Agriculture/Hydroaquaoponic Bioscience Sensor - Mobile App with Simulations & Software for Industry & Science Education Curriculum Module

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ABSTRACT

There is a lot of technological buzz over the past few years regarding taking care of lettuce and hydroponic greenhouse plants and fish. We first review and discuss the recent technologies in the field of hydroponics, especially the hydroponic sensor curriculum project. The College of Engineering at The University of Akron developed a sensor that can detect hydrology, ph, electrical conductivity, nutrient levels, and temperature of hydroponic plants & aquaponic systems. The sensor can optimize the healthy monitoring of plants and fish in greenhouses, homes, schools, and universities anywhere in the world. The goal is to provide sustainable monitoring for growing healthy greenhouse foods 24/7. In this paper, we propose a sustainable solution for optimizing plant growth by using computer simulations and smart phone applications for plant growers and fisheries to access data in real-time and provide guidance on how to manage healthy environments for plants, such as "electric conductivity is lower than the standard for the tomato, so please add 5ml of nutrients". The app will be extended to social media connection, which is enabled by the web access features, where the user can network with hydroponic and aquarium user groups to share information (how to grow a lettuce), ask questions (where can I buy seeds), and gaming for virtual fish and plant growing. The app can be used on a computer, a smart phone or a tablet and provides numerous features that currently need many separate apps, especially in emerging areas such as hydroponics and aquaponics. The data visualization component in the app can enhance the analysis of the variables and data collection. Using the app, plant growers can track results and grow better crops. The app also provides hands-on interactive simulations that connect to the national science standards, providing optimal use of nutrients by taking care of greenhouse plants and fish for hydroponics and aquaponics.

Keywords: Hydroponic Sensor, Aquaponics, Mobile App, Science Education Curriculum Module, Simulation.

1. INTRODUCTION

Humans require food, water, and living space in order to survive. These things do not exist in endless abundance and are derived both from abiotic and biotic sources, making human's dependent upon the optimization of land area and the preservation of biodiversity. The human population is increasing, and is predicted to expand from 7.0 billion to 9.5 billion people within the next 40 years [1]. A parallel increase in the demand for food species is implied, and estimates claim that food production requires to be doubled in order to compensate. The trouble with this becomes evident upon the consideration of the productivity of current systems of agriculture and fresh water harvesting: despite our efforts, 1.0 billion people suffer from hunger modernly, and 1.2 billion live in areas with water scarcity. To make matters worse, the affluence of the world is increasing, meaning that more of the future's consumers will demand higher-quality resources [2].

There is a lot of technological buzz over the past few years regarding taking care of lettuce and hydroponic greenhouse plants [3-7]. Matt Liotta of PodPonics [5], Timothy J. Madden, President, and Chief Operating Officer of Biodynamics [6], and Dave Mosher of Gotham Greens [7] have taken a lead in initiatives to utilize emerging technologies to take care of greenhouse plants.

- Matt Liotta of PodPonics [5] took a high-tech approach to provide local fresh lettuce in mass quantity, nutritious and chemical-free at competitive prices in an urban setting. Matt's ideas to grow plants upward by outfitting old shipping containers, with technology that provides the plants with the precise amount of water, light, oxygen and nutrients they need. The system also uses a blue light technology, row after row, stack upon stack, thousands of seedlings spout, bathed in the glow of artificial blue light. PodPonics currently provides lettuce to Atlanta Public Schools, Emory and Georgia tech, and expects to be in a major grocery store by spring. PodPonics produced 62 tons of the salad staple and plans to triple that this year.

- Timothy J. Madden of Biodynamics [6], an innovative controlled environment agriculture firm specializing in anaerobic powered hydroponic crop production, has developed a way to provide the infrastructure for the greenhouses, the grow materials, seeds, plants and nutrients as well as the sensor and applications that enable the greenhouse gardener and hobbyist to optimize the health of all green house plants. Tim is also looking into optimizing the healthy in the aquaponics industry.

- Dave Mosher describes the Gotham Greens [7], 15,000 square foot greenhouse facility in a revamped old bowling alley New York. The first commercial scale urban operation of its kind in the U.S. The company is on track to deliver 100 tons of produce by year one. On top of an old bowling alley in northern Brooklyn sit's the greenhouse. Inside the produce thrives under the supervision of computer controlled network of sensors, motors and plumbing.

The hydroponic sensor, simulation and app are designed to take care of the hydroponics industry and science education worldwide. The sensor is nearing manufacturing and commercialization stage. The sensor was constructed to out price and outperform all other sensors on the market. The science education curriculum module was created to discuss the scientific and experiential value of the sensor.

In this paper, we propose a sustainable solution for optimizing plant growth by using computer simulations and Mobile Apps for plant growers to access data in real-time and receive guidance on how to manage healthy environments for plants, such as "electric conductivity is lower than the standard for the tomato, so please add 5ml of nutrients". The app will be extended to social media connection, which is enabled by the web access features, where users can network with hydroponic and aquarium user groups to share information (how to grow a lettuce), ask questions (where can I buy seeds), and gaming for virtual fish and plant growing. The app can be used on a computer, a smart phone or a tablet and will provide numerous features that currently need many separate apps, especially in emerging areas such as hydroponics and aquaponics.

There will be data visualization component that will enhance the analysis of the variables and data collection. We will optimize plant growth for better yield and cheaper cost to produce cleaner and pest resistant to plant/fish disease sustainable to. Using the app, plant growers can track results and grow better crops. The app also provide a hands-on interactive simulation that connects to the national science standards [8], optimal use of nutrients by taking care of greenhouse plants and fish for hydroponics and aquaponics, which takes the guesswork out!

2. THE HYDROPONIC SENSOR & APP

The hydroaquaponic sensor was designed and developed in the College of Engineering at The University of Akron. The sensor consists of a single electrode pair that is used in a novel manner to measure pH, electric conductivity (EC), temperature, and water level. The sensor module includes a micro-controller, an LCD display, and wireless capabilities. The pH, EC, temperature, and water level can all be measured by the single electrode pair, which will significantly reduce the complexity and cost. The output of each sensing unit will be sent to the micro-controller for further data processing. The wireless unit will send the sensor data to the user through Bluetooth or WiFi. The goal for the project was to produce a cost effective sensor that measures the pH, nutrients, hydrology, temperature, and electrical conductivity. The hope as that this type of monitoring device will provide cost effective optimal healthy monitoring of global community and green house plants. The development of Mobile Apps is useful for the farmers, hobbyist and academics for growing healthy plants as well as for studying their physiological changes according to variance in effecting factors.

We have also talked with a private entrepreneur Steve Thomas who can economically build a special sensor variable by variable depending on what the end user requires regarding the agriculture and hydroaquaponics.

A team of researchers and scientists at The University of Akron are developing apps and software that will be able to simulate and predict the optimal health of hydroponics greenhouse plants and aquaponics systems. We have also developed science education curriculum modules that enhance the academic and industry standards for interacting with the virtual simulations and actually taking care of the greenhouse plants. The App can:

- Teach optimal ph and hydrology, nutrients, electrical conductivity and the temperature of various greenhouses and aquariums
- Track the data within the different locations and for different users, hobbyists, farmers, scientist and science educators.

We have devised a company and plant profile as well as an educational profile that will help us understand the needs of the companies, hobbyists and science educators. The simulations allow users to make choices and predict the optimal health so that one can achieve the correct choices with a healthy plant and aquariums. There will be a longer piloted project to collect data for sensor technology and the science education training from the following end users; Aquaplanet with owner Bevan Suits, Kingstown, Jamaica at the Family Garden with Rebecca Harper, Tim Madden with the Biodynamics Company, the Family Promise with Jeff Wilhite in Akron, BP Gardens, Green Gro Technologies with James Haas, the Vertical Hydro Garden in California and the Veterans Agricultural learning Opportunities and Resource center Program which provides hands on experience for veterans in preparation for employment in the agricultural industry. There may also be a piloted greenhouse pilot project at a vocational school called Choffin, with Ralph Zerbonia who owns Aquaponitech in Youngstown, Ohio, and Sue Raftery with Agrown. The pilot locations will provide models for training in agriculture life skills, small business, housing and employment.

3. IMPORTANCE FOR AGRICULTURE, AQUACULTURE, AND SCIENCE EDUCATION

This project was presented at the Global Inaugural Committee meeting at NABT 2013 in Atlanta, Georgia and accepted by the NSF I-Corps sites and teams grant. The sensor and app will coordinate with virtual simulation software to animate data solutions by providing techniques that take care of hydro and aquaponics plants and fish from a mobile device. The hydroaquaponic sensor can monitor the health of plants/fish in greenhouses, homes, schools, and universities anywhere in the world. The goal is to provide sustainable monitoring for growing healthy greenhouse foods. The sensor is important for agriculture and fisheries and is ecologically sustainable, as it provides many environmental benefits. The sensor and its app will be used in coordination with virtual simulation software to animate data solutions by providing data visualization techniques that take care of hydroaquaponics plants/fish from a mobile device.

A flow chart has been created with software XMind for the data analysis and content and we are coding for data visualization of 10 greenhouse plants and 4 fish species for the app. The science curriculum topics include:

- agriculture and aquaculture;
- importance locally and internationally;
- how schools and universities can utilize the sensor and curriculum modules;
- how end users will monitor, share and manipulate the variables to increase plant and fish yield
- ecologically sustainability & environmental benefits;
- detecting proper variable levels such as nutrients, ph. and semi-quantitative chemical & mineral analysis, nitrates, ammonium.

The proposed solution will also include data simulations, gaming, and training for end users, a business portal to purchase supplies, and social media portal. The simulations will allow the user to make choices to monitor and predict the optimal health of the plant. This novel development will eventually be able to remotely take care of plants and fish through wireless climate monitoring and control system which enables the end user at the greenhouses to use devices (sensor nodes), placed inside the greenhouses (which have sensing, data processing and wireless communication capabilities). All measurements/data collected from member greenhouses will be stored in a database on the central server which can be collected and shared among end users. End users can collect data over a web page on Internet or through a mobile application. In the meantime, using the mobile application they can send commands to sensor nodes to remotely control climate control systems (e.g. heating, ventilation, and misting) manually and/or automatically.

4. METHODS

The mechanics of the sensor includes digital readings of the pH, temperature, electrical conductivity and hydrology. The pod can be placed in the grow cubes so that the probes on the bottom of the senor can detect the variable settings. It is encased in plastic egg type settings and is approximately 3 inches long by 2 inches wide.

The data retrieved by the hydroaquaponic sensor is sent to the user's Smartphone or Tablet using Bluetooth low energy technology, allowing it to communicate with Bluetooth Smart Ready devices. Bluetooth Low Energy is a wireless technological standard which consumes very little energy. Every 15 minutes the hydroaquaponic sensor measures pH, EC, temperature, and water level. The data is stored data in the sensor's memory. Every two hours the sensor sends data to the user's Smartphone via wireless unit. When the water, heat, pH, EC, or fertilizer levels of user's plants are in need of special attention, the Mobile App will create an alert to tell the user what needs to be done. The App will give the user a chart of the temperature levels in the water of the user's plant and compare it with the ideal levels for the user's chosen plant species.

The data can also be manually entered. We think it would be beneficial to always have the manual entry as an option just in case anything goes wrong with the sensor. The data collected from the users themselves will show us the optimal setting of how to use the information. We have a basis of what we have found to be optimal settings, however this app will be more social and you will be able to compare the results of one user to that of the other user. User profiles will be important to this app. Not everyone likes to grow the same types of plants so what we want is to make it versatile so that everyone can enter the plant of their choice. They will then be able to monitor the plant and find helpful information about the plants/fish with the app. For the hydroaquaponics we will also show you how many fish that you must need per plants. Maybe one fish can power 5 strawberry plants but only 1 tomato plant and so on. We will take advantage of the users using the app to provide us with that data if it's not available.

To sample the market, we use research questions about the value and need of the sensor, its app, simulations and data visualization software which is also related to science education modules. The design of the app will keep users such as farmers, hobbyist, school or scientist in mind as sample data is collected and used so that the results and responses can adjust accordingly. For example, you can enter data to the app and its simulation will show a visual result such as too much of this nutrient will cause a particular result. A medium response button will show a different result and make a recommendation to maintain health. A button will show what would happen to the plant if you did not add enough of a particular nutrient, have the right pH or temperature. Ultimately, the results will predict the health of the plant and recommend some needed steps to achieve optimal health. There will be a list of hydroponics greenhouse plants and their optimum pH, EC on the beta version of our Mobile App.

There will be a portal for ordering nutrients, seeds, plants, greenhouse materials, and pH solutions from the hydroponic sensor website. The simulations will allow users to make choices and predict the optimal health so that they can make right choices with a healthy plant growth. There will be piloted locations to collect data for the greenhouses, sensor, apps and educational modules. Once the data is collected we can determine more about which of the variables are used effectively and the value of how the sensor and app are used in industry and education. Data will need to be collected from the virtual simulations applications from the farmers, hobbyists, scientists, and commercial market. The actual data collection from live plants and connections remotely between other greenhouses will also be collected. Once collected the market sample predict to the lab how to adapt the sensor and apps to fit the market needs. Our software will be designed to visually animate the results of the data collection. These ideas are to help the participants interact with the data and simulate it before actually taking care of the plants. The data visualization software will help analyze and animate the display with the results.

5. RESULTS

As we collect the data from the company, plant and science educational profiles we will be able to predict and optimize the needs of the customer segments. The app will be designed to help collect the data, provide data visualization to compare how the variables work to increase plant/fish growth and deter from the unhealthy choices so the participant can make practical decisions when taking care of their hydroponic plant. We will also focus on training. This section of the paper will grow as we collect more of the company, plant and fish profiles. Until then we can look at how PodPonics and Gotham Green project we funded and how they have collect date to prove the viability of their crops to their investors.

6. DISCUSSION

The challenge will be to follow through with the second stage of the NSF I - Corps teams grant which is lineage from the NSF I - Corps sites grant and continue to commercialize and train communities about the sensor and app. We will be able to predict the optimal health of the plants & fish virtually and actually as well as collect large amounts of data over a short period of time to show the effect of coordinated sensor and app technology. The company, plant and educational profiles will enable A Dose of Gnosis LLC [9] and the team from the NSF - I Corps grants to analyze the needs of the greenhouses, aquariums, hobbyist, retailer and educational centers. In this way we can target the intended uses for the sensor, and develop the app and the educational materials so as to provide the necessary steps to optimize plant health and plant production. We hope to be able to commercialize the sensor and app to the farmers, hobbyists, educators, as well as the aquaculture, fisheries and fish tanks. The large amount of data can be analyzed with either SAS or Tableau software and the piloted centers should be able to compare data collection techniques to understand how to increase each garden's efficiency.

So far we have sent out the profiles, visited and interviewed many of the field sites so that we can get a wider view of how each garden is taken care of and how A Dose of Gnosis can help with optimizing the plant and fish growth. We also need to complete a profile for the hobbyists, fishing industry, and aquaculture for future growth. We hope to receive results soon so that we can start to promote the app and the sensor app kit bundle. The research about other Hydroponic technology companies that take care of plants and optimize the health of plants with certain variables as well as universities research sites in Arizona, California, Cornell, Akron, will help us to aim the development of the science resources to cover the needs of all market segments. The data collection so far is from the company, plant and science education software. We have the profiles stored in excel spreadsheets. We will begin to analyze the results to be able to report on the most important variables relating to optimizing healthy plant growth.

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