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 [ijirset@gmail.com](mailto:ijirset@gmail.com)

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# Automatic Hydroponics Detection System and Robotic Pest Management for Enhanced Crop Cultivation

AbhinandBinu, Dr Bycil V J, Remin Mohammed, Manav D R, Viswanathan P V

U. G. Student, Department of Robotics and Automation, Rajadhani Institute of Engineering and Technology, Thiruvananthapuram, Kerala, India

HOD, Department of Robotics and Automation, Rajadhani Institute of Engineering and Technology, Thiruvananthapuram, Kerala, India

U.G. Student, Department of Robotics and Automation, Rajadhani Institute of Engineering and Technology, Thiruvananthapuram, Kerala, India

U.G. Student, Department of Robotics and Automation, Rajadhani Institute of Engineering and Technology, Thiruvananthapuram, Kerala, India

**ABSTRACT:** Hydroponics refers to the art of growing plants in water (either saline) without soil (land). Nutrients for the plants are supplied to the roots in the form of solution that can be either in the form of static or flowing. Hydroponics can be cultivated both in green house and glass house environment. The limitation in green house environment is to maintain the temperature, pressure, humidity value at a particular level. In addition to that, monitoring on PH value and electrical conductivity in hydroponics is another challenge that has to be monitored and maintained. Manual monitoring is in practice which is a very trivial task else the plants may die out. Our project, the Automated Hydroponics Detection System, is a groundbreaking endeavor aimed at revolutionizing modern farming practices. By integrating advanced sensors, robotics, and automation techniques, we present a comprehensive solution for hydroponic farming, enhancing plant growth, minimizing manual intervention, and optimizing yield.

**KEYWORDS:**Hydroponics, Green House

## I. INTRODUCTION

In recent years, agriculture has witnessed a significant shift towards precision farming methods to optimize resource utilization and increase crop yield. Hydroponics, a method of growing plants without soil by using mineral nutrient solutions in a water solvent, has gained popularity due to its ability to produce higher yields in smaller spaces with less water compared to traditional soil-based farming. However, managing hydroponics systems requires constant monitoring of environmental parameters such as pH, temperature, humidity, and light levels to ensure optimal plant growth and health. Additionally, pest management remains a critical aspect of crop cultivation to prevent yield losses due to pest infestations.

To address these challenges, we propose an automatic hydroponics detection system coupled with a robotic pest management system. The automatic hydroponics detection system monitors and regulates pH, temperature, humidity, and light levels in the hydroponics environment using sensors and actuators controlled by Arduino Uno. The robotic pest management system, powered by Raspberry Pi 4, employs computer vision for pest detection and pesticide spraying, enhancing crop protection and yield.

## II. RELATED WORK

Previous studies have explored various aspects of hydroponics automation and robotic pest management. Researchers have developed systems integrating sensors and micro controllers to automate hydroponics parameters such as pH, nutrient levels, and environmental conditions. Additionally, advancements in computer vision technology have enabled the development of robotic systems capable of autonomously detecting and managing pests in agricultural settings.

Wang et al. (2018) proposed an automated hydroponics system using micro controllers for pH and nutrient monitoring. Similarly, Li et al. (2020) developed a robotic pest management system capable of detecting and eliminating pests using computer vision and pesticide spraying mechanisms. These studies provide valuable insights into the technological advancements and challenges in automated agriculture systems.

However, existing systems often lack integration between hydroponics management and pest control, requiring separate monitoring and intervention processes. This research seeks to bridge this gap by proposing an integrated system that combines hydroponics automation and robotic pest management to streamline crop cultivation processes and maximize yield.

### III. METHODOLOGY

The proposed system consists of two main components: the automatic hydroponics detection system and the robotic pest management system. The hydroponics system utilizes sensors to monitor pH, temperature, humidity, and light levels, while the robotic system employs computer vision and robotic arms equipped with cameras and pesticide nozzles for pest detection and management. However the following system can be divided into

1. Hydroponics Framework
2. Automatic Hydroponics Detection System
3. Robotic pest management system
4. Components

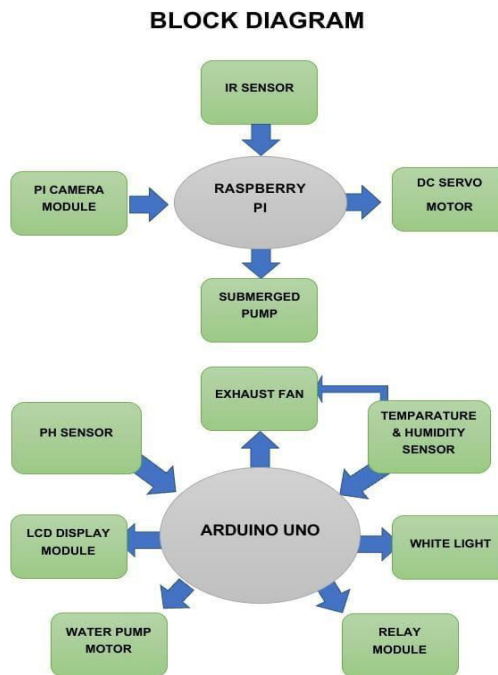


Figure 1 : Block Diagram of Proposed System

#### 1. Hydroponics Frame work

The Hydroponic system which has the best benefits as compared to other systems is the Nutrient film technique (NFT) hydroponic system . Hydroponics alludes to developing plants without the utilization of soil . As a result in the case of the NFT system, it delivers nutrients to plant roots using water. The nutrient water is delivered to the plants either actively or passively. Active systems use pumps and siphons to circle the water, while passive ones essentially keep the plants drifting over the water. NFT hydroponic systems are active and work in the same manner as the ebb and flow technique. In ebb and flow, the water is delivered and recovered in intervals. While in the NFT system the water is

continually coursing through the channels. In our typical NFT framework shown in Fig. 2, the crop sits in little openings on top of an encased channel, otherwise called a tray.



Figure 2 : Hydroponics Framework

### 2. Automatic Hydroponics Detection System

The hydroponics system is built around an Arduino Uno microcontroller, which interfaces with various sensors including a pH sensor, DHT11 sensor for temperature and humidity, and a daylight sensor. The pH sensor continuously monitors the pH level of the hydroponic solution, and when it deviates from the desired range, the Arduino triggers the release of nutrient solutions to adjust the pH accordingly. Additionally, the DHT11 sensor measures temperature and humidity levels, and the daylight sensor controls artificial lighting to supplement natural sunlight. The circuit diagram for the understanding of the automatic hydroponics system is shown in figure 3.

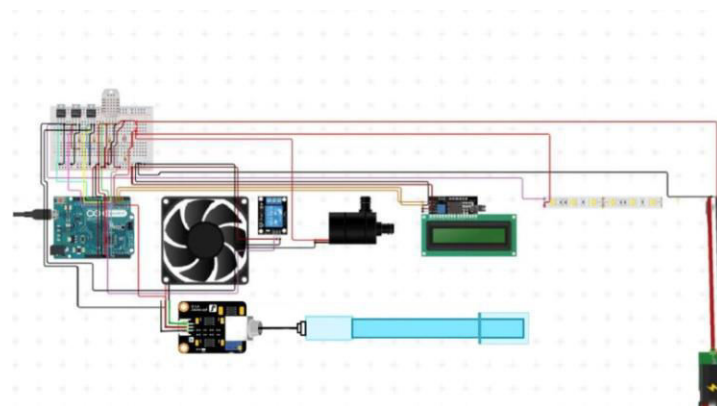


Figure 3 : Circuit Diagram of Automated Hydroponics System

### 3. Robotic pest management system

The robotic pest management system utilizes a Raspberry Pi 4 microcontroller for autonomous control. The motile robot is equipped with infrared (IR) sensors for navigation and obstacle avoidance. The robotic arm mounted on the robot carries a camera and a pesticide nozzle. The camera captures images of plants, which are processed using computer vision algorithms to detect pests and identify leaf aging or plant disorders. Upon detection, the Raspberry Pi triggers the pesticide nozzle to spray the affected area, effectively managing pests and promoting plant health. The circuit Diagram showing the robotic pest management system is shown in figure 4

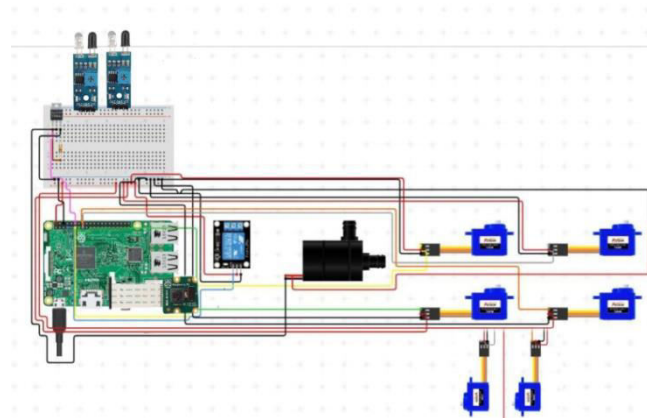


Figure 4 : Circuit Diagram of Robotic Pest Management System

#### IV.COMPONENTS

A. Microcontroller : The Arduino Uno microcontroller processes data from the sensors and controls various aspects of the hydroponics system based on predefined logic. For example, if the pH level deviates from the desired range, the Arduino activates a pump to add pH-adjusting solutions to the nutrient tank. Similarly, it regulates the operation of other components based on sensor readings to maintain optimal growing conditions.

B. DHT11 Sensor : DHT11 sensor is for measuring the temperature and humidity, These sensors are essential for monitoring key parameters in the hydroponics system. The average temperature needed for plant growth is 25-27°C. The temperature and humidity readings from the sensor are shown on an LCD display and once the temperature exceeds a set point, an exhaust fan will be triggered on to control and maintain the temperature and humidity.

C. PhSensor : The pH sensor measures the acidity or alkalinity of the nutrient solution, ensuring it stays within the optimal range for plant growth. The pH value is also displayed on the LCD display and once the pH value is decreased from the required value, nutrient solution is supplied to the plant automatically.

D. Water Pumps : Precise delivery and even proper supply of nutrition is necessary for a hydroponics system. So we have to use water pumps for supplying nutrient solutions in the hydroponics system, for pumping the additional nutrients according to changes in pH values and also for pesticide spraying.

E. Raspberry Pi : The Raspberry Pi 4 microcontroller serves as the brain of the robotic pest management system. It processes data from sensors and cameras, executes computer vision algorithms for pest detection, and controls the movement and actions of the robot.

F. Robot Description: The motile robot is equipped with infrared (IR) sensors for navigation and obstacle avoidance. It also features a robotic arm with a camera and a pesticide nozzle. The robotic arm's end effector, which includes the camera and pesticide nozzle, is designed to detect pests and apply pesticides as necessary. The robot's mobility allows it to navigate through the hydroponics system autonomously and perform targeted pest management tasks.

G. Daylight Sensor : It is used for controlling the grow lights which are used to provide artificial sunlight to the plants. In our proposed automated hydroponic system, people can grow different types of plants but each plant has a different required amount of daylight. Strawberries and cauliflowers do not require a longer period of light per day; if they get 12 hours of light per day they will not flower. Whereas crops like lettuce, wheat, potatoes, etc. require up to 18 hours of light per day. Hence if the plants do not get an adequate amount of natural sunlight, people can provide them the necessary amount with an artificial source like grow lights.

H. Computer Vision: Computer vision refers to the use of algorithms and image processing techniques to analyze visual data captured by cameras. In this context, computer vision is employed for pest detection and identification of plant disorders. The camera mounted on the robotic arm captures images of plants, which are processed in real-time to

detect pests, such as insects or pathogens, and assess plant health indicators, such as leaf aging or disease symptoms. Based on the analysis, the robotic system can take appropriate actions, such as spraying pesticides or alerting operators to potential issues

I.Figures and Tables

Table Head	Crops	Ph Value
1	Asparagus	6.0-6.8
2	Broccoli	6.0-6.8
3	Cabbage	6.5-7.0
4	Cucumber	5.0-5.5
5	Lettuce	6.0-7.0
6	Spinach	6.0-7.0
7	Strawberry	6.0
8	Tomato	6

Water is a fundamental component of hydroponic farming and the water utilized should remain inside the fitting temperature range which is usually 18-26°C. Because the temperature of the water also changes the pH measurement . To measure the temperature of the water, we used regular water thermometers like probes. Maintaining the temperature in a particular range for the development of plants is very fundamental. The ideal range for temperature for most plants is between 19 to 28 °C . Plants require a specific range of temperature, which permits the appropriate conditions for the plants to become better and healthier. In our system, DHT22 sensors are used to measure the temperature and humidity of the environment. Ultrasonic sensors give a better solution in exact level estimations of water levels and water flow. The utilization of sensors would guarantee the utilization of a perfect proportion of water that would be suitable for appropriate seasons, climate, and weather .

V.EXPERIMENTAL RESULTS

Experimental tests conducted on the integrated system demonstrate its effectiveness in automating hydroponics cultivation and pest management. The automatic adjustment of pH levels in the hydroponics solution ensures optimal nutrient uptake by plants, leading to improved growth and yield. The robotic pest management system successfully detects and eliminates pests, reducing crop damage and increasing overall productivity.

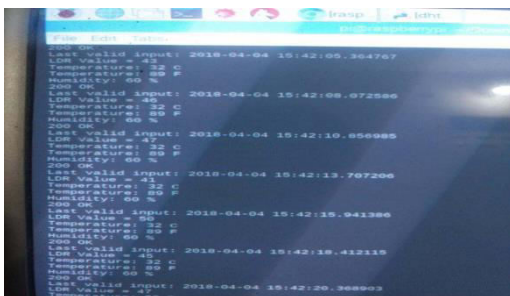


FIGURE 5 : RESULTS IN PC SCREEN



FIGURE 6 : REALTIME DATA IN LCD DISPLAY

VI.CONCLUSION

In conclusion, the proposed automatic hydroponics detection system and robotic pest management system offer a viable solution for enhancing crop cultivation in hydroponics systems. By automating monitoring and intervention processes,

the system reduces labor requirements and minimizes human error, thereby improving efficiency and yield. Future work could focus on further optimizing the system's algorithms and expanding its capabilities to address additional challenges in modern agriculture.

However, there are certain aspects to our model that we intend to improve. For instance, there should be a system developed to check the quality of the yield. This will act as a positive feedback to farmers who are new to farming. Moreover, the current hydroponic model is not immune to waterborne infections that may affect the crops. Developing a cost-effective subsystem to purify the water after certain amount of re-use will decrease the probability any infection to the crops.

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