enrichment
tech

Orangutan Enrichment Manual

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Introduction

Why we designed this system

Physical interaction among orangutans is important to maintain their cognitive abilities and physical strength. We learned that Orang Utans like to play with one another by swinging on vines, and incorporated our own vine network as a trigger for the feeder and hose system. For example, touch sensors within the vines will activate the sprinkler and delight them with water splashes to ensure they remain healthy, and physically active.

A Cohesive System

The vine, feeder, and sprinkler system perform as a cohesive system to encourage fair play, and promote the physical, and mental well being of the Orang Utans. There should be an equitable distribution of food amongst them for health and interactive purposes. Each system should be able to run on their own, whilst keeping the Orang Utan’s strength and curiosity in mind at the same time. When needed, each system can also function seperately by modifying their respective code (attached in the manual).

Previous Research

Before embarking on this design journey, we had to factor in several considerations.

1. The environment:

The Orang Utan exhibit consists of four free ranging habitats - all connected by ropes with raised platforms, an island - surrounded by a moat, a Sumatran Orang Utan house - with a visitor viewing deck, and an exercise yard - consisting of 2 cages.

2. Their group organization:

There are a total of 25 Orang Utans in the Singapore zoo. 18 are exhibited each day on a rotational basis, while the rest are kept in the exercise yard. The two species of Orang Utans, Bornean, and Sumatran, are kept separately. They are highly social creatures, mingling in groups of 2-3 / 4-5 depending on their personalities and species. Something special we noted was that the zoo creates mixed exhibits with multiple species. For example, there is also a family of 4 otters who live on the main island along with the Orang Utans.

3. Their habits and characteristics:

Orang Utans are very strong animals who can destroy or pry anything open with their strong fingers.

They are voracious eaters - the fastest ones can husk a coconut in 4 seconds.

They may regurgitate when bored - this is resolved by switching to a vegetarian diet, thereby decreasing aggressive behavious as well.

They play in the morning by swinging, rolling and fighting.

4. Our design constraints

- Orang Utans respond to visual and auditory stimuli
- They are largely motivated by food - and the type of food given is also significant
- Weight gain may be a problem if food based enrichment devices are dominated by a single individual
- Any device made must be able to fit into their naturalistic habitat

Building each component

About

This manual includes how-to instructions on how to operate our enrichment system for Orang Utans. It features three main building blocks:

(1) Touch capacitive vine system,

(2) Automated feeder system, and

(3) Sprinkler.

All of these components are modularized, and this manual will break down each of their respective development iterations. Afterwhich, you will be able to run everything with the appropriate code referenced in section (4) Code.

Description

The vine is the sensory input, that determines the output of the feeder and sprinkler.

When something/someone touches one of the vines, the capacitive touch sensor senses the input.

Two orangutans are required to cooperate and touch the vines at the same time for it to be considered a ‘success’.

This signal is sent from the transceiver to a receiver on the feeder and the sprinkler, which activates either the feeder or the sprinkler.

To avoid overfeeding the orangutans, the feeder can only be activated once every 15min.

Once it has been triggered, it will lay dormant until 15min has passed.

In the meantime, the sprinkler will be activated to reward the orangutans for cooperative behaviour.

1. Touch Capacitive Vine System

Materials needed:

1. 2 separate vines made of stainless steel
2. Arduino
3. Transceiver (sends signal to receivers on feeder and sprinkler)
4. Capacitive touch sensor

Artificial vine, with touch sensor hooked up

Instructions:

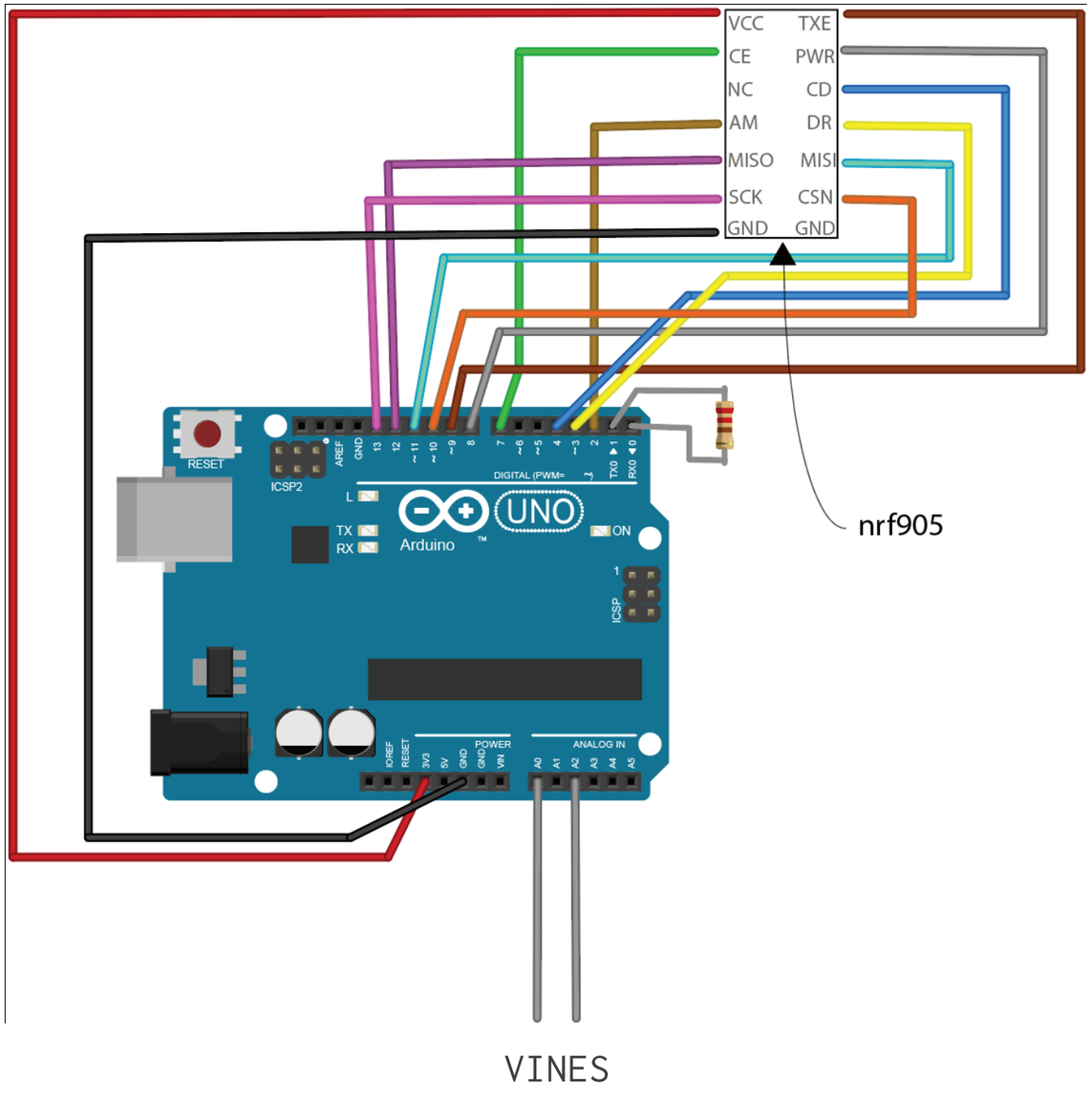
- The two vines act as touch sensors, setting off the feeder and the hose accordingly
- The vines are connected to the two wires on pins A0 and A2 (refer to the arduino diagrams)
- The vines contain a steel cable that runs through them and hence are entirely conductive and work well as touch sensors
- The vines are currently already present in Orangutan enclosure itself and hence seamlessly fit in with the setup.

Points of consideration:

The capacitive touch sensor can be very sensitive. An increase in humidity may cause it to respond and trigger an output without the vines actually being touched. Therefore, it is important to calibrate the sensitivity parameters so it will only trigger when vines are touched.

Touch Capacitive Vine System (cont)

Arduino Setup:



Transmitter code:

Explanation

The Transmitter transmits a “TURN HOSE 120” or a “TURN 90” signal to trigger the hose and feeder correspondingly.

When value0 and value1 (from both the touch capacitors) are above a threshold value, the transmitter sends a signal to turn the feeder or hose accordingly.

The timeInterval (milliseconds) can be modified based on the requirement.

Snippet

```
if((value0 > (movingAverage0 + capThresholdval))  && (value1 > (movingAverage1 + capThresholdval)) ){

    /*If the value is above the treshold and the time interval between two consecutive turns of the fee
    the feeder is triggered, else the hose is triggered*/
    if(millis() >= (currentTime + timeInterval)){
      transmitter.send("TURN 90");
      check90 = true;
      currentTime = millis();
    }else if (check90 == false){
    transmitter.send("TURN HOSE 120");

    }
  }else {

     transmitter.send("TURN HOSE 0");

   }

   if(check90 == true){
    timeDiff = millis() - currentTime;
    if(timeDiff > 3000){
      transmitter.send("TURN 0");
      check90 = false;
      currentTime = millis();

    }
   }
```

2. Automated Feeder System

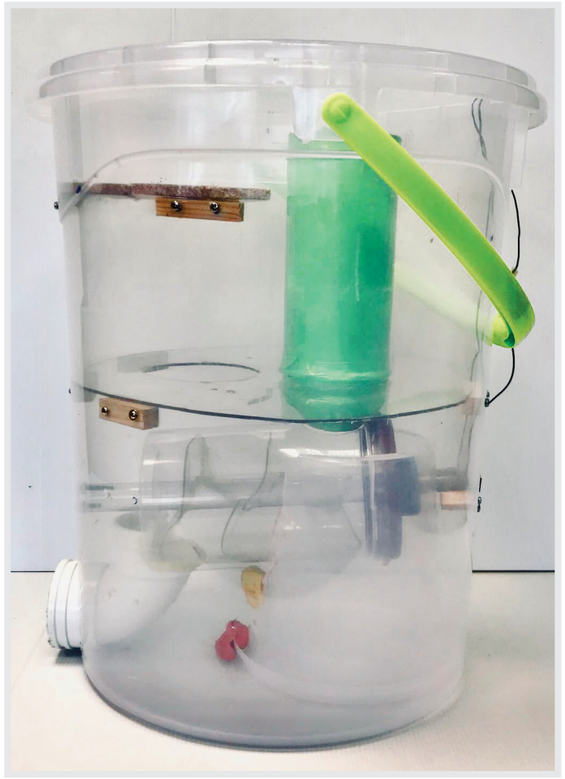
How to use:

The hopper is filled with nuts at the start of the day. When the feeder is activated, nuts will fall from the hopper into the dispenser, which contains an Auger screw.

The feeder dispenses a portion of food (nuts) once every hour. In addition, it will also dispense when the vines are successfully triggered.(i.e. Two orangutans cooperate and touch/pull the vines at the same time.) This only works once every 15min.

The receiver receives the signal from the transceiver connected to the vines, which will run a code that causes the motor connected to the Auger screw to rotate.

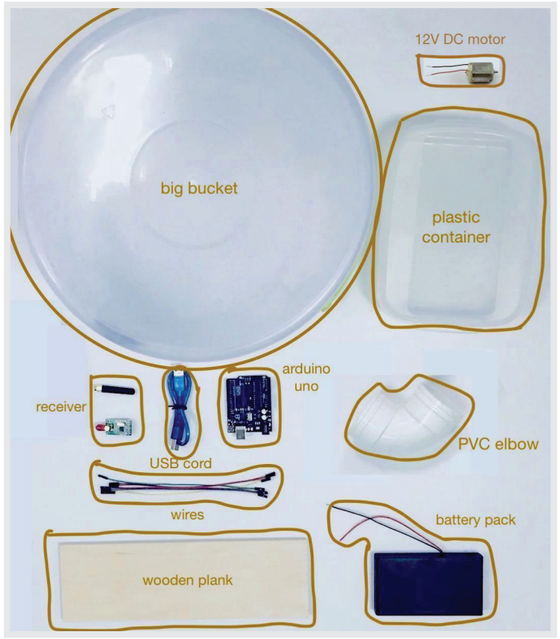
When the Auger screw rotates, it will push the nuts in one direction, towards the outlet, causing nuts to fall out.

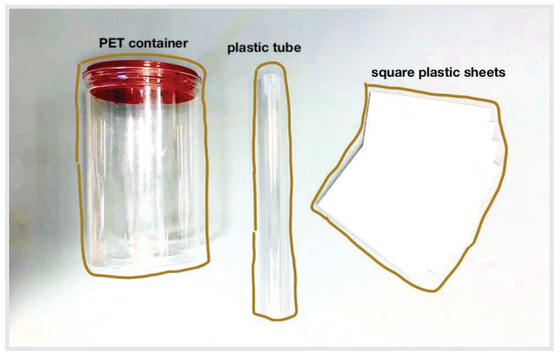


The Orang Utan automated feeder consists of 3 modular components:

- **Auger + Outlet elbow (dispenses the food)**
- **Arduino (sends instructions to device)**
- **Hopper (container for food)**

Materials needed:



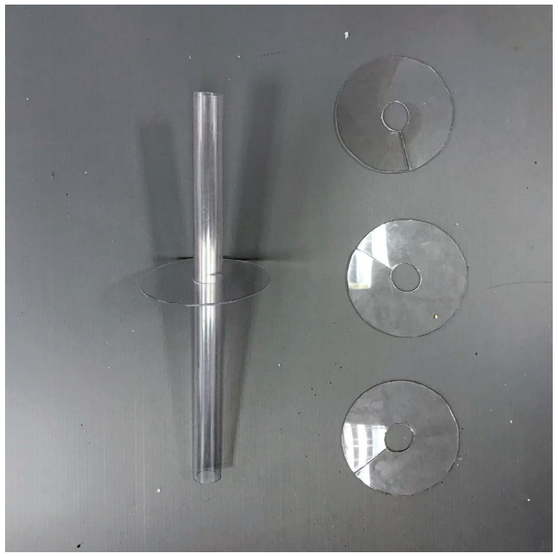


1. 1 30x40 (cm) Plastic Bucket
2. 1 10x7 (cm) Plastic container
3. 1 17x10 (cm) Plastic container with lid
4. 1 16x8.5 (cm) tin
5. 1 6.5 (cm) diameter PVC elbow
6. 1 22x2 (cm) plastic tube
7. 3 10x10 (cm) square plastic sheets
8. 1 Arduino Board
9. 1 Receiver
10. 1 Power Bank
11. 1 13x15 (cm) wooden plank
12. 1 12V DC motor
13. 2 long wires

Instructions:

A. Auger Screw

1. Cut the square plastic sheets into circles, with a hole in the middle. The hole should match the circumference of the plastic tube.



2. Cut off ¼ of the circle so that only ¾ remain.

3. Heat the ¾ circles to soften them and stretch them. The end product should look like the image below.

Automated Feeder System (cont)

4. Glue the pieces onto the tube so that it spirals down.

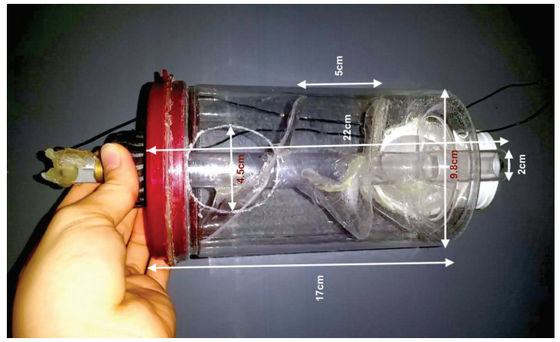
B. Dispenser (with Auger screw)

5. Glue the PVC elbow to the PET container after cutting a matching shape into both.

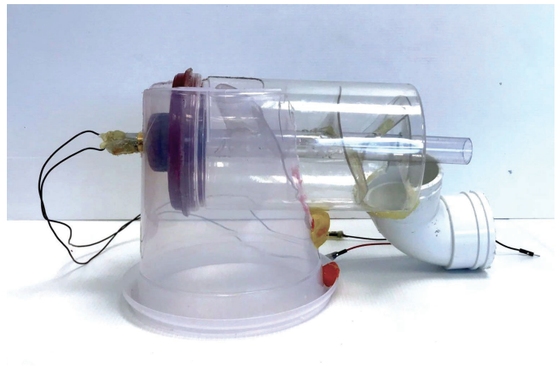
6. Cut a round hole on the top of the container for food to enter. The hole must be big enough for the food.

7. Fit the Auger screw into the PET container.

8. Glue the motor into one end of the Auger screw.



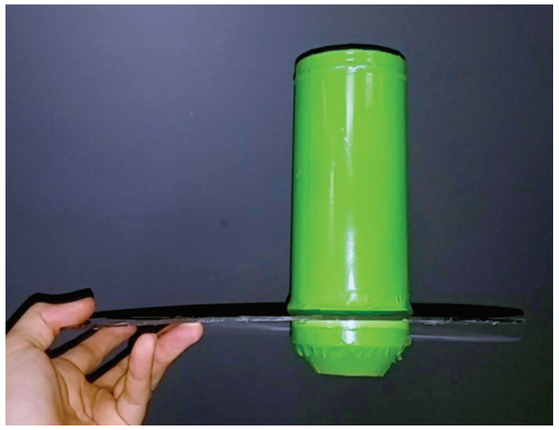
9. Cut any plastic container in the shape of the dispenser and mount the dispenser into the container to stabilise it.



C. Hopper

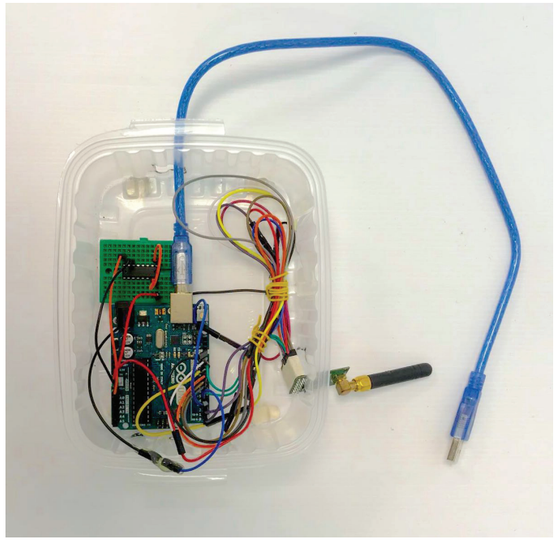
10. Cut a hole in the bottom of a tin to match the size of the hole on the top of the dispenser.

11. Cut a hole in a hard plastic sheet to fit the hopper.



D. Arduino

12. Connect the Arduino Uno to the motor, transceiver, and USB cord. THe USB cord will connect to a power input.



E. Putting it together

13. Cut a hole at the bottom of the bucket to fit the PVC elbow.

14. Drill two wooden cuboids into the bucket to secure the motor of the dispenser.

15. After measuring the height of the dispenser, nail wooden cubes to the sides of the bucket for the plastic sheet and hopper to rest on.

16. Attach another platform using the wooden block at the top using the same method.
This platform should cover less than ½ of the surface area.

17. Fit the dispenser at the bottom, the PVC

elbow should protrude out a little from the hole in the bucket.

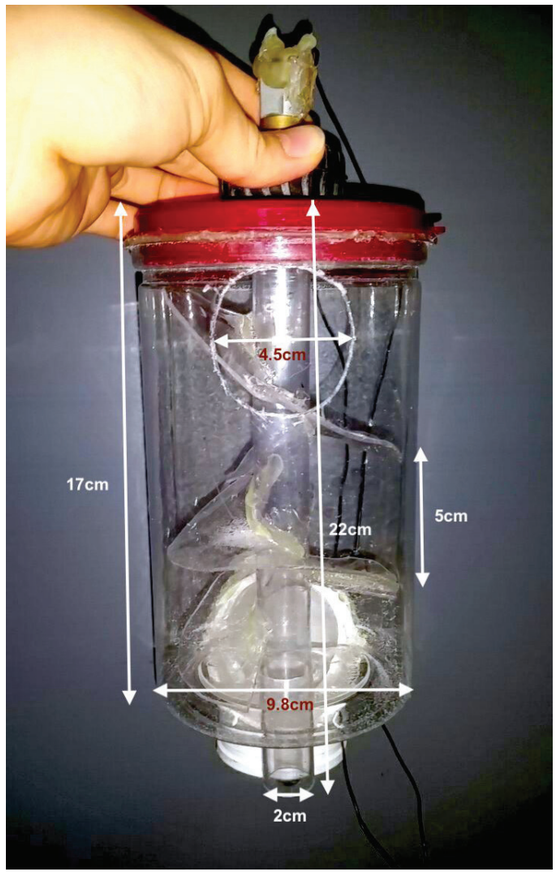
18. Fit the plastic sheet and hopper above the dispenser, with the hole in the hopper right above that on the dispenser.

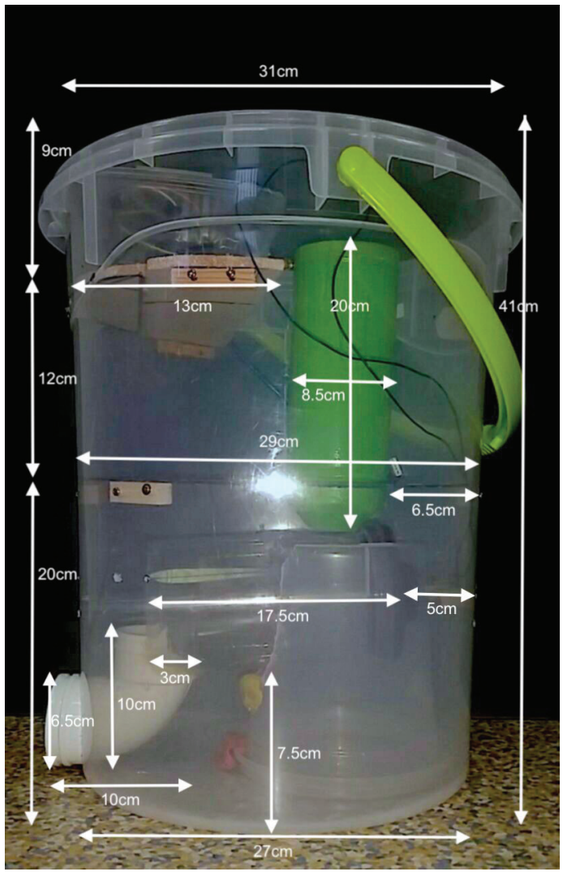
19. Place the box with the electronics on the wooden platform.

Automated Feeder System (cont)

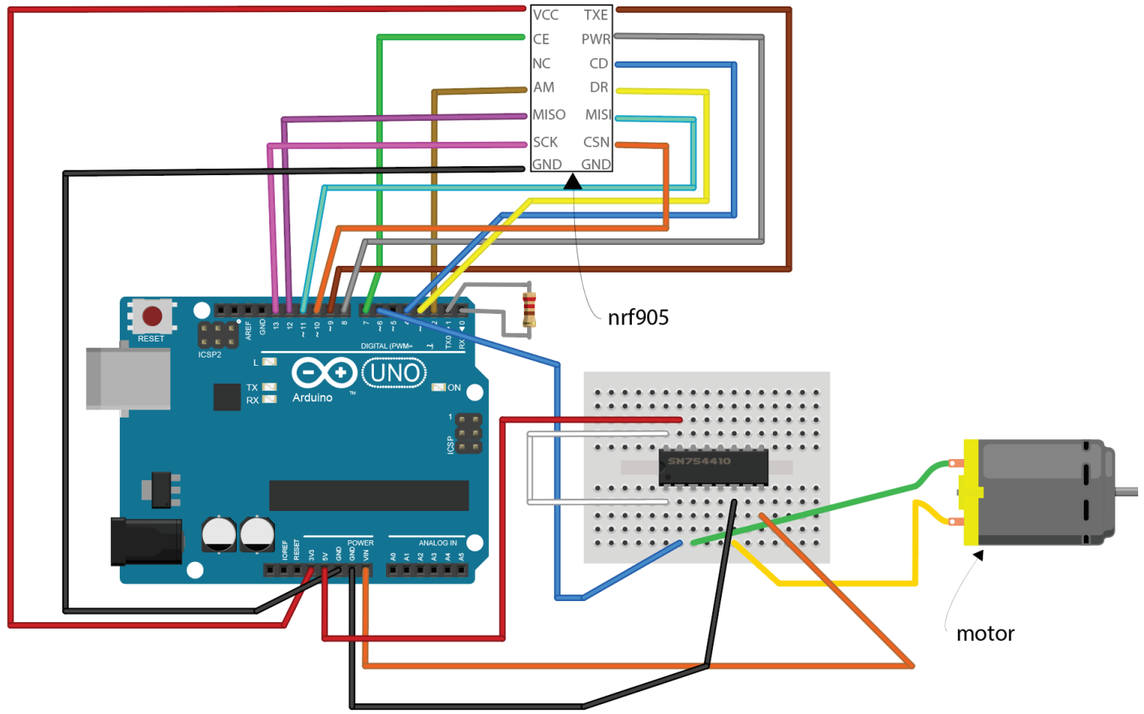
Dimensions

These are the dimensions of the devices we made. If remade in the future, we suggest that larger containers be used to make the hopper and dispenser, in which case a stronger motor will be needed to rotate the Ruger screw.





Arduino Setup



Code

Will receive signal “turn 90” which activates the motor on the feeder (state HIGH) to spin the screw.

```
void onResponse(String command) {

    //Changes state based on signal from transmitter
    if(command == "TURN 90"){
        state = HIGH;
    }else if (command == "TURN 0"){
        state = LOW;

    }
}
```

3. Sprinkler System

Description:

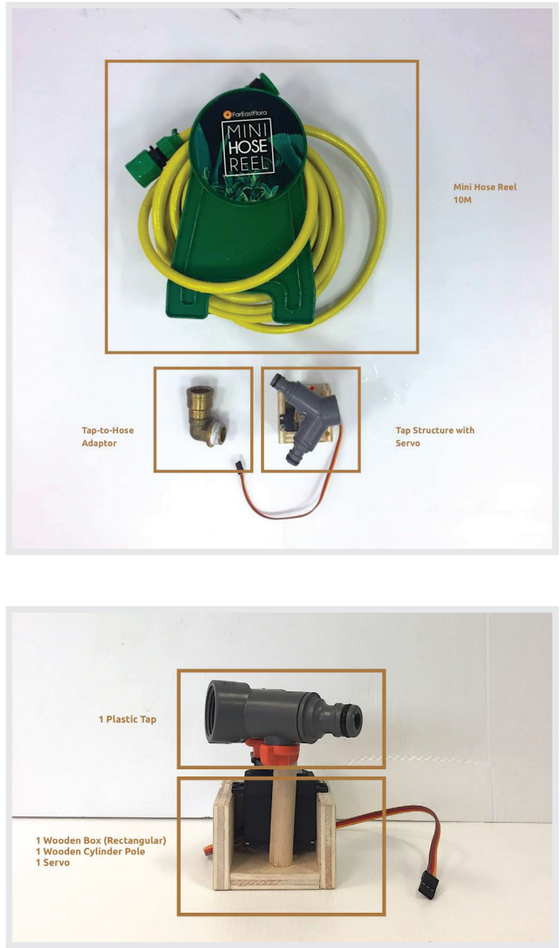
After observing how the orangutans in the enclosure enjoyed playing with cool water in the hot weather, we decided to develop an automated sprinkler to engage them in water play. When the zookeeper brings out the hose and sprays water across the moat, they would gather where the water hits to cool themselves down. Automating this process saves time for the zookeeper and clues the orangutans into adopting new behaviours to deal with hot weather. We alternated the outputs of the feeder and sprinkler to ensure that the orangutans are getting the most out of our enrichment system, preventing overfeeding and encouraging diversity of engagement.

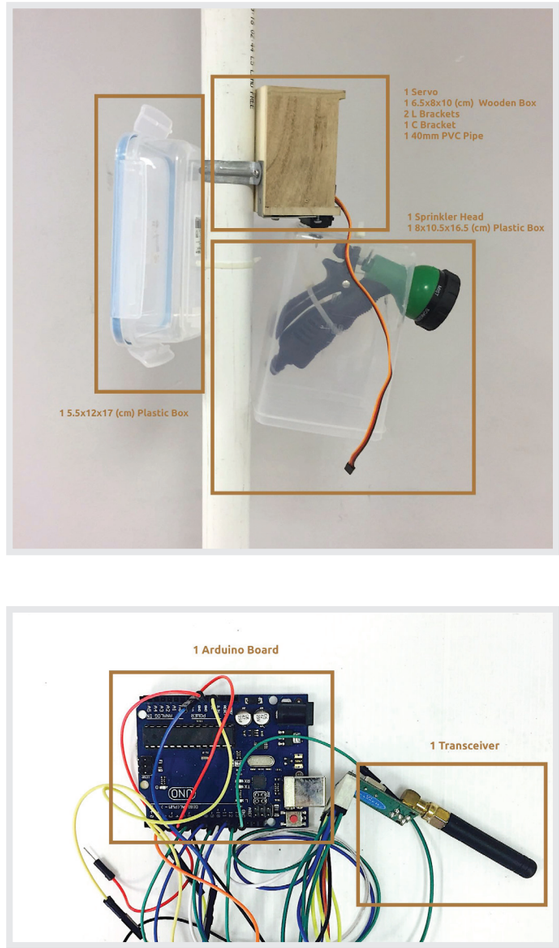
Our water system has two components - the automated tap and the automated sprinkler. The automated tap needs to be attached to a water source in the zoo via a tap-to-hose adapter. The water source at the Zoo should preferably be left open at the start of the day to feed water into the hose. When the vines are successfully triggered (i.e Two orangutans cooperate and touch/pull the vines at the same time), the tansceiver at the tap component receives the signal from the vines' transceiver and turns on the tap. Following which, the sprinkler component will be activated to rotate and spray water with a horizontal projectile. The frequency at which the sprinkler is automated is randomized, depending on the frequency at which the vines are triggered. Within the Sprinkler system, both the tap and the sprinkler components has a servo, an arduino and a powerbank each to operate the system.

In summary, when the sprinkler is triggered by the vines, the following occurs:

1. The transceiver for the tap valve receives a signal to open the valve. Simultaneously, the transceiver for the sprinkler receives a separate signal to rotate the sprinkler.
2. The tap valve is twisted open and the sprinkler is triggered to rotate by their respective servos.
3. After a set duration, the sprinkler valve will be closed by its servo and the sprinkler will stop rotating as well.

Materials needed:





1. 1 Tap-to-hose Adapter
2. 1 Plastic Tap
3. 1 6x6.5x4.5 (cm) Wooden Box
4. 1 8cm Wooden Cylinder Pole
5. 1 6.5x8x10 (cm) Wooden Box
6. 1 5.5x12x17 (cm) Plastic Box
7. 1 8x10.5x16.5 (cm) Plastic Box
8. 1 40mm PVC Pipe
9. 2 L Brackets
10. 1 C Bracket
11. 1 Mini Hose Reel (10M) with Sprinkler head
12. 2 Arduino Boards
13. 1 Transceiver
14. 2 Power Banks
15. 13 screws

Sprinkler System (cont)

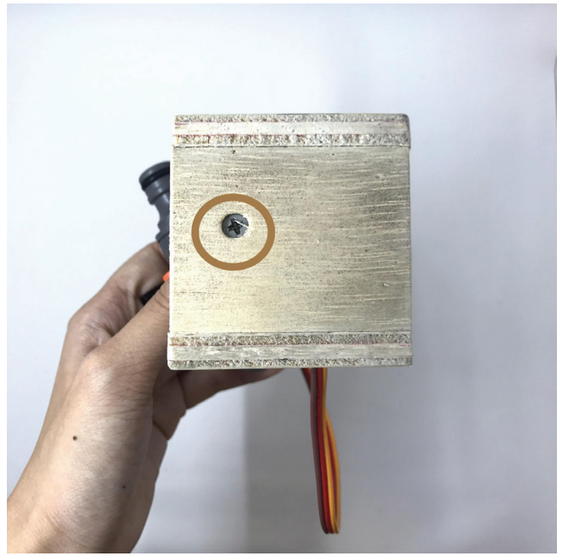
Instructions:

A. Tap Valve Component

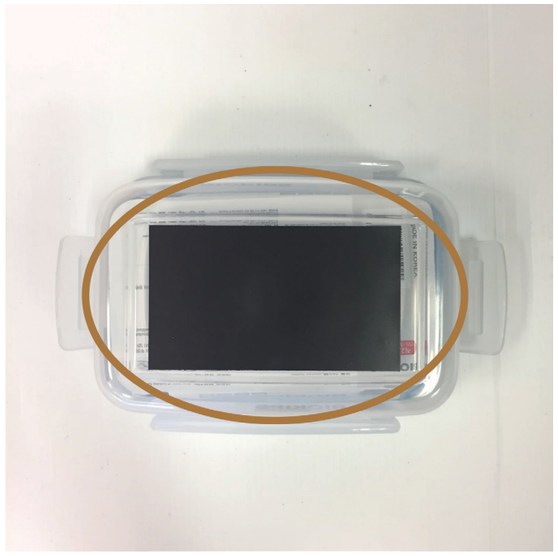
1. Drill a hole through the side of a wooden box. Screw a large servo onto the bracket. Ensure that the servo fits snugly in the box.

2. Drill two small holes through the tap valve, and screw the tap valve to a large servo. This ensures that the servo twists the valve.

3. Drill a hole on either side of a wooden connector. Screw one end to the grey pipe of the valve. Screw the other end to the base of the wooden bracket. This keeps the grey pipe of the valve in place.

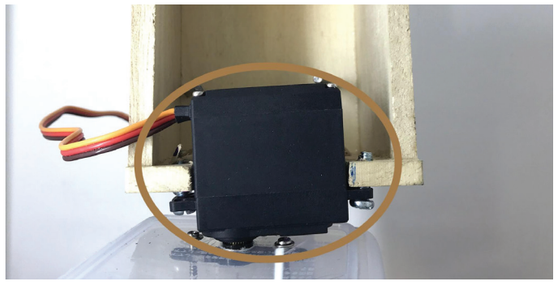


4. Attach a magnetic card to a small plastic box. Drill a hole through the box for the wires connecting the servo to the Arduino to pass. Place the Arduino, transceiver and a power bank in the box and attach it to a nearby metallic surface.



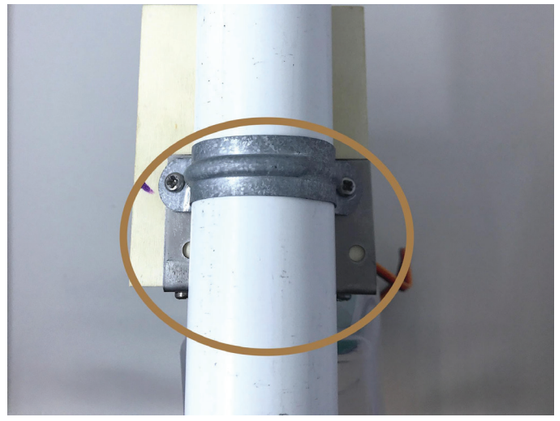
B. Rotating Sprinkler Component

5. Drill two holes on one side of a wooden box. Attach a large servo to the wooden box with two screws. Ensure that the servo fits snugly and tightly in the box.



6. Fit a curved bracket around a PVC pipe and use 2 L brackets to hold the weight of the wooden box.

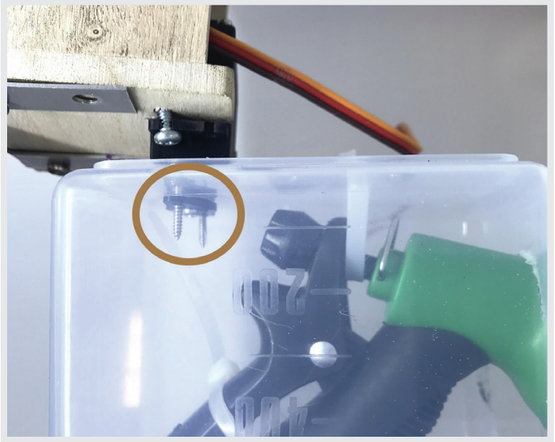
7. Drill two holes through the base of the wooden box. Screw it onto the curved bracket. It should be attached to the PVC pipe at this stage.



8. Using a Dremel, carve a circular hole in a plastic box big enough to allow the sprinkler head to pass through.

Sprinkler System (cont)

9. Drill three holes through the top of the plastic box. Screw the plastic box to the servo using 3 screws - 1 in the middle and 2 at the sides. The middle hole is used to screw the box to the rotating mechanism of the servo.



10. Drill two holes through the base of another small plastic box to contain the Arduino, transceiver and power bank. Attach the box to the pipe using a cable tie.

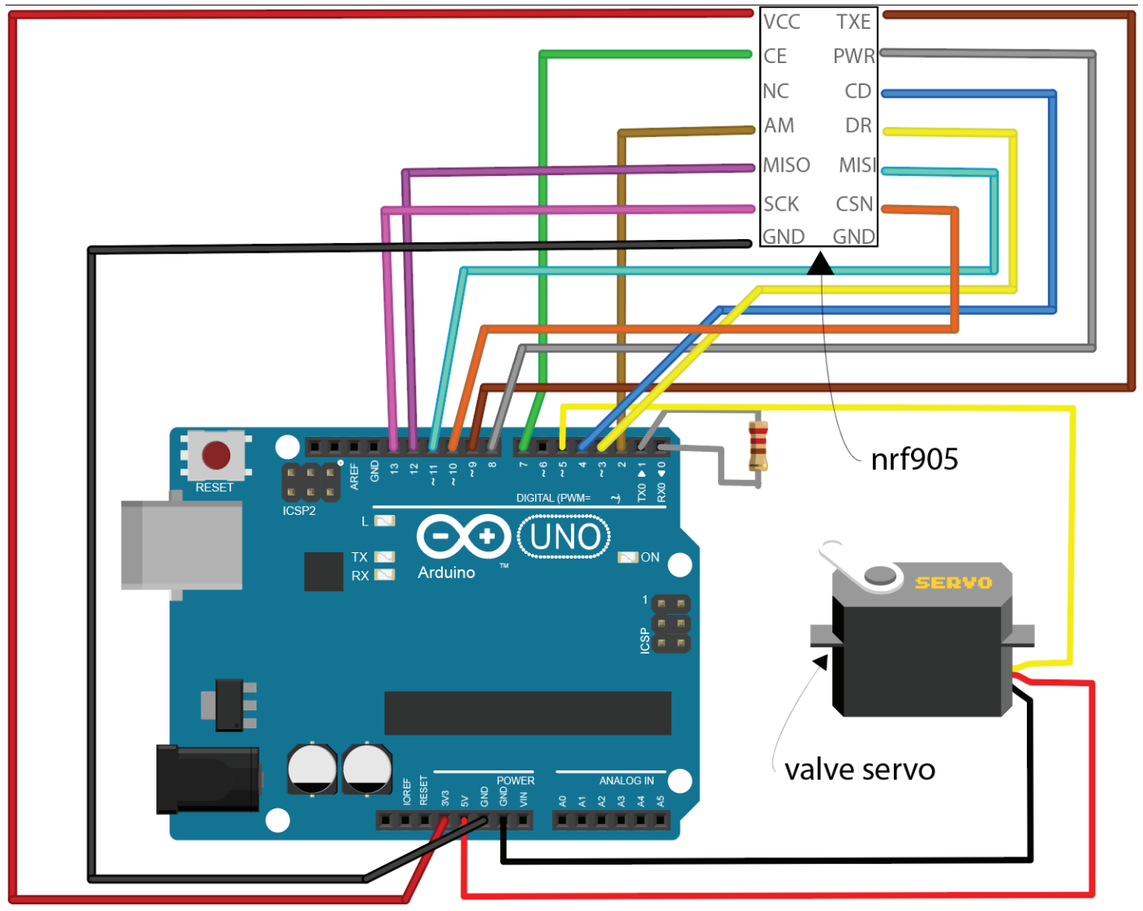
Points of consideration:

Initially, the sprinkler servo was too small to withstand the weight of the sprinkler and the plastic box attached to it. Make sure to use a big servo with strong power to hold the combined weight of the plastic box and sprinkler.

When creating the wooden box structure to hold the weight of the sprinkler and the plastic box, ensure that the wooden box is sturdy enough to hold the servo in place. We found that minimizing the number of components used to create the wooden box structure made the structure more robust.

The wooden box structure used to hold the tap valve servo in place needs to be study enough to prevent the servo from moving when it is activated. We recommend to use a thick wooden connector to ensure that the wooden box has enough grip to hold the tap valve in place.

Arduino setup:



Code:

The hose will receives signal “turn 120” which activates the valve servo on the hose.

```
void onResponse(String command) {

  if(command == "TURN HOSE 120"){
    angle = 120;
  }else if(command == "TURN HOSE 0"){
    angle = 0;
  }
}
```

Code

Now that we've broken down how each component works, it's time to get it running electronically with code! The code can be downloaded from

https://github.com/sadhikabilla/Orangutan-Enrichment

There are 3 modes for each system:

Manual

In the manual mode, the zookeeper triggers either the feeder to dispense or the hose using a button input.

Debug

In the debug mode feeder and the hose are separated. This is done for ease in debugging each component.

Automatic

In the automatic mode the vines act as the touch sensors & these sensors trigger the hose or feeder accordingly, depending on the signal received (currently feeder triggered at 1 hour interval as requested by Kumaran, when the feeder is inactive, hose is triggered)

Sustainability Plan

Enrichment devices promote new behavioural habits that can be beneficial for the Orangutans wellbeing. It is doubly important to keep everything running smoothly by maintaining the vine, feeder, and sprinkler systems well.

Cleaning:

We thoughtfully designed each of the three components as modular pieces such that anyone can easily remove parts to clean. For example, the feeder consists of 3 layers that can easily be detached. The motor feeder dispenser (with augur screw) can be removed from the mount. The second layer of the feeder can be taken apart, and the hopper connected to it can easily be detached. The box of electronics which lie on the last layer can also be removed in an accessible way.

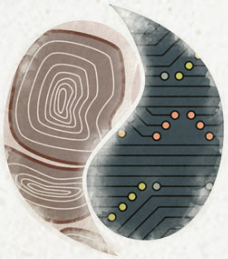
Replacement of parts:

Moving forward, our prototype can be replaced with other durable materials to ensure their longevity.

We recommend replacing most of the raw plastic materials with metals such as steel, or wood.

All seemingly loose screws can also be bolted down, instead of relying on screws. In addition, each system can also be housed in a durable outer shell that can appear to be more naturalistic when placed in the exhibit.

For example, the opening of the sprinker system can be camouflaged within the surrounding trees, and the automated feeder can be covered within a metal tree stump (as suggested by Kumaran).



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Department of Communications and New Media
National University of Singapore

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