Customizable 3D-Printed Phone Cases

CS 581 Computational Fabrication

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Introduction & Motivation

The idea of implementing a sliding puzzle was from browsing the existing products of the phone case market and noticing little to no interactive components other than PopSockets and other various forms of assistive hand-held methods. Instead of purchasing off-the-shelf products, we wanted to provide a solution where users can easily customize a phone case, which would be easily fabricated using 3D printing. We also wanted to integrate a fun component that hasn't been implemented on a phone case before. After some discussion, we settled on an idea of combining a sliding puzzle and a phone case.

Related Work

Some of the related works that went into the design would definitely have to be existing products on the market today. Examples would have to be phone cases that already have implemented PopSockets[1], Pop-It Bubble Wrap[2], and Standing Phone Cases[3]. After researching on the market, we eventually saw the opportunity of making something that wasn't seen on the market. This provoked the idea of implementing a customizable puzzle piece that can be integrated into any type of phone case.

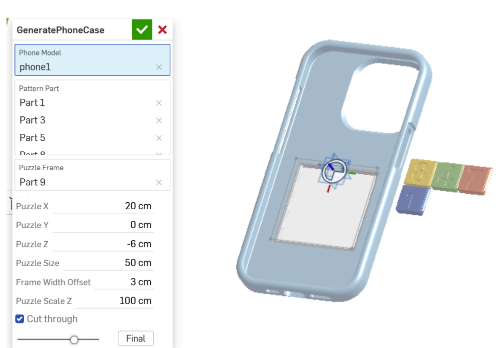
Approach

In the development of the approach of designing the phone case, we had first struggled with how we wanted to have the phone case look like. In our earlier iterations, we mostly focused on the direction of innovating user usability while accomplishing aesthetic appeal. However, after a couple of iterations we decided to focus on creativity and eventually settled onto the idea of integrating a sliding puzzle.

Computational:

In the process of computationally creating the design, we had decided on using Onshape as the interface and to allow users to select their preference on phone models, selecting dimensions puzzle piece holders, as well as the puzzle tiles. One of the main issues that were computationally caused would be the usage of Onshape for new users, and also the difficulty to manipulate 3D meshes for phone model designs.

- **Problem:** The computational problems on Onshape were the models of the phone cases and puzzles were classified as meshes, meaning it had no specific lengths and center. Which in return made it hard to adjust the puzzle size and position for customization. Also, because mesh is hard to edit, it also makes it hard to modify the basic case model. For example, it is impossible to thicken the back of the phone case to match the width of the puzzle automatically.



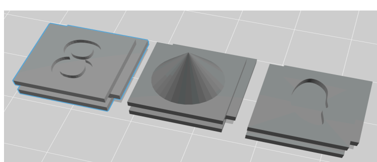
- **Solution:** As for the solution to this issue, we calculated the bounding box to acquire the model's length and center. These values are used in basic transformations like translation and scaling. For more difficult modification like model editing, we used boolean operations, without modifying the basic model mesh. For example, we applied boolean subtraction on the phone model to cut through it and put our puzzle on it. We also used boolean operations to customize the tiles.

```
const getLength = function(body, axis)
{
    const bounding_box = evBox3d(
        context,
        {
            "topology" : body,
            "tight" : true
        }
    );
    return (bounding_box.maxCorner[axis] - bounding_box.minCorner[axis]);
};
```

Fabrication:

To fabricate the product, we went through various iterations dealing with issues of sizing, printing, and combing pieces together. The fabrication process is divided into two: the phone case and the puzzle pieces.

For the phone case, we sourced readily-made phone case 3D models from thingiverse. We wanted the phone case to be durable for everyday usage, while maintaining some level of flexibility so that phones could be easily manipulated into the case. While we first attempted to print initial prototypes using PLA from the readily available MakerBot FDM printers, we failed due to the warping issue discussed below. Printing with TPU and flexible resin provided the properties we desired. We ended up using flexible resin to print the final case product since it was much cheaper than TPU to print. Flexible resin prototypes were around $1 each, while TPU prints cost around $16. All case products were fabricated at the EPIC studio. The puzzle frame is integrated into the case, with the same material as the rest of the case. While we were initially concerned that the flexible property of the case might make the puzzle pieces fall off easily, the frame part turned out to be rigid enough to contain the pieces with a tight fit.



The puzzle pieces were printed with PLA with the MakerBot printer, since they did not require a specific material property. Through the pipeline, the pieces are scaled along with the puzzle frame to fit different phones. While the pieces printed in default scale can still fit the puzzle frame, they can be a bit tight or too loose to move around. In order to secure a right fit for the pieces, we had to further fine-tune the scale of the pieces. The resulting scales we used was -3% to +3%, depending on the phone model. For the 3x3 puzzle we used for this project, it took around 40 minutes to print all eight pieces. While printing all eight pieces in one printing iteration would save more time, we printed the pieces in three batches to avoid warping from premature cooling.

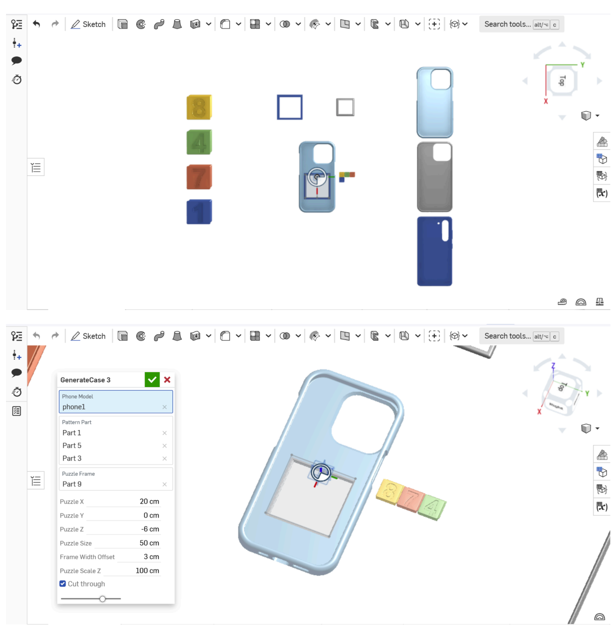
One major challenge in fabrication was warping. This mostly occurred due to the open environment of the printer. External airflow ended up prematurely cooling the printing object, which caused warping and evantually the object fell off the printing plate. This issue was exacerbated with large and flat prints such as phone case and sliding puzzle prototypes.

After consulting with the Grad TA, we learned more about environment shielding by closing the open areas of the 3D-printer as this could prevent warping to occur and relieves the stress of warping any future iterations. As shown in the figure above, we covered three open sides of the printer to prevent external airflow disturbing the printing process. This resulted in improved results. As demonstrated in the figure below, we were able to drastically decrease warping with environment shielding. However, it was not completely resolved as warping still occurred for large objects such as a phone case. This became the main reason why we did not print our cases using the Makerbot printer.

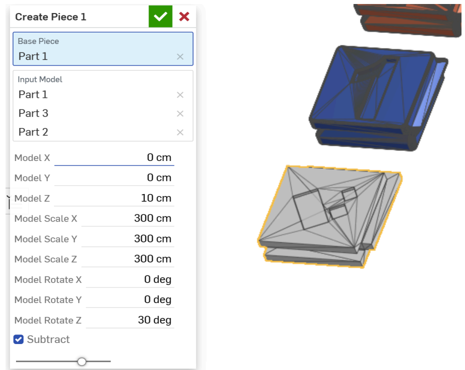
Results

As a result of the project, we were able to fully develop a working prototype of an integrated phone case with a working puzzle piece. In earlier developments, our first idea was to plan out on how to display the puzzle and develop more of a customizable option for users. We began by printing both the puzzle piece and phone cases, and even tested out different prints and designs. We believed that we had satisfied our project goals of making a customizable phone case as we were able to provide customizable options with diverse users having either Androids or iPhones.

1. Interface:



2. Customizable dimensions of tile pieces:



3. Finalized puzzle phone case:

Individual Contributions

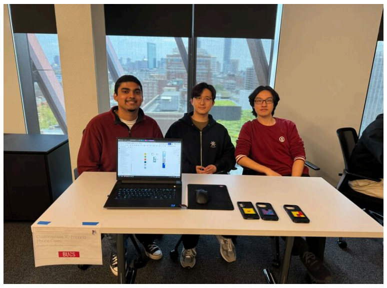
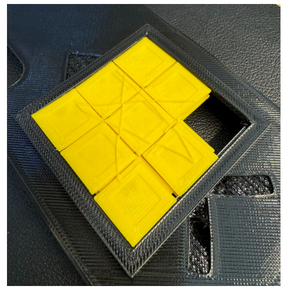
John: Fabricated the phone case and puzzle. Printed and tested prototype models for the phone case and sliding puzzle. Fine-tuned and tested the scale of the puzzle pieces so it would be easily slidable without falling apart. Coordinated with EPIC lab to fabricate phone cases with desired strength and flexibility.

Chunhao: Designed the pipeline to let users customize their case on OnShape. Implemented the pipeline using FeatureScript provided by OnShape. Designed the UI that users can interact with, together with default case sets and piece designs that the user can choose from.

Dylan: I had made some designs for the puzzle in the earlier iterations. After meeting with the professor and considering emphasizing customization for the project, the team had agreed on the ideas of making an automated converter to pipeline of rendering PNG (2D images) into STL files (3D images), via Python scripting. I had begun working on the converter but soon realized the limited time to implement a fully operating file converter. Eventually having us to detour and focus more on having the customization on Onshape. Written out the majority of the report for the group.

Demo

- The setup for Demo day:


Conclusion

Through this project, it was quite interesting to learn more about 3D-printing and the ideas of integrating unlikeable pairs in aspects of fabrication and computation. In the overall production of the finalized product, we believe the project was deemed successful to the objective goals. Because of limited time, we are unable to fulfill our goal that enables users to customize their designs from hand-drawing images. If given more time and resources to the product, we would also implement a more comprehensive system that users can choose from other designs instead of only puzzles. Overall, we believe that the production of this product was successful as we had made something that had never been seen before in the phone case market.

References

1. PopSockets Phone Cases
2. Pop It Bubble Wrap Phone Cases
3. Standing Phone Cases