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Smart irrigation system using Arduino

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Abstract
The expansion of agriculture to secure the necessary food is linked to the availability of irrigation water. However, the limited sources of irrigation water necessitate the search for new technologies to reduce the loss of this water. This study aims to design a program for a smart irrigation system powered by solar energy that is environmentally friendly and cheap. This system can be applied to irrigation. Drip irrigation and its impact on the amounts of water used in irrigation, as the application of this program, is part of the solution to the problem of water shortage that Libya suffers from, in addition to reducing the amounts of water that is wasted during the irrigation of agricultural crops. In this study, a network of smart irrigation systems was designed. The smart irrigation system senses the soil moisture content through humidity sensors and works to turn on or stop the water pumps using relays to implement this procedure. The main advantage of using this irrigation system is to reduce human intervention and ensure proper irrigation. The microcontroller is the main unit for the entire irrigation system. Photovoltaic cells provide solar energy as a power supply to supply the entire system. The system is controlled by the microcontroller. Once the microcontroller obtains data from the sensors, it compares the data as pre-programmed, generating signals. Output and activate the relays to operate the pumps to start the irrigation process.

Keywords: Irrigation, Arduino, humidity, sensors, photovoltaic cells, solar energy

Introduction

At the beginning of the last century, researchers began developing irrigation methods. They introduced irrigation under the soil surface using clay pipes and sprinkler irrigation methods, or open irrigation using metal pipes.

Irrigation methods witnessed the beginning of a revolution in the era of plastic since the 1930s, when many researchers developed irrigation methods above the surface of the soil and used drippers using very clean water and low pressures, but the use of this method remained limited until the 1960s when drip irrigation systems began to be developed [1].

With the increase in population around the world significantly, and the limited sources of food and fresh water for irrigation and drinking, these sources must be exploited to the maximum extent possible and with high efficiency, or more accurately, it can be said that we must not be extravagant or wasteful in these blessings that God Almighty has given us. The exploitation of Fresh water to irrigate the largest amount of agricultural crops without any waste or extravagance is considered the desired result for producing any agricultural crop, as waste or extravagance may affect the water reserve, and on the other hand, reducing and reducing the amount of water used for irrigation may affect the crop. Therefore, water consumption must be moderated and rationalized. Currently, the latest technologies are being used to ensure quality and high efficiency in irrigating agricultural crops. One of these technologies is the use of sensors to measure the percentage of soil moisture to ensure that all cultivated plants receive enough water.

Idea

The idea of the study was based on a smart irrigation system that waters plants regularly. The microcontroller (Arduino) was designed and programmed and linked to the soil moisture sensor. The way this system works is to place the sensor in the soil to measure the moisture level, and then the data is sent to the microcontroller to turn on or stop the pump.

Study goals

1. Irrigating plants using an electric circuit.
2. Reduce water consumption.
3. Save time.
4. Effort saving.
5. Reduce cost.
6. Reduce electricity consumption.

What is a smart irrigation system

The smart irrigation system is a low-cost system, as it relies on reasonably priced devices. Some estimates, especially in Egypt, indicate that the cost of one hectare of the smart irrigation system is less than 1000 dollars, and the farmer can use a smart phone or computer to view the latest information regarding the soil and the crop.

Unlike traditional irrigation methods, the system operates according to a pre-programmed and timed schedule. Smart controls monitor weather conditions, soil conditions, evaporation and water use by the plant, to automatically adjust irrigation scheduling according to the actual conditions of the site, for example, as air temperatures increase. High or low rainfall, irrigation controllers take into account site-specific variables, such as soil type, the rate at which water is delivered to the field by the irrigation system used (sprinkler, drip, etc.), and to adjust irrigation operating times or schedules. There are several options for smart irrigation controllers. [2].

Smart irrigation controller saves water and money

Experts agree that smart irrigation systems and controllers, compared to traditional controllers, conserve water across a range of scenarios. Research studies also indicate that the control system for controlling smart irrigation water may save 30-50% of water compared to flood irrigation if used with modern irrigation systems [3].

Irrigation system components

Arduino

Arduino is an open source software and hardware through which you can simply control devices and perform a large number of functions based on the interaction of the programming and hardware with the inputs you choose, so that the outputs achieve the goals you want.

Fig 1: The Arduino board used

Pump

The NI Aquarium R385 water pump is the perfect choice for any project that requires moving water from one place to another.

Potential uses/projects include; a small water pump or an automatic watering system for plants, and when the liquid is pumped, the pump works very quietly. The pump is also capable of pumping air although the pump is quite noisy when pumping air.

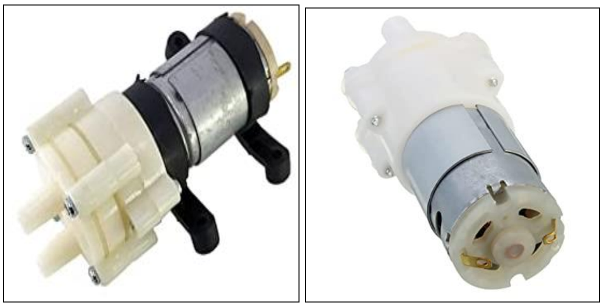

Fig 2: The pump used in the implementation

The R385 requires between 6 to 12 V DC and between 0.5 to 0.7A and will deliver maximum operating values when power is at the upper end of these ranges. The pump can handle pumping hot liquids up to a temperature of up to 80°C; it can suck water through the tube from a height of up to 2 meters.

Humidity sensor

The "soil moisture detector" sensor senses moisture in the soil. It is considered one of the sensors that is easy to use. It is one of the analog sensors. It works on two copper rods. The contact rate between them increases with the increase in water in the soil. It is considered suitable for monitoring the percentage of moisture in the soil for plants. And controlling the amount of water for irrigation

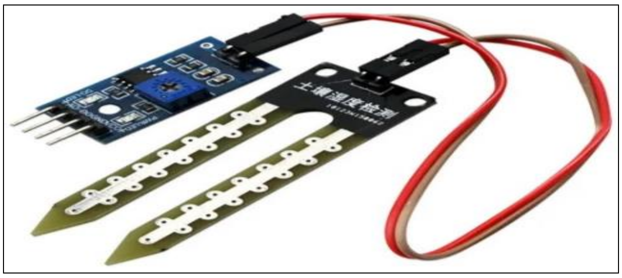

Fig 3: Soil moisture sensor

Table 1: Specifications and dimensions of the humidity sensor

Sensor parts	Dimensions
Panel PCB Dimension	3cm x 1.5cm
Soil Probe Dimension	6cm x 3cm
Cable Length	21cm
Interface Description	Wire
VCC	3.3V-5V
GND	GND
DO	digital output interface (0 and 1)
AO	analog output interface

How the sensor works

The output voltage of the sensor changes depending on the change in humidity in the soil. When the soil is wet: the output voltage decreases, and when the soil is dry: the output voltage increases. The output in the form of a digital signal (D0) can be low or high, and this depends on the soil moisture. If the soil moisture exceeds a pre-determined threshold value, the unit gives a low output, otherwise the output is high. The threshold value of the digital signal can be adjusted using a variable resistor, and the output can also be analogue, so you will get an output value ranging from 0 to 1023.

Reilly

The relay is considered a switch that operates according to the application of voltage. It can be turned on and off, and thus the current passes or does not pass. Figure 4 shows the relay.

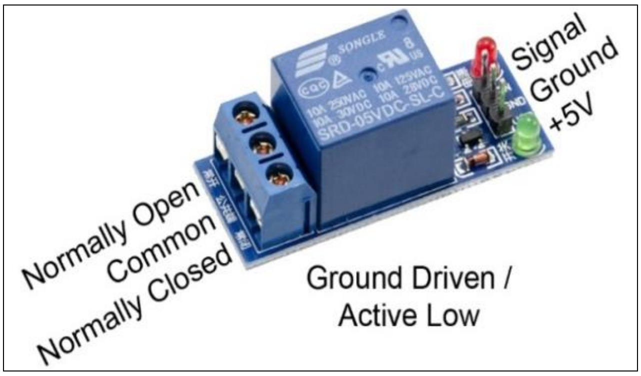

Fig 4: The relay used

Table 2: Relay specifications

Normal voltage	DC 5V
Normal current	70mA
Maximum load current	10A/ 30VDC,250V AC/10A
Maximum switching voltage	250 V AC, 30 V DC
Runtime	≤ 10 ml/s
Release time	≤ 5 ml/s

Connection board
Quite simply, it is a flat plastic board containing metal connection points in the form of rows and columns used in assembling electronic circuits. It does not require soldering and is reusable, which makes it easy to use to create temporary models and experiments to design circuits.
This board consists of several sectors and holes. These holes serve as connection points to which the ends of various electronic parts can be installed. They are connected in a row to the holes surrounding them horizontally in the two sectors located at the end of the board. As for the sectors in the middle, the holes are connected in a row vertically.

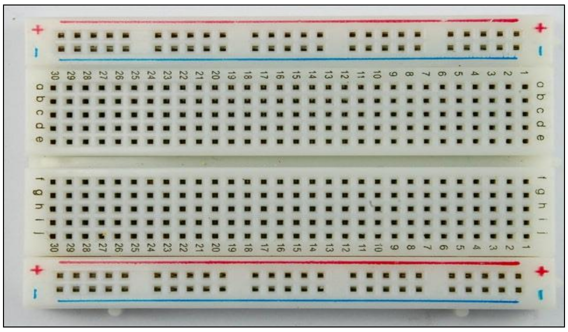

Fig 5: Connection board

Connecting wires
An electrical wire is a type of conductor and at the same time a material that conducts electricity. The conductor itself is usually copper or aluminum (or copper-clad aluminum) and is either a solid metal conductor or a cut wire.

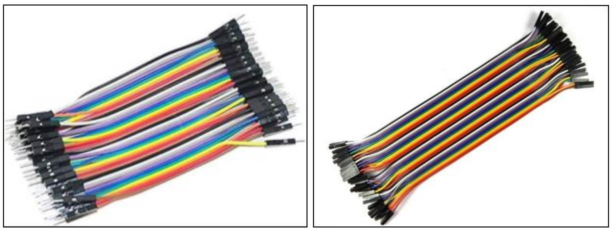

Fig 6: Connecting wires

I2C LCD Display Screen
The LCDI2C screen is very suitable for displaying phrases and numbers easily. It is easy to connect (two wires for power and two wires for data transfer) and works according to the i2c protocol, which converts data from parallel to serial form. Two lines can be displayed on the screen and 16 characters of letters, numbers, or any readable symbol for each line.

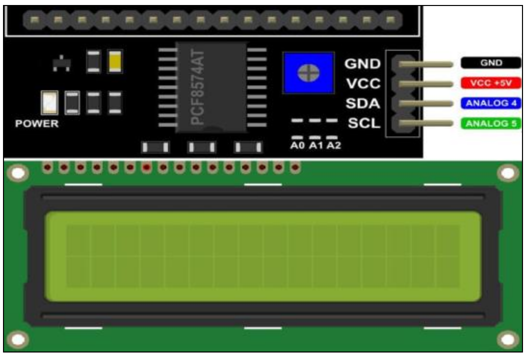

Fig 7: LCDI2C Screen

Voltage measuring device
Solar panel
A solar energy system with a PWM charge regulator was used as the primary source to supply both the control circuit (Arduino) and the pump.

Dimensions and specifications of the solar panel

Model No	LUM150M
Peak power/p_{MAX} (W)	150
Power Tolerance range (W)	3%±
Open Circuit Voltage/V_{OC} (V)	22.55
Rated Voltage/V_{mp}(V)	18.5
Short Circuit Current/I_{sc} (A)	8.52
Rated Current/I_{mp} (A)	8.11
Max. System Voltage (V)	1000
Dimension (mm)	1480*665*30
Weight (Kg)	10.6
Series Fuse Rating (A)	15

Fig 8: Charge regulator (PWM)

Table 4: Charge regulator (PWM) Specifications

Rated voltage	12V/24V
Rated current	20A
Max PV voltage	50V
Max PV Input Power	260W (12V), 520W (24V)

The practical side
This part explains the design and construction of a low-cost smart irrigation system using the electronic circuit drawing program Fritzing and programming it using the Arduino IDE program so that this system can be operated without any human intervention.

- **The Arduino board used in the system**

An Arduino microcontroller board was used, based on a controller with an ATmiga328P processor, which controls the smart irrigation system after programming it in the C++ language. It is fed from the 12 V port via the solar panel system.
The VCC and ground terminals of the Arduino were connected to the positive and negative terminals of the breadboard to supply them electrically with a voltage of V5, as shown in Figure 9.

s

Fig 9: Experiment board

Connecting the soil moisture sensor
The ground port of the sensor was connected to the negative port on the breadboard, and the VCC port of the sensor was connected to the positive port on the breadboard. The analogue signal input of the sensor was connected to one of the analogue signal inputs on the Arduino, where used the A0 input.

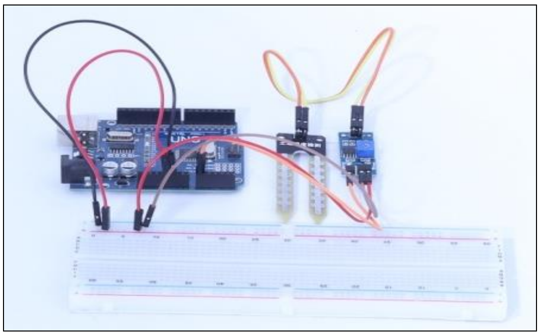

Fig 10: Soil moisture sensor

Relay connection

Two points feeding the relay coil were connected to the breadboard, and the digital point of the relay was connected to the digital port of the Arduino, where port 2 was chosen. The NO point was connected to the pump and the COM point was connected to the source. The other port was connected directly from the voltage source to the pump.

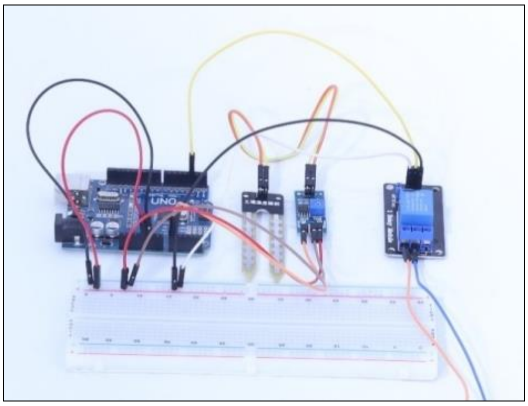

Fig 11: Relay connection

- **Pump connection**

The negative end of the pump was connected directly to the negative source, which is the solar energy system, and the positive end of the pump was connected to the NO port of the relay, and the COM port was connected to the positive end of the source.

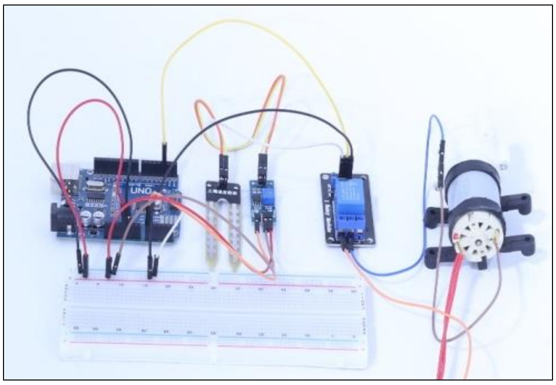

Fig 12: Connecting the water pump

- **Connecting a display**

The SCL port is connected to the SCL port on the monitor, the SDA port to the SDA port on the monitor, and the two power ports on the monitor are connected to two breadboard ports.

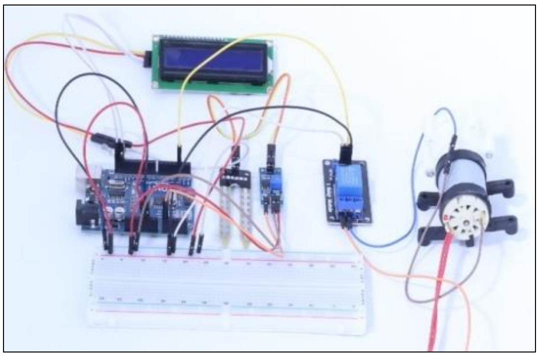

Fig 13: I2C LCD display

- **Connecting the solar energy system**

The two wires of the solar panel were connected to a charging regulator of the PWM type, in order to regulate the electrical voltage of the load, which is the smart irrigation system, as well as regulate the charging process for the battery to feed the irrigation system in the event of irrigation in the evening or when the weather is cloudy.

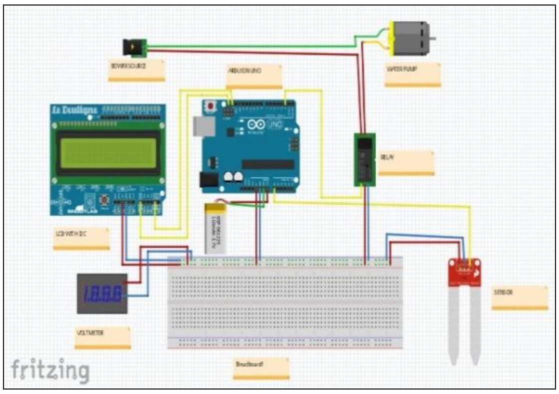

Fig 14: Model of the smart irrigation system using the Fritzing program.

How the smart irrigation system works

When the irrigation system is turned on, the sensor reads the soil moisture percentage and sends these readings to the microcontroller, and then the data inside the program code (program code) is compared with the values inside the program to give the command to turn on or stop the pump. Figure 15 shows the moisture sensor data curve with the pump running.

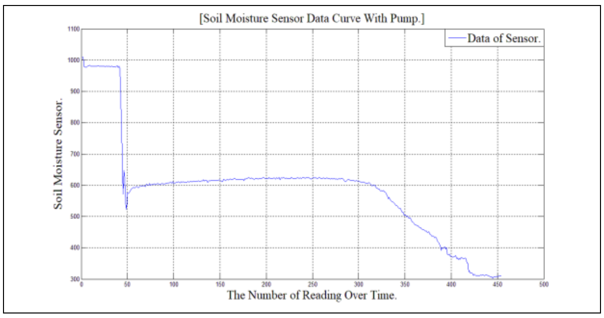

Fig 15: Humidity sensor data curve with pump running

MATLAB was used to plot the humidity sensor data curve with the pump operating. When the sensor is placed in dry soil, that is, devoid of moisture, the sensor reading will be at the highest value, as shown by the curve in Figure 15. It gives a signal to the Arduino board to operate the pump, so the pump pumps water to the place to be irrigated, and the sensor continues reading the moisture in the soil. As the level of moisture in the soil increases, the value of the sensor reading decreases until it reaches the saturation level at a certain level of humidity, and then the sensor sends signals to the Arduino board to be compared with the required humidity level that the soil moisture level has reached the operating limit to stop the pump from operating. The sensor continues to read the level of soil moisture, as the plant roots absorb water from the soil in addition to the heat that evaporates water from the soil and other factors that contribute to reducing the moisture in the soil to a certain degree, at which the sensor sends a signal to the Arduino board to turn on the pump again, as this system works properly automatically without the need for human intervention in the irrigation process.

Conclusions

- A smart irrigation system was obtained after it was designed based on sensing during the operation of the pumps to obtain the water needs of the plant and based on the moisture content in the soil.
- The energy source is economical and environmentally friendly at the same time.
- The system's irrigation process reduces labor consumption without human intervention.

Recommendations

1. It is possible to add a sensor to measure the air temperature.
2. The smart irrigation system can also be operated on three-phase voltages.
3. Also the possibility of conducting an economic feasibility study for this project.
4. Sensors can be added: temperature sensor, water level sensor, and rainfall sensor.
5. Web pages can be designed to apply the proposed system on computers and mobile phones to monitor the reading of the soil moisture sensor, the temperature sensor, the rainfall sensor, and the water level in the tanks.

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