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HCDE 451
March 12, 2018

A10 Final Report - Infinity Mirror Frame

Concept

For my final project, I designed and created a frame for an infinity mirror.

My infinity mirror, mounted on a wall and powered up.

The “infinity” effect of an infinity mirror occurs as the result of light reflecting between two parallel mirrors. This effect can occur either in a room with mirrors on opposite walls viewed from within, or on a flatter surface by making one of the two mirrors a one-way mirror, causing any objects or light sources between those mirrors to reflect back and forth, creating a perception of depth.

For my project, I make use of the latter effect here by placing an LED strip between two mirrors, one of which is one-way, to make a thin frame appear to have a 3D dimension. The LEDs are powered by a controller box that I built into the frame, and controlled by the box’s remote for which I built a holder onto the front of the frame, allowing users to control the lights either with the remote mounted or from across the room with the remote removed. The frame can be hung on a wall by a hole on the top of the frame, and the LEDs are powered by a 12V input in the bottom left of the frame.

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Goals

Given that I knew that the infinity mirror effect was feasible, my goal in creating this prototype was to evaluate desirability and usability. With my prototyping process, I sought to answer these evaluatory questions:

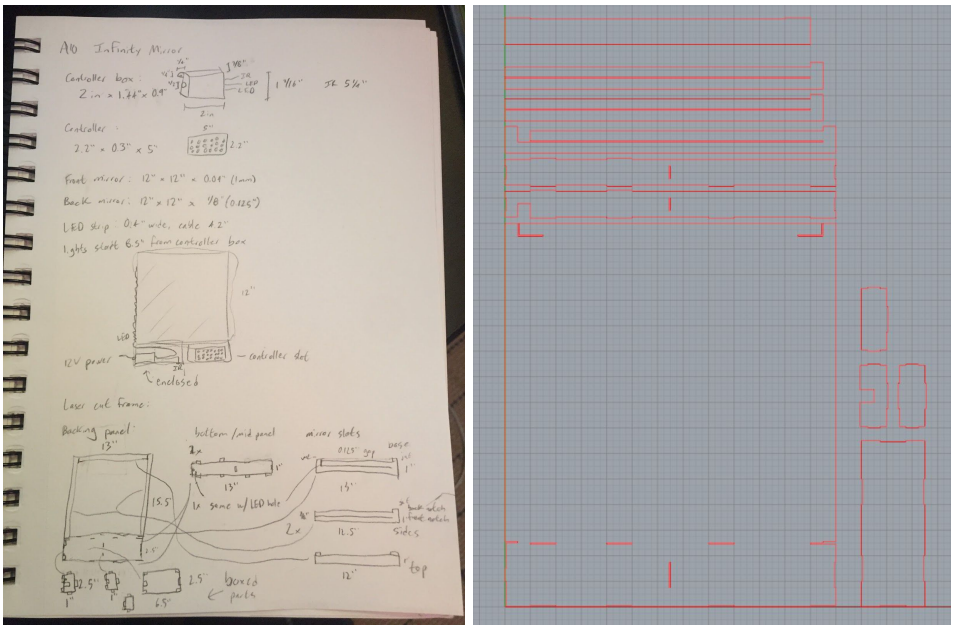
- How can I create an infinity mirror frame such that the resulting effect was desirable?
- How can I hide the frame's internal electronics in a desirable fashion?
- How can I incorporate the LED controller remote into my design such that it is usable?
- How can I create a usable frame such that my prototype could be mounted on a wall?

Process

To test my concept, I planned to first create a laser cut frame to evaluate the infinity mirror effect with a basic prototype before creating a second iteration out of 3D printed pieces attached to a back panel laser cut to shape.

Laser Cut Prototype - Implementation

As my prototype involved external components—a mirror, a one-way mirror, an LED controller box, an LED controller remote, and a 12V power supply—I began by measuring out the dimensions of each of these objects to prepare myself for incorporating them into my designs. I then sketched out my laser cut design, where I planned to place the controller box and remote below the mirror such that the controller box was hidden and the remote was easily accessible.



Measurements and laser cut prototype sketches (left) and laser cut model (right).

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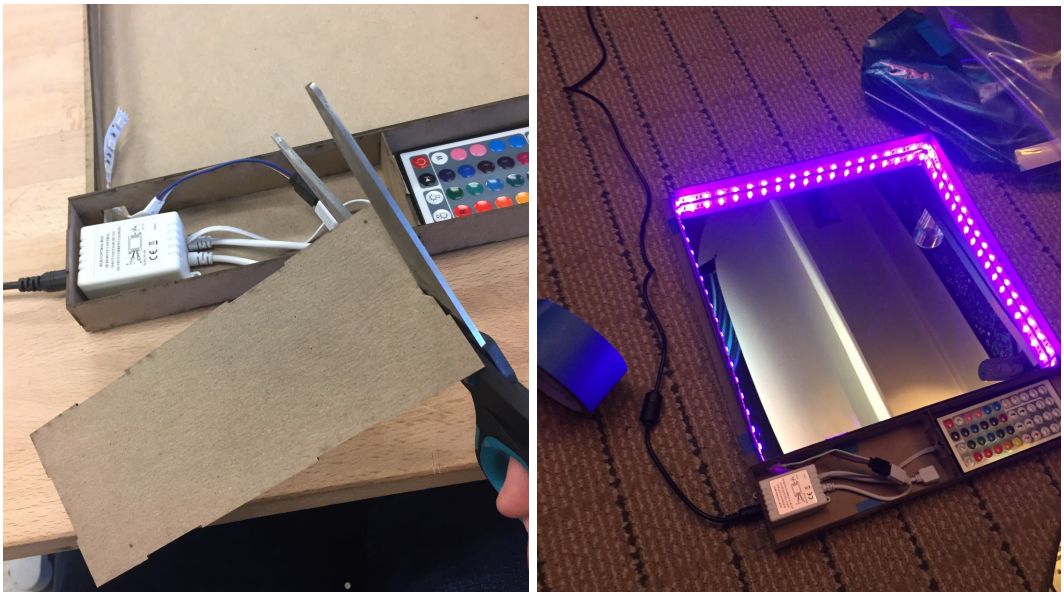
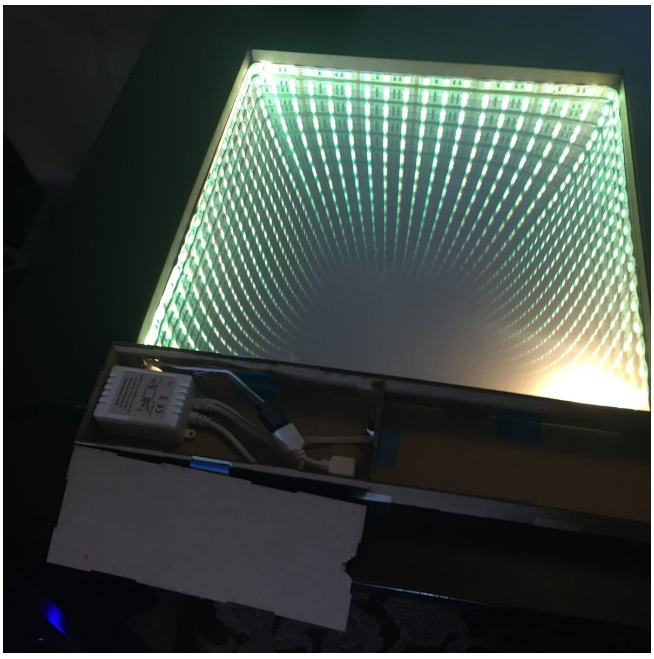
I laser cut my model without issue, but as I assembled my first model, I discovered two issues I had not previously considered: the controller box's infrared receiver did not work through the chipboard, and the mirrors were slightly smaller than the advertised 12 by 12 inches. To remedy the IR receiver issue, I cut a small hole in the enclosure.



Cutting a hole for the IR receiver (left) and assembling the prototype (right).

Despite the discrepancy in mirror size, I successfully achieved the infinity mirror effect:



Laser cut infinity mirror prototype with enclosure open.

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Laser Cut Prototype - Evaluation and Analysis

With my laser cut model complete, I moved on to evaluate my first prototype. As I decided not to attempt to mount my laser cut prototype, I was left with three evaluative points:

- Does the effect work desirably?
- Are the electronics hidden fashionably?
- Does the LED controller remote work as expected?

From my own evaluation, I found that as a result of flimsiness of the chipboard and the discrepancy between the mirrors' reported 12" size and actual size, the one-way mirror on top would slip below the LEDs, causing the infinity mirror effect to become distorted. This result led me to measure the mirrors and plan to provide a quarter-inch margin in my next prototype that would hold the mirrors securely in place. When I held the laser cut prototype vertically, I found that the LED controller remote would sometimes fall out of the space I had designed for it. To account for this in my next prototype, I planned to design a clamp that would mount it in place over the controller's enclosure.

I also conducted a brief, informal usability evaluation where I asked a participant to plug in the mirror and use the remote to change the color of the LEDs. I have uploaded this evaluation (which I unfortunately recorded in portrait mode) to Vimeo: https://vimeo.com/259810028. From this evaluation, I learned on the positive side that the power plug works effectively in the controller box's enclosure but that at the same time, the enclosure seemed to block the remote's IR signal from successfully reaching the controller from any angle other than directly pointed at it. As such, I planned to provide a wider space for the IR receiver in my next prototype.

From the evaluation of the laser cut prototype, I came up with four changes:

- Mount the LED controller remote on top of the LED controller enclosure
- Measure the mirrors to provide a solid, supporting frame
- Create a wider IR receiver gap
- Add a hole to mount the frame on the wall

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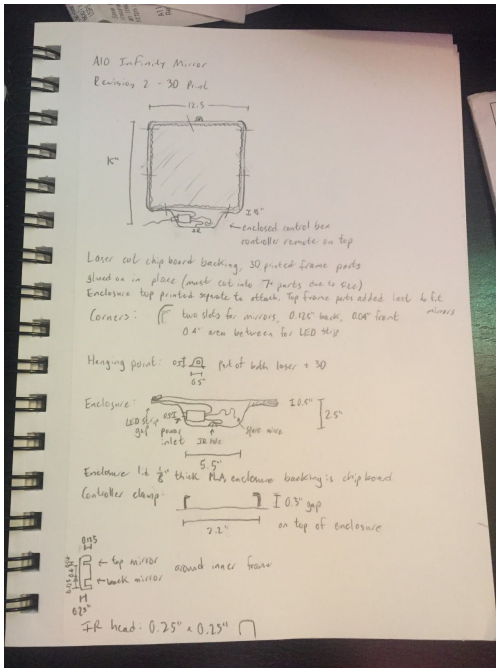
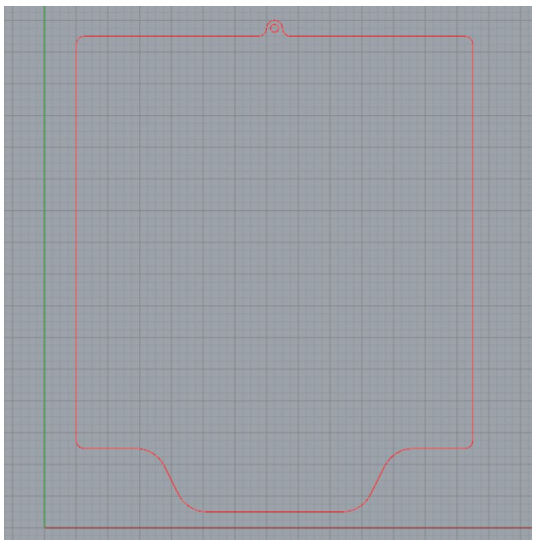
3D Printed Prototype - Implementation

To begin my 3D printed prototype, I sketched out my design in consideration of the changes learned from the evaluation of my laser cut prototype.



Measurements and sketches for 3D printed revision.

I planned to use laser cutting for this prototype for the backboard of the model, providing me a stable, thin backing to my prototype.



Laser cut backboard model.

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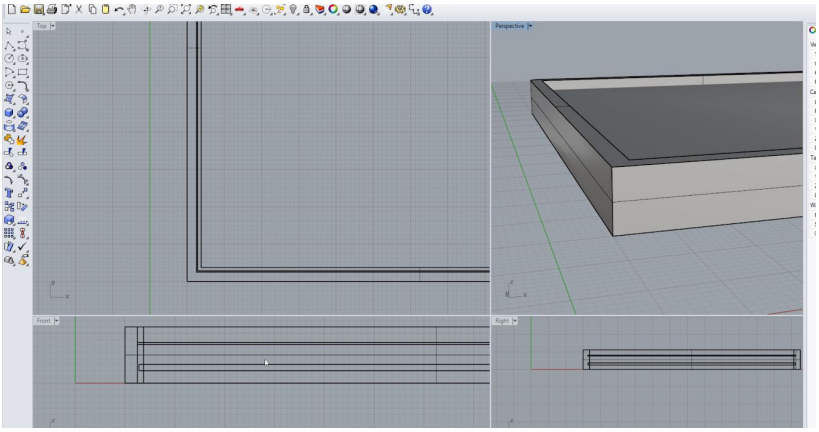
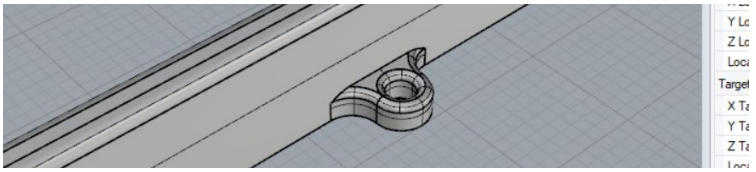
With this backboard as an outline, I proceeded to model my design in Rhino3D, where I began by creating the frame portion of the prototype by using extrusion and boolean operations. First, I created the main frame by extruding the frame area and then subtracting the inner space from it. To make space for the mirrors, I again used extrusion to create 3D objects the size of the mirrors, and subtracted those from the main frame.



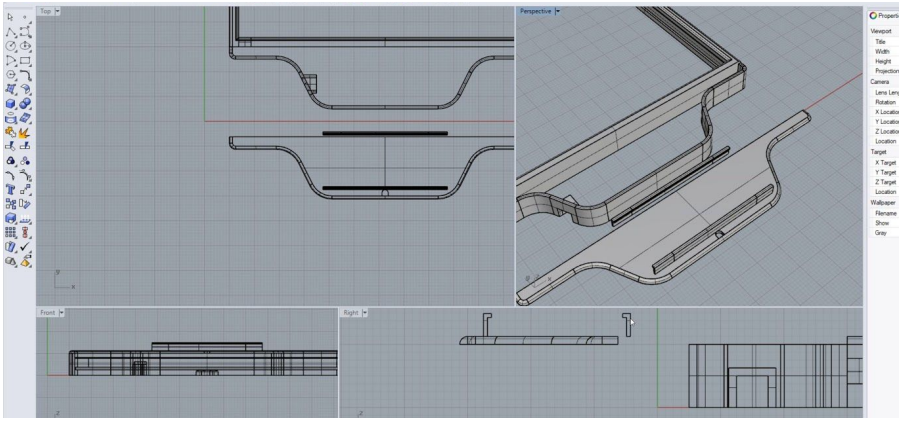
Initial progress, modeling the frame section of the prototype.

Then I added a small gap on the top of the frame that could be used to mount it on a wall.



Mounting hole, made a quarter-inch thick to stably hold the infinity mirror.

With the main frame done, I then modeled the enclosure section of the prototype where the controller box would sit and the controller remote would mount. I also created a quarter-inch gap in the base of the enclosure lid for the IR receiver to protrude out of.



Further progress, with the enclosure walls complete and working on the remote mount.

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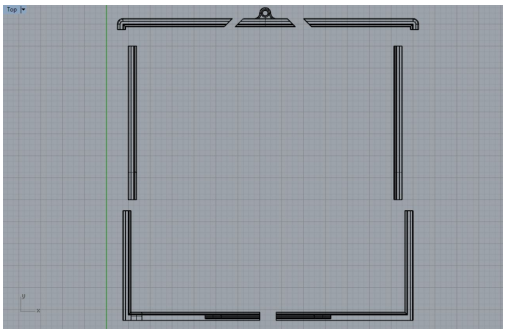
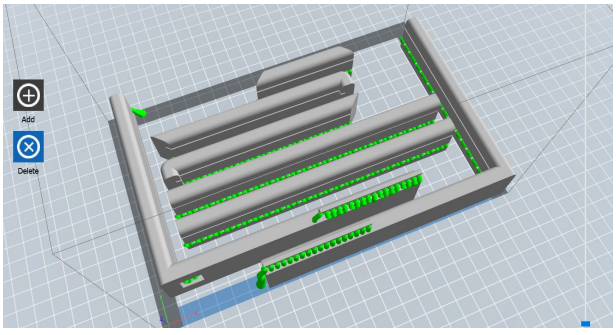
With my model complete, I proceeded to explore how I would print a 12.5” x 15”model in a 3D printer with a 9” x 6” build area. I researched online and found that a 3D model can easily be split into pieces and the parts reconnected with super glue, so I began considering how to break up my model. I also knew that I would need to separate the top of the enclosure to add the controller box and the top wall of the frame such that I could slide the mirrors in after lining the inner frame with LEDs. To achieve these needs, I used cutting planes to split my model into 11 pieces: four enclosure pieces and seven frame pieces.



The mirror frame, split into seven pieces.

While I initially expected to need to do eleven separate print jobs, I realized I could place several pieces into single models to save time. At first, I reduced my eleven pieces into five prints, but then with the help of a CoMotion Makerspace employee I was able to fit everything into just two print jobs.

In preparation to print my model, I auto-generated supports, creating them in the mirror gaps and in the remote mount clamp. In some places however, supports were not generated where they needed to be. At this point, I also learned from a classmate about his troubles fitting together moving parts and I read online about how PLA typically requires a 0.5mm tolerance to fit together multiple pieces or external components. To be safe, I increased the back mirror’s slot from 1/8” to 3/16” and created a slant upward from the front mirror’s 0.04” slot. These changes increased the tolerance for fitting in the mirrors, allowed supports to be generated consistently for the back mirror slot, and removed the need for supports on the front mirror slot. The mirror ended up barely fitting into the printed frame, so these changes turned out to be vital.



Preparing the model for printing.

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Both of my print jobs completed successfully, though the edges of the pieces were a bit rough and uneven where I removed the print brim. These imperfections impacted the model's ability to fit together nicely, so I spent a few hours clipping and filing the edges to shape. The supports also failed to print correctly in a few places, but this issue did not impact the model's form.

Clipping and filing the supports and edges from the model.

I then began assembling the prototype by super-gluing the pieces together and onto the backboard that I had laser cut. As I went, I added the LEDs and controller box before adding pieces that would limit my access to these components.

Assembling the model.

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After some trouble fitting connecting the LED strip to the top pieces, as the mirrors prevented me from reaching the LED strips to tightly bind them to the top part of the frame, I had completed my 3D printed infinity mirror prototype.

Complete infinity mirror prototype, with the LEDs off.

3D Printed Prototype - Evaluation and Analysis

To evaluate my prototype, I ran through the same tests as I did with the laser cut prototype to evaluate the following:

- Does the effect work desirably?
- Are the electronics hidden fashionably?
- Does the LED controller remote work as expected?
- Can the infinity mirror be mounted on a wall?

I additionally brought this prototype to class for the final project showcase. Between that and sharing the prototype with friends, I gathered some feedback about where I could improve the prototype in future iterations.

As with before, the infinity mirror effect worked desirably, and with this prototype the mirrors stay stably in place. However, as a result of my struggles lining the top of the frame with the LED strips, the strip is adhered messily and I left several fingerprints and glue marks inside the top of the mirrors where I cannot reach to clean them off. Many people commented on this blemish. In a future revision I would split the top of the frame into additional parts such that I could attach the LED strip to the bottom half of those pieces before boxing them in with the mirror.

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While the electronics were hidden in much the same way as the first prototype, the centered approach—with the remote mounted on the enclosure—looks far nicer than the off-balance approach I took initially, with the enclosure on one side and the remote on the other.

With this prototype, the LED controller remote works far better than on the laser cut prototype. Not only does the signal work from almost any angle, it works while the remote is mounted on the frame (though this may be because IR signal goes through PLA and not chipboard). I had not originally planned for this feature, but it allows users to control the LEDs without ever removing the remote. I had hoped that the remote would “click” in and out of its mount, but instead the mount sturdily holds it in place, requiring the user to slide it in or out from the sides.

When I mounted the mirror on a wall, I used a simple picture frame nail. The mounting seems stable, but the mirror tilts to one side due to the off-center weight from the controller box. In a future iteration, I would place a balancing weight on the other end to counteract this effect.

From the evaluation of the laser cut prototype, I came up with three changes:

- Redesign the splitting of the model such that the LED strips can be adhered to the top of the frame more easily. This change could be easily done by splitting the top frame pieces at the point where the outer mirror sits.
- Widen the remote mount such that it could click in and out rather that just slide.
- Place a balancing weight in the enclosure to allow the frame to hang without tilting.

Conclusion

Overall, I found the process of modeling this infinity mirror frame to be rewarding and educating, as it required that I split my model up to fit in the printer as well as account for tolerances with real-world objects such that they would fit cleanly into my prototype, neither of which we had previously discussed in class to my knowledge.

Moving forward, I plan to use what I learned from these evaluations to create an improved, modified version of this prototype that has an infinity mirror on both sides of the frame to create an “infinity tunnel” illusion. This iterative process of implementation, evaluation, and analysis has been very helpful towards creating a product that I can enjoy hanging on my wall, sharing with friends, or placing on my portfolio.