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Learning Through Replication by Fabricating ThanatoFenestra
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Introduction

At the start of our summer research program, we were presented with the opportunity to learn through replication by fabricating a project at the crossroads of Memory Studies and HCI. We settled on *ThanatoFenestra*, a "photographic family altar designed with the purpose of supporting a ritual to pray for the deceased',' originally designed by Daisuke Uriu and Naohito Okude in 2009 [1]. We chose this project to understand how design technologies convey family practices. The aim of our project was to replicate the *ThanatoFenestra* concept to use in future human-computer interaction research on the social perception of memory technologies. In this paper, we will detail the design process and technical implementation of ThanatoFenestra's reconstruction, including the challenges we encountered and modifications needed to make a fully working design.

Background and Replication Objective

ThanatoFenestra is a Japanese Buddhist altar reimagined into a circular frame which displays a projected image that is manipulated by a candle flame [1]. The concept addresses space challenges of urban living by miniaturizing a traditional Butsudan altar. Zen Buddhist ideals inspired the circular shape of the structure, which understands the circle as a window into the afterlife [2]. A circular wooden frame with Japanese paper is attached to the rear that acts as the projector screen. From the front, a wooden shelf is nestled below the frame's center. The shelf's purpose is two-fold: it suspends the incense bowl above a tea candle and it hides the sensors that will read the candle flame's condition.

The original concept used a PC laptop, projector, and a custom microcontroller hidden outside the frame. Our goal was to recreate the design with open-source and off-the-shelf components, and fully enclose all electronics for a single portable artifact.

Design and Implementation

A. *Package Design*

We kept the original design's user interface (the frame),and created a new enclosure. By sketching and rendering 3D models in AutoDesk's Inventor (Figure 3), we iterated through ideas to extend the frame's package from below to encapsulate a Raspberry Pi, breadboarded circuit, and a Miroir M75 micro projector. Once a general template was obtained, we translated the 3D model into a series of cardboard prototypes to determine sizing and component placement.

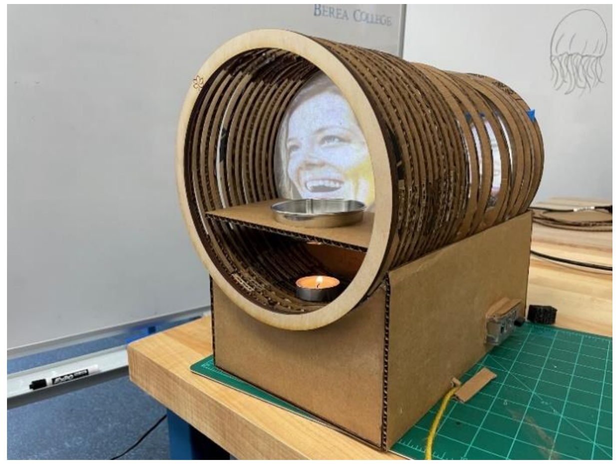

Figure 1 Laser cut cardboard replica of ThanatoFenestra

The enclosure accommodates the projector's throw ratio, originally 16 inches. To reduce the length of the package for usability, we used a custom cut plane mirror to fold the projection in half. The total length of the altar is 12 inches–4 inches for the frame's depth and 8 inches enclosing the projector and electronics. The final version *(Figure 1)* uses laser cut corrugated cardboard and birch plywood for the face.

B. *Microcontroller & Sensors*

The Xtel microcontroller used in the original design was a custom board designed by Uriu's lab, which we could not procure. We first decided to use an Arduino to collect data from the light and temperature sensors. Our implementation used two CdS photoresistor light sensors (same as the original) and a TMP36 temperature sensor, a cheaper alternative to the original thermistor sensor. The TMP36 was less sensitive than the original but it allows us to get adequate values to trigger events in our program.

We first tried the PyFirmata library for receiving and analyzing data from the Arduino, however, we found that controlling the Arduino through PyFirmata resulted in too much delay. To avoid this issue, we opted to use an MCP3008 Analog-to-Digital Converter chip to allow the digital GPIO pins on the Raspberry Pi to input data from the analog sensors.

C. *Computer Control*

The original design used a PC in the background to process the microcontroller input and send images to a projector. The software used Javascript and Adobe Flash for "archiving photographs, data analyzing, and showing photographs on the main PC" [1]. For our purposes, a PC could not be easily

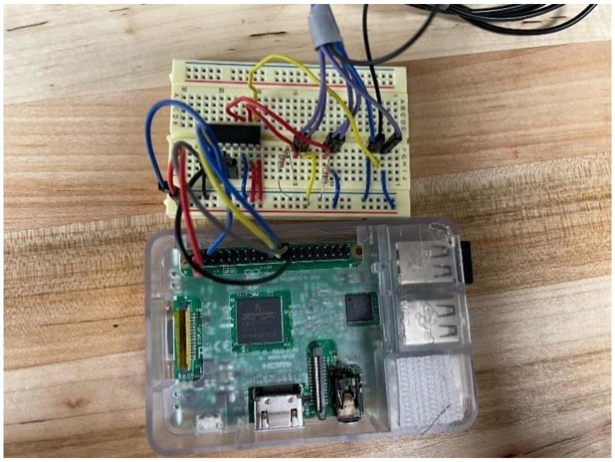

Figure 2. Sensors connected to Raspberry Pi 3 B+ via MCP3008 ADC.

embedded, and the Adobe Flash framework had reached an end-of-product-lifecycle. This prompted us to update our system to use a Raspberry Pi 3B+ as an embedded computer, and to use Python and the OpenCV framework for image display.

D. *Sensor-driven Display*

With no access to the original code, we reverse-engineered a control and display algorithm based on Uriu and Okude's demonstration video and diagrams from their paper (See our Github repository for details [3]). Our program is designed to judge the condition of the candle flame by taking in data from the light and temperature sensors to trigger image events from a custom program.

d.1. *Temperature*. When a candle is lit and the temperature sensor reads an ambient temperature of at least 60℃, it initializes the program and projects a black screen. As the temperature rises, the opacity of the projected image gradually decrements to reveal an increasingly clearer picture. A reading of 60℃ provides 100% opacity and with each integer increase of the temperature the opacity falls 10%. Once the temperature sensor reads 70℃, the transparency effect is lifted to display a clean image.

d.2. *Light*. Input from the two light sensors are designed to shift the displayed image on the X and Y axes and scroll to the next photo in the image library. The first light sensor determines the movement of the images across the X-axis, either left or right. The second light sensor determines the movement of the images across the Y-axis, either up or down. Therefore, moderate flame movement will trigger a fluttering effect, while greater flame movement will trigger an image change.

When the candle is extinguished and the light sensor values drop below the values provided at program initialization, an "infinity cycle" is triggered causing a rapid photo change. Additionally, as the temperature falls the images will "fade away" as the opacity increases to a black screen, signaling the user has ended their session with the altar.

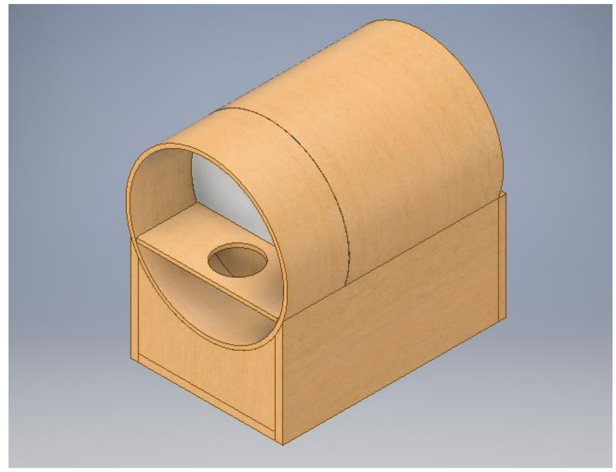

Figure 3. CAD model of revised package design.

Reflection & Future Work

This project combined skills acquired from engineering technologies and applied design college courses such as electricity and electronics, computer programming, and 3D modeling. As undergraduates who possess diverse skills, working collaboratively gives an experience that we consider to be close to that of the industry.

In the final weeks of our summer program, we intend to progress our cardboard prototype to a robust family altar. We will begin testing whether a 3D printed package solution or a wooden enclosure is best suited for the altar. We plan to fabricate a custom PCB to replace our breadboard circuit to better fit our embedded Raspberry Pi 3B+. Additionally, we will continue to experiment with mirror types and placement to shorten the projector throw ratio and the overall package footprint of the altar.

Conclusion

We believe the human need to memorialize deceased family members is appealing to family homes today and will continue to be across generations. Therefore, by replicating ThanatoFenestra, we profited from an exceptional hands-on learning experience by redesigning and discovering new solutions to a techno-altar capable of transcending cultural borders.

Acknowledgements

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References

[1] Daisuke Uriu and Naohito Okude, "ThanatoFenestra: Photographic Family Altar Supporting a Ritual to Pray for the Deceased." 2010.

[2] Daisuke Uriu and Naohito Okude, "Designing for Domestic Memorialization and remembrance: A Field Study of Fenestra in Japan." 2016.

[3] https://github.com/cheskynd/TFURCPP