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Optimized Nursery for Indoor Onion Nourishment (ONION)

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ABSTRACT

An Optimized Nursery for Indoor Onion Nourishment (ONION) was designed as an automated smart hydroponic greenhouse that is capable of monitoring, assisting and controlling optimal safe environment parameters for culturing white inions. It addresses the problem of infestation, direct and inevitable climate change, lack of assistance and human error which are known to be causes of the low production yields. The system considers four important parameters, which are very essential to the growth of white onions, namely pH level, ambient temperature, humidity and internal light intensity. Microcontroller-based actuators are used to maintain optimal and safe environment that triggers the cooling system (fan), solenoid valves, and LED strips (light). The greenhouse environmental parameters are continuously monitored and the sensor data are logged online. A GSM module was also added to enable to system to send SMS messages to the user whenever the four parameters deviate from their safe values. During critical states, the actuators can be controlled by the user through the online monitoring program or thru SMS control messages. During experimentation and testing, the system was proven to be very efficient and functional which is ideal in optimizing and maintaining high growth rate of white onions.

Key words: greenhouse, microcontroller, onion culture, SMS, hydroponic

1. INTRODUCTION

The Optimized Nursery for Indoor Onion Nourishment (O.N.I.O.N) is an automated and environmental-friendly daycare system that is well-designed for assisting and monitoring the fragile growth rate of white onions. Lots of different scientific approaches are made to solve or automate how agricultural farms or aquaculture environment are monitored and controlled.

It all began with the use of microcontroller systems that automate human processes and controls [1] and sensor-based systems to monitor and control the important parameters that are necessary in order to promote optimal growth for the species being cultured [2], [3] and [4].

It is also important that several parameters must be maintained in order to promote optimal growth rate and yield [4,5,6]. These parameters include pH, temperature, salinity, dissolved oxygen, light intensities, carbon monoxide content and many others depending on the type of agricultural crops or aquaculture species are grown [8].

While some advanced technologies are used to support the monitoring system for aquacultures like using machine vision and behavioral response analysis [9], the most popular way in optimizing developing an optimal greenhouse environment is by using wireless sensors networks (WSN) and internet of things (IoT) [9], [10] and [11]. This research presents system that promotes optimal growth of white onions using microcontroller-based sensor system. The communications incorporated uses GSM modules and online logging system that connects the automated hydroponic greenhouse and the remote user or farmer. This is one reason why the internet connectivity is very important and experts are doing all possible ways to improve the communications systems of internet service providers [12]

2. PROBLEM SETTINGS

The nursery stage of planting white onions is the most delicate part and needs careful monitoring and maintenance of its environmental parameters. Onions are known due to its fragile and highly decomposable tissue structure and they are prone to many factors which may cause spoilage or decrease in its growth rate. Several factors including infestation, human error, and climate change as well as the geographical structure of farmlands are needed to be considered. White Onions grown in the open fields have higher risks than those cultured inside greenhouses. Central Visayas, leading the country's onion production, is most affected by natural calamities. "An unfavorable climate, such as too wet or too dry condition, affects the cropping intensity as well (Iizumi, 2015)." Being said, it is basically an alarming factor that affects the production of good quality white onions. This research aimed to design a system that monitors and assist basic parameters in planting white onions. The proposed system is able monitor the greenhouse environment and transmit data to an online logging system. The system will also alert the user thru SMS regarding the status of the parameters being monitored in the greenhouse.

3. DESIGN AND METHODOLOGY

The Smart Greenhouse monitors four essential factors for planting white onions namely pH level, temperature, humidity and light intensity. The state of each of the parameters are monitored continuously using a dedicated sensor-based system on each parameter. Ideally, each parameter must be maintained to a certain safety level. In the event that these parameters deviate from their safe levels, the microcontroller will trigger the actuators designed to correct the unsafe factors and force them to go to their safe levels. An SMS message will be sent to the user during the instances the system detects unsafe level on each and every parameter. Every plant or root crops have their own required parameters in order for them to grow and survive. Onion varieties are classified into two categories, the long-day category (better for cool climates) and short-day (better for warm climates) category. White onions are under the short-day varieties. These are the required values for the white onions, the leaf, root, and bulb development occur in cool temperatures between 55°F (12.78°C) and 75°F (23.89°C). The optimal onion leaf growth must be at the range from 68°F to 77°F (20°C to 25°C). Then once the "bulbing" has started, it can tolerate temperatures higher than 75°F (23.89°C). The ideal nutrient pH level is between 6.0 and 6.7. Lastly, the considered light wavelengths for white onions are red light (630-660 nm), blue light (400-520 nm), and green light (500-600 nm).

Figure 1 below shows the conceptual framework of the research project

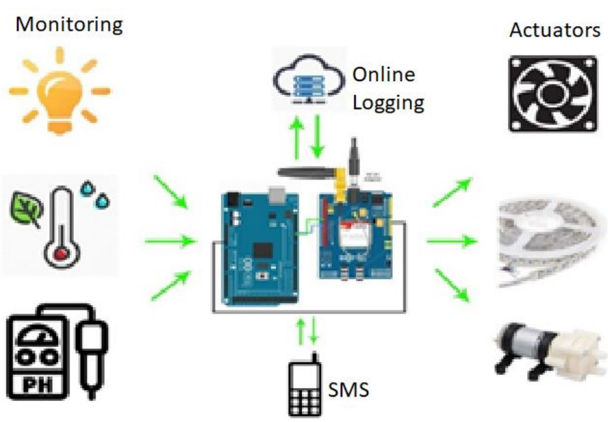


Figure 1: Main Conceptual Framework

Figure 1 shows the conceptual framework of the proposed hydroponic system that will culture white onions. Figure 2 below shows the detailed block diagram of the ONION system. It is shown that the actuators are triggered every time the microcontroller monitors a deviation of sensor values beyond their safe levels.

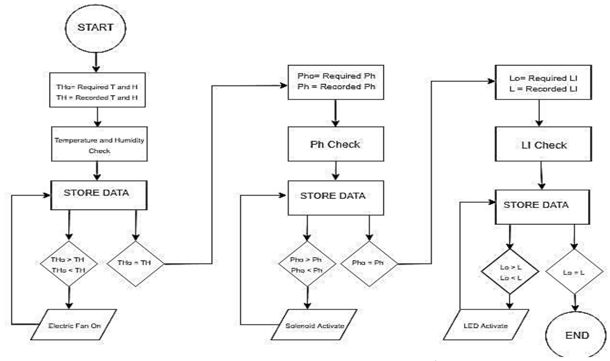


Figure 2: Detailed Block Diagram of the System

The system uses Mega-Arduino, a programmable device that stores and processes information together with the relay module, and a GSM module integrated into the microcontroller. The Data Logging System stores and plots the data collected by the endpoints (sensors). The graphs are used to demonstrate the behavior and fluxes of the working environment of the system.

Table 1 below summarizes the actions done by each part of the system.

Table 1: Summary of Actions done by the hydroponic system

Item	Function/Action
Microcontroller system	Serves as the central control system that is responsible in gathering data from the sensors, triggering the actuator system, post updates on the online data logging system and send/receive SMS message to the user.
Light sensor	Monitors the ambient light inside and outside the house
Temperature and humidity sensor	Monitors the temperature and humidity inside the greenhouse
pH sensor	Monitors the pH level of the water inside the greenhouse
Fan	Turns on every time the temperature inside the greenhouse is above the safe temperature level
LED strips	Used to change the lighting intensities inside the green house
Water/Base dispenser	Used to correct the water pH level inside the greenhouse
Online logging system	Monitors and updates the status of each parameter
GSM modules	Used to send and receive SMS from the user. It sends SMS to the user to notify him that at least one parameter is outside the safe level. It receives SMS from the user to detect what actuator is to be triggered.

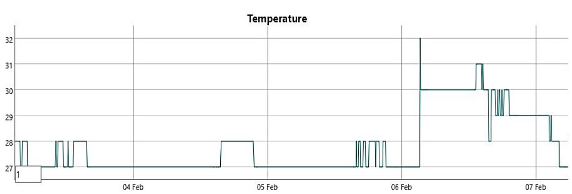
A mini greenhouse prototype was designed and built that will demonstrate the operations done in full size white onion hydroponic system. Figure 3 and figure 4 below show the sketch of the greenhouse and the working prototype respectively.

Figure 3: Sketch of the ONION system

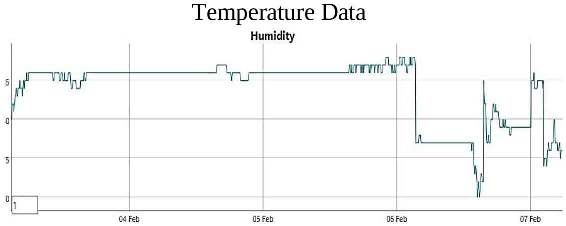
Figure 4: Actual working prototype of the ONION System

4. DISCUSSION OF RESULTS

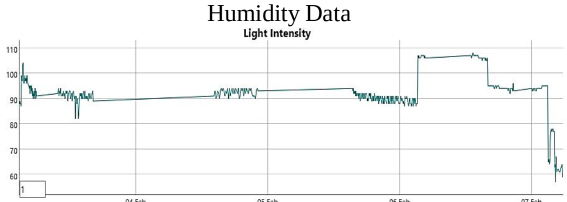
The ONION system monitors the status of the four parameters that are responsible for the optimal growth of white onions. The sensor readings are sent to an online data logging system. In this data logging system, the sensor readings are regularly refresh and shown graphically. The graphs on figure 5 below show sample snapshots of the monitored parameter states from the prototype.



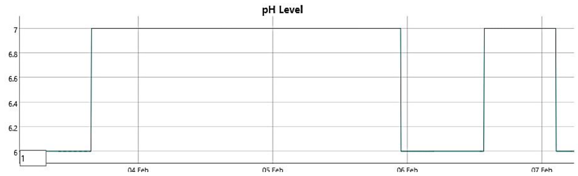
Temperature Data



Humidity Data



Light Intensity Data



pH Level Data

Figure 5: Sensor Data

The sensors' numerical values are also shown in a tabular form in the data logging system. Figure 6 below shows a snapshot of the data logging system.

←T→				id	date ▼ 1	temp	hum	light	phlvl	temp2	hum2
	Edit	Copy	Delete	1445	2019-02-07 06:15:36	27	76	58	6.00	26	77
	Edit	Copy	Delete	1444	2019-02-07 06:10:25	27	76	58	6.00	26	78
	Edit	Copy	Delete	1443	2019-02-07 06:05:13	27	75	59	6.00	26	77
	Edit	Copy	Delete	1442	2019-02-07 06:00:02	27	75	59	6.00	26	77
	Edit	Copy	Delete	1441	2019-02-07 05:54:50	27	75	59	6.00	26	77
	Edit	Copy	Delete	1440	2019-02-07 05:49:38	27	76	59	6.00	26	78
	Edit	Copy	Delete	1439	2019-02-07 05:44:27	27	76	59	6.00	26	77
	Edit	Copy	Delete	1438	2019-02-07 05:39:15	27	76	59	6.00	27	75
	Edit	Copy	Delete	1437	2019-02-07 05:34:04	27	76	64	6.00	26	77
	Edit	Copy	Delete	1436	2019-02-07 05:28:44	27	76	63	6.00	27	76
	Edit	Copy	Delete	1435	2019-02-07 05:23:34	27	75	63	6.00	27	74
	Edit	Copy	Delete	1434	2019-02-07 05:18:19	27	76	62	6.00	27	76
	Edit	Copy	Delete	1433	2019-02-07 05:13:08	27	77	61	6.00	27	77
	Edit	Copy	Delete	31	2019-02-07 05:02:20	27	76	61	6.00	27	76
	Edit	Copy	Delete	1430	2019-02-07 04:57:31	27	76	62	6.00	27	76
	Edit	Copy	Delete	1429	2019-02-07 04:52:42	27	76	62	6.00	27	75
	Edit	Copy	Delete	1428	2019-02-07 04:47:53	27	77	62	6.00	27	75
	Edit	Copy	Delete	1427	2019-02-07 04:43:04	27	77	62	6.00	27	74
	Edit	Copy	Delete	1426	2019-02-07 04:38:15	27	77	61	6.00	27	75
	Edit	Copy	Delete	1425	2019-02-07 04:33:26	27	77	62	6.00	28	77
	Edit	Copy	Delete	1424	2019-02-07 04:28:37	27	77	67	6.00	27	76
	Edit	Copy	Delete	1423	2019-02-07 04:23:48	27	78	57	6.00	27	76

Figure 6: Snapshot of the Sensor data from the data logging system

The system also uses GSM module to link the ONION system and the user. This is primarily used for remote controlling of the actuators of the system. The system automatically sends SMS to the user to inform him that a certain sensor value goes to its unsafe level. In manual mode, the user can then control the actuators by sending SMS messages back to the ONION system. Figure 7 below shows a snapshot of the exchange of SMS data between the proposed system and the remote user.

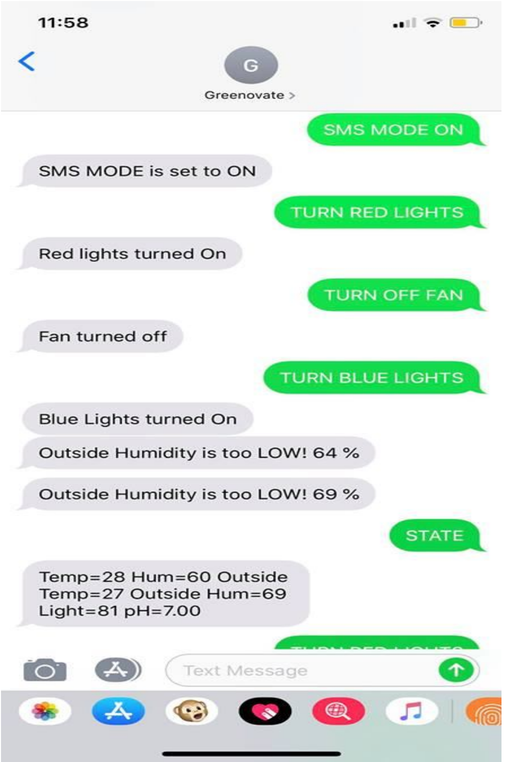


Figure 7: Snapshot on the SMS communications link between the ONION system and the remote user

The efficiency and the response time of each of the actuators are also analyzed. Response times are very important to ensure that whenever one parameter deviates from its safe values, it can be immediately corrected by the system. Table below shows the efficiency and average response times of the actuators.

Table 2: Efficiency and Response Times of Actuator System

Actuator	Mode	Efficiency %	Response Time (sec)
Mechanical Fan	Online Mode	100	15.4
	SMS Mode	100	15.2
Water Solenoid Valve	Online Mode	100	15.6
	SMS Mode	100	10.9
LED Strip	Online Mode	100	14.1
	SMS Mode	100	11.4

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Findings

The Optimized Nursery for Indoor Onion Nourishment project is a feasible project that is capable of monitoring important environmental parameters in planting white onions namely temperature, pH, humidity and light intensities.

The microcontroller is link to an online data logging system wherein all the values of the sensor data can be monitored. These values are graphically presented online. The tabular values of entire data can also be viewed online.

The ONION system uses a set of actuator system that will correct the environmental conditions inside the greenhouse. These actuators include mechanical fan, LED strips and water solenoid valve.

The ONION system uses a GSM module that can be used to remotely monitor and control the green house. During experimentation, the efficiencies on both online mode and SMS mode in controlling the actuators are all 100%. The average response times to activate an actuator is around 14 seconds.

5.2 Conclusions

It has come to our conclusion that the proposed greenhouse project intended for used in planting white onions is an efficient way of promoting indoor agricultural activities. When adding different varieties of plants in the system, the values of the safe parameters can be reprogrammed to optimize its growth rate.
The ONION system can be implemented in a large scale of full-size hydroponic system and expect promising results.

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