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Design of Versatile Hydroponic Prototype for Efficient Genesis of Nutrient Environment - A Machine Learning Approach

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***Abstract*—Agriculture has always played a key role in the growth of the nation. The usual method of soil-based agriculture involves lots of dependencies like smaller farms, costly manures, and pesticides, etc. Also, study shows there is an immense need for organic and healthy food in recent years. In this paper we present a farming technique called hydroponics and with the power of machine learning algorithms we modify the existing passive hydroponics system to possess the novel ability to enhance the overall plant growth based on the crop type and crop's ability to consume the nutrients. Here we grow plants in a small, enclosed area. This is a type of agriculture which can be more effective if controlled and monitored properly. In this system, we monitor and control all the necessary things which are required by plants using reinforcement learning. The data captured can generate multiple growth traits automatically using large data sets. This system can be used by home growers as well as commercial growers.**

***Index Terms*— Hydroponics, Machine Learning, Reinforcement algorithm, raspberry pi.**

I. INTRODUCTION

The motive of this project is to strengthen and improve the usage of hydroponic systems in place of traditional farming and to create an environment friendly soil and human intervention independent system for indoor plant growth. In general, a hydroponic system demands a plant which is sourced with a solution containing soluble nutrients and water. Whereas in the usual soil-based method the entire process of farming right from germination completely relies on soil and its quality. Also, parameters like EC and pH of the water solution are controlled and maintained by a fixed value while installing the system [3], [4] in almost all conventional hydroponic systems. In this paper, we built a system that not only monitors but also controls all the key parameters that contribute to the overall plant growth leading to a much better indoor efficient farming mechanism. Our proposed system is equipped with a nutrient solution tank and based on the plant's ability to consume all the nutrients; the system then applies this solution to a water bed based on the algorithm. The algorithm was programmed using python on a single chip computer called Raspberry Pi which maintained and monitored all the parameters within optimum levels. Raspberry Pi was equipped with all the essential sensors like Temperature, Humidity, pH level and others along with integration of IoT technology for remote monitoring and control. In short, our setup was designed to maintain all the desired parameters in the standard range with the intelligence of sensing the plants ability to consume by sensing various growing aspects of a hydroponic system. The goal of the prototype was to make an efficient hydroponic system that is reasonably effective in terms of cost and automation.

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II. ABOUT HYDROPONICS

A. What is Hydroponics?

A combination of two different Greek words, “hydro” for water and “ponics” for labor forms the word hydroponics. The process of gardening without soil or hydroponics has been around in the world for hundreds of years. The research regarding soil less gardening by scientists started around 1950. Followed by which many advanced western countries have started to adopt hydroponics for cultivation with surprising results. Hydroponics facilitates several other benefits to our world such as indoor gardening that consumes considerably less amount of water than traditional soil gardening and further maintenance is much easier. Also, the system demands fewer pesticides on hydroponic crops and as hydroponic gardening systems use no topsoil thereby eliminating erosion. There are four types of hydroponic systems currently in practice which are categorized as Wick, Ebb and Flow, Nutrient Film Technique and Deep Water Culture systems [2][6].

III. PROTOTYPE WORKING

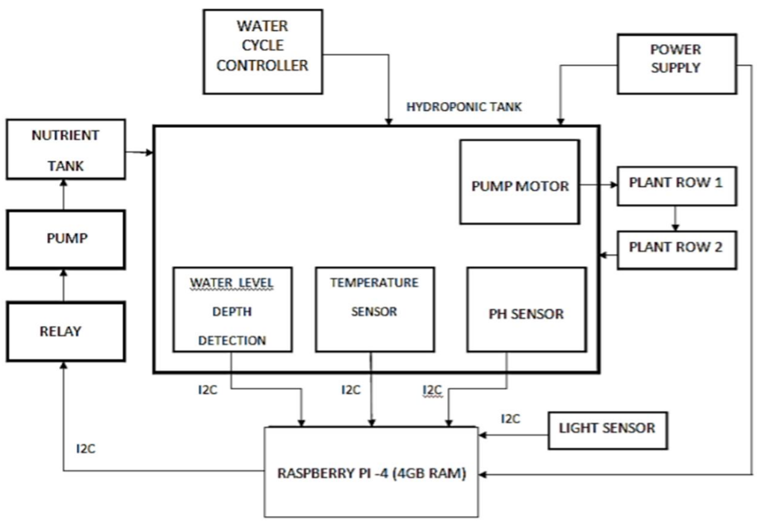

Figure 1: Block diagram of System Abbreviations and Acronyms

Fig.1. shows a block diagram of Hydroponic Prototype for efficient genesis of Nutrient Environment using Machine Learning Algorithm. In this system sensors like water level sensor, temperature sensor and PH sensor are controlled by the algorithm uploaded on raspberry pi 4 and are placed inside the hydroponic tank to get the readings.

The reinforcement algorithm is implemented to sense and accumulate the data. Further a detailed analysis is made by the algorithm to decide the nutrient levels of each crop based on the standard nutrient patterns and our own novel analysis which relies not only on the crop type standards[5][7] but also on the way the crop responds to various environmental conditions such as cold temperatures, rainy environments, etc. The supply of nutrients, water and the growth of plants is monitored continuously. Water level depth detection sensor detects the depth of water and nutrient solution in the hydroponic tank. After reduction in the amount of solution in the tank, the pump passes the water and nutrients to the hydroponic tank and pH sensor monitors the pH value to be maintained for the plant. Temperature sensor is used to monitor the temperature of the tank after adding nutrients. As hydroponics is an indoor plantation system the amount of light given to the plants should be sufficient for proper growth.

IV. OUTCOME

In the fields where the soil does not bear enough nutrients to pamper the plants, Hydroponics can definitely play a vital role in defying the obstacles eradicating the dependencies on various soil-based farming techniques. Plants are simply arranged such that their roots are dissolved in water mixed with appropriate nutrients and the pH is well maintained to take care of the healthy growth of plants. This greatly automizes the usual process of manually monitoring the pH levels and EC values for a given crop. Thereby eliminating the dependencies on human intervention and completely automating the hydroponics system which can sense what the crop needs and accordingly adjust by itself.

V. Components Description

A.Raspberry Pi

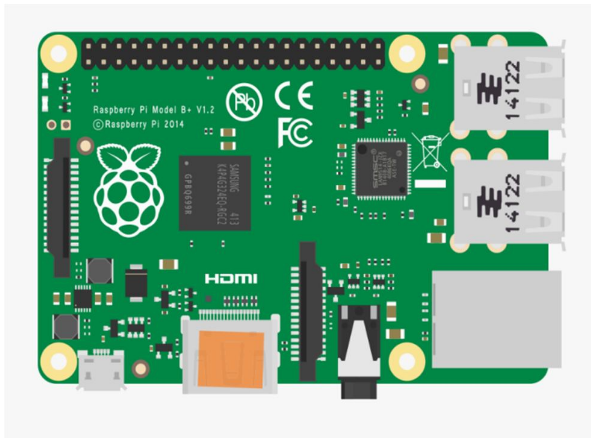

Figure 2: Raspberry Pi

The first version of Raspberry Pi launched in 2012 and then kept on upgrading by its community development has finally lead to the launch of Raspberry pi-4 which is built on BCM271, Quad core cortex A72 64 bit processor and has a huge computing capability with 2.4 GHz clock, 4GB RAM, 2.4 GHz and 5.0 GHz IEEE 802.11ac wireless, Bluetooth 5.0, BLE. This processor board was most suitable for the current experiment selected and thus performed well beyond our expectations on the field. The small form factor of the board also makes the entire practical setup much handy and can easily be ported and transferred to any place with a quick fewer connection reliability.

B. Water level Depth Detection sensor

Water level Sensor is the most important and cost-effective high sensor that was incorporated into the system to detect the levels of liquids present in both the waterbed and the nutrient tank. These sensors are basically constructed with a series of wires placed at various levels in depth of the tank which makes it possible to make contacts when the liquids reach a threshold level and produce a signal for microcontroller. These sensors operate at DC 3-5 volts. The sensor was powered by an external 5v regulated source as connecting it directly to the Raspberry Pi would lead to power surge and ultimately damage the overall system.

C. Temperature Sensor

The DS18B20, Water Temperature Sensor was employed in this system basically to measure the water temperature and the soil temperature. This sensor has a reading range from -5 degrees centigrade to +50 degrees centigrade (23F-122F). This offers a resolution of 0.1degree. the temperature is measured by sensor DS18B20 which is waterproof and used to measure the temperature of liquid (nutrient solution) it is a low price and good accuracy (-0.5 to +0.5 degree centigrade) as per datasheet.

VI. Flow Chart And Reinforcement Algorithm

Reinforcement learning is a subset of Machine Learning. Reinforcement basically triggers suitable action to maximize reward for a given process. It is powered by various software techniques and machines loaded to find the most optimum possible path it should take in each situation. In reinforcement learning, usually there is no answer for the given outcome, here the reinforcement agent simply takes a decision on what to get the given task accomplished. In the absence of a training dataset or missing data, the actions are bound to learn from its prior experience. If an event occurs in response to a relation for a given event, then that leads to an increase in the

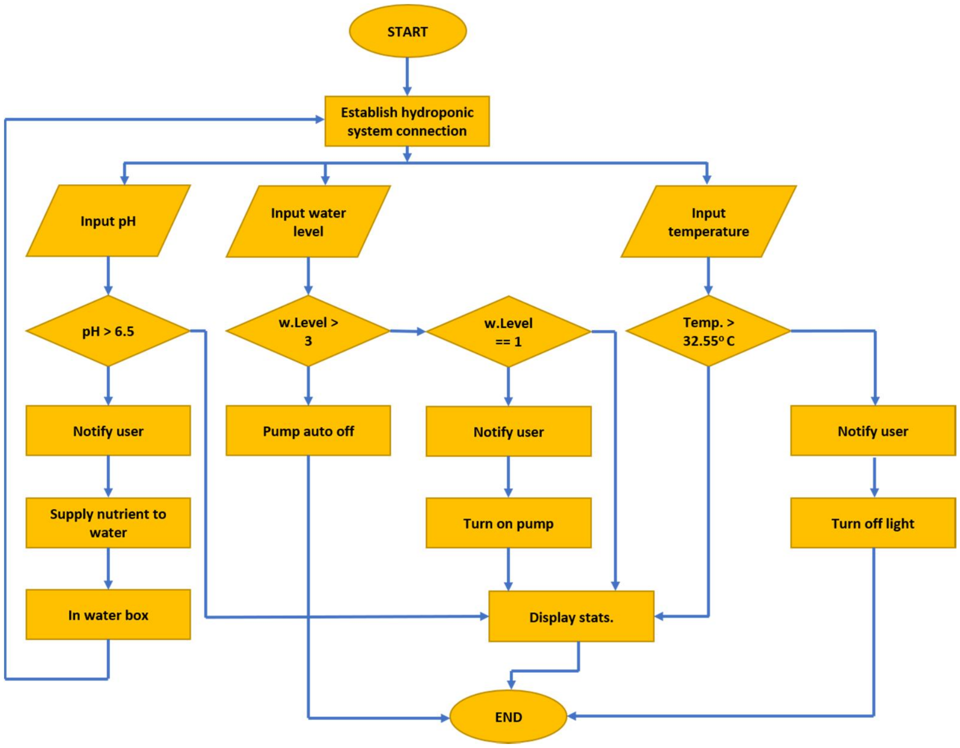

Figure 3: System Flow

occurrence of the probability of the same situation. Trial and Error is what makes the Reinforcement learning drive itself and call itself a dynamic approach. Steps for working of the system are as follows:

1. Start
2. Get sensor data
3. Supply nutrients and water
4. Monitor growth of plant
5. If growth good points awarded
6. Else change value of supply
7. Repeat monitoring process.
8. End.

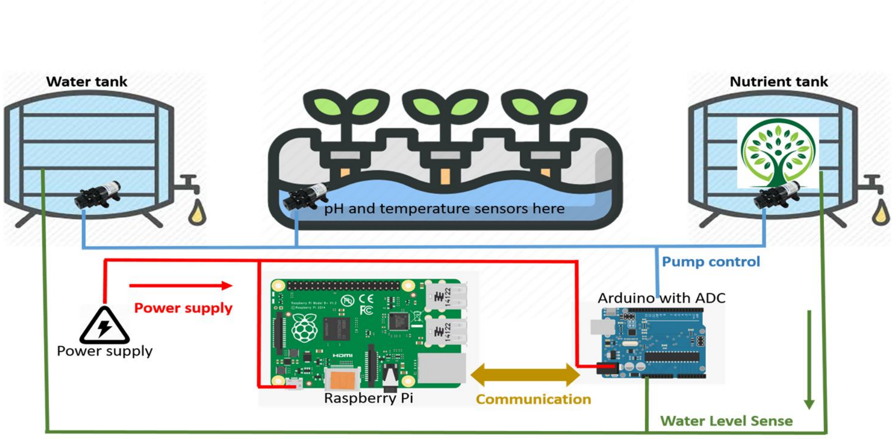

Figure 4: Hydroponic system setup

VII. Results

A. Growth of Plants

Plants require nutrients, water, light for proper growth and all of them are provided to the system for effective growth of plants with help of reinforcement learning. A Machine learning program when induced in a system makes it learn and work effectively based on the data it adapts. Using hydroponic system for growing plants have shown greater yield of crops than the soil-based agriculture method.

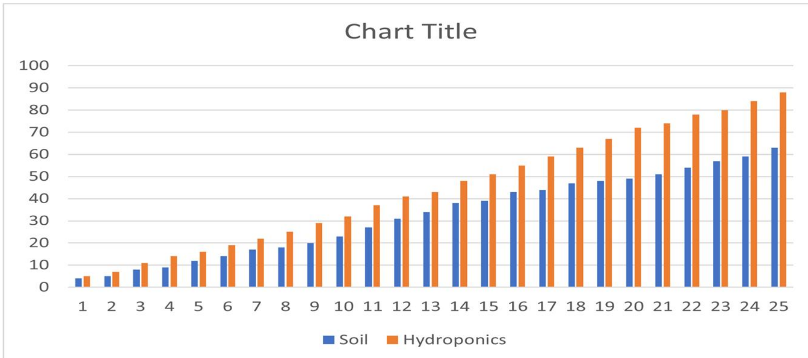

Figure 5: Soil Vs Hydroponics growth comparison chart

Following are the pictures of roots and plants grown by our system. We can observe a healthy growth of plants based on the supplied nutrients.

Figure 6: Growth of Plant within a span of 10 days

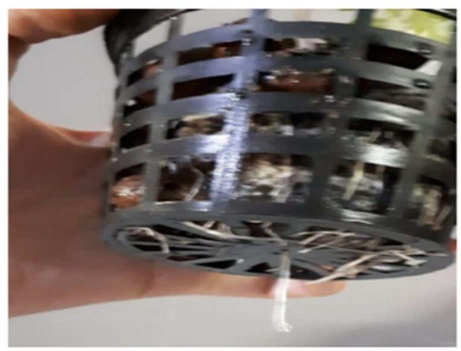

Figure 7: Growth of Roots within a span of 10 days

Here we observe that plant is healthy if roots are healthy and growing nicely. Hence, we can also say that growth of plants depends on proper growth of the roots of plants.

Figure 8: Growth of Roots within a span of 15 days

Figure 9: Grown plants in 25 days

VIII. CONCLUSION

By using Machine learning based Hydroponic system, nutrients are provided to the plants through less water with its data logging, detailed reports, environmental sensors, and the ability to adapt to any crop for efficient genesis and monitoring system nourishment. All the sensor parameters were continuously monitored by our novel approach thereby the system showed a considerable increase in the crop growth in comparison with soil-based systems. The inclusion of the external environmental conditions into the hydroponics system has shown a significant improvement that shows how important it is to consider these kinds of novel analysis methods for the overall improvement of the farming sector. Actuators such as water pumps and solution pumps are triggered in order to adjust system parameters. It's very well noted in this system that hydroponic system with a dynamic approach using machine learning based algorithms like reinforcement learning has led to a novel approach of automating the traditional hydroponics system and further optimize the plant's growth in comparison to soil and traditional hydroponics system.

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