cooling pad)
  If the soil moisture is low, then start solenoid valve
  If the soil moisture is high, then no action

In this article, we find the similarity of problem under Euclidian equation [17]. This method is to consider the distance between the present problem and old problem. If distance is nearly that means those problems are similarity. This distance can be expressed as in

$$d = \sqrt{\sum_{i=1}^{n} (p_i - q_i)^2} \tag{1}$$

Where d is the distance between the present problem and old problem
p_i is the value of each present problem
q_i is the value of each old problem
n is the maximum of number sequence

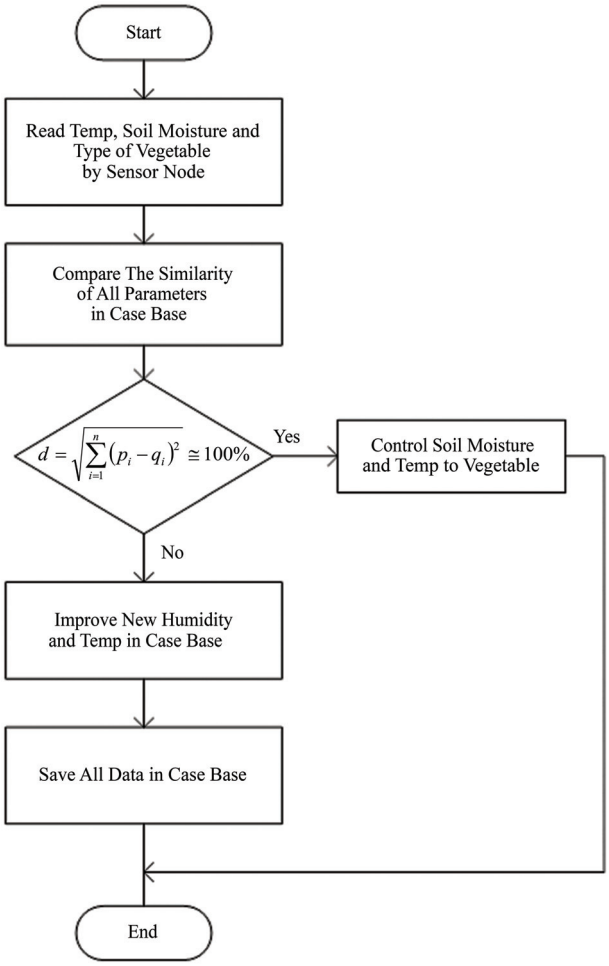

Figure 4 Algorithm of main program

Figure 4 shows the algorithm of the main program, we start at the sensor node which gets temperature, soil moisture from both sensors and type of vegetable. Then, the similarity comparison of all factors will be perused based on equation (1). The controlling of soil moisture and temperature of vegetables will be obtained if the distance in equation (1) is approximately 100 percent. Otherwise, the system will improve new humidity and temperature in the case base before saving all data according to the retain process.

Figure 5 and Figure 6 describes more details of some functions. The plant function consists of many types of plants such as Chinese morning glory, Chinese kale, Chinese cabbage and Asparagus.

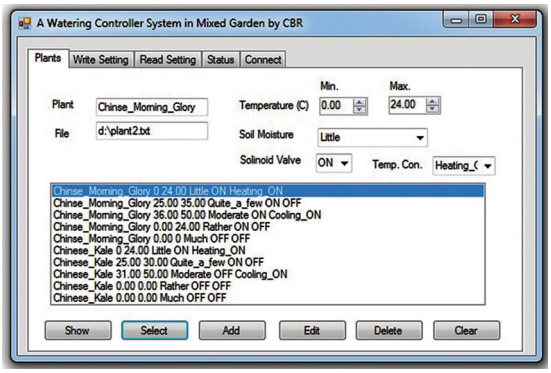

Figure 5 All cases in Chinese morning glory

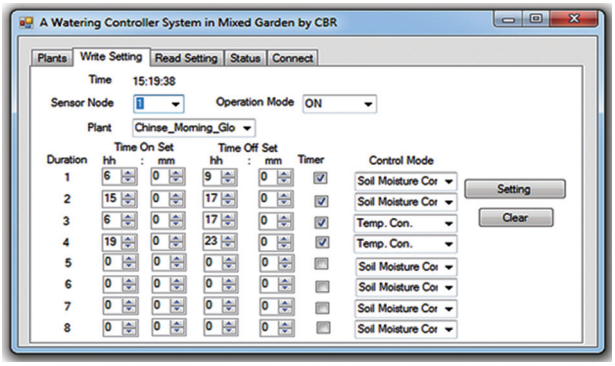

Figure 6 All parameters for controlling sensor node

This function assigns the soil moisture into 5 levels like little, quite a little, moderate, rather and much. The temperature control sets the value between 0 °C and 100 °C. The temperature control is capable of controlling the status of heating, cooling and off respectively. The status of solenoid sets on and off. The writing function defines the maximum number of sensor nodes equal to 10 nodes. The operation mode of the sensor node is able to set on and off. There are 5 control modes i.e., the mode of watering control on the time, the mode of watering control based on soil moisture, the temperature control mode on the time, the mode of increasing and decreasing temperatures.

Experiments

We implement our work by means of measuring the growth of Chinese morning glory based on watering by comparing with the timer system and worker. This experiment may not be fair with timer system and worker. However, this is the first experiment in the mixed garden where there was no one to implement the hardware. We need to know

the result under basic methods of gardening. Therefore, the timer system and worker may be considered. Although there are many vegetables in mixed garden, we perused only Chinese morning glory for first case study. Typically, the Chinese morning glory requires temperature approximately 25 °C to 35 ºC and much soil moisture. We randomized the number of Chinese morning glories to 5 lines per each day for measuring average high. We have also recorded all results until 14 days of this experiment. We studied more parameters in our experiment as shown in Table 3.

Table 3 All parameters for experiment

Parameter	CBR	Timer System	Worker
Type of Vegetable	Chinese Morning Glory	Chinese Morning Glory	Chinese Morning Glory
Total Number of Vegetables	15 Lines	15 Lines	15 Lines
Method of Agriculture	Flowerpot	Flowerpot	Flowerpot
Total Days of Experiment	14 Days	14 Days	14 Days
Number of Flowerpots	1	1	1
Size of Flowerpot	25 x 12 Cm.	25 x 12 Cm.	25 x 12 Cm.
Temperature	>= 25 ºC	Nature	Nature
Soil Moisture	Much	Nature	Nature
Number of Times of Watering per Day	2 Times (Morning and Evening)	2 Times (Morning and Evening)	2 Times (Morning and Evening)
Volume of Water per Day	280.42 ml.	661.78 ml.	661.78 ml.
Type of Soil	Sandy Loam	Sandy Loam	Sandy Loam
Ratio of Soil	1 : 1	1 : 1	1 : 1

Results and Discussion

Table 4 persents all results between 5th and 14th days of period, the growing up of Chinese morning glory of each method may be different. We recorded the average high of Chinese morning glories for each day; they were measured randomly. All results in terms of graph are shown in Figure 7.

Table 4 Result of all experiments

Day	Worker (Cm.)	Timer System (Cm.)	CBR (Cm.)
5	5.06	5.46	6.32
6	6.36	6.78	8.30
7	7.52	7.74	9.10
8	8.08	8.70	10.06
9	8.72	9.58	11.20
10	9.34	10.38	12.26
11	10.30	10.96	13.10
12	10.82	11.56	13.90
13	12.24	12.76	15.28
14	13.42	13.46	16.42

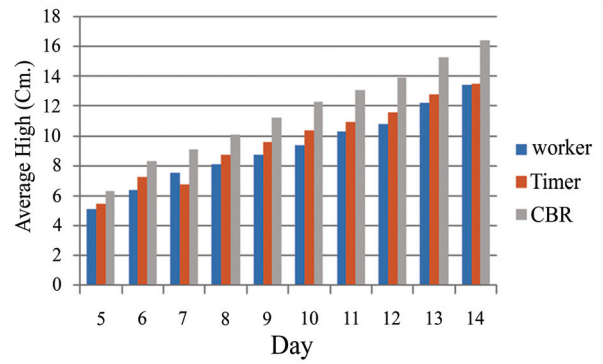

Figure 7 Average high versus various days

Our results in Figure 7 illustrates the growth of Chinese morning glory on 5th to 14th days of period. We can see that CBR technique may provide average height more than those of the timer system and worker. This is because CBR technique controls the appropriate temperature and soil moisture. The Chinese morning glory may grow up continuously in the suitable environment. Nevertheless, the result of the time system is better than worker since the timer system may supply the water on the time every day but the watering by worker to vegetable may delay. By this reason, the growth of the Chinese morning glory of worker may not be continuous. Moreover, those of both methods may not control the temperature and soil moisture in the appropriate environment.

Conclusions

We have proposed a watering controller system in mixed garden based on temperature and moisture by Case Base Reasoning (CBR) technique via wireless network. Arduino Uno R3 microcontroller has applied interfacing to temperature sensor and soil moisture sensor at the sensor node. This sensor node can send all information to the computer server via wireless communication module in order to process according to each type of vegetable, temperature and soil moisture based on CBR method. We have also tested our watering system under CBR technique to Chinese morning glory by comparing with the watering systems by timer and worker. As the results, showed that our method can provide an average height of Chinese morning glory greater than those of timer system and worker approximately 16.51 percents and 20.82 percents respectively. This system is also convenient and suitable for various vegetables in the mixed garden because it can reduce the complexity of wire installation and it's easy to apply even if the user is not a gardener.

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