Neonatal Intubation Simulation with Virtual Reality and Haptic Feedback

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Respiratory distress syndrome (RDS), a neonatal disease characterized by difficulty breathing, is remarkably common among premature infants. Patient outcomes resulting from RDS are undesirably poor. Unsatisfactory patient outcomes are in part due to ineffective training methods. The high stress environment of the delivery room and the precise nature of the procedure are nearly impossible to emulate using current training methods; including video instruction, and mannequin intubation. Thus, a more realistic training method that better represents both the difficulty of the procedure as well as the tense external environment would improve physician competency and outcomes. Virtual reality (VR) is an innovative tool becoming increasingly used in the medical field, particularly for simulations. VR provides a means by which individuals can be visually immersed in a non-physical, yet responsive, environment. Incorporation of haptic feedback devices allows users to feel virtual objects, allowing for a more immersive experience.

● The clients desire a virtual simulation which simulates a neonatal intubation procedure for under $6000
  ○ The simulation should incorporate a virtual reality headset (Figure 3) alongside a haptic feedback device (Figure 4) to create a simulation with somatosensory feedback (Figure 5)
    ○ Virtual reality (VR) is an emerging tool in clinical medicine [10]
    ○ Haptic feedback devices provide force feedback, allowing users to 'feel' virtual objects [11]
    ○ The simulation should have a resolution of 0.02mm to compete with current haptic simulation systems [12]
  ○ The final design will incorporate a variety of software including:
    ○ Unity (game development)
    ○ Solidworks (3D modelling)
    ○ Blender (3D rendering and animation)
    ○ 3D Systems OpenHaptics
    ○ Geomagic Touch (haptic integration)

● The current virtual environment models a simple operating room, including:
  ○ one deformable sphere
  ○ one rigid sphere
  ○ one rigid endotracheal tube
  ○ three rigid laryngoscope blades
● The surgeon can travel about the OR while interacting with rigid and deformable objects

● The endotracheal tube is inserted into the mouth to scoop aside the tongue and epiglottis, revealing the vocal cords [6]

● 7% of term-newborns undergo respiratory distress [1]
  ○ Rates increase substantially in premature infants

● 30-70% of intubation attempts are unsuccessful, partially due to inadequate training methods [3-5]
● Procedure must be done gently, quickly, and precisely [6]
● Current training methods include video instruction and Neonatal Mannequins [7,8]
   ○ Mannequins fail to accurately mimic neonate anatomy and other physical properties [8]
     ○ Unnatural texture and movements
     ○ Easily identifiable vocal cords
   ○ While useful, without practicing an intubation first-hand, one cannot hope to perform the procedure correctly under stress [7]

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Figure 1: The endotracheal tube is inserted into the mouth to scoop aside the tongue and epiglottis, revealing the vocal cords [6]

Figure 2: Gold standard intubation models fail to accurately emulate the complex physical properties of the respiratory tract [9]

Figure 3: The Oculus Rift is a prominent VR headset, compatible with most developing platforms [13]

Figure 4: 3D Systems Touch haptic feedback device is an affordable, effective tool for somatosensory feedback [12]

Figure 5: A 3D Systems haptic device simulating a virtual surgery [14]

Figure 6: Rigid laryngoscope blades will later be used in conjunction with the Touch haptic feedback device

Figure 7: The above image illustrates a simple, proof-of-concept operating room developed in Unity, intended to simulate a clinical environment and exemplify the character-object interactions that will be encountered while developing the surgical simulation

● Refine the virtual reality environment
● Implement two haptic feedback devices
● Introduce multiple difficulty levels for the simulation
● Develop equations and models to simulate the tissue’s physical properties

Figure 8: BME 400/402 Fall 2018

Figure 9: BME 400/402 Spring 2019

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References: