Arduino Platform for Optimized Irrigation in Strawberries Fields

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Arduino Platform for Optimized Irrigation in Strawberries Fields

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Abstract - **The paper is focused on the development and implementation of an autonomous and automatic system for irrigating in a strawberry field. For this purpose a smart irrigation system using Arduino was created. The software takes into account information related to water tank level, soil moisture and solenoid valve position, while providing farmers with daily information about the state of the culture. The output values of the sensors transmitted to the microcontroller are analyzed and , depending on the threshold imposed by the user, a decision is made whether to water the plants or not. Thus the microcontroller gives the command to open or close the solenoid valves. The water level in the tank used to supply the installation is also monitored using an ultrasonic sensor. System information such as date and time, soil moisture in the three areas, the condition of each solenoid valve and the amount of water in the tank are displayed in real time. The results yielded by different tests confirmed the functionality of the irrigation system, which remained in operation throughout the season.**

Keywords: ***Arduino, smart irrigation system, soil moisture sensor, water level sensor***

I. INTRODUCTION

Global human population growth amounts to around 83 million annually, or 1.1% per year [1]. Because of that, the concerns of agricultural researchers are based on the development of methods to increase the amount of food while the specialist in Electrical Engineering focus on the development of smart irrigation systems that monitor the most important parameters for best harvest.

The whole process of irrigation can be performed now with the help of smart irrigation by using only around 20 percent of the total amount of water required by the traditional methods [2]. If smart irrigation systems can be used instead of traditional systems, they can help the plants to grow properly because they optimize the irrigation process and provide water only when needed.

In the actual context of climate changing this should be seriously considered wherever the solution can be implemented.

Smart irrigation systems are expected to regulate water flow in soil without much human intervention, while maintaining moisture of the plants. A possible solution consists in turning ON/OFF the solenoid valves by detecting the water content in the soil. Such systems will not only minimize the excess wastage of water but also allow for the diminishing of labor along with other overheads.

Many authors have addressed this issue. In [3], the authors developed a modern irrigation system that is focused on the strategy of transmitting water to the field but not on monitoring soil moisture. Won-Ho Nam et al [4] used a wireless sensor network to create an application for irrigation management. This uses RFID tags for monitoring the irrigation parameters and carrying out decisions according to it. Daniele Masseroni et al [5] evaluated the performance of an automated irrigation system in Europe for paddy irrigation considering parameters such as Hydraulics, Control, and Economics with its sustainable investment for the farmers.

The approaches discussed are applicable only for a single type of crop, but it is not adapted to the variable type such as rice, corn, and raisins on a common plantation region. According to [6], a web application was developed and connected to Arduino via a Wi-Fi shield in order to monitor the greenhouse and control the temperature and the soil moisture. Other solutions were also presented in [7] - [9].

This paper is organized as follows - Section I summarizes the importance of the irrigation system and includes a literature review on the existing systems. Section II describes how the system works. Section III presents the operating algorithm. The implementation details of the system approached in this paper are approached in Section IV, while Section V is dedicated to tests and experimental results. At the end in this paper conclusion and future work are presented.

II. SYSTEM DESCRIPTION

The irrigation system presented in this paper is designed to take into account various parameters depending on soil requirements and the wishes of the farmer: type of crop, climatic zone, temperature, soil moisture. Thus, depending on the type of crop for which the irrigation system is used, these parameters can be calculated and set as needed.

This paper deals with a strawberry crop for which previous studies on the necessary environmental conditions have been made. The circuit diagram of a smart irrigation system is depicted in Fig. 1.

The software program on which the whole system is developed is largely designed by the author but also has some predefined sequences that are found in most applications.

This system is an original one designed to independently monitor different areas of a crop and to act differently on each area as needed. Initially, the basic operating conditions were determined. The thresholds of soil moisture sensors for this type of crop and for the ultrasonic sensor that monitors the amount of water in the thank have been calibrated. It works by monitoring the moisture content of the soil and deciding whether the solenoid valves are open or close and how long the plants should be watered. Because the soil resistance varies with moisture, it is used as one side of a voltage divider, whose remaining side is represented by a 470 kΩ resistor. According to the voltage division rule,

$$V_m = \frac{R_m}{R_T} \cdot V_s \tag{1}$$

$$V_m = \frac{R_1}{R_1 + R_2} \tag{2}$$

where:

V_m – Voltage across the m-th resistor;

R_m – Resistance across which the voltage drop has to be determined;

R_T – Total resistance;

R_1 – Resistance of soil;

R_2 – 470 kΩ Resistor.

V_s – applied voltage.

The voltage across the probe varies with moisture [10].

This voltage is read via the A0, A1 and A2 pins of Arduino. The analog value is converted by the internal ADC of Arduino and one will get a reading in-between 0 and 1023. The value 0 is associated to the fully wet condition whilst the value 1023 is associated to fully dry condition. The program continuously compares the read value with the reference value, set to 400 in program.

The 3 humidity sensors will monitor the three areas of interest and will continuously transmit data to the microcontroller which will analyze them and, depending on the threshold chosen as user reference will give command to start or stop the solenoid valve via the relay.

The water used in irrigation process is stored in a cylinder tank 1.3 m in length and 0.8 m in diameter. To monitor the amount of water, an HC-SR04 ultrasonic distance sensor is used. The control program measures the water level and performs the codification of the measured fluid height in percentages. 0% corresponds to the condition “empty tank” whilst 100% corresponds to the condition “full tank”. With the help of this sensor the farmer knows at any time the water level in the thank.

The LCD display is used to display:

- the soil moisture level provided by each sensor;
- the pump status (ON / OFF);
- the tank water level;
- the time and date, to provide the user with accurate system status data at any time.

III. Operating Algorithm

The Arduino board microcontroller continuously receives data from the ultrasonic sensor that monitors the water level in tank and from the humidity sensors that monitor the amount of water in the soil.

Based on the data received from the sensors and according to the thresholds imposed by the user, the microcontroller determines the actions to be performed.

The smart irrigation system approached in this paper uses the following algorithm:

Step 1: Start the process;

Step 2: Check the water level in tank;

Step 3: If the level is 100%, the relay is set to OFF and submersible pump is set to OFF;

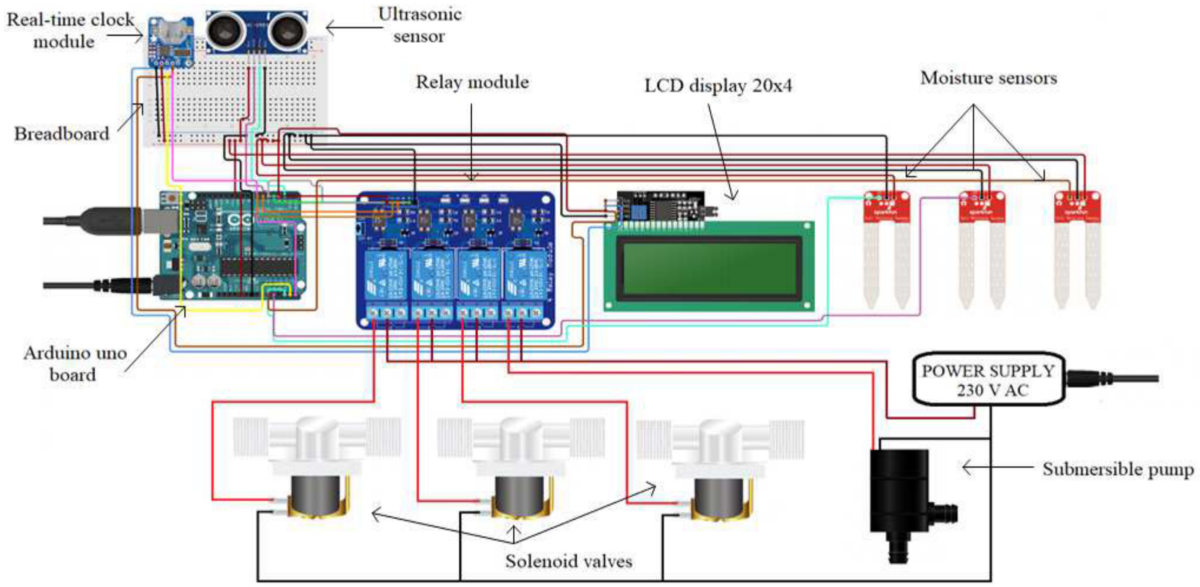

Fig. 1 Block diagram of the studied automatic irrigation system.

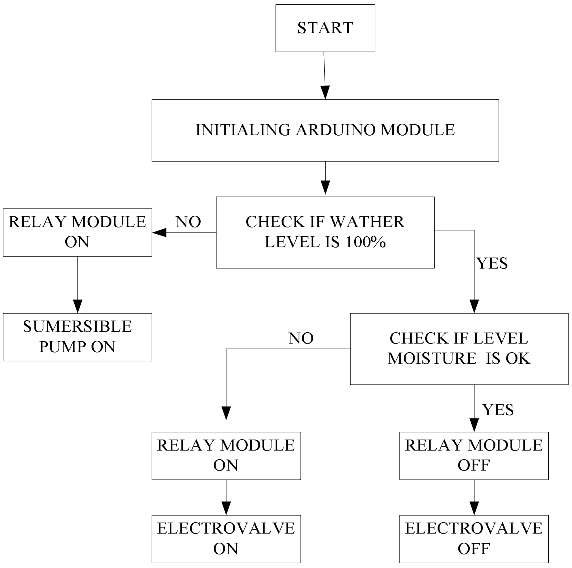

Fig.2 Flowchart of an automatic irrigation system

Step 4: If the level is less than 100%, the relay is set to ON and the submersible pump is set to ON;

Step 5: Check the moisture level of soil;

Step 6: If the level is much more than a threshold set by user , there is no need for irrigation, the relay is set to OFF and the solenoid valves close the water circuit;

Step 7: If the level is less than a threshold set by user, irrigation is needed, the relay is set to ON , the solenoid valves open the circuit and water will flow towards plants;

Step 8: After the process completed, it moves to original state;

Step 9: The process will run again after 1 minute.

IV. IMPLEMENTATION

The implementation of the smart irrigation system was done in a strawberries field. In this field, before the implementation of the new system watering was done using a drip irrigation system, which for this type of crop is much more efficient than other methods of watering such as sprinkling. Yet the problem of excess water has not been completely solved. Traditionally, the plants were watered according to the free time of the farmer who decided to water every other day, without having any information about the real amount of water needed at that time.

Fig. 3 proves the need of a smart irrigation system which monitors the amount of water in soil. In this case, one can see the amount of water used in excess in some areas.

As described above, the designed and implemented irrigation system is based on monitoring the soil moisture in three random areas where the watering of the plants should be done according to the values provided by the sensors and the threshold imposed by the user. The system is depicted in fig. 4. The process will start or stop for each area independently of the others, depending only on the chosen moisture level.

Fig. 3 Irrigation without moisture soil monitoring.

V. TESTING AND EXPERIMENTAL RESULTS

The implemented smart irrigation system has been tested for 7 days. Testing process has been done considering different parameters like type of soil, type of plant and weather conditions. For the accuracy of the obtained results, during the test period, the humidity sensors were placed randomly in the field and the manual watering continued in the areas where no sensors were located.

The three sensors for measuring soil moisture were placed in different areas of the field to cover as much space as possible. In order to obtain accurate data, they were placed close to the strawberry plants (Fig.5).

The LCD screen from Fig. 6 displays the soil moisture level provided by each sensor, the status of each solenoid valve, the water level in the tank and the time. In the case presented here, the humidity level imposed by the user has only been reached in one of the three zones and therefore only solenoid valve 3 is open whilst the others are close.

Fig. 7 shows the results of the experiment performed on different days. The bar graph representation illustrates the difference between the compared methods of watering.

When a plant is watered manually by estimating in ad-

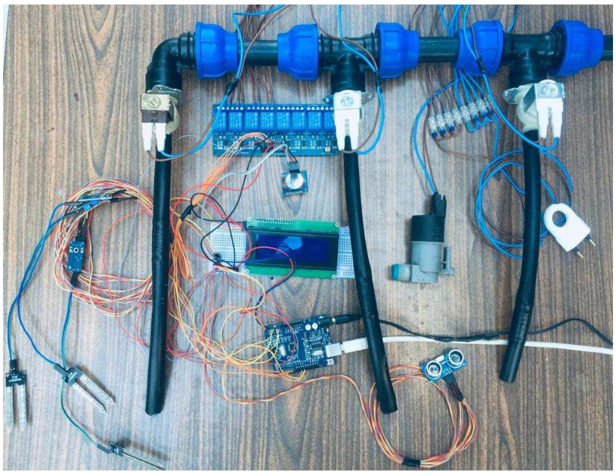

Fig.4 Hardware setup of the approached smart irrigation system

Fig. 5 Moisture sensor implementation

vance the necessary quantity without using sensors, the water consumption is higher than that needed by the implemented automatic irrigation system based on Arduino.

Different weather conditions result into different quantities of water consumptions.

The performed tests show that using the irrigation system with Arduino and soil moisture sensors consumes only the required amount of water. No excess water consumptions for irrigation are expected to be noticed, the

TABLE I AMOUNT OF WATER USED

Amount of water used	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**
With sensor	100	80	60	95	105	120	90
Without sensor	200	0	200	0	200	0	200

saved water remaining available for other scopes.

Table I depicts the amount of water used each day of the test period.

As one can see in Table I the traditional watering was done using 200 liters of water every two days. When the smart irrigation system was used, watering was done every day using different amounts of water.

In a global picture, in the case of traditional watering, 800 liters of water were used and when using the smart system, 650 liters were used.

CONCLUSION

This paper is dedicated to a performing irrigation system. It is focused on the optimization of plants watering process with respect to real weather conditions.

In particular the smart irrigation system proposed in this paper has been made in order to increase the efficiency of the irrigation process and to reduce the effort of far

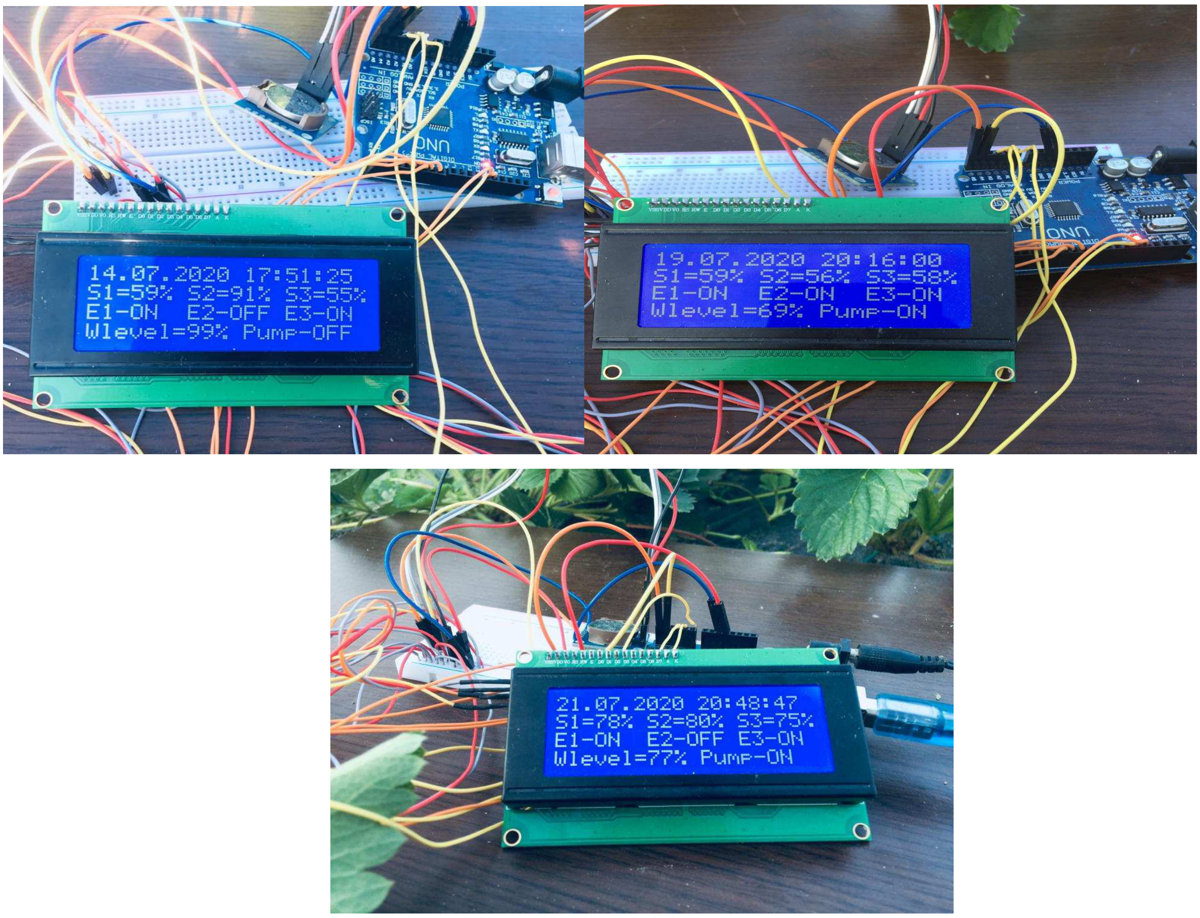

Fig. 6 System testing

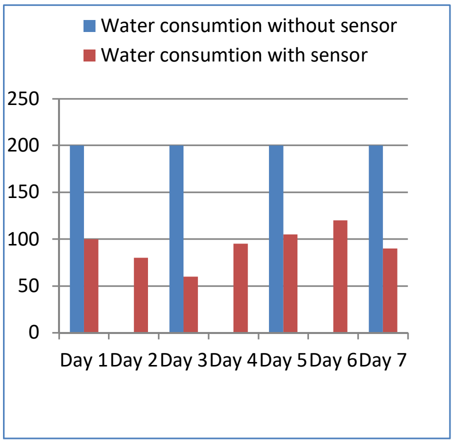

Fig.7 Bar-graph representation for experimental results.

mers and other people who need system irrigation for their garden. It is versatile and economical.

This system can be developed in an easy manner. According to various types of plants and soils, it can be adjusted with a minimum human effort.

The main advantages provided by this system are:

- The system is user friendly, being easy to program and operate.
- The maintenance costs are very low.
- It keeps the farmer updated with the pomp status and moisture soil level.
- It does not require any intervention of the farmers other than monitoring the automated system

The system was tested in order to determine its functionality.

The tests results proved the superiority of the new irrigation system over the traditional watering system which did not take into account the moister level of the soil.

Water savings were noticed in all cases due to the new technique. The watering process has been starting automatically in an optimized manner relative to the time of the day, unlike the case of using the old system when a farmer was needed to perform this operation.

This shows the importance of the system in the correct growth of plants and water saving. Therefore it would be useful in places where water remains a challenge for the practice of irrigation. With the implementation of smart system, advantages of drip irrigation and water quantity monitoring led to the solution of the problem.

For the test period there was a saving of 150 liters but a very important thing was regular watering using the optimal amount of water.

This system is ideal for farmer`s needs because all sensors and components are accessible and low priced

Many different approaches, tests, and experiments have been left for the future. Future work concerns the extension of this system to more complex tasks.

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