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Soil Less Farming With Industry 4.0

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Abstract

An Internet of Things (IoT) architecture for soil-less farming systems using Industry 4.0 is introduced. The architecture emphasizes the control of water quality in distributed soil-less food production systems by adhering to Industry 4.0 standards. Soil less agriculture can be defined as growing plants in the greenhouse system in solid environments other than soil which is enriched in nutritional solutions. There are two types of soil less agriculture 1) Hydroponics – which grows plants in water 2) Aerologics - which grows plants in air. Soilless cultivation is highly used in protected agriculture to improve control over the growing environment and to avoid uncertainties in the water and nutrient status of the soil. Industry 4.0 is the current trend of data exchange and automation in manufacturing industrial technologies. Industry 4.0 is a combination of cyber-physical systems, the Internet of things, cloud computing and cognitive computing. Industry 4.0 is also referred as the fourth industrial revolution. Although, it has been applied for monitoring soil-less farming, where cyber physical system is used to control the water nutrients which highly supports to grow plants. Cognitive computing can help soil less farming to identify risks and frauds. It analyses information to predict water, nutrients using Naive Bayes Algorithm. The acquired data can be stored in cloud for future reference.

Keywords: *Hydroponics, Industry 4.0, Soil less Farming, Cyber Physical Systems, Cognitive Computing*

INTRODUCTION

Agriculture plays a vital role in Indian economy since it is source of living. Agriculture provides huge income and employment. Industry 4.0 is an industrial revolution which is an application of IoT in manufacturing processes using cyber physical systems [1]. The fourth industrial revolution is the Internet of Things applied in the field of manufacturing. The Cyber physical systems are used to communicate and cooperate with each other and with human workers remotely via the wireless web. Researcher states that most of the economic value of Internet of things is in business to business applications such as manufacturing and agriculture [2]. Industry 4.0 mainly focuses on industrial, manufacturing and agricultural processes. It reduces development time, costs and meets consumer demands [3] effectively. However, applications of Industry 4.0 in agricultural sector is limited for monitoring [4], tracking the equipments, resource allocation, managing production yields, supply chain management and cost reduction. Aquaponics and hydroponics [5] are the preferred agricultural technique due to its sustainability and ease of control. The main objective of this paper is to introduce soil less agriculture a cost effective IoT platform that injects Industry 4.0 in order to optimize, automate and enhance the production of small scale food production industries based on hydroponics and other sustainable soil-less farming methods. The proposed system is intended to address food security issues where food crops should be produced intensively in limited spaces and made accessible to feed growing populations. This paper is organized as follows. Section II on soil less farming and their advantages and disadvantages. Section III explains the Literature survey of soil less farming with industry 4.0. Section IV defines the methodology of the proposed project in detail. Section V lists the system requirements to implement the proposed methodology. Section VI presents results on Industry 4.0 and soil less farming to monitor then food production.

SOIL LESS FARMING

Crops are often grown in soil medium, either in containers or in the field. In soil-based agriculture, different types of soils and nutrients are used to grow different crops. Limited space for agriculture has made it difficult for people to rotate crops. In order to improve the productivity soil less farming is introduced. Soilless agriculture is a method of growing plants in nutrient solutions. The solutions contain essential cations and anions like calcium, magnesium, potassium, nitrogen, etc.

Nitrogen, Potassium, Phosporous are the essential nutrients required for plant growth. Soil less farming can be achieved in three methods: hydroponics, aeroponics and aquaponics.

Hydroponics is a kind of hydro culture, which is a method of growing plants without soil by adding nutrients to the water solvents. In this method, the plants grow on a neutral, solid and inert substrate such as clay balls, sand or even rock wool. A nutrient solution provides water; oxygen and minerals need to grow the plants.

Aeroponics is different from hydroponics since it doesn't use substrate. This method refers to the plants grown in an air culture which grows in a normal and natural manner. The nutrient solution is directly sprayed onto the plant's roots.

Aquaponics is a combination of both aquaculture and hydroponic agriculture. An electric pump is used to move nutrient-rich water from the fish tank through a solid filter to remove nutrients that the plants cannot absorb. The resultant solution provides nutrients for the plants and is cleansed before returning back to the fish tank.

Advantages of Soilless Agriculture

- Soilless agriculture avoids the use of toxic chemicals. Unlike soil-based cultivation, where farmers have to use fertilizers and pesticides to increase crop yield and to keep weeds and pests away, hence crops are somewhat protected from pests and weeds.

- Soilless agriculture is optimal in urban areas where space is finite for soil-based gardens.

- Nutrient loss is highly reduced with soilless cultivation because the nutrient requirements for crops are determined in advance.

- Soilless cultivation is admitted to cause less pollution.

- Compared to soil based cultivation, the productivity from soilless cultivation are significantly higher as a result of intensive practices and the possibilities of continuous, year-round production.

Disadvantages of Soilless Agriculture

- Crops cultivated using this method is more prone to pathogen attacks due to high moisture levels.

- Crops are also exposed to rapid death due to their lower buffering capacity.

LITERATURE SURVEY

Agung Putra P and Henry Yuliando et.al [6] explained extreme temperatures, chemical toxicity, and oxidative stress also made the biosphere facing a huge problems and it affecting agricultural system. The soilless culture slowly transformed from open to close-loop system. If closed irrigation systems are adopted could increase the water-use efficiency, also reduce the environmental impact of greenhouses and nurseries. By implementing the soilless farming method, some researchers produced a better quality of agricultural products, which is similar to consumer preferences. This method is known for better results mainly in water use efficiency, while maintaining the quality of the yield. It is a flexible growing method that lets the grower have full control over the growing environment, including the active root zone. Proper nutrition factors should be maintained constantly.

P.C.P De Silva et.al [7] proposed an agricultural food production process is not properly optimized or such optimization of conventional food production systems is costly. Industry 4.0 mainly focuses on streamlining industrial and production processes, reducing development time, reducing costs and meeting consumer demands effectively. This architecture provides a fail proof distributed smart farms based on Industry 4.0. It can be deployed in urban and/or rural areas to cater to growing food demands with minimum human intervention. It needs a centralized control to provide food for inhabitants of a city in a smart and autonomous manner.

Dieisson Pivoto et.al [8] proposed a Smart farming method which relies on data transmission and the concentration of data in remote storage systems to enable the combination and analysis of various farm data for decision making. To characterize the scientific knowledge about Soilless Farming that is available in the worldwide scientific literature based on the main factors of development by country and over time and to describe current Soilless Farming prospects in Brazil from the perspective of experts in this field is used to connect the technologies and the collected data in order to automate decision-making strategies. The management of these technologies and integration in supply chains and on farms Integration between the different available

Husnaina, S. Rochayatia et.al [9] recommended estimating the level of contamination by detecting the route of exposure to the humans from the consumption of heavy metals in food crops. Clearly indicate that the wastewater-irrigated soils were moderately enriched with Zn, Cu, Pb, and Cd, while the crops contaminations exhibited variations relative to FAO/WHO permissible limit. The Health Risk Index (HRI > 1) indicated also that Cd and Pb contamination in most of the vegetables had potential for human health risk due to consumption of plants grown in this area uses waste water as a medium of irrigation. Countermeasures are needed to cure the toxic metal contamination.

Depardieu Claire, Nicolas Watters et.al [11] suggested that rain-shelter is an environmental friendly agricultural practice for soilless production. Combining the use of rain shelters with either a locally-produced growing media or a capillary mat technology were the most environmentally friendly and economical practices for soilless strawberry production. To reduce disease incidence of powdery mildew and gray mold while improving yields of strawberry plants grown in organic substrates. The rain shelters for soilless strawberry production are more profitable and environmental friendly cultivation method for strawberry producers. When plants grown under greenhouse conditions they had a significant production peak earlier, coinciding with the period of high prices for fresh strawberries

Taweesak Viyachaia et.al [12] encountered soil- borne diseases, nematodes and accumulation of salinity when production in the same area was practiced continuously. The growth of chrysanthemum carried out in two soilless systems known as tray system and trough system.

The tray system used seedling trays as container, and the trays were arranged over the raise base covered with polyethylene sheet. The trough system made up of polyethylene sheet with a thickness of 0.04 mm laid over polyethylene sheet. The production of chrysanthemum produced in the trough system was higher than that of the tray system due to the larger substrate volume. The quality of chrysanthemum produced in the tray and the trough system were similar except leaf appearance and stem diameter. The expected climate change will worsen the condition as it will lead to root damage.

METHODOLOGY

The proposed project proposes a practically efficient and flexible scheme which supports both soil less farming and industry 4.0. Soil less farming is a method of cultivating crops in hydroponic manner. Hydroponics is a method of growing plants in water. Industry 4.0 is a technology which deals with internet of things, cloud computing, cognitive computing and cyber physical systems. The proposed project improves the yield of food production. Room Temperature, Water Temperature, Moisture, Humidity, Light Intensity and pH are monitored using Arduino IDE. The Observed values are initially shown in serial monitor later it moved to the webpage. The same will be uploaded in the JElastic cloud environment.

MODELLING HYDROPONICS PLANTS

Hydroponics is a process of growing plants in water based nutrient solution. To start with hydroponics soaks the seeds in the water then makes to sprout the seeds. These sprouted seeds are placed in the water medium. The water medium should contain necessary nutrients required for plant growth.

The hydroponic plants can be grown using two methods: closed loop method and open loop method. In closed loop method the water in the tank is recycled again and again only by adding necessary nutrient to it. In open loop method the nutrient less water is removed from the tank. The outlet is directly connected to the fish tank. The closed loop structure for hydroponic plant is shown below in figure1 [9].

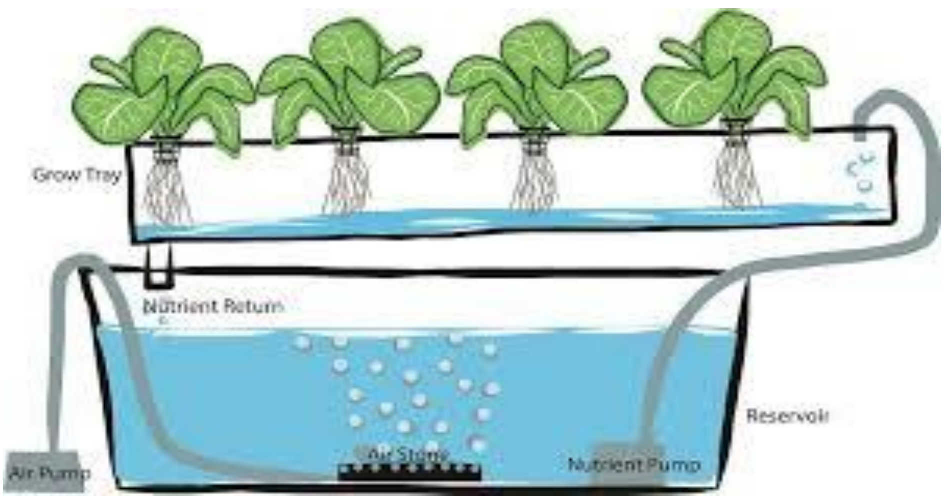

Figure 1 Closed Loop Structure

PLANT MONITORING

The process of germination increases whenever temperature increases similarly it affects the plant growth if the temperature goes beyond the limit. Once the plant reaches the optimum temperatures then germination begins to decline. The growth of the plant is affected at both extreme heat and extreme cold. The Room temperature may increase due to various reasons like light source, chemical explosion, photosynthesis reaction etc.

Likewise, when watering hydroponic plants, it is essential to use water at the appropriate temperature. Since the roots of the hydroponic plants are very sensitive it is necessary to monitor the water temperature. The plants get affect with extreme temperatures. Watering the plants with too hot or too cold will make the plants under stress and cause damage. The amount of oxygen and other gases will decrease when the water temperature increases. The solubility of the gases gets reduced. Water temperature will increase due to some metabolic changes. Potential Hydrogen is used to measure the nature of water soluble substance. The potential hydrogen is commonly referred as pH. The pH scale ranges from 0 to 14. The pH value for pure water is 7 since it is neutral. If the values are less than 7 it becomes acidic and if the values greater than 7 are called alkaline solution. The normal surface water Ph level ranges from 6.5 to 8.5. The acidic solution is not suitable for plant growth due to the presence of battery acid. The amount of water available for the plants is considered as Moisture. Sensing the moisture content help to find whether the plant gets enough water or not. The presence of water is more important since nutrients are added in the water. If the does not get enough water then the nutrients cannot reach the plant.

The amount of water evaporated is calculated as humidity. Increase in humidity will increase the strength of the solution. Excess of nutrients may leads to root damage. The amount of light which the plant can able to absorb are measured as Light Intensity. The Plants require light source to perform photosynthesis. The Light intensity can be affected to time of the day, climate, and geographical location. The light intensity is measured in foot candle units. The increase in light energy increases the temperature similarly; decrease in light will reduce photosynthesis.

USER INTERFACE AND CLOUD STORAGE

The User Interface (UI) is used to communicate between user and the system. It is also known as human-computer interface. It includes both hardware and software. The user interface design is mainly deals with the appearance of the proposed project. The output of the project is shown in a webpage. The cloud environment is a large storage area which is used to perform high computational process. It is used to provide high level services. The proposed project uses JElastic cloud environment to store the data for future reference. JElastic is a cloud service provider which supports platform as a service. Hence we can able to run the project in the cloud environment. The block diagram explains the work flow of the proposed project which is shown below in figure2.

SYSTEM REQUIREMENTS

- Arduino is a microcontroller board which has limited memory used to store and process the code based on the ATmega328P
- LM 35 sensor is used for monitoring room temperature.
- DS18B20 is used to monitor the water temperature.
- PH meter to check the alkalinity of the solution.
- Moisture sensor is used to measure the water content for a hydroponic plant.

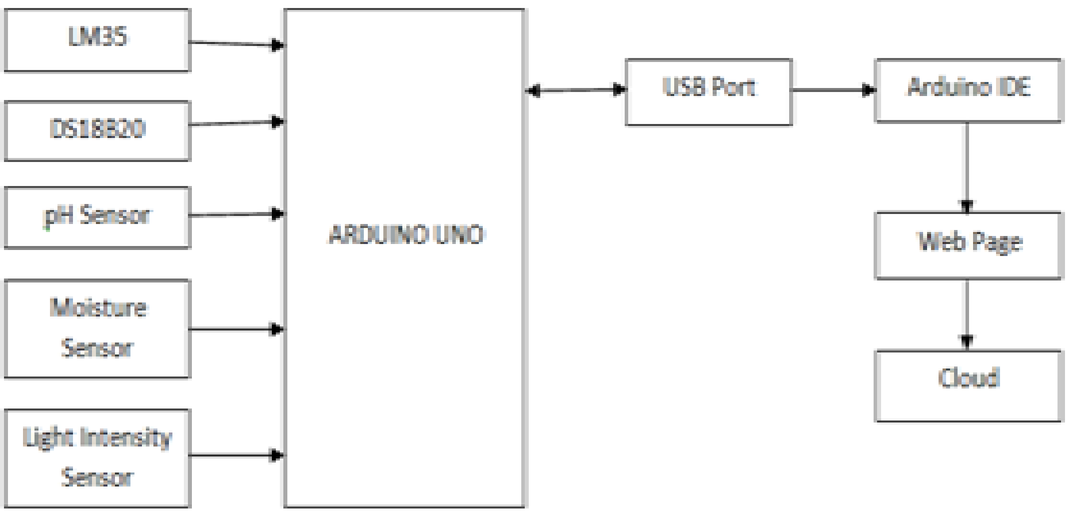

Figure 2 Block diagram of soil less farming

- Light Sensor is to measure the intensity or brightness of the light suitable for plant growth.
- Apache Tomcat 7.0 is used as a web server.
- MySQL database is used for data storage.

RESULT

A hydroponic plant is grown by adding necessary nutrient in the water solution. The sensors are deployed the nutrient solution to monitor the range of nutrient values in the solution. The sensor values are displayed in the Arduino IDE. The Experimental result shows that the parameters like Temperature, Moisture, pH and Light intensity plays a vital role in plant growth. The Proposed method demonstrates the hydroponic plants improve the space and water required for plant growth.

The use of agrichemicals for plant growth is a major threat to the plants hence it is avoided by this approach. In soilless agriculture no toxic pesticides are needed since the crops are protected indoors. From the above experiment, the values suitable for hydroponic plants are listed in the table 1

Table 1 Range of values suitable for plant growth

Parameters	Range of values
Room Temperature	15 – 35 degree Celsius
Water Temperature	20 - 30 degree Celsius
Moisture	20 – 30 % minimum
Light Intensity	14-16 hours per days
pH	5.8 – 6.5

CONCLUSION

The proposed project explained the details about soil less plant monitoring system. It facilitates the plant growth by monitoring temperature, moisture, Humidity, pH and light intensity. This automation reduces the manual effort and it increases productivity of plants. The experimental results showed that the proposed method improved the productivity of the plants. It provides a positive impact on the agricultural process as a whole. Future enhancement of this project can be made in the domains of cognitive computing and cyber physical systems. The cognitive computing is a technology which is used computerize the human thoughts and cyber physical system deals with computer based algorithm. The project continues to apply a deep learning technique to predict necessary nutrients required for the plant growth.

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