3L04 Final Exam

The Auto Gard (Smart Garden)

Muqtadir Hussain

400250481

Abstract:

Gardening, besides being a convenient source of fresh produce is an amazing recreational activity one can indulge in during their leisure time. However, being engaged in gardening and ensuring the well being of plants does require a certain level of commitment, patience and not to mention practice and may prove to be difficult for people away from home or with busy schedules. The proposed solution is a miniature smart garden powered and controlled by an Arduino microcontroller with various sensors and actuators which allows to remotely monitor the conditions of the garden and take actions to alter said conditions as needed.

Problem:

Plants require specific environmental conditions for healthy growth and yield. These include but are not limited to moisture in the plant's soil, pH level of the soil, temperature and humidity in the plant's surroundings and amount of sunlight reaching the plant. Any shortcomings or excessiveness in said conditions may lead to plant damage, yield loss and potentially even death of the plant.

Proposed Solution:

The Auto Gard is a microcontroller powered environmental monitoring system for plants that monitors the stated conditions simultaneously around the clock using appropriate sensors and according to the logged data either takes pre-programmed actions once certain conditions are met or relays the information to the owner so appropriate action can be taken on time.

Sensors and Design:

The Auto Gard is an elaborate device that can be set up with any small to medium size container or pot. The device consists of various sensors and actuators connected to a central Arduino which receives, processes and transmits data. The control of these components is achieved through a set of algorithms which make decisions based on sensor readings and pre-programmed thresholds. Another significant feature is the ability to modify the devices code for various plant species and breeds based on their specific requirements. An **ESP8266 Wi-Fi Module** is integrated with the device to allow connection to an IoT service for remote monitoring, access and 24/7 control. An easy to use IoT service to stream, log and interact with the data is AdaFruit and due to its simple compatibility with Arduinos, is the service of choice.

Figure 1: ESP8266 Wi-Fi Module

The first thing that comes to mind when growing plants is sufficient water for the soil. Most plants require periodic watering in specific amounts without which the plant will fail to survive. [1] In order to monitor and control the moisture content of the soil, the device makes use of an **IC2 Capacitive Soil Moisture Sensor** and a water pump motor attached to a pre-filled water container. Most soil moisture sensors work based off resistivity where two prongs are inserted into the soil and the integrated sensor measures the conductivity between the two to determine the moisture content. Although these work well, they have a short life span after which the exposed metal on the prongs begins to oxidize, altering their resistivity and therefore requiring constant code re-calibration to maintain accurate readings.

In order to overcome this obstacle, a superior capacitive sensor is used. Capacitive measurements use only one probe, don't have any exposed metal and don't introduce any DC currents into the soil/plants. The capacitive touch measurement system gives a reading range from about 200 (very dry) to 2000 (very wet) and based on this reading, the Arduino is able to make a comparison to the specific moisture requirement of the plant and periodically turn on the water pump until required levels are met, before switching it off.

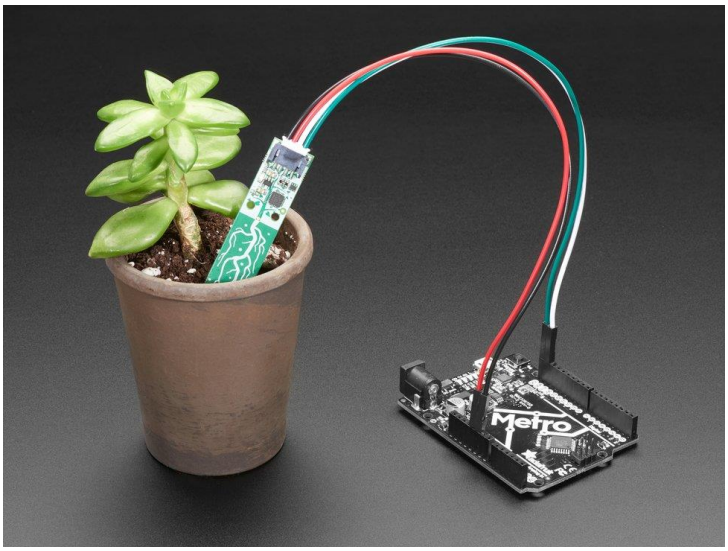

Figure 2: IC2 Capacitive Soil Moisture Sensor

Furthermore, a [2] **water level sensor** is inserted into the water container to alert the user when it needs to be refilled, Water level sensors work with a set of exposed parallel conductors on its surface which together, act as a variable resistor. Since water is an excellent conductor, the change in water level results in an inversely proportional change in corresponding resistance which is used by the Arduino to determine the remaining water level.

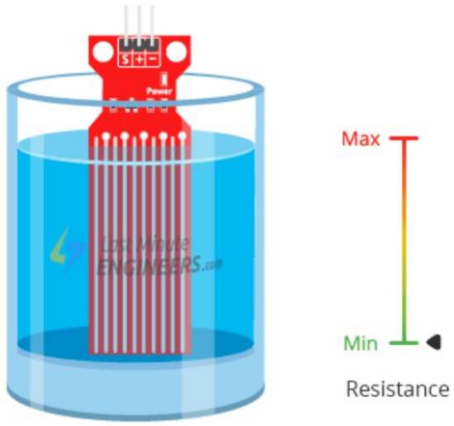

Figure 3: Water Level Sensor

Similarly, environmental temperature and humidity are important factors which need to be kept in check for healthy plant growth and yield. These conditions vary from plant to plant and their negligence are surprisingly a very common cause of plant health degradation that goes by unnoticed by most people with less experience growing plants. The Auto Gard solves this issue with a [3] **DHT11 Temperature and Humidity sensor**. This uses a capacitive humidity sensor and a thermistor to measure the conditions of the surrounding air and outputs a digital signal which is compared to the reference conditions of the plant (easy-to-change plant specific code). Based on this, a notification is sent out to the user through the IoT service alerting the user of any immediate changes which need to be made to plants environment.

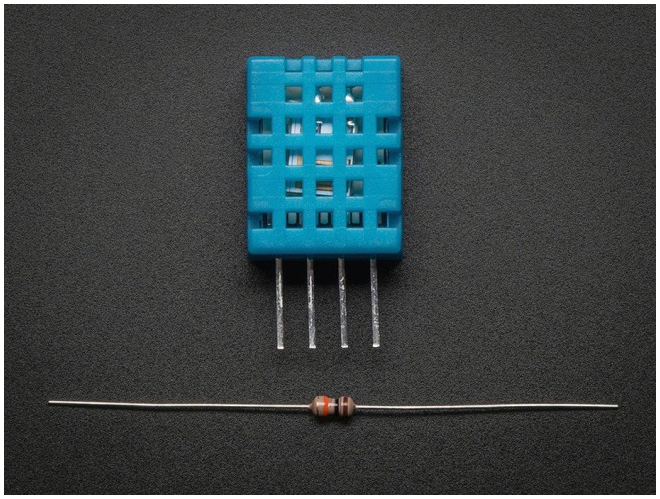

Figure 4: DHT11 Temperature and Humidity sensor

[4] Another extremely important requirement for the healthy growth of plants is sufficient sunlight. Besides nutrients from the soil, sunlight is a key energy source for all plants and through photosynthesis, plants absorb energy from the sun which fuels the processes necessary for survival. Although sunlight is the best for plant growth since artificial lights cannot replicate the specific wavelengths that are optimal for plants, artificial light can work well as a supplement especially during dark winters and conditions where sunlight is scarce. The Auto Gard makes use of **Photoresistors** to determine the need of artificial light sources. Also known as light dependant resistors (LDR), photoresistors decrease their resistance with respect to incident light intensity on the components sensitive surface. Based on this varying resistance, the photoresistor along with the Arduino can determine the luminosity in the environment and accordingly switch on external artificial light sources (LED's) to provide the plant with sufficient light.

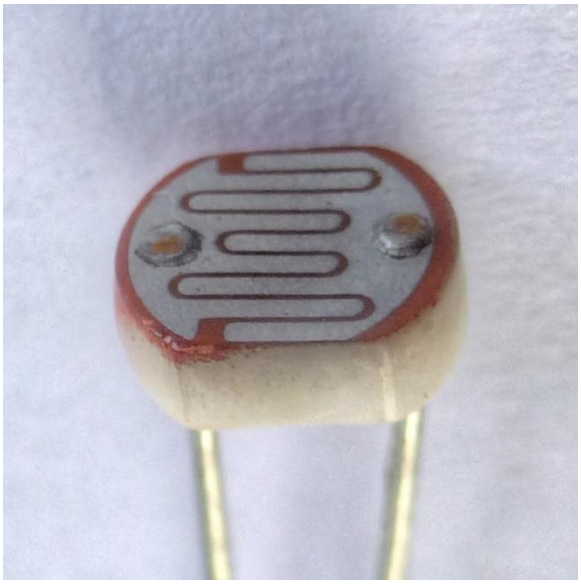

Figure 5: Photoresistor

[5] Soil pH affects the amount of nutrients and chemicals that are soluble in water. While some nutrients are more readily available under acidic conditions, others are more available under alkaline conditions. Most nutrients however are readily available to plants when the pH is near neutral and is therefore the optimal condition for most plants. Soil that is too acidic may result in plant damage and poor growth whereas soil that is too alkaline may result in nutrient deficiencies. Soil pH is therefore an important condition to monitor and control for healthy plant growth. The Auto Gard makes use of a waterproof and dustproof **Soil pH sensor** that can measure the pH value from 3 to 9 with a high accuracy of up to $\pm$ 0.3 pH.

This sensor takes periodic measurements of the soil's pH and sends alerts out to user regarding any changes which need to be made such as the addition of fertilizers. The Soil pH sensor is interfaced with the Arduino board using the MAX485 Modbus Module as shown below:

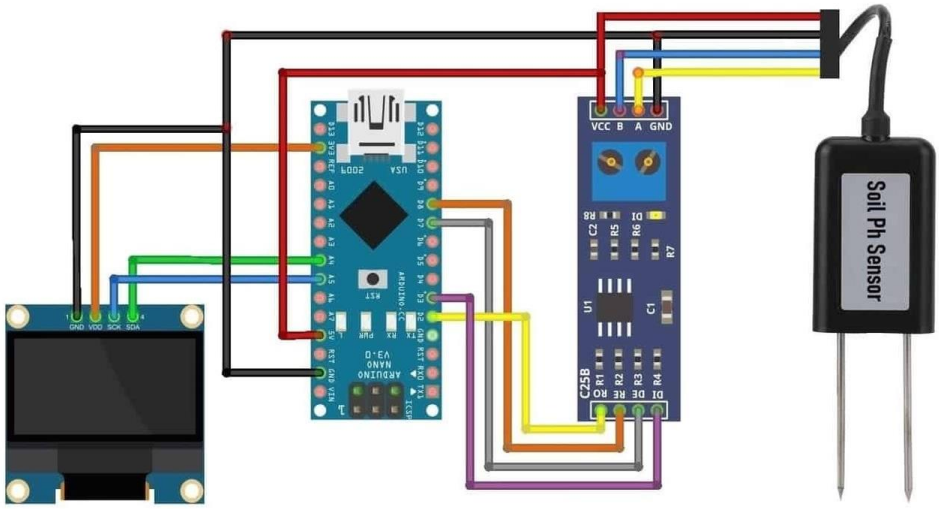

Figure 6: Soil pH Sensor Module

All together, the Auto Gard is an efficient and reliable device for plant owners which can allow them to excel in their gardening skills while ensuring the healthy growth of all sorts of plants.

References:

1. A. Industries, “Adafruit Stemma soil sensor - I2C capacitive moisture sensor,” *adafruit industries blog RSS*. [Online]. Available: https://www.adafruit.com/product/4026. [Accessed: 13-Dec-2021].

2. Last Minute Engineers, “In-depth: How water level sensor works and interface it with Arduino,” *Last Minute Engineers*, 18-Dec-2020. [Online]. Available: https://lastminuteengineers.com/water-level-sensor-arduino-tutorial/. [Accessed: 13-Dec-2021].

3. Evil-Mad-Robot, “DHT11 temperature-humidity sensor,” *Evil Mad Scientist Shop*. [Online]. Available: https://shop.evilmadscientist.com/productsmenu/716#. [Accessed: 13-Dec-2021].

4. “Do plants grow better in sunlight or artificial light?,” *Greenhouse Today*, 29-Mar-2021. [Online]. Available: https://www.greenhousetoday.com/do-plants-grow-better-in-sunlight-or-artificial-light/. [Accessed: 13-Dec-2021].

5. “DIY soil ph meter using soil ph sensor and Arduino,” *How To Electronics*, 26-Mar-2021. [Online]. Available: https://how2electronics.com/diy-soil-ph-meter-using-soil-ph-sensor-arduino/. [Accessed: 13-Dec-2021].