Robotics for Sustainable Agriculture in Aquaponics

Dahi Murad Al-Khatib
Al-Ruya Bilingual School
RBS
Sabah Al-Salem, State of Kuwait
dahi900@gmail.com

***Abstract*— The purpose of this research is to develop a robot that can balance the pH levels and ammonia levels in aquaponics farms. The robot design is a waterproof robot that has a carbon dioxide pump, oxygen pump, biofilter, and pH indicator. The robot will use these tools to maintain and manage the aquaponics farm and stabilize its pH and ammonia levels. Integration of robots in agriculture in many different ways help farmers in managing their crops and maintaining their farms. Yet the robots do not help provide a sustainable agriculture or optimize organic farming. Population increase causes agricultural deficiencies that are resolved through the utilization of robots. This paper provides information on recent researches about robotics and agriculture and provides a new idea for a robot that can be used in aquaponics.**

Keywords—agriculture, aquaponics, sustainable, organic farming, precision agriculture, hydroponics, aquaculture, pH, ammonia

I. Introduction

Living in the 21st century, humans face some big problems due to the increase in the world's population. One of these main problems revolves around food sustainability and agriculture. The quick increase in the world's population has caused farms to use steroids and fertilizers excessively to try to provide enough food for everyone [2]. The drastic increase in the world's population has caused a need to develop mass production of consumable products sufficient to spread across the world. Reference [9] states that it is imperative to consider ways that global agriculture and food systems eradicate famine. Farming adheres to the concept of quantity over quality rather than quality over quantity. Increased population and food sustainability are issues that affect the quality of produced food. A factor such as accelerate food production is a result of poor quality production or growth of plants resulting in unhealthy foods. The reason for unhealthy plant cultivation is mainly that farmers cannot naturally plant everything to sustain the global consumption rate due to the extended period the planting process takes from germination to harvesting [3]. Agriculture has revolutionized for solving world hunger by devising technological advancements to facilitate farming. Utilization of robots in agriculture assists farmers to water, fertilize, and harvest plants. The intent of creating robots to function in agriculture is to solve main society issues. However, no robot built has fully succeeded in solving the agricultural depletion problem. There are other types of agriculture other than the normal planting methods such as hydroponics. Hydroponics is the practice of growing plants without soil. [10] Aquaculture is the practice of growing aquatic organisms, which produces more fish and helps provide food sustainability for the world. [10]. Aquaponics, which is a combination of aquaculture and hydroponics, is a revolutionary idea that can solve agricultural sustainability dilemma [10]. With aquaponics, agriculturalists could efficiently feed a community with healthy and organic food that consumes less water while simultaneously establishing a fish farm.

II. Literature Review

Aquaponics is an upcoming agricultural method with great potential and could be the key to sustainable agriculture. Studies have shown that 50% of the people asked about aquaponics had never heard of aquaponics [11], whereas 70% of people asked about hydroponics had heard about hydroponics [11]. Commercial aquaponics farms are being developed in Europe, but more stakeholders are needed to help develop this method of agriculture as only 17% of the people that heard about aquaponics were willing to invest in an aquaponics project [11]. Projects are being done to help raise awareness about aquaponics to help achieve a sustainable agriculture.

Reference [4] researched robot integration in agriculture to achieve sustainable agriculture, optimize organic farming, and optimize agricultural field management. The Robotics Associated with High Technologies and Equipment did studies for Agriculture (RHEA) on creating robots with sensors, high-resolution image sensing, Global Positioning System (GPS), and Geographic Information System (GIS) providing farms precise management over their agricultural land and crops [5]. The emergence of precision agriculture is due to the innovation of robots. Precision agriculture relies on robotic precision and application of sensors and cameras to complete all sorts of agricultural tasks. The owner of Frogmore Farm at Thornton Curtis recognizes that a precision tool, Dart drill has revolutionized cereal cropping by eradicating microclimate caused by tightly packed cereal crop and decreased fungal disease [1]. Agricultural robots have helped farms become more efficient in harvesting and maintaining their crops, which has slightly sped up their production rates [5]. Precise agricultural robots are developed at the Australian Centre for Field Robotics (ACFR) such as the Ladybird Robot.

Figure 1. Ladybird Robot [3]

The ladybird robot is developed to help farmers with crop yield. They rejected the use of diesel to run the robot, so they used solar panels instead [3]. The ladybird depends on its GPS and inertial navigation system (INS) to navigate. It uses sensors and cameras to detect the crops. Stereo cameras create images that allow the robot to determine the shape, color, and health of the plant. While laser sensors are used to determine the height of the plant. The ladybird also helps control weeds, which can be a big issue for most farmers as weeding-related operations cost the Australian government $2.5 billion annually [3].

ACFR have also developed a precise agricultural robot called the Robot for Intelligent Perception and Precision Application (RIPPA). The RIPPA is similar to the ladybird as it uses sensors and cameras to determine the shape and color of the crops. The RIPPA fertilizes plants, detects weeds, and manage them both chemically and mechanically. The RIPPA supports environmental conservation of energy through utilization of solar panels an alternative energy source [3].

Figure 2. Robot for Intelligent Perception and Precision Application (RIPPA) [3]

People have tried to use robots to harvest delicate fruits that are extremely sensitive thus, achieved minimal success as the tasks were too challenging for the robots. The robot could not master hand and eye coordination like a farmer that could cradle the delicate fruits gently. Therefore, robots in this field are considered too slow, ineffective, and expensive.

Weed related issues have been causing many problems for farmers all over the world. The Danish Institute of Agricultural Sciences (DIAS) has developed robots related to weeding issues. Since there are many different weed species, this robot needs cameras to detect and deal with the different types of weed it could come across [7]. In agriculture, there is a relationship between the crop results and environmental moisture. The Rosphere prototype is structured as a small, spherical robot that monitors the moisture in precision agriculture [7]. Monitoring the moisture in precision agriculture is vital to ensure that the crops are not ruined by the moisture [6].

III. Concept / Design

Many different agricultural robots are trying to help fix our main problem of sustainable organic agriculture. However, there is no research study on the integration of robots to resolve simultaneously global food or agricultural deficiency and optimal agricultural efficient production. The purpose of this research is to develop a robot that can balance the pH levels and ammonia levels in aquaponics farms. Aquaponics is a system where a fish tank's fish waste produces ammonia. The ammonia turns into nitrites by bacteria and used as a fertilizer for the plants. The plants then return cleaner water into the fish tank [10]. Use of aquaponics on an industrial scale, the production rates will be extremely high and all the crops will be organic. Chemicals and fertilizers are not used excessively in aquaponics. The only fertilizers for the plants are the nitrites that come from the ammonia. This means that the food that you harvest from aquaponics is healthier, and the food harvested is enough to feed the world if farms start to use these methods [8]. There is no such thing as a perfect method; everything has its flaws and issues. Some possible issues that occur in aquaponics are increases in ammonia levels. Ammonia could reach dangerous levels and kill the fish in the tank. This will also kill the plants because they will be using toxic ammonia as a fertilizer. The study creates a robot to help alleviate pH and ammonia dispersion to lessen the possibilities of something going wrong with the aquaponics farming process. The robot concept is to create a waterproof robot that has a carbon dioxide pump, oxygen pump, biofilter, and pH indicator. Ammonia (NH_3) is a base. Therefore, when the pH levels become very high at above 8.5, we know that the ammonia levels are high in the fish tank. When the pH level becomes very high, the robot will turn on the biofilter to clean the tank and will turn on the carbon dioxide pump to lower the pH level. If the pH levels drop and become very low, the biofilter turns off, and the oxygen pump turns on to increase the pH level. To lower the pH levels the robot could also use nitric acid, muriatic acid, and phosphoric acid [12]. To increase the pH level the robot could use calcium carbonate or potassium carbonate [12]. This robot will help maintain a certain pH level so the fish and plants in the aquaponics farm co-exist and reach desirable harvesting. Farming using the aquaponics approach using precision robotics reduces the maintenance necessary to run an aquaponics farm and the success rate of growth for both plant and fish improves.

IV. Implementation

Placement of the robot in the fish tank initiates implementation of the aquaponics robotics approach. The robot is then powered on and automatically starts detecting the pH level of the water. The robot will act according to the results it gets from testing the pH level of the water. It will use its carbon dioxide pump, oxygen pump, and biofilter to keep the water at a suitable level for aquaponics farming. Some types of fish prefer a slightly acidic or slightly basic environment. Recommended pH levels in aquaponics farms range between 6.8 and 7 because you need to count for three factors [12]. The three factors are the bacteria, fish, and plants. The preferred fish pH level ranges from high sevens to low eights. Plant pH level preference ranges from high fives to low sixes [12]. The farmer can manage the range at which the robot will begin to increase the pH level and decrease it. Management of ammonia levels ensures proper fertilization for the plants without the ammonia levels becoming deadly for both the fish and the plants. If there is a malfunction with the robot, the farmer can remove the robot from the fish manually until the issue is resolved.

V. Conclusion

As the 21st century throws issues and problems at us, innovation of robots assists in resolving issues and attains solutions. Finding a solution for sustainable agriculture concurrently with global population, implementations of robotic technical applications try to repair the problems. Integration of robots in agriculture help farms with field management and maintenance. This makes it easier for farmers to deal with their farms and keep them well maintained, but it does not provide everyone in the world organic food. Jointly, robots with the aquaponics agricultural system apply concepts efficiently to provide sufficient amount of organic vegetables to the whole world. Assimilation of robots into this system facilitates the management and maintenance of the aquaponics farm. The production of vegetable in the aquaponics farm that incorporates robots in the process is cost efficient with minimal spoiled vegetables due to the assistance of maintenance of pH and ammonia levels in the water. The robot in this research focuses on stabilizing the pH and ammonia levels in an aquaponics farm before they reach dangerous levels. The robot helps us achieve vital sustainable agriculture during this era of rapidly increasing populations. This robot also helps us optimize organic farming simultaneously, which allows us to feed everyone healthy and organic food with minimal effort. Studies on many aspects of robotics used to advance agriculture are at its fundamental stages. A recommendation to research on robots that can facilitate harvesting crops from an aquaponics farm with efficiency and precision will improve and develop aquaponics farming.

VI. References

[1] G. Ashcroft, "Just what are the pros and cons of precision drilling cereal crops?," *Farmers Weekly,* vol. 140, no. 8, p. 48, 20-26 February 2004.

[2] R. Bogue, "Can robots help to feed the world?," *Industrial Robots: An International Journal,* vol. 40, no. 1, pp. 4-9, 2013.

[3] R. Bogue, "Robots poised to revolutionise agriculture," *Industrial Robot: An International Journal,* vol. 43, no. 5, pp. 450-456, 2016.

[4] L. Emmi, L. Paredes-Madrid, A. Ribeiro, G. Pajares and P. Gonzalez-de-Santos, "Fleets of robots for precision agriculture: a simulation environment," *Industrial Robot: An International Journal,* vol. 40, no. 1, pp. 41-58, 2013.

[5] P. Gonzalez-de-Santos, "RHEA - 2012: Robotics and associated high-technologies and equipment for agriculture," *Industrial Robot: An International Journal,* vol. 40, no. 1, 2013.

[6] J. D. Hernandez, J. Barrientos, J. Del Cerro, A. Barrientos and D. Sanz, "Moisture measurement in crops using spherical robots," *Industrial Robot: An International Journal,* vol. 40, no. 1, pp. 59-66, 2013.

[7] S. M. Pedersen, S. Fountas, H. Have and B. S. Blackmore, "Agricultural robots-system analysis and economic feasibility," *Precision Agric,* vol. 7, pp. 295-308, 27 July 2006.

[8] J. Suhl, D. Dannehl, W. Kloas, D. Baganz, S. Jobs, G. Scheibe and U. Schmidt, "Advanced aquaponics: Evaluation of intensive tomato production in aquaponics vs. conventional hydroponics," *Agricultural Water Management,* vol. 178, pp. 335-344, 2016.

[9] J. Dewbre, "Food security," *OECD Observer,* no. 278, pp. 22-23, March 2010.

[10] Anonymous, "Recipe for successful aquaponics," *Alternatives Journal,* vol. 40, no. 4, p. 53, 2014.

[11] V. Milicic, R. Thorarinsdottir, M. Dos Santos and M. Hancic, "Commercial aquaponics approaching the european market: to consumers' perceptions of aquaponics products in europe," *Water,* vol. 9, no. 2, p. 80, 2017.

[12] S. Bernstein, "Maximum Yield," 20 March 2014. [Online]. Available: https://www.maximumyield.com. [Accessed 1999].