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Development and Experimental Implementation of a Smart Irrigation System

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ABSTRACT : *Irrigation scheduling is crucial to effectively manage water resources and optimize profitability of an irrigated operation. There has been mounting pressure to limit water supply to irrigated agriculture and to produce more food with minimal water. Consequently, the search for technologies or measures to save or conserve water in irrigated agriculture has intensified all over the world. Tools that can be customized to a field's characteristics can greatly facilitate irrigation scheduling decisions. Apart from the conventional time-based sprinkler or manual irrigation systems, this research deals with an efficient smart irrigation system for water conservation. The sensing system is based on a feedback control mechanism with a centralized control unit which automatically regulates the flow of water on to the field in real time based on various parameters such as instantaneous temperature, soil moisture, humidity and sunlight intensity. Thereby, achieving great savings on water consumed, controlling soil moisture status related to irrigation events, minimizing drainage and run-off events, and improving nutrient use efficiency.*

KEYWORDS - *Smart irrigation, Irrigation scheduling, Automation, Eco-efficient*

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I. INTRODUCTION

Population growth in any country results in an increase demand on water supply [1]. Therefore, main focus should be on water conservation. Usually, growers determine how much water is needed to irrigate the field based on the amount of time elapsed since last irrigation cycle. An automated irrigation system enables the users to constantly monitor the relative soil moisture at many different locations throughout the field to more precisely schedule irrigation cycles.

Using a smart irrigation system apart from the conventional time-based sprinkler or manual irrigation system leads to higher efficiency and water conservation. Therefore, reducing drainage and run-off events. The system consists of various sensors that are connected to the microcontroller. The microcontroller is programmed with a specific algorithm based on the desirable soil moisture required at all times. Depending on the algorithm, the microcontroller triggers the pump to control the flow of water only when required rather than pumping the water at various intervals.

II. SYSTEM ARCHITECTURE

The Fig. 1 represents the block diagram of the complete system. The soil hygrometer probe is submerged into the soil and its output is fed to the microcontroller. The temperature & humidity sensor as well as the LDR is directly connected to the microcontroller.

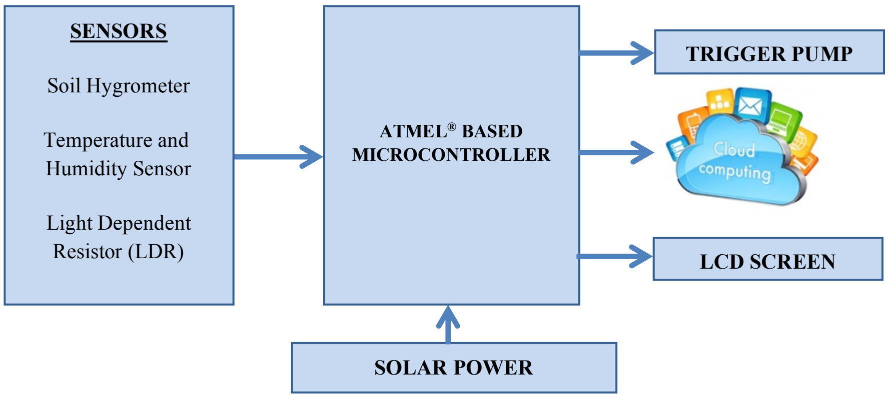

Fig.1: Block Diagram of the system

The microcontroller used is Atmel® based which is powered using solar energy by connecting solar panels to the controller. The output from the microcontroller is send to three sources. One to trigger the pump, the other to a LCD screen placed on the module to display the various sensor readings in real time and also to a webpage through cloud computing where all sensor reading and status can be accessed through PC or mobile phone at any time anywhere.

III. INSTRUMENTATION PART

Four parameters are sensed in the system: Soil Moisture, Temperature, Humidity and Sunlight Intensity.

3.1. Soil Moisture

Fig.2: Soil Hygrometer Detection Module

Moisture content of the soil is a major factor determining plant growth. Soil moisture is sensed using a Soil Hygrometer Detection Module as shown in Fig. 2. The sensor measures the volumetric water content (VWC) by measuring the dielectric constant of the media using capacitance domain technology [1]. The sensor works on the principle that the resistance of the soil between two points decreases with the increase of water content in the soil [1]. Water is a good conductor of electricity in the presence of ions. Therefore, more the amount of electrolytes in the soil, more will be the conductivity of the soil. This means that the resistance of the soil decreases. The sensor has an accuracy of ±3% VWC, resolution of 0.1% VWC and works between the temperature of -40°C to +50°C.

3.2. Temperature and Humidity

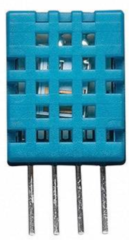

Fig.3: DHT11 Temperature and Humidity Sensor

In the current work, temperature and humidity is measured using an Adafruit DHT11 sensor as shown in Fig. 3. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin [2]. Surrounding air temperature and humidity is used to calculate the evaporation rate. The humidity sensor has an accuracy of 5% and temperature sensor has an accuracy of ±2°C.

3.3. Sunlight Intensity

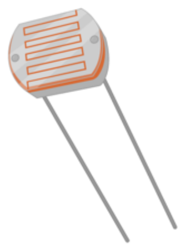

Fig.4: Light Dependent Resistor (LDR)

Sunlight Intensity is measured using a Light Dependent Resistor (LDR), as one shown in Fig. 4. LDR also called a photoresistor is a light-controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity; in other words, it exhibits photoconductivity [3]. Sunlight intensity aids in calculating the evaporation rate which is ideal for irrigation scheduling.

IV. DEVELOPMENT AND WORKING OF THE SYSTEM

The Fig. 5 shows an image of the working Smart Irrigation System module. The module is installed in the field to be controlled. All the output from the various sensors such as Soil Moisture Sensor, Temperature & Humidity Sensor and the LDR is fed to the microcontroller in real-time. The microcontroller is a stand-alone device which is powered using solar energy. The microcontroller is programmed with an algorithm as per the desirable soil moisture required at all times. Comparing the sensor feedback in real-time, the microcontroller decides when to pump the water depending on the soil moisture as well as environmental condition. Therefore, the water is pumped only when it is required rather than pumping it randomly in fixed intervals, which can lead to great savings on water consumed. Thereby minimizing drainage and run-off events and efficient water management leading to water conservation.

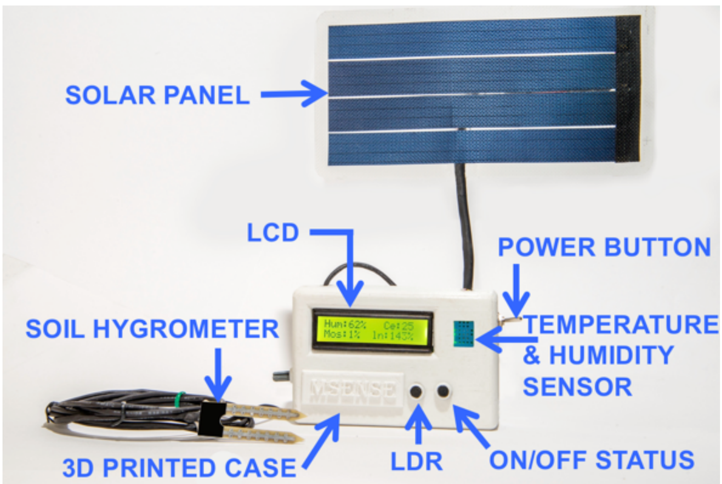

Fig.5: Smart Irrigation System module

The various sensor readings in real time is displayed on the LCD screen placed on the module and is also send to a webpage through cloud computing where all sensor reading and status can be accessed wirelessly through PC or mobile phone at any time anywhere.

V. EXPERIMENTAL INVESTIGATION

The smart irrigation system was tested for six months at the premises of Dubai International Academic

City, United Arab Emirates. The system was installed to cover a lawn of 20x20m^2 area. It was earlier irrigated using time-based sprinkler; 3 times a day at the interval of 8 hours. Conventionally, it was set at a daily water consumption of 80 litres for irrigating the mentioned area.

The smart system was installed at the area for testing purposes. The system calculates various parameters such as soil moisture, temperature, humidity and sunlight intensity in real-time and was designed to pump the water only when required as per the algorithm. The LCD screen on the module displays the various parameter readings, the time when the field was last irrigated as well as the water consumption rate. These values are also accessed using a mobile device or PC through cloud computing.

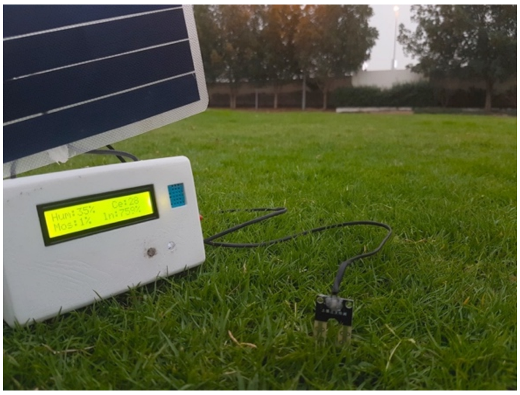

Fig.6: Testing of the Smart System

The smart system was tested for six months from October 2016 to March 2017. The average values of parameter readings and water consumed for irrigating the mentioned area per week are tabulated below to calculate the efficiency of the system.

Table 1: Weekly average values of parameter readings and water consumed from smart system

Week	Temperature (°C)	Humidity (%)	Sunlight Intensity (Kwh/M^2)	Water Consumption (Litres)
1	38	45	5.55	**56.9**
2	37	43	5.4	**56.7**
3	33	51	5.67	**56.3**
4	33	50	5.3	**56.3**
5	33	51	5.05	**56.5**
6	34	43	4.48	**56.5**
7	33	35	4.3	**56.2**
8	30	55	4.22	**56.5**
9	29	42	4.01	**56**
10	31	57	3.68	**56.9**
11	25	40	3.77	**55.4**
12	27	51	3.51	**56.2**
13	30	32	3.84	**55.9**
14	27	64	3.95	**56.5**
15	25	53	3.97	**55.9**
16	24	54	3.99	**55.7**
17	29	51	4.25	**56.2**
18	28	38	4.44	**55.6**
19	21	44	4.91	**55**
20	24	59	4.95	**55.6**
21	20	53	4.98	**55**
22	23	67	5.2	**55.6**
23	30	39	5.33	**55.7**
24	31	30	5.45	**55.6**
25	27	29	5.37	**55**
26	30	45	5.48	**55.9**

VI. CLOUD COMPUTING – ONLINE PORTAL

All the readings can be displayed in real-time through a web interface in a smartphone or PC. All readings are transferred using a SIM900 module connected to the microcontroller. SIM900 can be further interfaced to web using post commands [4].

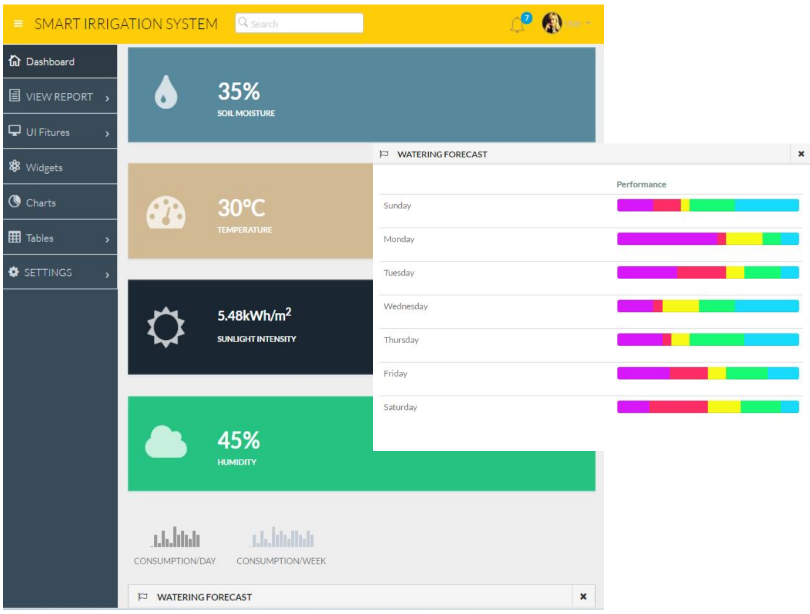

Fig.7: Online Portal – Web

VII. RESULTS

Fig. 8 represents a graph plotted between the water consumption rate in case of conventional time-based sprinkler versus the smart irrigation system during our testing period.

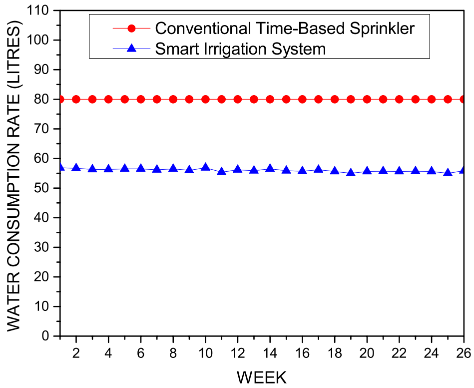

Fig.8: Water Consumption Rate for Conventional Time-Based Sprinkler versus Smart Irrigation System

The graph clearly shows a saving of 25 litres of water per day for irrigation in case of the mentioned field using Smart Irrigation System; which is a huge saving in the long run. This proves the smart irrigation system is much more efficient than the conventional time-based or manual sprinkler by 31%.

ADVANTAGES OF USING SMART IRRIGATION SYSTEM

I. Effective water management and water conservation.
II. Great savings on water consumed.
III. Minimizing drainage and run-off events. [5]
IV. Improving nutrient use efficiency.
V. Minimize water stress of the plant, that of over-irrigation and under-irrigation. [6]
VI. Optimize an irrigated crop's growth.
VII. Enhance and protect the produce quality. [7]

VIII. CONCLUSION

The research deals with the development of a smart irrigation system using various sensors such as Soil Hygrometer, Temperature, Humidity and Sunlight Intensity. Automation helps in utilization of water for irrigation as per desirable requirement of the crop resulting in better yield of crop compared to normal practices carried out. The system enables irrigation of the field only when it is needed and thus highly contributing to conservation of water. Also, the smart system eliminates the intervention of human being for irrigation purposes.

The research proves the smart system is much more efficient than the conventional time-based or manual sprinkler by 31%. During our six-month testing phase at the 400 sq.m area lawn, we were able to save nearly 25 litres of water per day in irrigation. As the smart system is solar powered, it does not require providing any electricity and can prove savings on energy consumed.

The smart system highly serves for effective water management and conservation. The system results in the reduction of water required to be taken from rivers, streams, and groundwater, with improvements in water quality, instream flow, and energy savings, among many other benefits. In addition to reducing water use, efficiency improvements can increase crop yield and quality while reducing input costs.

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