Neonatal Intubation Simulation with Virtual Reality and Haptic Feedback

Advisor: Professor Beth Meyerand
Cients: Dr. Ryan McAdams
Dr. Brandon Tomlin
Team Members

Team Leader- Carter Griest
Communicator- Isaac Hale
BSAC- Isaac Hale
BWIG- Joey Campagna
BPAG- Roberto Romero

From Left To Right: Joey Campagna, Roberto Romero, Isaac Hale, Carter Griest.
Overview

- Neonatal Intubation - Global Need
- Intubation Procedural Background
- Current Training Methods
- PDS Summary
- Existing Technologies
  - VR Developing Platforms
  - VR Headsets
  - Haptic Devices
- Developing Platform Evaluation
- Headset Evaluation
- Existing Obstacles & Future Work
Neonatal Intubation - Global Need

• 7% of term-newborns undergo respiratory distress\(^1\)
  • Increases substantially in premature infants

• In 2005, nearly 10% of births were premature\(^2\)
  • Highest rates in North America and third world countries
  • Estimated that prevalence increased since 2005

• Anywhere from 30-70% of intubation attempts are successful\(^3\)\(^-\)\(^5\)
Intubation Procedural Background

- Intubation may be necessary if the neonate is under respiratory distress

- Procedural steps:
  - Insert endotracheal blade
  - Scoop and lift tongue to visualize vocal cords
  - Insert endotracheal tube through vocal cords
  - Once successful, secure tube

- Procedure must be done gently, quickly and precisely⁶
Current Training Methods

- Video instruction:
  - While useful, without practicing an intubation first-hand, one cannot hope to perform the procedure correctly under stress\(^7\)

- Neonatal Mannequins:
  - The primary neonatal intubation training method is via the use of expensive mannequins
  - Mannequins fail to accurately mimic neonate anatomy and other physical properties
    - Unnatural texture and movements
    - Easily identifiable vocal cords\(^8\)
PDS Summary

Function:
- Client desires virtual simulation to simulate neonatal intubation procedure
- Includes haptic feedback
- Requires environment which accurately emulates procedure

Performance Requirements:
- Must be accurate to 0.02mm to compete with current haptic feedback systems
- Virtual environment must be detailed and load in real time without buffering

Ergonomics:
- Should feel similar to real procedure in regards to tools used and actions performed

Cost:
- Should cost under $6000
Existing Technology: Haptic Devices

3D Systems produces a variety of haptic feedback devices, each offering varying levels of precision, maneuverability, and load capability.

Phantom Touch
Phantom Touch X
Phantom Premium
Existing Technologies: VR Headsets

**Standalone VR headsets**\(^9,10\)
Examples: Oculus Rift, HTC Vive
- Greater positional tracking
- Integrated haptic “remotes”
- High cost ($400-500)
  

**Mobile phone VR headsets**
Interfaces with mobile phones
- Low cost ($120-200)\(^9,10\)
- Files interface directly from app Store\(^11\)
  
Existing Technologies: Development Platforms

Solidworks
- Free (through UW)
- Must be rendered using separate software to interface with haptic devices\textsuperscript{12,13}

GeoMagic 3D
- Directly compatible with 3D System’s haptic devices\textsuperscript{12}
- Very expensive (~$2000)\textsuperscript{14}
Tentative Timeline

- Establish VR-haptic interface, create virtual neonatal model (BME 301, Spring 2018)
- Refine neonatal model; create lifelike appearances and textures (BME 400/402, Fall 2018)
- Refine haptics; fully integrate feedback into neonatal model (BME 400/402, Spring 2019)
- If incomplete, pass to another BME team or developing firm
## Design Matrix - VR Headsets

<table>
<thead>
<tr>
<th>Design Criteria (weight)</th>
<th>Oculus Rift</th>
<th>Samsung Gear VR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost (35)</strong></td>
<td>2/5 (14)</td>
<td>5/5 (35)</td>
</tr>
<tr>
<td><strong>Resolution (20)</strong></td>
<td>4/5 (16)</td>
<td>5/5 (20)</td>
</tr>
<tr>
<td><strong>Refresh Rate (20)</strong></td>
<td>5/5 (20)</td>
<td>3/5 (12)</td>
</tr>
<tr>
<td><strong>Cranial Tracking Ability (15)</strong></td>
<td>5/5 (15)</td>
<td>4/5 (12)</td>
</tr>
<tr>
<td><strong>Versatility (10)</strong></td>
<td>3/5 (6)</td>
<td>4/5 (8)</td>
</tr>
<tr>
<td><strong>Total (100)</strong></td>
<td>71</td>
<td>87</td>
</tr>
</tbody>
</table>
Current Chosen VR Headset: Samsung Gear VR

- Versatile/portable: no separate computer required for use\textsuperscript{9}

- Cost effective: around $400 cheaper than the Oculus model\textsuperscript{10}

- Higher resolution: offers 1440x1280 pixels per eye (when paired with Samsung Galaxy S6) - 42\% greater than Oculus\textsuperscript{9}
## Design Matrix - Development Platforms

<table>
<thead>
<tr>
<th>Design Criteria (weight)</th>
<th>Solidworks</th>
<th>GeoMagic 3D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost (30)</strong></td>
<td>5/5 (30)</td>
<td>3/5 (18)</td>
</tr>
<tr>
<td><strong>Haptic Compatibility (20)</strong></td>
<td>3/5 (12)</td>
<td>5/5 (20)</td>
</tr>
<tr>
<td><strong>Anatomical Accuracy (20)</strong></td>
<td>4/5 (16)</td>
<td>4/5 (16)</td>
</tr>
<tr>
<td><strong>Ease of Use/Design Capabilities (20)</strong></td>
<td>5/5 (20)</td>
<td>4/5 (16)</td>
</tr>
<tr>
<td><strong>VR Platform Compatibility (10)</strong></td>
<td>5/5 (10)</td>
<td>4/5 (8)</td>
</tr>
<tr>
<td><strong>Total (100)</strong></td>
<td><strong>88</strong></td>
<td><strong>78</strong></td>
</tr>
</tbody>
</table>
Current Chosen Development Platform: Solidworks

• Free (through campus software library)

• Familiar: no need to re-learn user interface

• Versatile: possesses more intricate design capabilities (more surfacing features, greater selection of file types)\(^\text{12}\)

• Established and used extensively in the medical field\(^\text{15}\)
Potential Problems

• Processing power of Samsung phones limits how detailed the environment can be

• Software/hardware compatibility

• Accurate emulation of tissue-like properties in virtual reality
  • Somatosensory properties
  • Destructive VR

• Unnatural movements of haptic device
Conclusion and Future Work

- Create 3D models for tools used during the procedure
- Integrate realistic models of newborn mouth and throat into VR
- Design a VR environment to resemble a neonatal operating room
Acknowledgements

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• Our advisor, Prof. Beth Meyerand, for guiding us throughout the preliminary design process

• The BME Department, for providing us with the opportunity to work on this project
References

Questions?