An eye on hydroponics: The IoT initiative

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Abstract— **The need for the soil in agriculture is crucial and its role is prominent. But the process of urbanization takes away the land in larger areas. So continuous cropping on the rest of the land makes the soil to lose it's fertility as all the nutrients are consumed. In quest of an alternative solution, we have gone through the Hydroponics. In this paper, we integrate IoT into our solution and also reduce power consumption by utilizing Solar Energy. Hydroponics is a special type of farming where the growth of plants takes place in a soil-free medium, provided with a blend of water along with nutrients. As an alternative for soil, we are here using Rockwool as support for plants to withstand. We provide the water with nutrients required by the plant, the plants do not have to call for root system on the lookout for water, nutrients, oxygen. In this process, the plant is permitted to spend its energy on its production. Hydroponics allows us to make farms in certain locations where conditions of soil are too poor to support farming, space is limited. The IoT system continuously monitors the farm and also displays the data with regards to the plant growth by which we can get the values of pH, water level, temperature, and humidity in the hydroponic reservoir. The role of pH sensor is main as we are using nutrient-enriched water. The initiation of IoT in Hydroponics assists farmers, by keeping an eye on the plant growth by delivering information regarding the aspects of the water, humidity, temperature. The respective statistics are achieved through cloud-connected sensors.**

Keywords— **IoT, smart-farming, monitoring, hydroponics and Automation.**

I. INTRODUCTION

We can see how the technology is spreading its wings. The wingspan of technology covers almost all the sectors that include medical, industrial, agriculture. There are a wide variety of applications for IoT in our daily life as smart agriculture systems [1]-[5], wearable healthcare module [6], smart transportation systems [7]-[9] and smart consumer electronics [10]-[12]. The challenges begin with the integration of existing technologies for the creation of an IoT ecosystem. But in recent years it has been a boon to farmers where the role of technology is thriving towards the benefit of farmers. Various methodologies are being implemented in the farming sector through IoT. The real automation is implemented and results are as desired. As agriculture is the backbone of economy in various developing countries, government supports the farmers to increase their income by adopting technological advancements and establish smart farming instead of traditional methods. The urbanization and industrial revolutions caused in reduction of fertile agricultural land area. Intense research works are undergoing in various parts of the world to overcome the lack of fertilized soil farms. A few technologies evolved from such research works and they are hydroponics, aquaponics and aeroponics. Among these, hydroponics has better impact as its more user-friendly and profitable. Latest advancements in hydroponics method are mentioned in [13]-[16]. Hydroponics provides the assurance to do cultivation without soil and limited resources. Hence it created a great impact in urban areas where hydroponics made it possible to do terrace farming.

The proposed system is an eye to farmers and this is achieved through IoT and automation by the delivery of time to time statistics through the cloud. The traditional farming has its own pros and cons. Control of pest might be the greatest drawback of all times. But in the case of hydroponics, it supports to eliminate the risk of pests and weeds. As here, providing all the needed essentials through water, the production will be pure and healthy. Environmental parameters like temperature and humidity, water quality and water levels have to be periodically monitored here.

A smart monitoring system for hydroponics based on Raspberry Pi and IoT is explained in paper. It is a low-cost system which supports the farmers to monitor their cultivation even from a remote location. Section 2 gives detailed design details of proposed automated hydroponics system and its technical description. Brief experimental process flow is provided in Sect. 3. Results and performance of the proposed system are mentioned in Sect. 4. Section 5 summarizes the features and concludes the work.

II. METHODOLOGY

A. Hydroponics: A technical blend in agriculture

Recent trends in agriculture has shown better results and also revealed new paths to achieve favorable outcomes. Understanding the present technology, noticing key issues and making advancements that address those issues is saidto be the thoughtful way of making the lives easier. Here, the present implementations that paved a path to agriculture to continue its rest of journey with technology.

In the present scenario, to address the key issues with an effective solution the need for IoT and Automation is essential. There are valid reasons which gather importance. The word that best suits the IoT is being connected. We can see the vivid range of connections to any device with any device.

B. Need for Automation Control

As a human, error can be a usual one but one should not neglect it. But in order to reduce the error and human resources, automation is the best solution. With the support of respective sensors, monitoring of environmental parameters as well as water quality and level can be monitored periodically. Farmer can reduce the manpower and resources via automated monitoring of farm condition. Automation ensures increase in output, by reducing costs, lowering the lead times.

C. Climate Statistics

Agriculture depends on the climatic conditions that vary from time to time. So, it directly affects the rate of production of the crop. By the use of IoT, we can get an update about climatic conditions and can be able to take the next step. The sensors that are placed in and around the farm communicates the information regarding weather situations like temperature, rainfall, humidity with maximum accuracy. The alert information will be conveyed whenever the weather is disturbing and this is done without physical presence.

D. Data Analytics and Cloud

Information in the form of data that is collected from the sensors and can't be stored in a conventional database as the storage matters. An effective solution for this is using cloud storage. The sensors collect data on a wide range. This data will be analyzed and made more understandable, informative through analytics tools. In this proposed system, Ubidots cloud dashboard is utilized for data storage.

E. Proposed System

A novel hydroponics system is proposed here and the pictorial representation of the same is shown in Fig.1. A soil-less environment is created by maintaining proper nutrition levels for plants through water supply. The demand for the hydroponics system is high as the agricultural land is diminishing day by day. The proposed system can be implemented in huge farm locations and even in household areas like balconies, terrace for better convenience. The association of appropriate IoT platform with necessary sensor network can provide a smart agriculture scheme for remote monitoring.

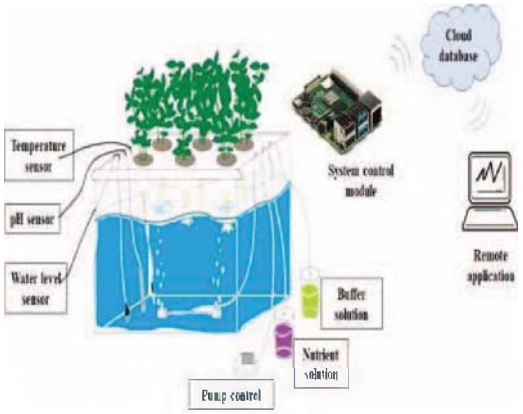

Fig.1: Pictorial representation of proposed Hydroponics system

III. EXPERIMENTAL PROCESS

According to the concept illustrated using the pictorial representation in Fig.1, experimental set up is developed for prototype implementation. The process steps are elaborated with the support of block diagram and flow chart.

A. Block diagram and flow chart

In the proposed device, the sensors capture analog data from the Hydroponics system. With the support of an advanced 10-bit ADC (Analog to Digital Converter-MCP3008), digital data is generated and communicate the same with Raspberry Pi 3 board which controls the operation of entire system. The processor will analyze the data and takes the necessary actions like message display, buzzer alarm, motor pump control and data storage in cloud dashboard. The block diagram representation of the proposed system is shown in Fig.2.

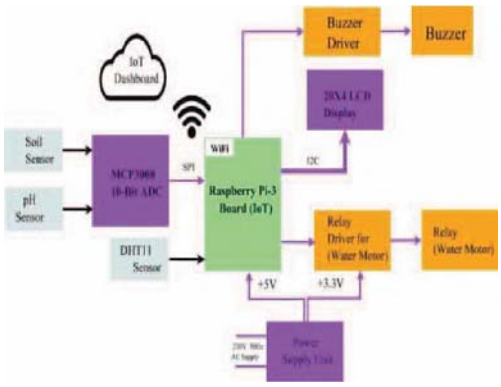

Fig.2: Block diagram of proposed Hydroponics system

The major steps involved in the proposed system is mentioned as flow chart in Fig.3.

B. Circuit diagram and components

The electronic circuitry of the proposed system is implemented using low-cost components without compromising on its performance level. The automated Hydroponics embedded system's circuit diagram is shownin Fig.4.

The major components involved in transmitter system are:

- Raspberry Pi-3 kit
- MCP3008 10-bit ADC
- Temperature sensor (DHT11)
- pH sensor
- Water level sensor/ Soil sensor
- 20x4 LCD
- Power supply

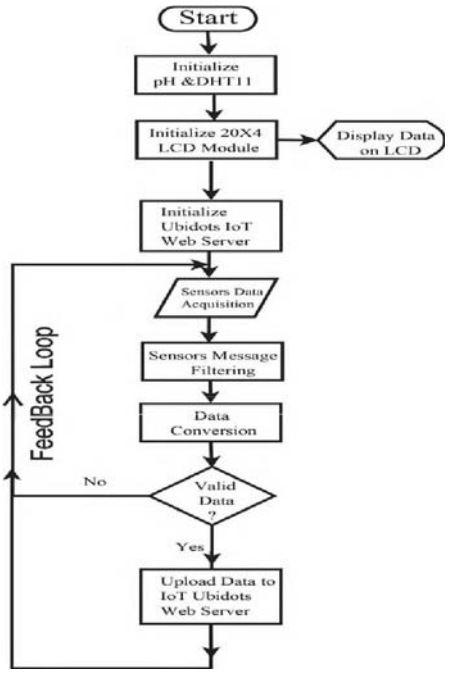

Fig.3: Flow chart of the process steps involved

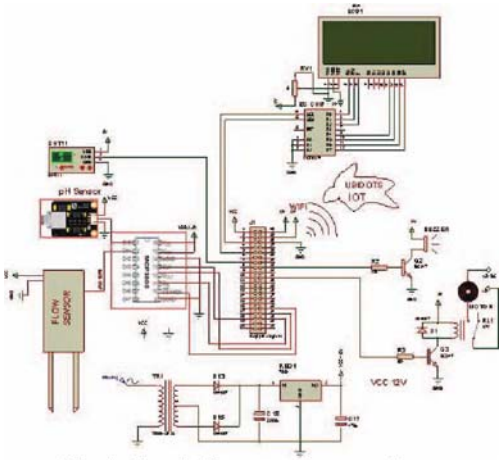

Fig.4: Circuit diagram of proposed Hydroponics system

The principal element of this automated system is Raspberry Pi 3b module, which is incorporated as it has both wireless LAN as well as Bluetooth connectivity.

Due to the advancement of IoT technologies, cloud dashboards are the principal element of Human-Machine Interface (HMI). This platform supports to preserve and to present the physical world data in the form of digital information. Upon requirements, these resources can be displayed on a computer or even a mobile device. In this proposed system, an IoT dashboard named Ubidots is utilized to represent the Hydroponics system performance data in a user-friendly manner. This supports to enhance the efficiency of the system with low cost.

DHT11 – In Knowing the climate conditions is necessary for agriculture. So, this DHT11 sensor which is a temperature and humidity sensors will give the readings of temperature and humidity that helps to track the climate conditions. The picture of temperature and humidity sensor is shown in Fig.5.

Fig.5: DHT-11 Temperature and humidity sensor

pH Sensor – In Hydroponics system, pH sensor plays a prominent role. The pH of nutrient-enriched water must be taken care of. Readings are taken from the water and will track the effective pH. The photograph of pH sensor is shown in Fig.6.

Fig. 6: Photograph of pH Sensor.

Water Level Sensor – To get to know the level of nutrient-enriched water this sensor is used. The level of water in the hydroponic system can be noticed by using this sensor. The image of the water level sensor is shown in Fig.7.

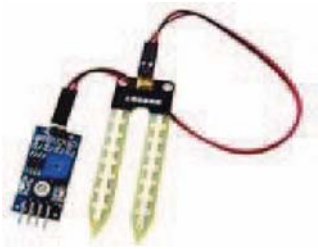

Fig. 7: Image of water level sensor or soil sensor.

20x4 Liquid Crystal Display - Data can be locally visualized and displayed with the help of this display. The image of the 20x4 LCD is shown in Fig.8.

Fig.8: 20x4 Liquid Crystal Display

VI. Results and Discussion

The proposed system is implemented and analyzed the performance in real time. The Hydroponics system monitoring and management are illustrated with the support of Ubidots cloud database. Various parameters like temperature, humidity, water level, soil level, pH value etc, of the Hydroponics system is consciously monitored using multiple sensor network. The periodic data is stored in a user-friendly cloud dashboard for the farmer's updates.

The photograph of prototype implementation is shown in Fig.9. The respective sensor data is displayed on the LCD screen as well as in cloud dashboard based mobile device application. The screenshot of different parameters is shown in Fig.10, Fig.11, Fig.12 and Fig.13.

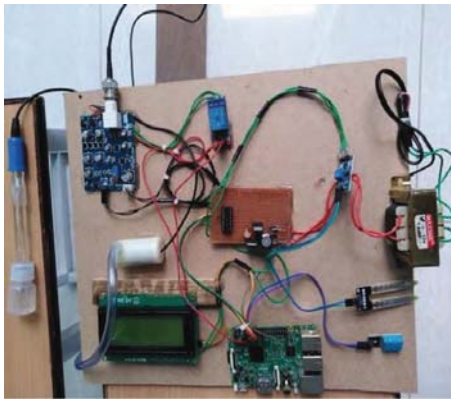

Fig.9: Photograph of real-time prototype implemented

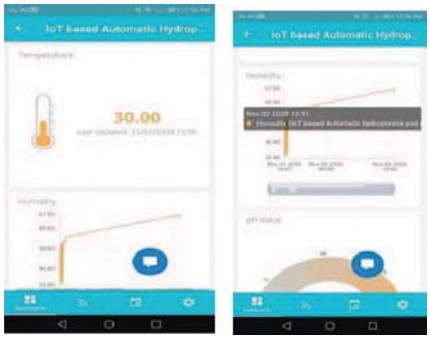

Fig.10: Screenshot of temperature and humidity parameters

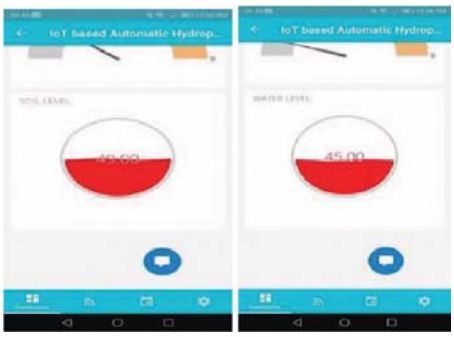

Fig.11: Screenshot of water and soil level parameters

Fig.12: Screenshot of pH value of nutrient solution

Fig.13: Photograph of LCD screen with parameters value

The performance of the prototype is verified in real time. The convincing results obtained with minimum power consumption. The proposed Hydroponics system will be an asset in this emerging world where farmers finds it difficult to find enough fertile soil land.

VII. Conclusion

The main focus is to make a hydroponic farm that communicates through the sensor network and helps the farmer to know the health of the crop. Here the proposed IoT system acts as an eye to farmers and also minimizes power consumption. The farmer can know certain parameters and monitor the farm remotely. This system is simple, efficient, and durable.

Power management in IoT deployment is an essential and priority given thing. More sensors and effective arrangement of the network could draw more power. So, in order to reduce power consumption here, in future solar energy will be utilized as an alternative power source. So, with help of solar energy and a good sensor network, we can achieve the desired results. We can utilize the solar energy to charge the battery and use it as a backup and can monitor the farm well.

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