VR simulation with haptic feedback for medical procedure

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Function

The client wishes to develop a virtual simulation environment that accurately models a neonatal intubation procedure. Tentatively, the client desires that a virtual environment be created which mimics the upper respiratory tract, throat, and mouth of a neonate. The virtual system should precisely emulate a clinical environment in order to function as a novel neonatal intubation training method for physicians. Furthermore, the virtual components should be integrated with a haptic feedback motor arm which pairs physical traits to the virtual objects, thus mimicking a clinical procedure with only the use of virtual reality and a portable haptic feedback device. Ultimately, this device should serve as a virtual, but effective, surgery training method.

Client Requirements:

- The virtual environment must accurately emulate the physical characteristics of an infant's tongue, larynx, trachea, and vocal cords to a degree of precision within the scope of a neonatal intubation procedure.
- A haptic interface must allow the user to provide manual inputs, to be visually represented precisely in a virtual environment. The interface must also register interactions in virtual space between the user's input and a preprogrammed objects, and relay these interactions back to the user via a haptic motor arm.
- The system must include a user-friendly software allowing changes in procedural specifications.

Design requirements:

1. Physical and Operational Characteristics

a. Performance requirements:

- The system must be constructed for use in both clinical and rural settings, demanding portability and durability.
- The system must be capable of running up to 25 full simulations per day.
- A virtual environment must be capable of simulating neonates in the range of 1-10 lbs.

b. Safety: Any electronic components must be enclosed within appropriate housing to minimize the risk of injury due to electric shock.

c. Accuracy and Reliability: The system must be accurate to .02 mm to compete with current haptic feedback systems and provide a realistic surgical environment.

d. Life in Service: The system must last at least 5 years with minimal maintenance.

e. Shelf Life: The device will be stored inside and will not be exposed to extreme weather conditions. It should not need maintenance while not in use.

f. Operating Environment: The system should be capable of operating in a variety of environments, including clinical and outdoor settings. The virtual simulation will be perfected by using feedback from expert neonatologists to accurately emulate a neonatal intubation procedure.

g. Ergonomics: The device should be intuitive to use and feel very similar to tools used during neonatal intubation such as the laryngoscope and endotracheal tube.

h. Size: The device must be small enough be carried around in a backpack or other case.

i. Weight: The device must weigh less than 40 lbs, light enough to be easily transported in a backpack or other case.

j. Materials: The system will be comprised of a pair of virtual reality goggles, a haptic feedback motor arm, and any computer hardware required to render the environment and power the system.

k. Aesthetics, Appearance, and Finish: The virtual reality should not be blurry. The user should be able to interact with the environment without noticeable buffering.

2. Production Characteristics

a. Quantity: One functional prototype will suffice for BME 301. Ultimately, however, the aim is to provide worldwide accessibility.

b. Target Product Cost: The device should cost under $3000.

3. Miscellaneous

a. Standards and Specifications: If successful, the device would require IRB and FDA approval to serve as a credible source of medical training.

b. Customer: The system will be used by training physicians who are practicing neonatal intubation procedures. Consequently, they will demand a realistic virtual environment with physical characteristics which accurately model a neonates anatomy and physiology.

c. Patient-related concerns: No concerns should arise from the use of this device as it will serve as an additional form of medical training, not an alternative to current training.

d. Competition: Competition exists among virtual reality platforms, but to our knowledge, there only exists a single haptic feedback system on the market currently, and there are no integrative VR and haptic feedback systems which are used for medical simulation.