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Fully Automated Hydroponic System for Indoor Plant Growth

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Abstract

Growing certain plants and vegetables in remote areas such as deserts and the north and south pole can be a challenge because of the extreme outside weather. Very few species of plants thrive in such situations and are often not used as a food source [1]. In this study, we created a system that can grow common plants and vegetables and can operate without depending on the outside climate. We achieved this by using a technique called Hydroponics. Hydroponics is a method of growing plants without using soil [2]. The system was automated using microcontrollers and sensors to keep human intervention at a minimum. An Internet of Things (IoT) network was created to improve reliability and allow remote monitoring and control if needed. The user is only required to plant a seedling and set initial parameters. Once done, the system is able to maintain the parameters and promote healthy plant growth.

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Keywords: Hydroponics; Automation; Internet of Things.

1. Introduction

The purpose of the project, Titan Smartponics, is to expand and improve the utilization of hydroponics as well as to create an environmentally independent system for indoor plant growth. In a hydroponic system, a plant is placed in a solution composed of soluble nutrients and water as opposed to soil. In most conventional hydroponic systems, parameters such as EC and pH of the water solution are set to the desired value while setting up the system [3], [4].

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There are several other parameters such as air temperature and humidity, lights, water temperature etc. which are not controlled or maintained. These parameters are important for a healthy and faster plant growth [2]. In this project, we built a system which monitors and controls all the parameters necessary for healthy indoor plant growth. In general, the process goes as follows: create a nutrient solution based on the plant being grown, apply this solution to a bed of water, place a germinated plant into the water such that the exposed roots are touching the solution. If the parameters are maintained within optimum levels, the plant should grow faster and healthier than its natural growth. Typically hydroponic systems require human interaction when it comes to the regulation of certain elements that allow the plant to grow [4]. The goal of the Titan Smartponics project is to make a system that is cost-effective and, most importantly, is completely automated and requires virtually no human interaction after placing the germinated plant into the system. The other aspect is to create a system that can be used by a typical consumer; meaning that it is relatively small and simple to use.

The Titan Smartponics project accomplishes automation by utilizing various microcontrollers, sensors, and IoT technology for remote monitoring, and control. In the most basic description of its operation, the system takes inputs from the sensors and provides a controlling action to keep different parameters in the desired range.

Automated hydroponics systems currently on the market are either very expensive or don't control all the parameters necessary for a healthy plant growth. The systems like LEAF provide the automatic control of the parameters but are priced in the high 2000's [5]. Some of the systems provided by SUPERCLOSET, are cost effective but lack the automation, monitoring and control of the environmental parameters [6]. This study provides complete automation with monitoring and control of all the parameters necessary for the growth of a plant.

2. Methodology

The system uses two Arduino boards for the analysis of the received data and control. A Raspberry Pi is used to run an open source automation software called Domoticz. Once the Raspberry Pi receives the input data, it updates the server. The system also uses a mobile app to enable monitoring and control from iOS or Android devices [7]. Because the system is relatively small (smaller than a mini refrigerator), it can fit into a small office space or a nook in the home. This accomplishes the second goal of the project. The complete automation and size are what make Titan Smartponics different from other hydroponic systems.

2.1. Hardware

In Fig. 1, the proposed system is presented. The system uses two Arduino microcontrollers acting as nodes. Nodes take the data from the sensors and send the data to a third Arduino acting as a gateway in the IoT network. NRF24L01+ radios are used for the communication between the nodes and a gateway. The gateway is connected to the Raspberry Pi running a local server which makes the data available on the web interface and mobile application. The LED's provide light to the growing plant. The lights are set to a 14 hour ON cycle to simulate daytime. A Real-Time Clock (RTC) is used to keep track of the time. The lights, along with a small exhaust fan, are controlled using a relay module. The camera mounted on the system can be accessed remotely through the Domoticz app as well as the web interface to monitor the state of the plant.

The state of the system is monitored by using various sensors. An air pump is used to infuse the water with oxygen for the plant to absorb through its roots. The system contains four sensors: an electrical conductivity probe, a pH sensor, a water temperature sensor, and an air temperature/humidity sensor, shown in Fig. 2. The electrical conductivity probe allows us to estimate an amount of salts or nutrients in the water. The pH probe must be calibrated using calibration liquids [8]. Measuring the pH allows us to properly adjust the pH of the water before putting the young plant into the system. The EC and pH probes are connected to a transmitter to convert the information received by the sensors into pH and EC values. Distilled water was used to have base pH value close to 7 and adjusted to be between 5.6 pH – 6 pH after adding nutrients. Measuring the pH of the water at consistent temperatures is vital since the pH is dependent on temperature [9]. The water was heated up to 25°C and then the pH was adjusted using acidic and basic solutions. A water heater heats up the water and automatically maintains the water at a temperature of 24°C and 25°C which is optimum for healthy root growth [2]. Carbon dioxide is supplied to the system by a carbon dioxide releasing pad.