Onsite Pediatric Earmold Fabrication

Ethan Zhou, Kayla Vallecillo, Erica Dong, Armaan Priyadarshan

Problem Statement

The earmold manufacturing process is unnecessarily convoluted, lengthy, and expensive, causing inconvenience for pediatric patients that use hearing aids (Anderson & Madell, 2014).

Methodology

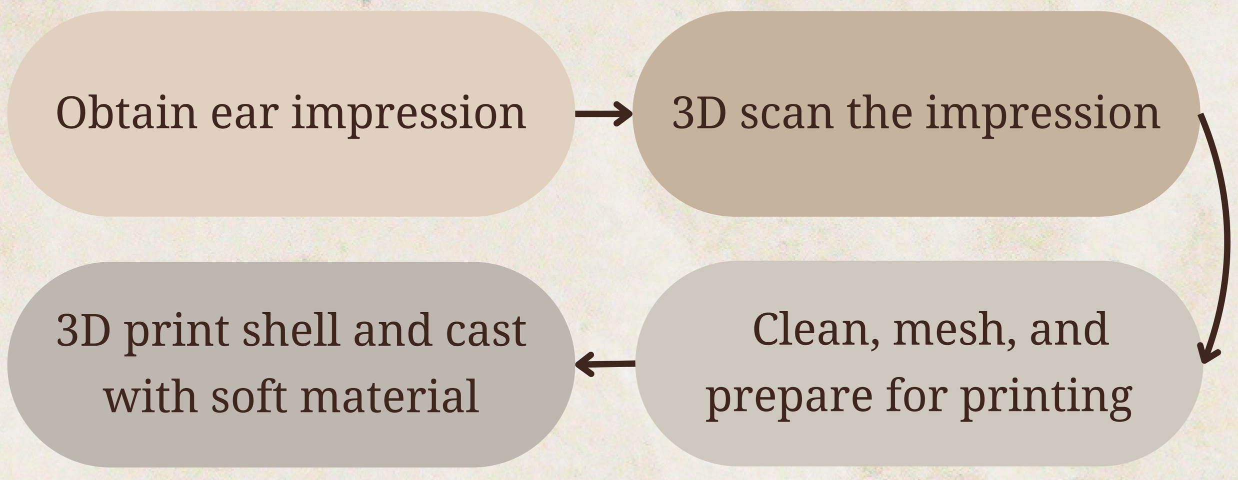

Figure 1: Methodology

Requirements

Onsite Earmold Fabrication	Predictive Model for Advance Fabrication
• Fabricated within the hospital site • Well-fitting and comfortable • Costs at most $100 each • Made of soft, long-term biocompatible material	• Produces earmold predictions that are accurate enough to be comfortable • Able to make earmold predictions at least three weeks in advance

Table 1: Level 1 requirements

Preliminary Designs

1. Ear Impressions

Figure 2: Ear impression

Pros
- Familiar process
- Safe and reliable for children

Cons
- Scanning requires extensive technology

2. 3D-Printed Earmold

Figure 3: 3D-printed earmolds

Pros
- Quick and reliable
- Requires minimal human intervention

Cons
- Soft materials are difficult to print - hard materials are unsuitable for children

3. Cast Earmold

Figure 4: Cast filled with rubber

Pros
- Enables use of soft materials

Cons
- Risk of human error
- Longer process

4. Predictive Model

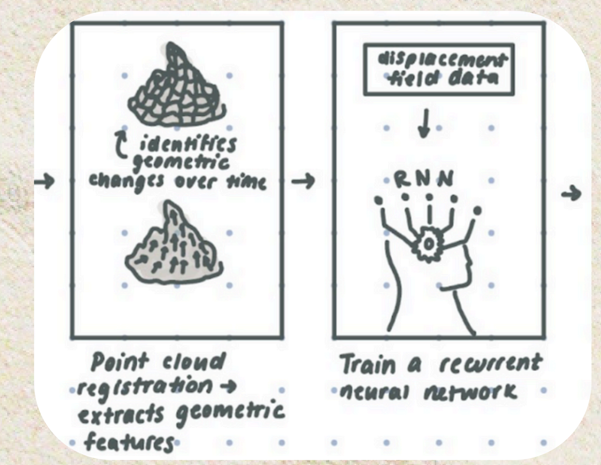

Figure 5: Model architecture

Pros
- Can be utilized remotely
- Enables advance instead of only quicker fabrication

Cons
- Can be inaccurate
- Currently waiting on IRB approval for better training data

Design Studies

Design #1: Ear Impressions
- Impression took **15 minutes** on average to obtain.
- Impression scanning and uploading takes **another 15-20 minutes**.
- The tools used for impression scanning were somewhat expensive.

Design #2: 3D-Printed Earmold
- It was created with less biocompatible and flexible materials than silicone.
- The first pair of 3D-printed earmolds did not fit comfortably for the user.
- The prints took **3 to 4 hours** to be created.

Design #3: Cast Earmold
- A rubber mixture was created and funneled into the cast (although silicon can also be used).
- The case was 3D-printed in **3 to 4 hours**.
- It took an **additional 25 minutes** to set up and cure.

Design #4: RNN Predictive Model
- A recurrent neural network was trained on longitudinal ear data for sequential prediction.
- The model obtained **61.8% accuracy** on validation set.

Final Design - 1 + 3 Combination

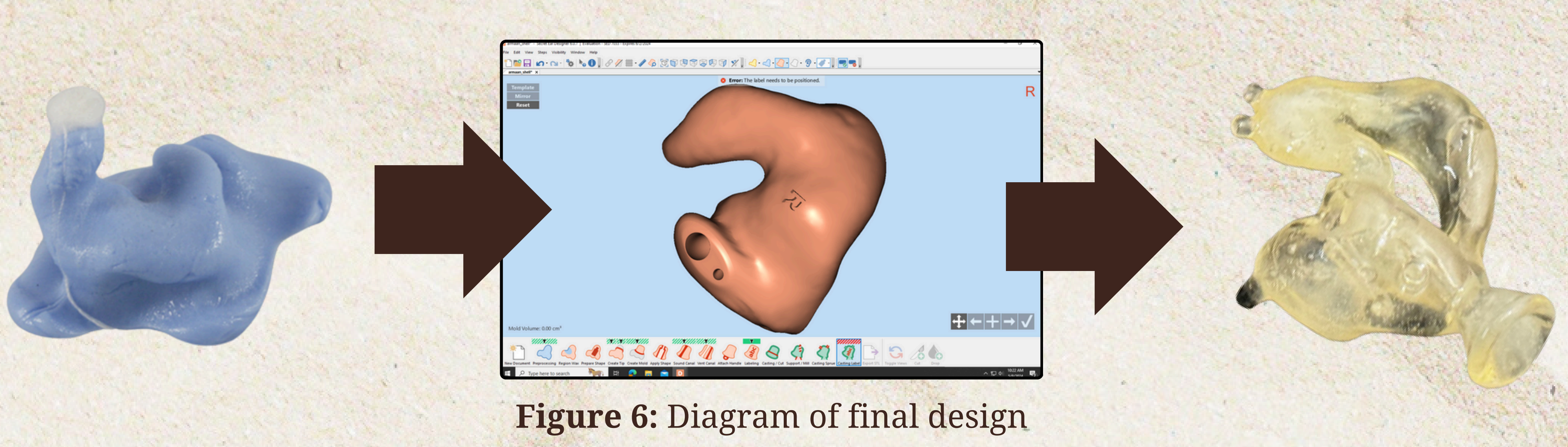

Figure 6: Diagram of final design

- Combines designs #1 and #3 - physical ear impressions and 3D scanning technology are used to generate an injection-ready earmold shell with the Cyfex Secret Ear Designer tool
- Decided to prioritize comfort of patient over speed

Features

- Custom earmolds are modelled based on ear impressions, a widely-known and simple process.
- Casts are 3D printed, which can be done in-hospital and relatively quickly.
- Fast-curing material with softness suitable for pediatric patients.

Conclusions

- Designed onsite pediatric earmold fabrication process
- Prioritized pediatric patient comfort over speed

Future Extensions

- Improve model by introducing convolutional architecture and training on more comprehensive data
- Compare and evaluate alternative onsite fabrication methods

References Anderson, K., & Madell, J. (2014). Improving hearing and hearing aid retention for infants and young children. *Hearing Review, 21*(2), 16-20.

ADVISORS: DR. YIHAO ZHENG, DR. KEVIN CROWTHERS