PolyNanny

Stand Number: _____

Project: PolyNanny
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Comments

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Summary / Abstract

The PolyNanny Project is an irrigation and environmental control system which uses sensors to keep the plants under the perfect growing conditions. This can be in a polytunnel or outside. The settings and control can be done from any location over the internet using our secure control panel. Each PolyNanny becomes another device in the growing world of Internet of Things (iot). The focus of this project from the beginning has been on proper use of resources in an effort to preserve the Earth. This has resulted in PolyNanny being designed with a minimum use of water and power consumption to allow for solar panels in the future.

PolyNanny can measure the soil humidity, ambient temperature and rainfall to determine how best to control the environment. The environment is set by the selective use of heaters, fans, grow lights and water valves. There is even the possibility to control the sound environment by playing music to your plants that sooth them and improve growth. An important element of the system is to provide feedback to the user. An IP Camera has two functions, giving live streaming video and timelapse (watch your plants grow in fast forwards).

The technology behind the project is a Raspberry PI and an Arduino that together form the brains and brawn of the system. With such a smart controller things can be timed independently. Each day can have a minute by minute timing system, be controlled manually or fully automatically under the control of a sensor. You can adjust the sensitivity and duration of the humidity and the rain sensors. The Raspberry PI hosts a full website which when viewed from a browser anywhere in the world, appears like any website even though it may be located inside the polytunnel. This website allows for full control of all the above features.

During the development of PolyNanny and preparing the small scale demonstration for the BT Young Scientist, I discovered a new and unique solution for saving even more water than a standard PolyNanny. This is a closed loop system which could be used in any polytunnel or raised beds with PolyNanny. The only water used up is from the plants or evaporation which is contained in the polytunnel and will eventually condense and return to the system. This is an exciting new prospect to investigate.

Today with modern technology it is expected that all claims can be proven with scientific experiments. The claims here are that PolyNanny is the most efficient method for the irrigation of plants and the closed loop system is ideal for minimising water usage. The first question which needs to be answered is “How much water do plants actually use?”. To conduct this experiment I have taken a 20L plastic bottle and used it as a reservoir. I have marked graduations on the bottle and marked the starting point after charging with water. Taking readings every 2 days has given me data to answer this question. When designing the apparatus for this experiment I didn't realise that I had made a closed loop system and only discovered its importance after.

I will be expanding the idea of a Closed Loop PolyNanny System on a full scale in the future.

Introduction

I came up with the idea for Polynanny when we bought a polytunnel for growing our own vegetables outside. Previous to this we had been growing them in raised beds open to the environment but we wanted to start growing the cabbage family which needed to be protected from white butterflies. We had a simple water timer which had fixed schedules of watering times. None of the pre-set programmes were very suitable. Certainly not for the beds and the polytunnel which each had different requirements. When it rained a lot we didn't need watering in the outside beds but still needed it in the polytunnel. We were wasting water, drowning plants and with the temperature in the polytunnel rising, sometimes baking the plants. When we were away in England we had to have someone at home looking after the plants. There was no way for us to check that the plants were okay. These were the problems we faced nearing the summer.

I had this exciting thought "What if I could control the plants from here with my iPhone?". The buzz phrase IOT (Internet Of Things) was hardly being used then. I was very interested in controlling things from anywhere in the world. In the beginning I was only thinking of controlling one water connection. This single water connection would be controlled by soil humidity. I heard of the Raspberry Pi and the Arduino through the mentoring I do at Coderdojo and wanted to find a reason to look into this. This seemed like a perfect project for this technology. I researched on the Internet and found a soil humidity sensor for the Arduino and discovered I needed a way to communicate between an Arduino and a Raspberry Pi. It is not the easiest thing to do and I would need to use a Python library called Nanpy which interfaces with the Arduino library to interface with the Arduino. This would require experimentation.

With all new technology a good designer keeps in mind the proper use of resources in the environment. I realised for the project to be a success I would have to conserve water. The other resource that PolyNanny needs is electricity and in the design I kept the power low so that in the PolyNanny could eventually be powered by solar energy. It was my original thought that PolyNanny would affect the environment mostly by getting people to grow their own vegetables, whether at home or on holiday. This was my original conception of

the project and fit in well with my wish to do something for the BT Young Scientist and Technology Exhibition.

Through experimentation and discussions with my brothers, who grow their own food professionally and nonprofessionally, the ideas and features of PolyNanny grew. It was clear that within one farm or house there was several different growing environments to contend with. This made me realise that PolyNanny needed to be capable of multiple systems. It would be necessary for some branches to be controlled by soil moisture, other outdoor branches by rainfall and some by flexible timers. In each case the water would be controlled by electronic valves driven by the Arduino. This is the basic function of PolyNanny, to control watering of plants in an ecological fashion. I realised this would need a scientific project to prove this theory. With today's technology, unfounded claims won't do and you need to scientifically prove what you claim.

The extended features which developed over time, were the ability to communicate with switches by Radio Frequencies (RF). The requirements which I identified were necessary are heaters, fans, grow lights, but any device which plugs into mains power can be controlled in the same way. The other feature that can be controlled is music which is connected directly into the Raspberry Pi. I looked up a lots of websites about playing music to plants and decided this would be an added feature. One of the most interesting new features was a IP camera which is connected over wifi to the Raspberry Pi. This allows me to view my polytunnel remotely and as well watch the plants grow in fast forwards via time lapse photography. This is both for entertainment and practically shows how things are growing when you're not at home.

All of the features can be controlled and viewed from anywhere in the world by using a web-server running on the Raspberry Pi. This web-server hosts a html5 page delivered by PHP which to all purposes looks like a website but is local. In order to accomplish this, it requires many languages and disciplines which I needed to learn. These are Html5/css, Javascript, JQuery, Php, Mysql, Python, Linux/shell, Arduino/C++, Objective C, and Java.

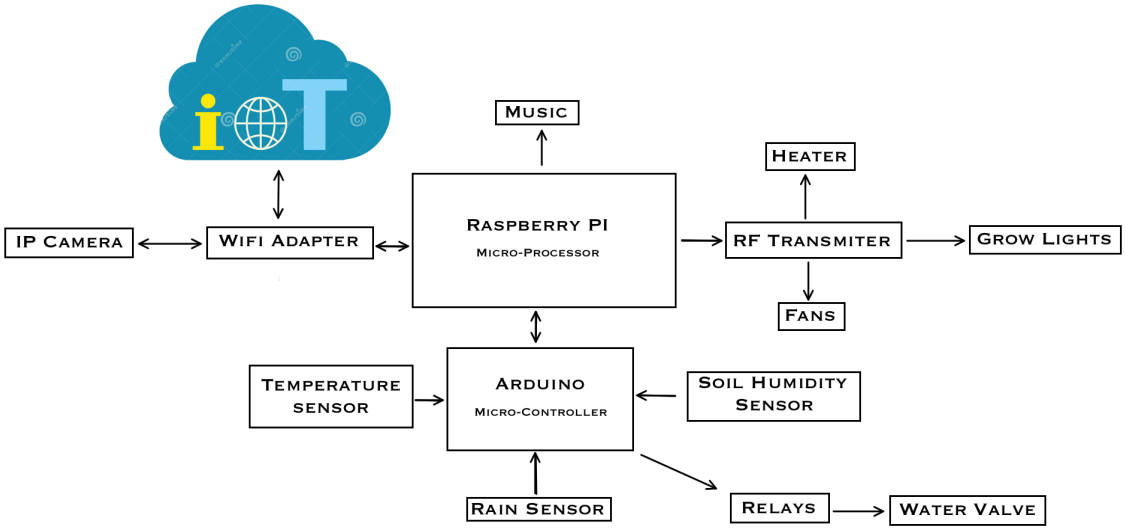
Experimental Methods / Development

My project has both a scientific portion and a technology portion. The parallel to experimentation would be development by the Iteration Method and it is necessary for me to have the hardware and software complete before being able to conduct this experiment. The first part of the development was to design the system. The final design is shown below but in the beginning I was really only concerned with soil humidity and watering. It was important to experiment with the key elements (Arduino, humidity sensor, valve). In this first experimental phase I realised that I would need a relay to control the valve because the valve is 12v and the Arduino is 5v. Once I proved that I could control the valve via the Arduino, I could move on to the full development of the system.

The Arduino is an open source micro-controller which can be used as a building block for development. The Arduino is the brawn not the brain. For the brain I use a Raspberry Pi or the Banana Pi (open source) which are micro-computers and use the Arduino as a slave I/O to the Raspberry Pi. There was not a great deal of information on this and I needed to consult the internet and experiment with several methods. I eventually chose to communicate via Javascript calling PHP calling Python calling Arduino by trial and error. From this point all the major data flows were determined and it was a matter of expanding this into a full system with all the features implemented.

Referring to the diagram, the Raspberry Pi is the most important part of design. The Raspberry Pi has been setup to run a Linux server. You connect to this via a smart device connected to the internet using a browser. You can display data from the Raspberry Pi on your device (website) and control all the functions of PolyNanny. I developed this internal website using PHP, Javascript, Html5/css, jQuery, and MySQL. All the functions shown in the diagram are controlled in this way.

In the design I had to take into consideration many other factors for example security, power consumption, water efficiency. The first system was installed in September and began running our own polytunnel. Most of the design was correct needing little iteration and only minor software changes.



The next step in the development was to create a Small Scale System for demonstration purposes at the BT Young Scientist. In doing this I had realized that I have made a Close Loop System, which means the only water which is used up is from evaporation and photosynthesis. This lead to me designing a new system of polytunnel irrigation in full scale. The polytunnel itself returns the evaporated liquid back into the beds and back into the close loop. In the Small Scale System there were improvements in both hardware and software that were learned from the from the original Full Scale System.

It is important for any development such as this to be able to prove scientifically your claims. This lead to my scientific experiment for this project. My hypothesis is that PolyNanny in a Closed Loop System uses much less water than conventional systems, the only water used or lost is the water used by the plant's photosynthesis.

To prove this, on the reservoir I have marked graduations of litres and measure and write up the results every second day. This is an ongoing experiment as there was a great deal of development before the experiment could start (winter is not the best time to grow plants). I will eventually compare this use of water against the same PolyNanny System without recycling water and manual watering without any Closed Loop recycling.

Results

The result of the project is that we have a fully working PolyNanny system which controls our polytunnel. The settings can be edited and the polytunnel viewed from anywhere with secure communication. A large target audience has been identified making it a prospect for further development.

The results of the scientific experiment to prove the efficiency of PolyNanny and to determine “How much water do plants actually use?” is not complete but enough to make some assumptions. The Closed Loop System (Appendices - Figure A) was only visualized during the final stages of building the small scale polytunnel. This discovery is a major result of the project. The results from the Small Scale are clear enough to make way for a Large Scale experiment in the future.

The Closed Loop System in Small Scale uses a reservoir located below the model polytunnel and a pumped system attached to the sprinkler. The drain from the growing bed is recycled back into the reservoir after watering the plants. This could be adapted as shown in Figure A and be developed on the Large Scale.

The preliminary results (Appendices - Figure B) show the usage of water measured every second day starting on the 20th of December. The plants were grown from seed and planted on the 20th and the 28th of December. The chart of usage (Appendices - Figure C) shows an average two day use of 92 ml or 46 ml per day. This would equate to a small amount of water for a full sized polytunnel indicating that the Closed Loop System has promise as a method of growing with minimum water use.

Conclusions and Recommendations

The current PolyNanny, as developed in this project, has shown promise as a marketable device. In consulting people in the field, who would be a target audience, they have shown an interest in purchasing it. It would need further development, cost analysis and a market study. With the ongoing investigation of the Closed Loop, this development may be well placed in a growing ecological market.

The experiment to determine how much water do the plants actually use and to determine the efficiency of PolyNanny is still ongoing.

In small scale after the initial charge of 1 liter of water, it would use 45 - 47 ml of water per day. Our polytunnel which is 6m x 3m, is 109 times bigger than my model. It should use 4.36 - 5.45 liters per day. This is equivalent to using a standard micro-sprinkler system of 3 minutes a day which is a small amount of water. Manually we were watering 30 minutes a day, prior to installing PolyNanny. These measurements are taken in the winter time, at room temperature, with little to no sun.

The Small Scale experiment was a success in that it proved that it would be very worthwhile to conduct an experiment on a Large Scale Closed Loop system.

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Kenneth Weiss - Private home grower

Matthew Weiss - Father and Electrical Engineer

Appendices

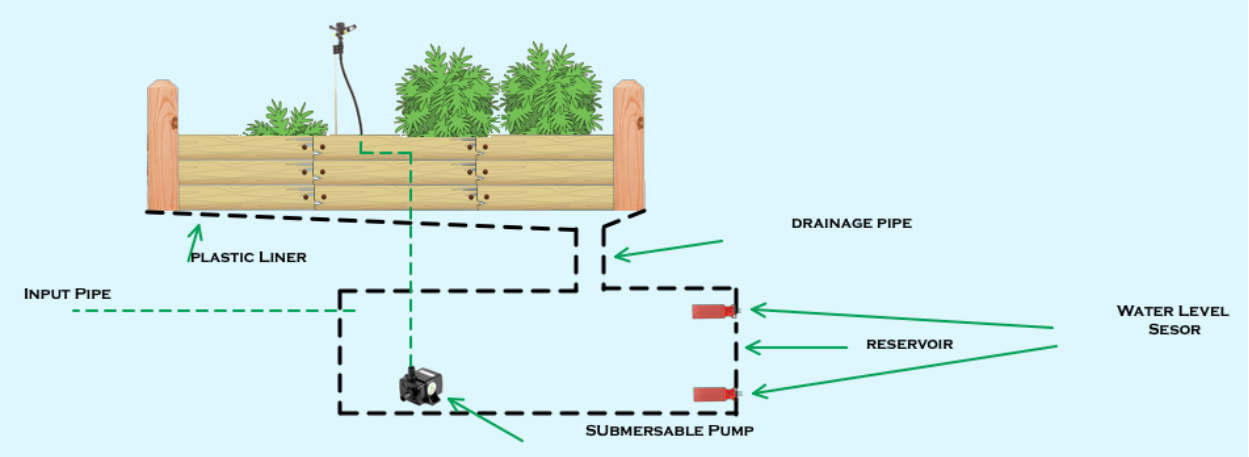

Figure A

Date	water used(ml)
20/12	90
22/12	94
24/12	90
26/12	93
28/12	95
30/12	94
1/1	
3/1	
5/1	

Figure B

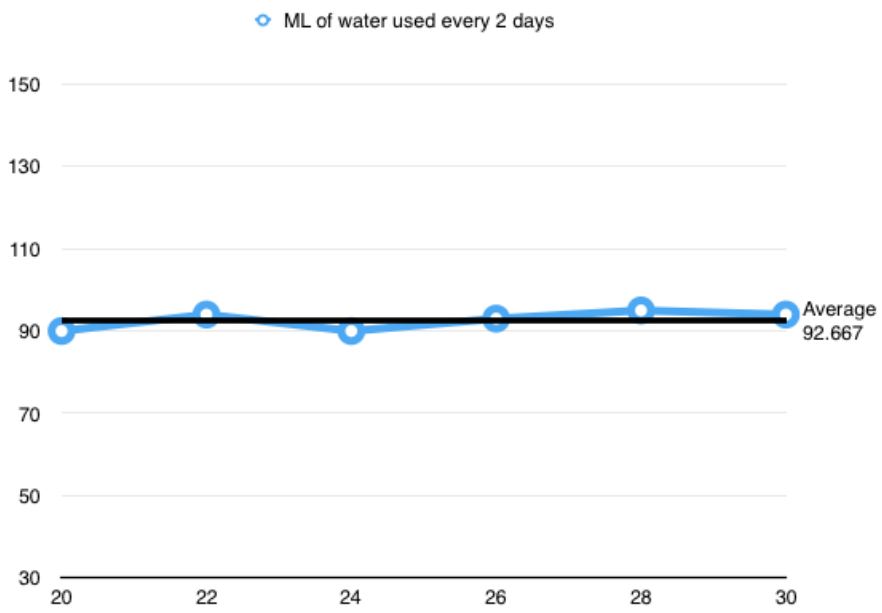
ML of water used every 2 days
150
130
110
90
70
50
30
20
22
24
26
28
30
Average
92.667

figure C

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