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Smart Irrigation System Using Internet of Things

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***Abstract*—This paper presents the smart irrigation system using Internet of Things (IoT) via the Arduino Mega 2560. The objectives of this paper are to investigate the concept of smart irrigation system using IoT, to develop a system using an Arduino Mega 2560 that processes the data from the soil sensor which automatically water the plant and to analyse the real time condition of soil of the plants via the smart phone that is connected to the internet. The scope of the study is focused on farming crops and gardening. The limitations of this project can be very expensive if it is applied on a big area. It had to install the sensors for every plant as it is needed to know the condition of the soil. Water pump must also be added for every plant in order to supply the water. In this project, it requires blynk application software on the smartphone and hardware implementation which can detect the condition of the plant by using the dht 11 sensor and moisture level sensor. The findings of this paper are based on the experiments that were done. The first two experiments were between smart irrigation and normal irrigation. After 7 days, the results showed that smart irrigation topple the normal irrigation. Then, it proceeded to the next 3 experiments which are with the appearance of sunlight, pH values of the water and the windy condition. The conclusion of this paper is based on the objectives which all the three objectives had already achieved**.

Keywords—smart irrigation, Arduino Mega 2560, soil sensor, dht 11 sensor, water pump.

I. INTRODUCTION

Irrigation is a term that refers to delivering water to the plants. Water is the most important thing to improve the productivity of the agricultural [4]. An automated irrigation system needs to be developed to optimize water use for agricultural crops [5]. The agricultural industry can revolutionize the industry to a greater production with less human intervention [6]. This paper is focusing on how to construct a system with a sensor which determines the dryness of soil moisture condition of the plant and activate the system to water the plant [1].

The problem statement of this project is the normal smart irrigation system operates using a schedule and timer. An improved irrigation system uses sensor to detect if the weather is raining in order to prevent watering the plant. There are potential that this irrigation system might water the plant during one part of the day and then there is rainfall in another part of the day. These systems are still ineffective as it is not focusing on the condition of the soil moisture of the plant. In order to overcome this problem, smart irrigation system is used [7].

The significance of the study improved the state of plants and make people happy. With the improvement of plants, the healthiness of people surroundings surely improves too. Gardening flexibility [3] be one of the main points too as many people want to do a bit of gardening activities but some of us are packed with hectic schedules and commitments. This problem can be solved easily with this smart irrigation system project using internet of things. Irrigation also can add to the wealth of the country. It also increases the country's economy and revenues at the same time.

This system uses a microcontroller device called Arduino Mega 2560 where all the sensors are attached in the ports of Arduino Mega 2560 using jumper wires. ESP 8266 is needed in order to connect with the internet. It has to intact with the Arduino Mega in order for it to connect successfully. An application named Blynk is the interface and supporting software. The state of dryness and wetness for soil, humidity values and temperature values can be seen through the smartphone via the Blynk application.

II. METHODOLOGY

A. Block Diagram of Smart Irrigation System

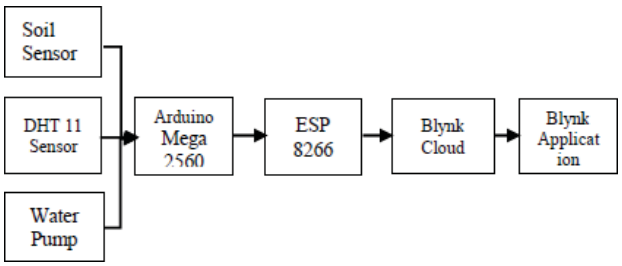

Figure 1: Block Diagram of Smart Irrigation System

Figure 1 shows the block diagram of the smart irrigation system. This system consists of three hardware that is linked to the Arduino Mega 2560 which are the soil sensor, dht 11 sensor and the water pump. The next flow is the esp 8266, blynk cloud and the blynk application.

B. Flowchart of the Smart Irrigation System

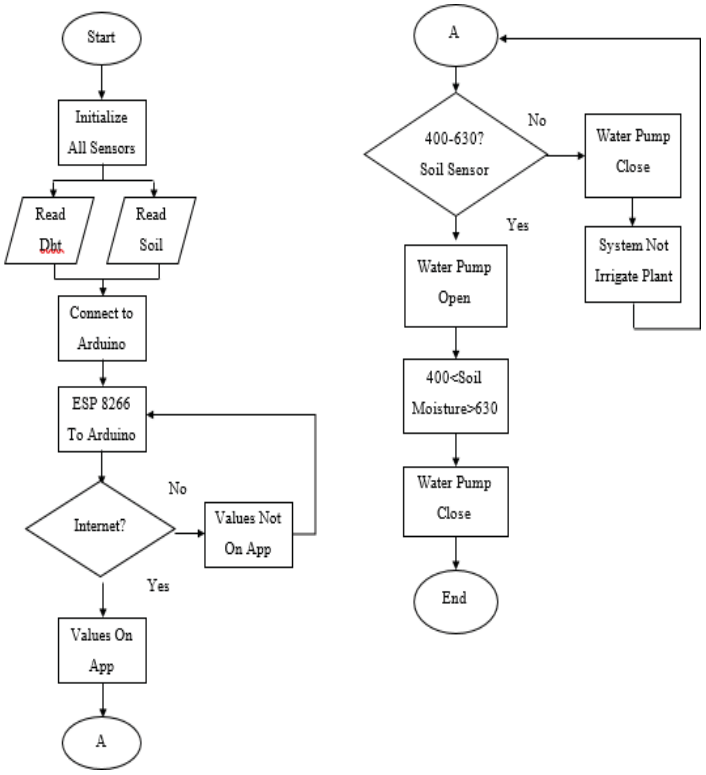

Figure 2: Flowchart for configuration of smart irrigation system

Figure 2 shows the working principle of smart irrigation system to measure the soil moisture. The samples data was taken for 7 days due to the purpose of proving that the running system is capable to provide the data of soil moisture, humidity and temperature.

III. RESULTS AND DISCUSSION

For this part, there were experiments on normal irrigation and smart irrigation. After looking at the comparisons of the data, the next experiments which were on 100% sunlight, 20% sunlight, 5.5 pH value and 8.5 pH value, windy and not windy were conducted using smart irrigation system. Every experiments were done for 7 days only in order to see the reactions on the leaves, stems, surroundings temperatures, humidity values and soil moisture values of the plant.

A. Normal Irrigation System

In this normal irrigation experiment, the temperature values are in the range of 28 to 39 degree Celsius. The humidity values are in the range of 70 to 81 and the soil moisture values are in the range of 557 to 610. The height growth for this plant is only 20.39 percent from the start of the experiment. The diameter of the plant growth for about 75 percent. It can conclude that the plant is over watering. It can be seen that on the leaves of the plant. There were yellow and brown colour at the edge of the plant surroundings it. It is a symptoms of the plant was over watering. This occur as too much water on the roots of the plant and hence, the plant cannot breathe.

Table 1: Temperature, humidity and soil moisture of normal irrigation system.

Date	Normal Irrigation		
Oct	Temperature Values (Celsius)	Humidity Values (%)	Soil Moisture Values
7	34.0	74	585
7	37.0	72	600
8	33.0	76	580
8	29.0	80	560
9	32.0	77	575
9	29.0	80	560
10	31.0	78	570
10	34.0	75	585
11	33.0	76	580
11	28.0	81	557
12	35.0	74	590
12	39.0	70	610
13	36.0	73	595
13	31.0	78	572

Table 2: Measurement of height & diameter for normal irrigation system

Date	Normal Irrigation	
Oct	Height (cm)	Diameter (cm)
7	5.10	0.20
8	5.24	0.23
9	5.46	0.26
10	5.67	0.28
11	.5.82	0.30
12	5.95	0.33
13	6.14	0.35

B. Smart Irrigation System

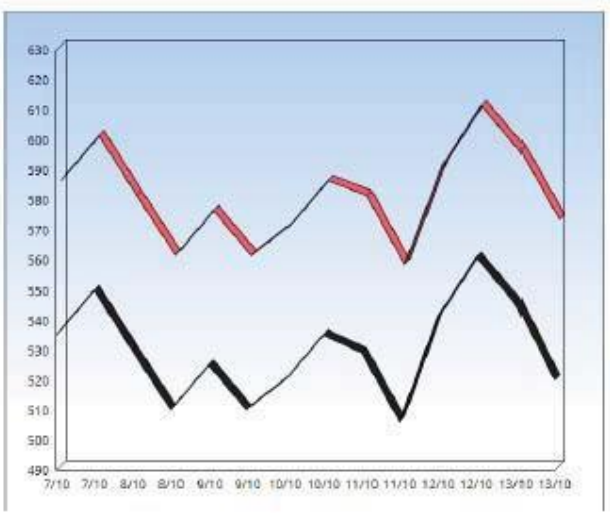

Figure 3: Comparison of normal and smart irrigation system

Figure 3 shows a comparison between the normal and smart irrigation system. The black represents the smart irrigation and the red represents the normal irrigation. From the graph, it can be seen that smart irrigation is the best option. So, the next 3 experiments were conducted using the smart irrigation system with the elements of design which are the presence of sunlight, the pH values and the speed of wind.

Table 3: Temperature, humidity and soil moisture of smart irrigation system

Date	Smart Irrigation		
Oct	Temperature Values (Celsius)	Humidity Values (%)	Soil Moisture Values
7	34	74	535
7	37	72	550
8	33	76	530
8	29	80	510
9	32	77	525
9	29	80	510
10	31	78	520
10	34	75	535
11	33	76	529
11	28	81	506
12	35	74	541
12	39	70	561
13	36	73	546
13	31	78	520

Table 4: Measurement of height & diameter for smart irrigation system

Date	Smart Irrigation	
Oct	Height (cm)	Diameter (cm)
7	7.01	0.20
8	7.43	0.23
9	7.83	0.27
10	8.00	0.30
11	8.43	0.33
12	8.88	0.36
13	9.00	0.40

In this smart irrigation experiment, the temperature values are in the range of 28 to 39 degree Celsius. The humidity values are in the range of 70 to 81 and the soil moisture values are in the range of 506 to 601. The height growth for this plant is 28.39 percent from the start of the experiment. The diameter of the plant growth for about 100 percent. It can conclude that the plant is healthy plant. From the leave, it shows that the colour of the leave is very green and has only 1 or 2 brown dots. It shows that the leave came from a very good plant. From the values of the soil moisture, the values of it are not too close to 630 and 400. It means that the moisture is in good range. This smart irrigation system is very good as it waters the plant with the right amount of water. Hence, the plant is not over watered or less watered.

C. Direct Sunlight

Table 5: Condition of the plant under direct sunlight

Date	100% Sunlight		
Oct	Temperature Values (Celsius)	Humidity Values (%)	Soil Moisture Values
14	29	80	512
14	33	76	533
15	32	77	526
15	34	75	537
16	35	74	540
16	32	77	526
17	31	78	522
17	30	79	516
18	34	75	535
18	36	73	545
19	35	74	540
19	37	72	552
20	31	78	520
20	38	71	587

Table 6: Measurement of height and diameter of plant under direct sunlight

Date	100 percent	
Oct	Height (cm)	Diameter (cm)
14	3.70	0.10
15	3.92	0.15
16	4.42	0.18
17	4.86	0.20
18	5.00	0.24
19	5.35	0.28
20	5.59	0.33

From the result obtained for a direct sunlight experiment, the temperature values are in the range of 29 to 38 degree Celsius. The humidity values are in the range of 71 to 80 and the soil moisture values are in the range of 512 to 587. The height growth for this plant is 51.08 percent from the start of the experiment. The diameter of the plant growth for about 230 percent. It can conclude that the plant is extremely healthy. The leaves are so greenly and only has 1 small dot. The stem is also in a good posture. If the amount of sunlight is good, there surely be a lot of good things happen to the plant. Natural sunlight can decrease the amount of bad bacteria on the plant and it is an original therapeutic way of removing the disease for plants. The process of photosynthesis occurred easily.

D. 20 percent sunlight

Table 7: Condition of the plant under 20 percent sunlight

Date	20% Sunlight		
Oct	Temperature Values (Celsius)	Humidity Values (%)	Soil Moisture Values
14	28	81	486
14	32	77	505
15	32	77	505
15	33	76	510
16	34	75	515
16	31	78	501
17	30	79	496
17	30	79	497
18	32	77	506
18	34	75	515
19	34	75	516
19	35	74	520
20	30	79	496
20	36	73	525

Table 8: Measurement of height and diameter of plant under 20 percent sunlight

Date	20 percent	
Oct	Height	Diameter
14	4.23	0.10
15	4.35	0.12
16	4.51	0.13
17	4.68	0.14
18	4.82	0.16
19	4.94	0.17
20	5.07	0.18

Based on the results obtained for a 20 percent sunlight experiment, the temperature values are in the range of 28 to 36 degree Celsius. The humidity values are in the range of 73 to 81 and the soil moisture values are in the range of 486 to 525. The height growth for this plant is 19.86 percent from the start of the experiment. The diameter of the plant growth for about 80 percent. It can conclude that the plant was being less watered even though the right amount of water was put it but due to lack of sunlight, the photosynthesis process cannot occur. From the leaves, it shows that the leaves is not in a good shape as it has some tear on it. Looking at the plant, most of the plant is wilting. These are the signs of less watering which are the changing colour of the leaves, a very slow growth, the plant looks damaged and the production of leaves are slow too.

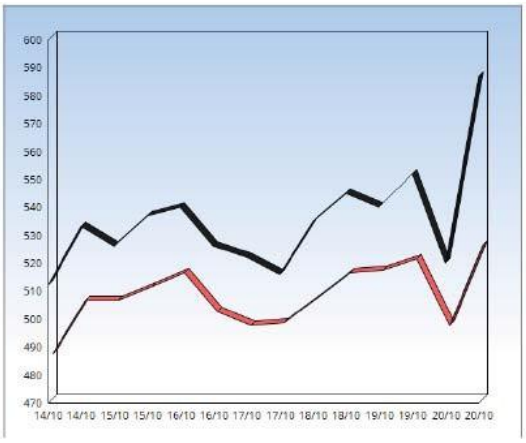

Figure 4: Comparison of the plant under direct and 20 percent sunlight

Figure 4 shows a comparison of the plants under direct sunlight and 20 percent sunlight experiment. Black represents the direct sunlight while red represents 20 percent sunlight. It can be seen the plant that received direct sunlight is stable as the line is not close to over watering and less watering.

E. 5.5 pH level

Table 9: Condition of plant for 5.5 pH level

Date	5.5pH		
Oct	Temperature Values	Humidity Values	Soil Moisture Values
21	32	77	527
21	34	75	538
22	33	76	529
22	35	74	542
23	36	73	546
23	39	70	560
24	35	74	541
24	35	74	540
25	34	75	535
25	36	73	547
26	32	77	528
26	38	71	558
27	37	72	550
27	34	75	535

Table 10: Measurement of height and diameter of plant for 5.5 pH level

Date	5.5pH	
Oct	Height(cm)	Diameter(cm)
21	3.93	0.12
22	4.20	0.16
23	4.49	0.19
24	4.82	0.21
25	5.03	0.24
26	5.23	0.26
27	5.41	0.28

In this 5.5 pH value experiment, the temperature values are in the range of 32 to 39 degree Celsius. The humidity values are in the range of 70 to 77 and the soil moisture values are in the range of 527 to 567. The height growth for this plant is 37.66 percent from the start of the experiment. The diameter of the plant growth for about 133 percent. It can conclude that the plant is in a superb condition. This 5.5 pH values does not kills the nutrients of the plant. It also make the roots to easily grow. The condition of the leave has only few dots but the overall colour is very green. The stem is looking strong too.

F. 8.5 pH level

Table 11: Condition of plant for 8.5 pH level

Date	8.5 pH		
Oct	Temperature Values	Humidity Values	Soil Moisture Values
21	32	77	507
21	34	75	518
22	33	76	509
22	35	74	522
23	36	73	526
23	39	70	540
24	35	74	521
24	35	74	520
25	34	75	515
25	36	73	527
26	32	77	508
26	38	71	538
27	37	72	530
27	34	75	515

Table 12: Measurement of height and diameter of plant for 8.5 pH level

Date	8.5pH	
Oct	Height	Diameter
21	5.48	0.10
22	5.57	0.12
23	5.69	0.14
24	5.75	0.15
25	5.84	0.16
26	5.97	0.17
27	6.11	0.19

In this 8.5 pH value experiment, the temperature values are in the range of 32 to 39 degree Celsius. The humidity values are in the range of 70 to 77 and the soil moisture values are in the range of 507 to 540. The height growth for this plant is 20.39 percent from the start of the experiment. The diameter of the plant growth for about 90 percent. It can conclude that the plant is watered enough but the result indicates that the plant is less watering since it uses an 8.5 pH values. The reason on the soil moisture values are smaller than the 5.5 pH values are there were many nutrients that were soften efficiently. This act impacted the compounds of iron, calcium and phosphate to accelerate. The compounds caused the defect of the soil. The condition of the leaf is not good as 5.5 pH values as it has many dots on it and the stem of the plant was not as good as the results on 5.5 pH values.

G. Weather condition; Windy and not windy

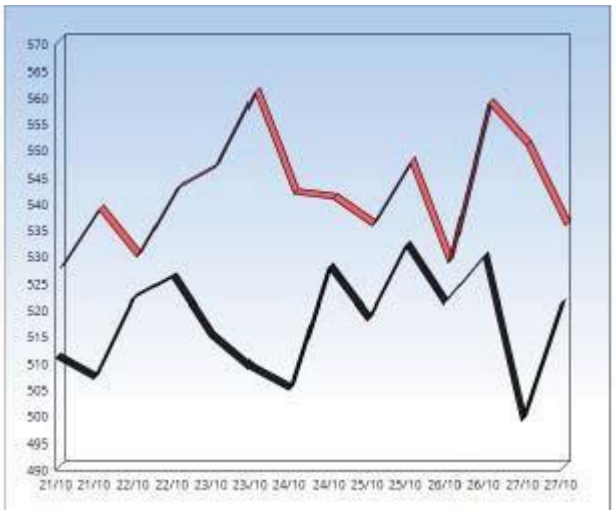

Figure 5: Plot of condition of plant during windy and no windy

From Figure 5, the black indicates the windy experiment and the red indicates not windy experiment. This plot shows that the no windy condition and results were better than the windy since there were many differences on the leaf and stem. The data also indicates that it is not too less watering and over watering.

Figure 6: Condition of leaf and stem during windy

In this windy experiment, the temperature values are in the range of 32 to 37 degree Celsius. The humidity values are in the range of 72 and 77 and the soil moisture values are in the range of 507 and 532. The height growth for this plant is 18.79 percent from the start of the experiment. The diameter

of the plant growth for about 80 percent. It can conclude that the plant is less watered. The reason water losses are high as the wind destroyed the condition of the plant and the plant lost water at the same time. The condition of the plant was damaged and the stem was bent so much due to force from the wind.

Figure 7: Condition of leaf and stem during not windy

In this not windy experiment, the temperature values are in the range of 32 to 37 degree Celsius. The humidity values are in the range of 72 and 77 and the soil moisture values are in the range of 528 and 522. The height growth for this plant is 21.28 percent from the start of the experiment. The diameter of the plant growth for about 100 percent. It can conclude that the plant is in good condition. The results of the leaves and stem are both in great condition. With no wind, it does not damage the plant and make the water lose in the roots of the plant. It is great for the growth of the plant.

IV. CONCLUSION

This smart irrigation system using Internet of Things project had achieved the first objective which is to investigate the whole concept of smart irrigation system using internet of things. The study is about the function of irrigation which is to water the plant with the right amount of water only when it needed water which is based on the condition of the soil. The system must have both software and hardware components which can be presented later on. The software that being studied is the Blynk application which can be used in all smartphone and it is very practical for the users to use. The hardware is the temperature sensor, humidity sensor, Arduino Mega and most importantly, the soil sensor as it detects the dryness of the plant and the water pump is going to open as the water comes out right when it detects the dryness between 400 to 630. This system creates a very good experience for the farmers to irrigate the plant. The farmers can even monitor the condition of the plant directly from the phone. With the right amount of water needed, they can save their bills on water too. Hence, this is such a great project. The second objective which is developing a system using an Arduino Mega that process the data from the soil sensor control the whole irrigation system by automatically water the plant was achieved too. There was some challenging while doing the hardware as some trying out the new sensors and finding the right sensors for the soil. The data do not only can process but the data can be stored for up to 1 year in Blynk Server. The final objective is to analyze the real time condition of soil of the plants via the smart phone that is connected to the internet was achieved too as the real time data can be seen on the phone as long as it has an internet connection. The data are updated every 1 second and the data is very accurate.

For future work, the suggestion on improving it is using a solar panel for the power consumption of the system. Hence, the system is going to be eco-friendly.

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