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ME 153 Final Report - Automatic Plant Rotator

Introduction:

Hanging plants are common everyday household décor, typically hung in front of a window. The hanging aspect of the plant allows the user to make better use of space as well as place the plant directly in front of a window for sunlight exposure. The problem arises from an uneven distribution of sunlight exposure to all sides of the plant. In order to prevent too much light exposure to the plant, someone has to manually take the hanging plant off the hook and rotate it. Then, hang it back up. This can be burdensome depending on how or where the plant was hung.

In addition, this can be problematic depending on the user, for instance elderly, short, or weaker individuals would have a difficult time reaching the plant and holding its weight. Furthermore, all users face the problem of remembering to rotate their plant after the proper amount of time to prevent asymmetrical growth and possible leaf scorch.

This report presents one possible design solution to the problem of rotating hanging plants. Our solution was to design a product that will automatically rotate the plant, in quarter increments, based on the amount of time the plant is exposed to sunlight. The key functionality of our solution was being able to turn our plant by some DC motor when a voltage is supplied. The design solution is presented in the form of a sketch in Figure 1.

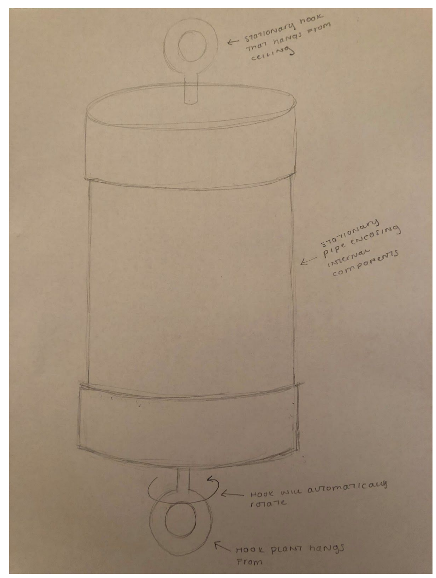

Figure 1: Overview sketch showing the key functionality

Prototype 1:

The first prototype aimed to establish the rotating mechanism of the design. The design of the first prototype was a plastic pipe with removable caps at both ends. A metal hook is assembled to through the center of the top cap. Both the top hook and pipe were to remain stationary. The rotating mechanism was another hook with a threaded shaft placed through a center drilled hole in the bottom cap. Additionally, two styrofoam disks were fashioned to have a diameter equal to the inner diameter of the pipe. These styrofoam disks were secured on the shaft using nuts and washers in order to provide stability to the hook for smooth rotation. This initial prototype consisted of the base assembly of the plant rotator, as well as the rotating mechanism.

Figure 2a: Prototype 1

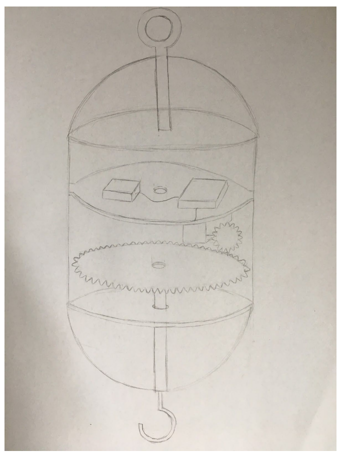

Figure 2b: Sketch of Prototype 1

The prototype was then tested by pulling on the hook while manually rotating it. This test proved successful as the hook was able to smoothly rotate through the drilled hole.

However, the styrofoam disks did not provide an adequate system stabilization. This could be improved by using a more sturdy material with lower friction for the disks. Also, after this prototype, a design to automate the rotating of the hook needed to be designed.

Prototype 2:

The second prototype was an iteration of the first with added motor function in order to rotate the coupling located at the bottom of the apparatus. Motor function implementation involved adding a placement holder for the motor, as well as an attachment in order to connect the motor shaft to the rotation coupling. The motor was powered using a 9V battery. Additionally, the previous

Figure 3a: Coupling mechanism attached to hook's shaft

Figure 3b: Motor used in Prototype 2

prototype was also sized down in order to have a more compact design.

When testing the rotation aspect with the implementation of the motor, the hook rotated freely. The ability of the prototype to sustain weight was also successfully tested by hanging a substantial amount of weight, more than that of a typical plant, from the rotating hook.

However, problems arose when testing the rotating of the hook with weight. The rotation would initially rotate the plant properly, but then it began to slip when the weight got too heavy. Therefore, this design could be improved by reinforcing the connection between the motor shaft and the rotation coupling, as the sizing was not completely fit to the shaft. This can be done through a different size connection with the use of a pre-manufactured coupling with a concentric tightening mechanism.

Prototype 3:

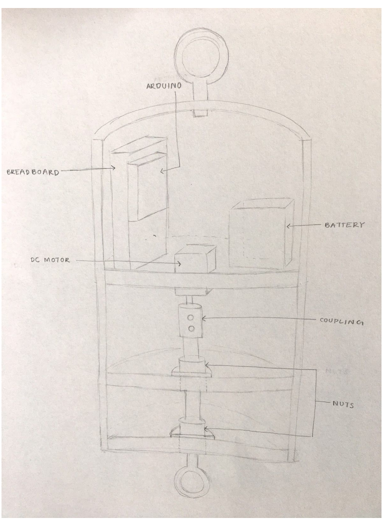

Figure 4a: Sketch of Prototype 3

The third prototype was an iteration of the second. For this prototype, a timer-based code for an Arduino Nano was started, the 9V battery was replaced by six double A batteries since the 9V battery did not have the proper capacitance, the motor was replaced by a larger motor having more torque and a lower rpm, and the coupling was enhanced to prevent slipping. The styrofoam disks were also replaced with wooden disks for more stability.

When tested with weight, the hook was able to properly rotate without slipping, thus, the mechanical rotation aspect of our design when subjected to substantial weight was successful.

However, the wooden disks still needed to be replaced with a more precise cut, low friction material for optimal stability.

Figure 4b: New motor (DC 6V, 3 RPM)

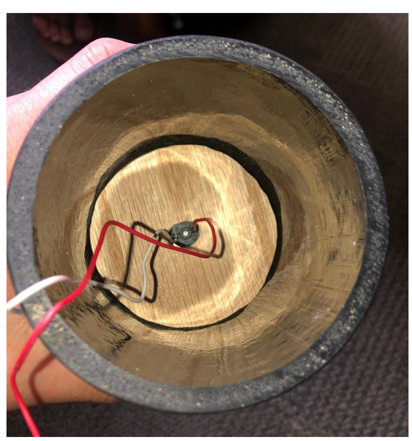

Figure 4c: Wooden disk and motor placement on top disk

Prototype 4:

The fourth prototype included finishing the arduino timer-based code and breadboard circuitry as well as replacing the wood cut disks with precision cut smooth plastic to better align the drive shaft, reducing points of friction and increasing overall stability.

When this prototype was tested with weight, the stability and rotation of the motor was greatly improved from that of the previous prototype. Overall, the mechanical rotating aspect of our design was finalized at this point. Further progress after this prototype was mainly focused on the Arduino aspect of our design.

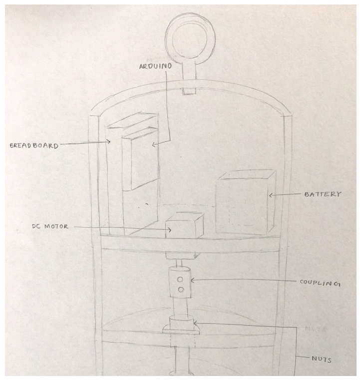

Figure 5a: Sketch of Prototype 4

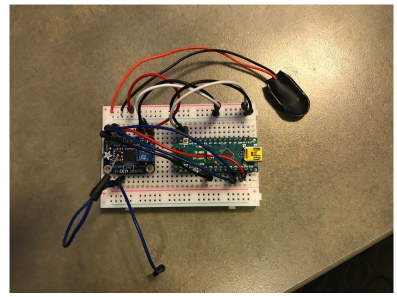

Figure 5b: Breadboard circuitry for Time-Based Arduino code

However, problems arose when trying to perfect the timer based code for the arduino nano. There was trouble when coding to tell the motor when to spin and when to be still. The improvements could be to perfect the timer based code, and start writing a light-based code as well.

Prototype 5:

This prototype was an iteration of prototypes one through 4. The goal for this prototype was to add screws in order to further stabilize the device, implement the photoresistor in the arduino code, add air holes to the cap to reduce heat, and add a hole for the photoresistor on the side of the pipe.

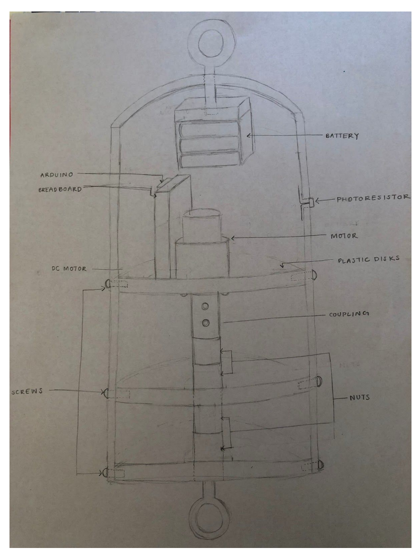

Figure 6: Sketch of Prototype 5

Threaded holes were drilled into the sides of the tube through to the plastic disks and screws were added to prevent movement of the disks, ensuring further stability. Holes were also drilled in the cap in order to screw the caps to the pipe to make certain that the caps stayed on the apparatus. This improved the soundness of the device as more than the desired amount of weight was able to be rotated. Also, the air holes helped dissipate heat from inside. When the Arduino code was tested with the photoresistor, an LED light was able to be turned on when exposed to light versus off when there was no exposure to light.

The arduino code worked in certain settings, but not all environments. The photoresistor would sometimes read values but not rotate the motor. This is a problem because our design is dependant on the light sensor working correctly. The improvement would be to calibrate the photoresistor correctly to tell the motor when to turn and for how long.

<u>Prototype 6:</u>

This prototype was the integrated product of our electronic and mechanical design components, and is an iteration of prototypes one through five. We incorporated our knowledge of arduinos, mechanical design, and course theory to construct the final product. Our design brought together the light sensing-timer code with the plant rotator shell and its internal components. The code was written such that the photoresistor continuously reads light intensity in terms of bits. The code then has three thresholds. The first for when there is no light and there is no motor rotation. Then, when the light intensity reaches a certain bit value, the time based code is run and begins counting. After it has counted three days of light intensity, the motor rotates. The last threshold is when the light intensity reaches an upper value, in which the motor will then rotate prematurely. This is done for high levels of sun exposure as to prevent leaf scorch of the plant.

Figure 7a: Plant rotator shell (left) and inner components (right)

For testing and presenting purposes a code was written and tested such that the photoresistor would rotate the motor if it sensed no light. Our prototype is fully functional and when tested, the photoresistor turns the DC Motor if it senses a change in light intensity (i.e. no light hitting the photoresistor). This performs as expected, but there could be a couple improvements.

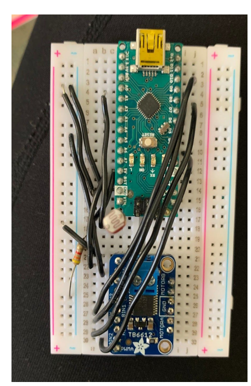

Figure 7b: Breadboard with wires consolidated

A few improvements from this prototype are to create an easier access to the battery pack for when the batteries run out and better secure the battery pack and breadboard inside the pipe. Improvements for the next prototype includes using a longer lasting power source such as rechargeable batteries with solar panels, replacing the breadboard with a printed circuit board, adding more photoresistors to obtain light intensity readings from multiple directions, and making the internal components more secure.

The overall functioning of our design for this final prototype is that when a 9V power source is supplied to the device, a photoresistor reads light intensity and communicates with an Arduino. If the light intensity is above a certain threshold, for a specified period of time, the Arduino then tells the motor to rotate. The motor is mounted on a plastic disk with the shaft fastened to a motor coupling. This coupling enables the motor to delivertorque to the rotating lower hook. Two plastic disks are also screwed within the pipe to prevent the motor from bearing vertical weight and to ensure concentricity of the rotating components.

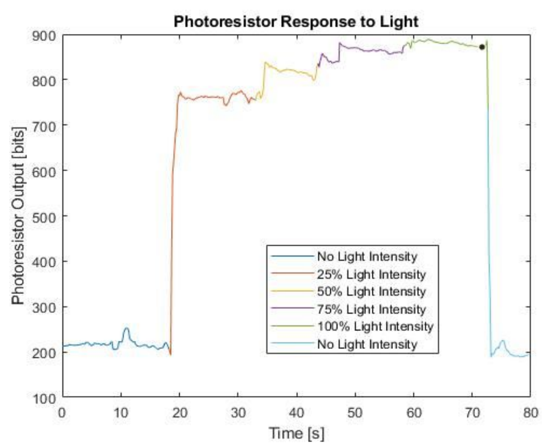

Figure 8: Photoresistor Analysis

Reflection:

1. The design process took a lot of time to implement. Our team's product took many hours to: formulate a problem which needed to be solved, figure out multiple solutions to the problem, then building the design over a six week period.
2. We succeeded in meeting all of our deadlines on time, and presenting a final product which was fully functional and worked. We failed when it came to optimizing our design to its full potential (i.e. solar powered, more compact, PCB).

3. We believe our prototype shows promise, as there aren’t any automatic plant rotator devices. It might be worth developing further if we could get the device to run solely on solar energy and creating a more compact device which would be able to spin heavy plants.
4. The next iteration would include solar panels with rechargeable batteries to have the device run itself and maybe condensing the circuitry with a PCB.
5. This quarter was tough because of all the classes group members took this quarter, but we were still able to find time to build prototypes and meet to brainstorm possible improvements. Our team worked smart and efficiently, as our design ended up being fully functional, so we believe this was a successful quarter.