Department of Electronic & Telecommunication Engineering
University of Moratuwa

Automated Enclosed System for Orchid Plantation

Design Driven Innovation

Group 12

This report is submitted in partial fulfillment of the requirements
for the module EN 3023: Electronic Design Realization.

April 2nd, 2019

Introduction to the Product

The product, "Automated enclosed system for orchid plantation" is mainly focused on enclosed(totally or partially) orchid (Dendrobium) plantation which addresses automated solutions to control Temperature, Humidity, and Lighting while automating irrigation system and fertilization process, according to their growth.

Why Dendrobium?

According to the research we have done, Dendrobium is more profitable and easy to cultivate than the other orchid varieties, with the existing environmental conditions in Sri Lanka.

Preferred Conditions for Dendrobium

- Varieties - Sonia 17, Sonia 28, Emma White, Sakura Pink
- Climate - 75% green shade net with 70-80% humidity, 18-28 C temperature
- Growing Media - Most common potting mixture consists of charcoal, broken pieces of bricks and tiles, coconut husk and fiber
- Irrigation - Mist or overhead sprinkler to provide water and to maintain humidity
- Nutrients - Foliar application to NPK 20:10:10 @0.2% weekly intervals starting from 3 days after planting
- Growth Regulators - Foliar application of GA3 50 ppm bi monthly intervals starting from 30 days after planning
- Repotting - Orchids need repotting regularly, usually every two or three years
- Splitting and division of plants - Plant grown to a large clump 2 or 3 old canes and new shoots, -divided before repotting

Some Facts about Dendrobium

- Pests - Snails and Slugs
- Harvests - flower fully matures in 3 or 4 days after it opens
- Yield - 8 - 10 spikes/plant/year
- Diseases - Bacterial soft and brown rot, Blackrot, Anthracnose

Conceptual Designs for overall project

First Design - The Matrix Design

Why Matrix Design?....

In order to secure the uniform growth among plants, the optimum idea is to maintain an identical supply of water and fertilizers to each and every plant. But, this is not possible in the conventional way of greenhouses.

But, this is feasible through the matrix design.

Every plant is assigned to particular position in a matrix and its status is recorded under its position.

By using a crane like structure, water and fertilizers are applied equally to every plant and water content in the soil can also be monitored.

Advantages

- Can track the status of every plant
- Well organized way of watering and supplying fertilizers
- Reliable and Easy
- Can expect an identical growth of plants

Disadvantages

- Difficult to install
- High cost in implementation
- Complex programming required
- Malfunction in crane operation can be disastrous for the plants
- Power and time consuming
- Not feasible in large scale cultivation

Second Design - Collective Addressing

Why collective addressing?

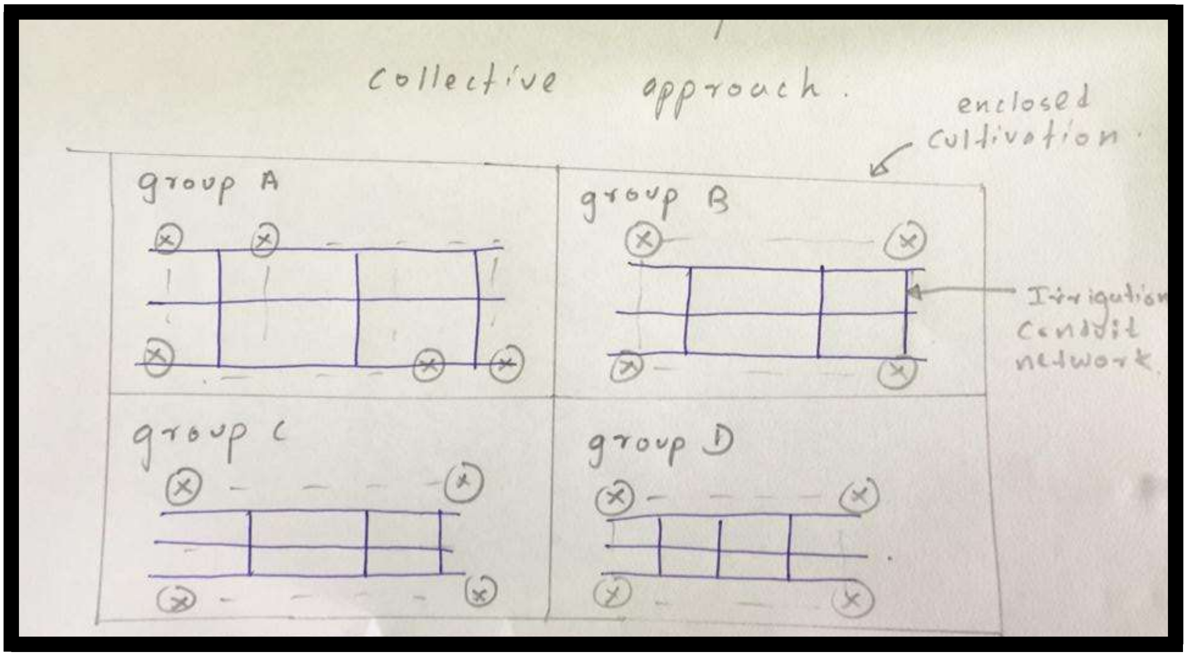
As mentioned earlier, in a large scale cultivation, individual accessing of plants is both time and power consuming and less robust to system failures.

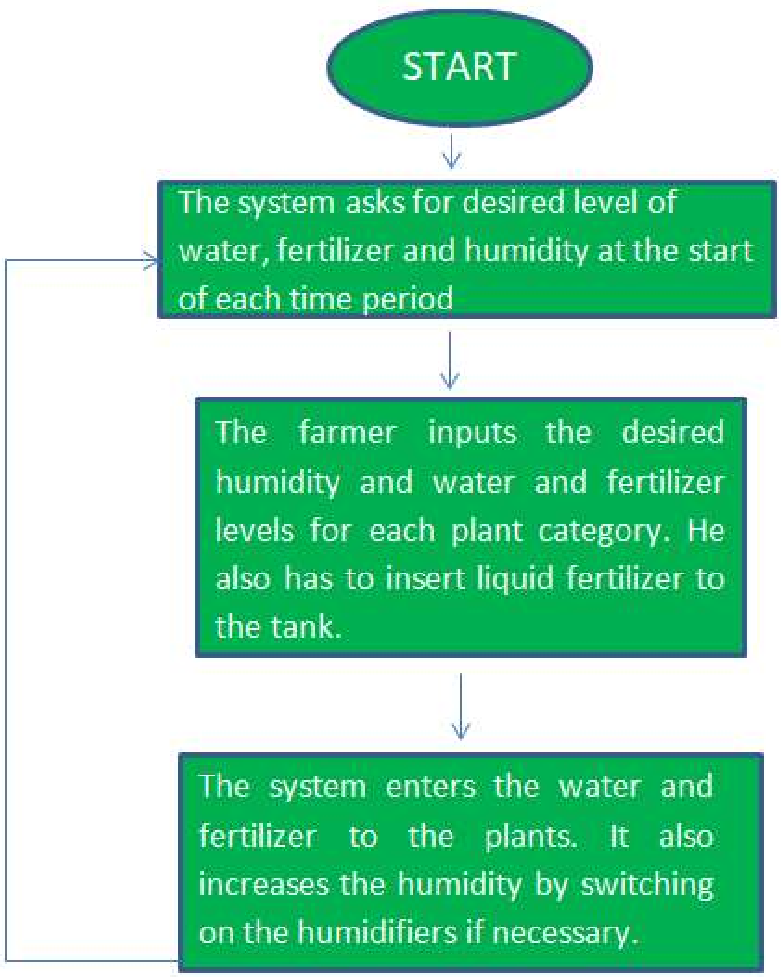
What is collective addressing?

The second design is accessing plants on a population basis.The control mechanisms in the system will now address the whole cultivation or partition of the cultivation at once.

Partitioning of the cultivation will be done on the basis of plant groups with similar growth rates.

Assumption - These homogeneous plant groups require same environmental conditions





Second Design - Collective Addressing

Advantages

- Since system workload is minimum, less time and power consuming
- Complexity of the system is largely reduced
- Simple design inherits robustness
- Installation is easy
- Easy troubleshooting
- Manufacturing cost is reduced.

Disadvantages

- A system to group the plants on the basis of growth should be implemented
- Should regularly carry on plant grouping which is a workload upto farmer
- Farmer will have to update the environmental conditions to each group from time to time. (system is only going to regulate them)
- Methods to irrigate and fertilize the system collectively should be innovated

Discussion on problems and solutions related to the conceptual designs

What's the best selection, greenhouse or shade net?

Although green houses are 100% enclosed agricultural systems that supports the regularization really well,

1. They are not economical to typical farmers.
2. Temperature and light inside has to be controlled which is power consuming.
3. Implementation is impractical for large scale orchid farmers.
4. Parts needed for the installation are not readily available in the market.

Solution for housing the plants

The ideal temperature for orchids is less than the ambient temperature in Sri Lanka. Hence the whole purpose of a greenhouse is not relevant in our project. Also building a greenhouse is too costly and as our target market is not well developed farmers, a shade net is prefered over a greenhouse.

Is temperature controlling feasible?

Usually the control mechanisms in green houses are to increase the temperature in winter in which is not the case in sri lanka. Hence no need to consider temperature increasing mechanisms. Available options to reduce temperature are

1. Exhaust fans- relatively good but power consuming
2. Air conditioners- problems in controlling humidity, power inefficient

But Sri lankan farmers are having a good harvest even by not discretely controlling temperature and shade nets naturally controls the temperature without consuming power at all.

Solution to temperature control

By comparing the cost incurred to control temperature vs the actual profit in doing so, we came a conclusion that installing any type of powered temperature control mechanism involving fans is non-profitable. Hence we avoided using any kind of powered temperature control device.

Is light controlling feasible?

According to research done, Direct Bright Sunlight is **not** an optimal lighting condition for orchid plantation. So in selecting a mechanism to provide orchids with their needed lighting conditions, we have some options in hand.

- We can cover the whole enclosed system and go for a completely
- automated lighting system which is power consuming and not economical or
- We can use a shade net of suitable covering percentage which has no power consumption or
- We can design an automated curtain controlling system which lacks of user friendly installation mechanism.

Solution to light control

According to our research, blocking all natural lighting and supplying artificial light was not neither economical nor healthy for plants.

Using a curtain system to open and close when desired was optimal, but this demanded a lot of power as the curtains will be active the whole day, and with respect to the final produce, it wasn't a profitable alternative.

The shade net that is already used by most gardeners was the preferred choice, even though its control didn't respond to stimuli.

How to control humidity ?

The natural habitat of orchids are tropical rainforests where the humidity is high and mild atmosphere is inherent.

- According to the researches, controlling humidity in orchids gives optimum results, ie large colorful and more commercially valuable flowers.
- Due to the high temperature, RH value of Orchid growing areas in Sri Lanka are usually lower than prefered values.

We will be adding technical methods to control humidity because of these facts.

Solutions to controlling humidity

Humidity control could be done in a number of ways. Controlling the humidity of separate plants was close to impossible as this would mean isolating the plants in watertight cubicles. Hence a common humidity control method was adapted.

Sprinklers could turn on and off when required. This choice is not adapted as the water will be in liquid form and will affect the water balance of the plant.

Closing the cracks in the green house to trap in humidity. Whilst this method reduces water wastage, as we chose a shade net over a greenhouse, cannot be implemented.

Neither was plant isolation a cost effective method. Installing humidifiers was our prefered solution as it was both cheap and gave optimum results.

How to irrigate the system?

Irrigation plays a vital role in agricultural systems. Orchids are usually prone to over watering by farmers and not watering according to a proper schedule withers the plant. An automated fully independent system will be implemented to irrigate the system in optimum way. The available options are,

- An overhead watering system with an network of conduits with nozzles.
- A bottom layer conduit network which spreads water by raised sprinklers.
- An ' each plant individually assessed' system where a small water tube goes to each plant pot.

Solution to irrigation system

According to information taken from farmers, a bottom layer watering system will yield to uneven water distribution.

The overhead system will have

comparable even distribution but the major issue we faced is the difficulty to control the water levels given to a single plant as this method will affect a number of plants at once.

Our preferred solution is having a system of pipes which address each plant separately. This gave us ideal control over separate plants and the cost was comparable with the profit.

How to fertilize the plants?

Fertilizers is a must in orchid plantation in order to achieve the desired flower harvest at the end of the period. According to research, orchids needed to be provided with different types of fertilizers at different stages of the plant, in recommended doses. Anyway as a relief, all of those fertilizers could be applied in liquid form. So how do we do that? Either

- We can use the same conduit network used for watering by introducing a controllable valve mechanism to it so that fertilizer is added to the water stream when needed or
- We can design a separate system to fertilize the plants.

Solution to fertilizing plants

We are going to adapt a fertilizer dispenser into the existing irrigation system in order to cut back on cost. As there are different types of fertilizers the gardener will have to specify what type it is to the system, and a week of fertilizing will be taken care of.

How to address the different growing rates?

Although the plants of same age are treated in the same environment with equal access to resources, plants may have different growing rates. Therefore the fertilizing and watering conditions for retarded plants should be different from the normal plants. Therefore a method to take care of plants with different growth rates is need to be implemented. Since plants cannot be individually assessed in such a large scale agricultural system,an alternative method will be needed.

Solution to addressing growing rates

A parallel project done by another group involves grading plants according to their growth. We intend to use their grading and identify four stages of growth. Then we will address the plants according to four treatment methods which will be perfected with further research.

It is quite convincing that the advantages in the collective addressing design outnumbers the advantages of matrix design by all means. If the collective addressing is modified so that the system addresses a group of plants with homogeneous growth conditions at once then almost all the advantages of individual access over collective address can be achieved.

So the selected conceptual design for 'automated enclosed system for orchid plantation' is collective addressing.

Hierarchical design

We are going to use a hierarchical design for our project electronic printed circuit boards. Following diagram is the fundamental hierarchical design.

There are three main parts

1. Processing unit
2. Control units
3. Power supply unit

   Each of these units are going to have their own pcb and the units are interconnected later.

   Inputs to the system

   1. Soil humidity sensor input
   2. Air humidity sensor input
   3. Light intensity sensor input
   4. Temperature sensor input
   5. Fertilizer and water tank level sensor inputs

   Outputs of the system

   1. Control signals to the humidifier
   2. Control signals to the irrigation controller
   3. Control signals to the fertilizer controller
   4. Control signals to the water flow controller

Processing unit

This unit contains

1. The microcontroller
2. The user interface display
3. User input keys
4. Sensor input collectors

Control unit

This unit interconnects power supply unit with the processor. The control signals from the processor are directed to

1. relays
2. Switches

The power lines from the power unit are switched in this unit. The sensors and actuators such as

1. humidifiers
2. Electronic taps
3. Water, light, temperature, soil and air humidity sensors

   Are turned on and off according to control signals.

Power unit

This unit performs

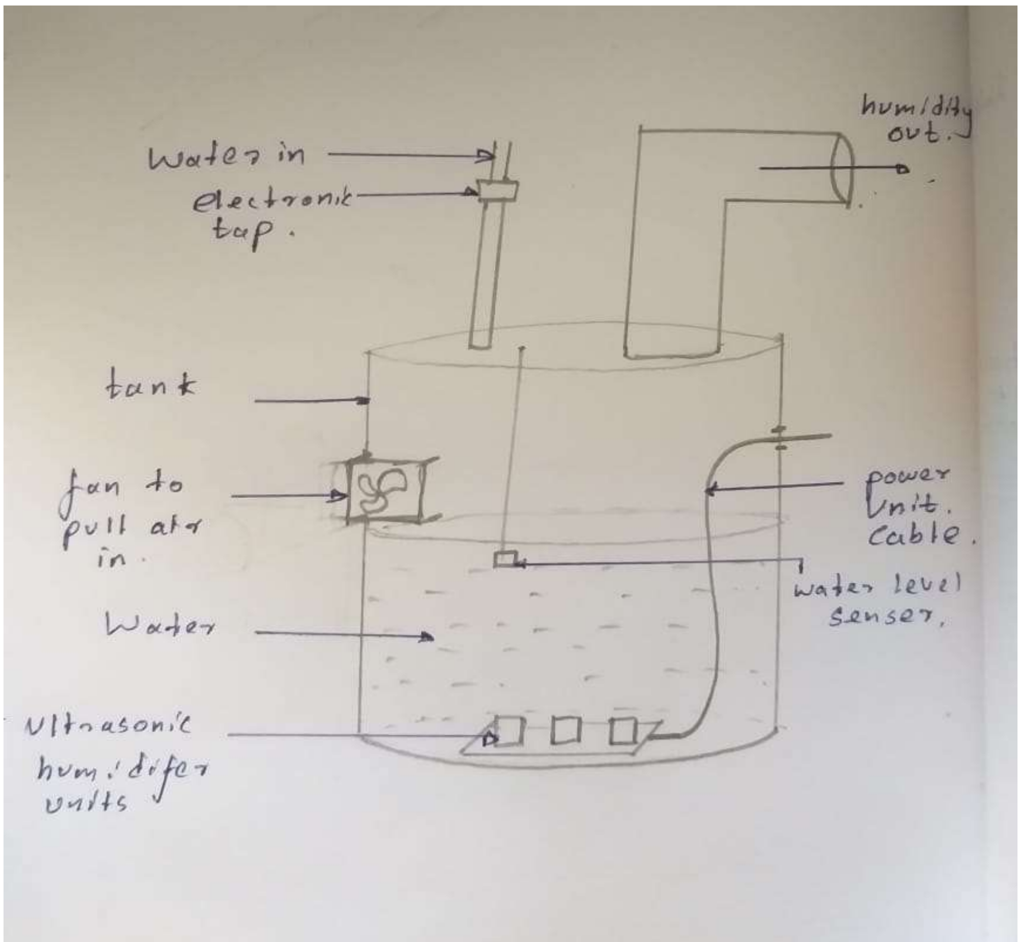
1. AC to DC conversion
2. Power distribution to each unit
3. Electrical safety procedures

The transformers and rectifier units are present in this hierarchical level.

Conceptual Designs for sub units

The humidifier unit

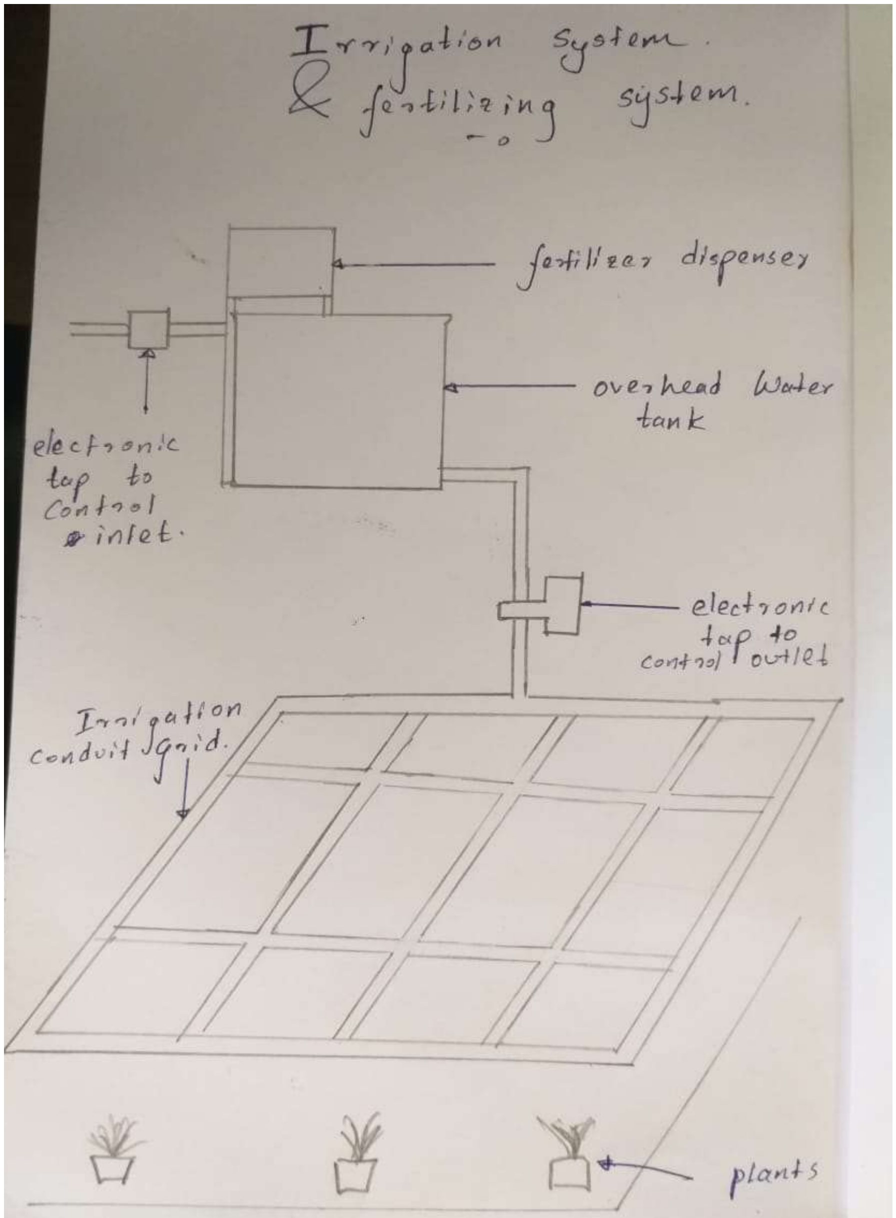
This is a conceptual design we came by up to now.



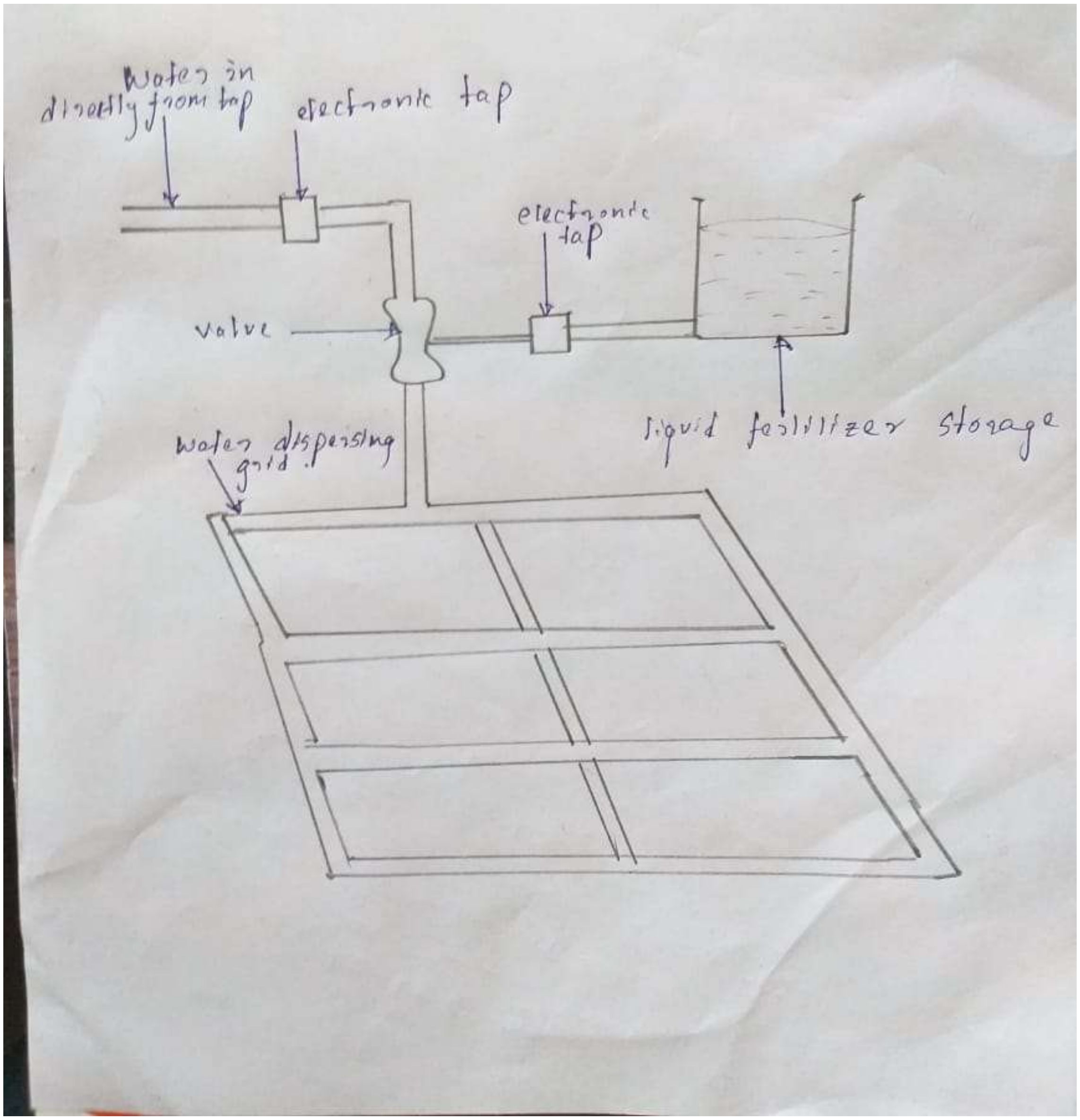
Irrigation system

1. Conceptual Design 1

This is a conceptual design for the irrigation system.

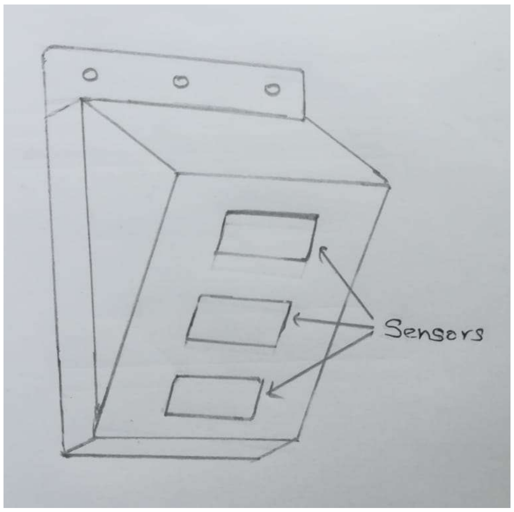


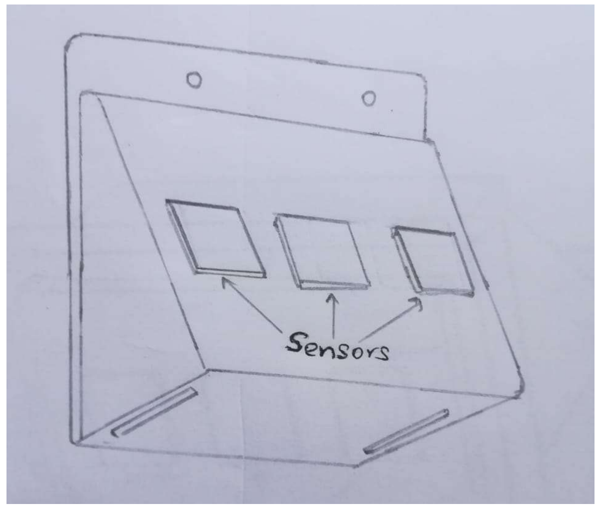
2. Conceptual Design 2

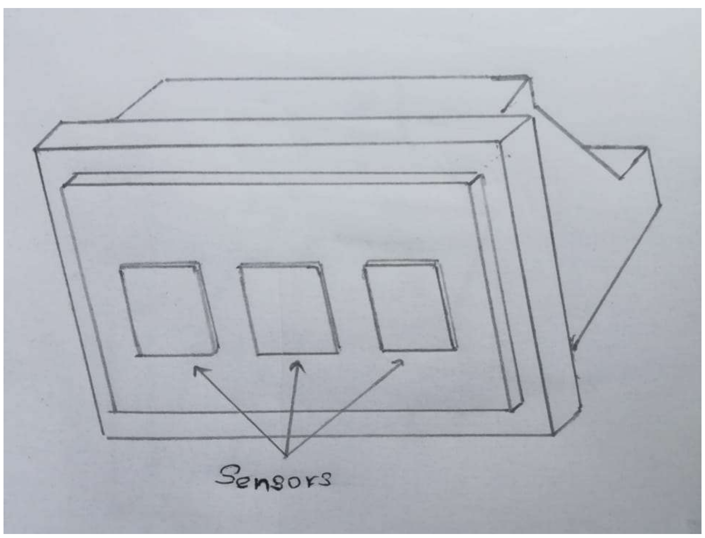


Conceptual designs for enclosures

Aerial hanging sensor unit enclosure

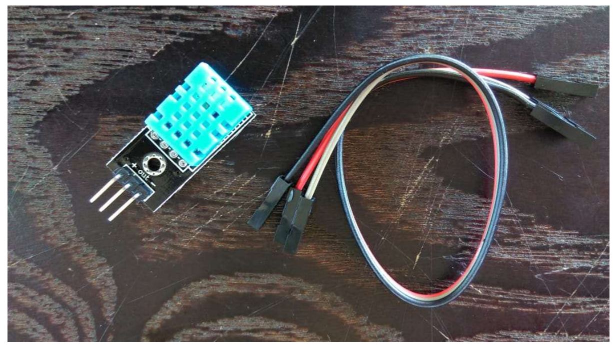






Components that we hope to use in the design

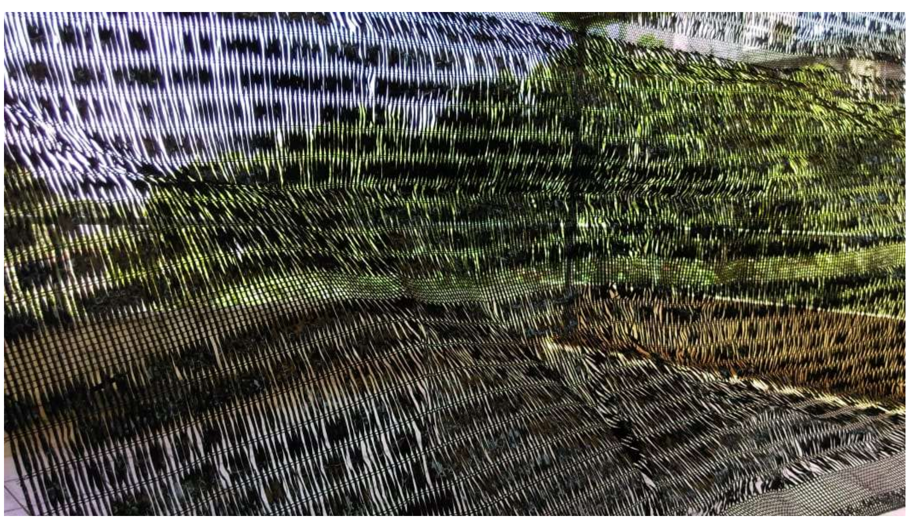
01. DHT11 temperature and humidity sensor



This sensor provides a calibrated digital signal output. We chose this module for out project as it is said to have a long term functionality. As our product is meant to function for years we realized that long term reliability is a very important factor in choosing a sensor. Also the sensor is cost effective and sensitive enough for our application.

02. 60% shade net

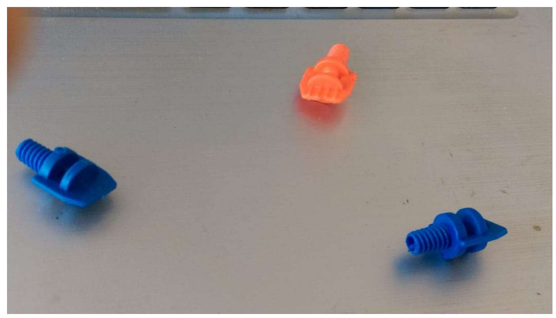
According to experts in orchid, the ambient temperature in Sri Lanka is too harsh for the plants. Hence a shade net of at least 60% is advised to be used. Hence we hope to use a shade net of 60% of Thailand make.



03. Sprinklers

In order to sprinkle water to the plants evenly we looked at a couple of sprinklers available in the market. Of the three sprinklers we looked at the black sprinkler has a heavy flow and as orchids are very fragile plants interpreters advised us to not use this specific sprinkler.

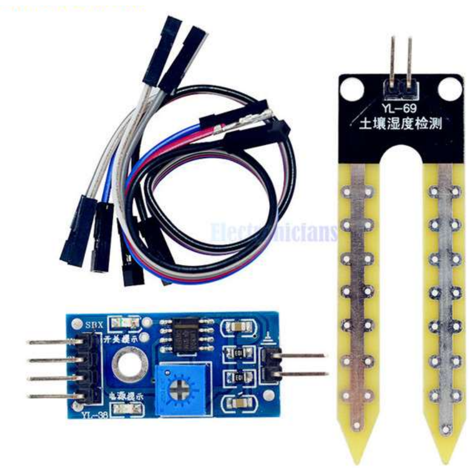
The blue and orange sprinklers are the prefered choice in this case and out of the two the flow of the orange sprinkler has a more even flow hence it is currently our choice for sprinklers.



04. Humidifier

An ultrasonic humidifier uses a ceramic diaphragm vibrating at an ultrasonic frequency to create water droplets that silently exit the humidifier in the form of cool fog. Ultrasonic humidifiers use a piezoelectric transducer to create a high frequency mechanical oscillation in a film of water. This forms an extremely fine mist of droplets about one micron in diameter, that is quickly evaporated into the air flow.

05. Soil Hygrometer Humidity Detection Water Sensor Module



A typical Soil Moisture Sensor consist of two components. A two legged Lead, that goes into the soil or anywhere else where water content has to be measured. This has two header pins which connect to an Amplifier/ A-D circuit which is in turn connected to the Microcontroller. Through this sensor we can get outputs both in digital and analog forms.

06. Light sensor TEMT6000

This light sensor is sensitive to ambient light in the environment. The usual applications of the sensor includes backlight dimming in handheld devices. Given that the sensitivity in our system is relatable to that, we considered this to be a suitable model for our purpose.