Neonatal Intubation Simulation with Virtual Reality and Haptic Feedback

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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
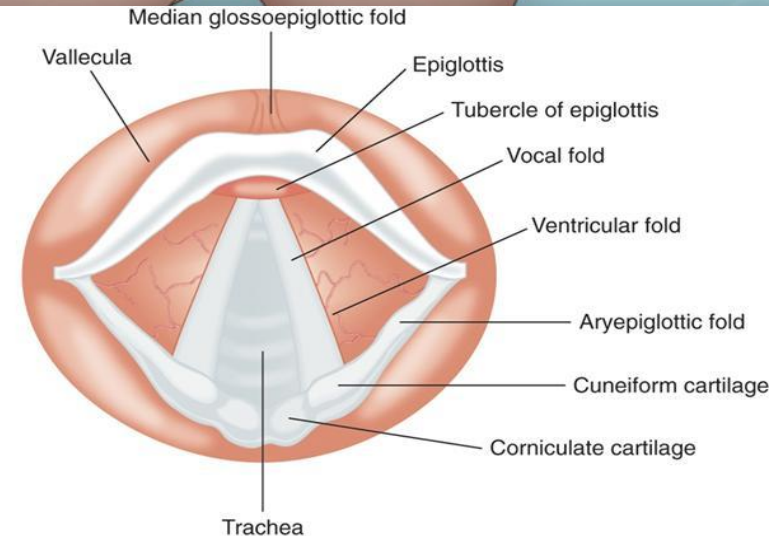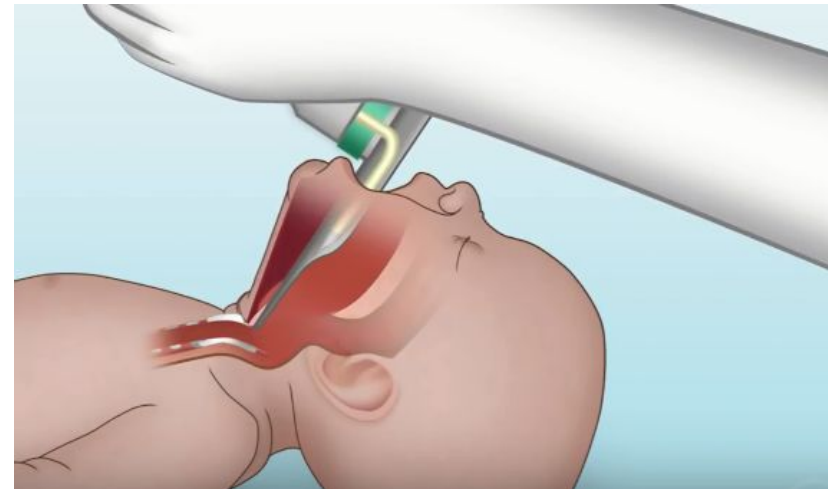- Existing Obstacles & Future Work
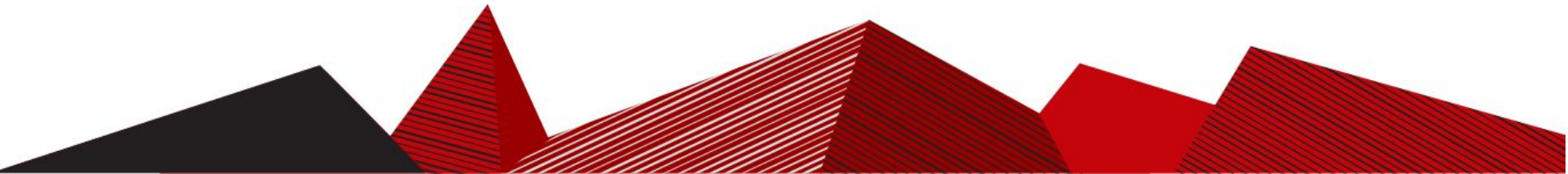
Neonatal Intubation - Global Need

- 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 precisely[6]

Median glossoepiglottic fold

Vallecula

Epiglottis

Tubercle of epiglottis

Vocal fold

Ventricular fold

Aryepiglottic fold

Cuneiform cartilage

Corniculate cartilage

Trachea

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)

https://newatlas.com/gear-vr-vs-oculus-rift-specs-comparison-2017/49015/

Mobile phone VR headsets

Interfaces with mobile phones

- Low cost ($120-200)[9,10]
- Files interface directly from app Store[11]
-
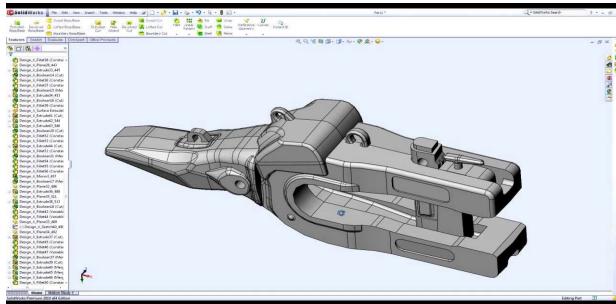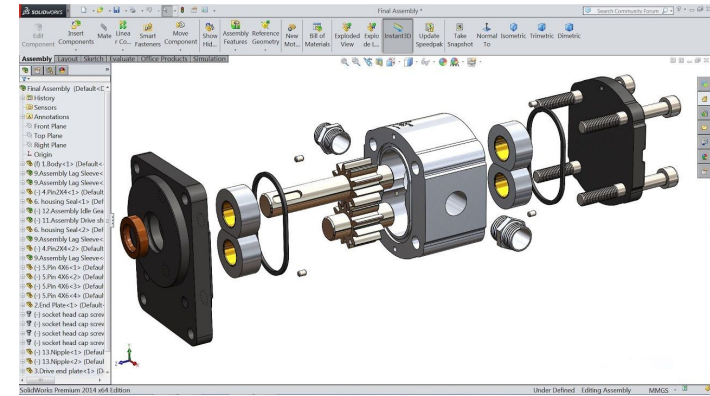   https://play.google.com/store/apps/details?id=com.samsung.android

Existing Technologies: Development Platforms

Solidworks

- Free (through UW)

- Must be rendered using separate software to interface with haptic devices[12,13]

GeoMagic 3D

- Directly compatible with 3D System's haptic devices[12]

- Very expensive (~$2000)[14]

Tentative Timeline

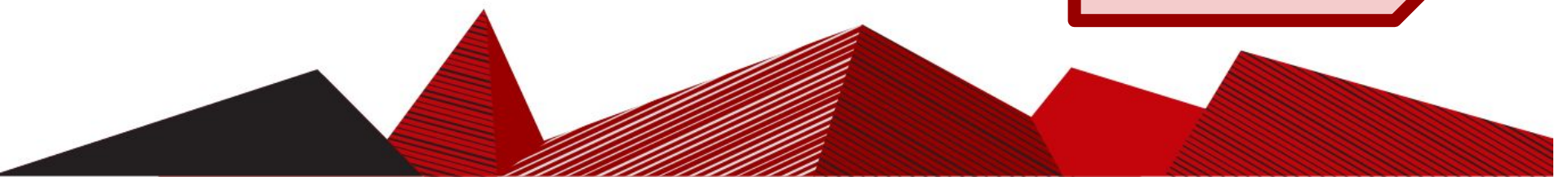**Establish VR-haptic interface, create virtual neonatal model**

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

Design Criteria (weight)	Oculus Rift	Samsung Gear VR
Cost (35)	2/5 (14)	5/5 (35)
Resolution (20)	4/5 (16)	5/5 (20)
Refresh Rate (20)	5/5 (20)	3/5 (12)
Cranial Tracking Ability (15)	5/5 (15)	4/5 (12)
Versatility (10)	3/5 (6)	4/5 (8)
Total (100)	71	**87**

Current Chosen VR Headset: Samsung Gear VR

- Versatile/portable: no separate computer required for use[9]

- Cost effective: around $400 cheaper than the Oculus model[10]

- Higher resolution: offers 1440x1280 pixels per eye (when paired with Samsung Galaxy S6) - 42% greater than Oculus[9]

Design Matrix - Development Platforms

Design Criteria (weight)	Solidworks	GeoMagic 3D
Cost (30)	5/5 (30)	3/5 (18)
Haptic Compatibility (20)	3/5 (12)	5/5 (20)
Anatomical Accuracy (20)	4/5 (16)	4/5 (16)
Ease of Use/Design Capabilities (20)	5/5 (20)	4/5 (16)
VR Platform Compatibility (10)	5/5 (10)	4/5 (8)
Total (100)	**88**	78

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)[12]

- Established and used extensively in the medical field[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

Many thanks to:

- Our clients, Dr. Ryan McAdams and Dr. Brandon Tomlin, for working with us to lay out design constraints and requirements

- 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
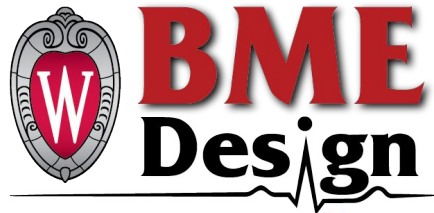
References

1. Reuter, S., Moser, C. and Baack, M. (2014). Respiratory Distress in the Newborn. *Pediatrics in Review*, 35(10), pp.417-429.
2. Beck, S., Wojdyla, D., Say, L., Pilar Bertran, A., Meraldi, M., Harris Requejo, J., Rubens, C., Menon, R. and Van Look, P. (2010). The worldwide incidence of preterm birth: a systematic review of maternal mortality and morbidity. *Bulletin of the World Health Organization*, 88(1), pp.31-38.
3. Kumar, A. and Vishnu Bhat, B. (1996). Epidemiology of respiratory distress of newborns. The Indian Journal of Pediatrics, 63(1), pp.93-98.
4. Haubner, L., Barry, J., Johnston, L., Soghier, L., Tatum, P., Kessler, D., Downes, K. and Auerbach, M. (2013). Neonatal intubation performance: Room for improvement in tertiary neonatal intensive care units. *Resuscitation*, 84(10), pp.1359-1364.
5. O'Donnell, C. (2006). Endotracheal Intubation Attempts During Neonatal Resuscitation: Success Rates, Duration, and Adverse Effects. *PEDIATRICS*, 117(1), pp.e16-e21.
6. OPENPediatrics (2016). *"Neonatal Tracheal Intubation" by Lindsay Johnston for OPENPediatrics*. [video] Available at: https://www.youtube.com/watch?v=lGTaA_UdIXw [Accessed 31 Jan. 2018].
7. O'Shea, J., Thio, M., Kamlin, C., McGrory, L., Wong, C., John, J., Roberts, C., Kuschel, C. and Davis, P. (2018). *Videolaryngoscopy to Teach Neonatal Intubation: A Randomized Trial*. [online] Available at: http://pediatrics.aappublications.org/content/136/5/912 [Accessed 10 Feb. 2018].
8. Kresge, N. (2018). *Improving neonatal intubation training to boost clinical competency | Children's National*. [online] Innovation District. Available at: https://innovationdistrict.childrensnational.org/improving-neonatal-intubation-training-boost-clinical-competency/ [Accessed 10 Feb. 2018].
9. Jespersen, C. (2018). *Oculus Rift vs. Samsung Gear VR - NerdWallet*. [online] NerdWallet. Available at: https://www.nerdwallet.com/blog/shopping/oculus-rift-vs-samsung-gear-vr-virtual-reality-headset-comparison/ [Accessed 13 Feb. 2018].
10. Shanklin, W. (2018). *Oculus Rift vs. Gear VR (2017)*. [online] Newatlas.com. Available at: https://newatlas.com/gear-vr-vs-oculus-rift-specs-comparison-2017/49015/ [Accessed 15 Feb. 2018].
11. Play.google.com. (2018). *Samsung VR*. [online] Available at: https://play.google.com/store/apps/details?id=com.samsung.android.video360&hl=en [Accessed 17 Feb. 2018].
12. Cad.softwareinsider.com. (2018). *SolidWorks vs Geomagic - CAD Software Comparison*. [online] Available at: http://cad.softwareinsider.com/compare/24-144/SolidWorks-vs-Geomagic [Accessed 17 Feb. 2018].
13. Mings, J. (2018). *Alibre and Geomagic Combined. 3D Systems Releases Geomagic Design. - SolidSmack -*. [online] SolidSmack. Available at: https://www.solidsmack.com/cad/alibre-and-geomagic-combined-3d-systems-releases-geomagic-design/ [Accessed 19 Feb. 2018].
14. Solidworks.com. (2018). *Overview*. [online] Available at: http://www.solidworks.com/sw/industries/life-sciences-overview-industries.htm [Accessed 19 Feb. 2018].

References

1. **Slide 3 Figure:** Amazon.ca. (2018). *Amazon*. [online] Available at: https://www.amazon.ca/Oculus-Touch-Virtual-Reality-System/dp/B073X8N1YW [Accessed 21 Feb. 2018].
2. **Slide 5 Top Figure:** OPENPediatrics (2016). *"Neonatal Tracheal Intubation" by Lindsay Johnston for OPENPediatrics*. [video] Available at: https://www.youtube.com/watch?v=lGTaA_UdIXw [Accessed 31 Jan. 2018].
3. **Slide 5 Bottom Figure:** Pinterest. (2018). *Intubation*. [online] Available at: https://www.pinterest.com/pin/388294799107149347/ [Accessed 2 Mar. 2018].
4. **Slide 6 Figure:** Pinterest. (2018). *School & Educational Supplies*. [online] Available at: https://www.pinterest.com/pin/835417799599311875/ [Accessed 2 Mar. 2018].
5. **Slide 8 Left Figure**: 3D Systems. (2018). *Touch | 3D Systems*. [online] Available at: https://www.3dsystems.com/haptics-devices/touch [Accessed 26 Feb. 2018].
6. **Slide 8 Middle Figure**: Immersion.fr. (2018). *Phantom Touch X | IMMERSION, imagination, interaction...*. [online] Available at: https://www.immersion.fr/en/phantom-touch-x/ [Accessed 26 Feb. 2018].
7. **Slide 8 Right Figure**: 3D Systems. (2018). *Touch | 3D Systems*. [online] Available at: https://www.3dsystems.com/haptics-devices/touch [Accessed 26 Feb. 2018].
8. **Slide 9 Top Figure:** Amazon.ca. (2018). *Amazon*. [online] Available at: https://www.amazon.ca/Oculus-Touch-Virtual-Reality-System/dp/B073X8N1YW [Accessed 21 Feb. 2018].
9. **Slide 9 Bottom Figure:** Play.google.com. (2018). *Samsung VR*. [online] Available at: https://play.google.com/store/apps/details?id=com.samsung.android.video360&hl=en [Accessed 17 Feb. 2018].
10. **Slide 10 Top Right Figure:** Solidworks.com. (2018). *Product Details*. [online] Available at: http://www.solidworks.com/sw/products/details.htm?productid=906 [Accessed 26 Feb. 2018].
11. **Slide 10 Left Figures:** Pro-creative.com.hk. (2018). *Geomagic - Hong Kong (Pro - Creative Technology Ltd) - Geomagic Design Elements*. [online] Available at: http://www.pro-creative.com.hk/Elements.html [Accessed 26 Feb. 2018].
12. **Slide 13 Figure:** (2017). G. (2018). *Gear VR (2017) | SM-R324NZAATPA | Samsung LATIN*. [online] Samsung latin. Available at: http://www.samsung.com/latin/wearables/gear-vr-2017/ [Accessed 26 Feb. 2018].
13. **Slide 15 Figure**: Worldvectorlogo.com. (2018). *SolidWorks — Worldvectorlogo*. [online] Available at: https://worldvectorlogo.com/logo/solidworks [Accessed 26 Feb. 2018].
14. **Slide 17 Left Figure:** Novamed-usa.com. (2018). *NOVALITE Laryngoscopes | NOVAMED USA*. [online] Available at: http://www.novamed-usa.com/neonatal_laryngoscopes.html [Accessed 28 Feb. 2018].
15. **Slide 17 Middle Figure:** Imgflip.com. (2018). *surprised baby Blank Template - Imgflip*. [online] Available at: https://imgflip.com/memetemplate/118367380/surprised-baby [Accessed 28 Feb. 2018].
16. **Slide 17 Right Figure:** Comstocksmag.com. (2018). *Opportunity of a Lifetime | Comstock's magazine*. [online] Available at: http://www.comstocksmag.com/longreads/opportunity-lifetime [Accessed 28 Feb. 2018].

Questions?