Donning and Doffing Simulator for Healthcare Workers Caring for COVID-19 Patients

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Introduction

- With the untimely introduction of COVID-19 into our lives, personal protective equipment (PPE) standards and procedures assumed an even more crucial role in protecting healthcare workers and patients.
- While instructor-led training exists and is practical, it requires instructor time and PPE resources for implementation, both of which were limited during the pandemic.
- Video-based lessons are affordable, safe, and require fewer resources, but they lack the practical hands-on experience essential for learning.
- In this study, we developed a VR-based training environment to simulate donning and doffing PPE for rapid sequence induction (RSI) with a COVID-19-positive patient.



Figure 1: Avatar interacting with PPE

Methods and Procedures

- Our VR-based simulation places the learner in a virtual environment that includes an anteroom and a contaminated operating room; both were designed with guidance from medical experts to ensure we replicated the physical training environment. Learners are instructed on donning and doffing procedures, interact with virtual PPE (Fig 1.) to test their knowledge and skills, and receive feedback.
- An instructional user interface informs the tasks to the user. Every time the trainee completes a task, the instruction panel is updated to show the next task.
- The scene achieves a high degree of immersion using a GGX bidirectional reflective distribution formula [1][2] alongside effects such as shadows, tone mapping, and color adjustment to increase realism.
- We developed an avatar animation system based on how a human skeleton moves by using a rigged 3D model. The head and hands of the avatar are animated using position and rotation data retrieved from the Head-Mounted Display (HMD) and the controllers used by the trainee.
- The rest of the avatar's body takes shape by using Inverse Kinematics [3] based on the position of the head and hands. This animation system also uses predefined hand poses for animating the fingers while grabbing an object at runtime.
- We implemented a cloth simulation system to simulate cloth physics on specific PPE such as face masks and gloves (Fig. 2.). This system uses a deformable body algorithm, Extended Position-Based Dynamics (XPBD)[4], which is a variation on the Position-Based Dynamics (PBD) cloth dynamics algorithm, fixing several performance and accuracy issues to allow models to be affected by gravity and collide with each other and other solid objects in the scene.

Donning Personal Protective Equipment



Donning Order:
a) Equip Surgical Scrubs, b) Perform Hand Hygiene, c) Equip N95 Respirator, d) Equip Surgical Mask, e) Equip Head Cover, f) Equip Visor, g) Equip Shoe cover, h) Equip Surgical Gown, i) Perform Hand Hygiene, and j) Equip gloves

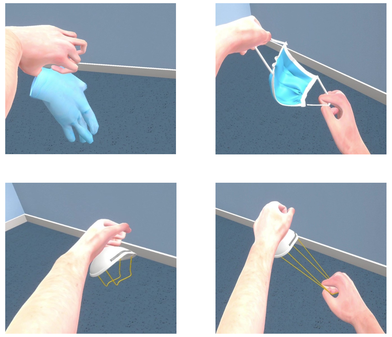


Figure 2: Deformable cloth simulation

Conclusion

- We have developed a donning and doffing simulation as an alternative or adjunct to current conventional training methods.
- Several existing technologies have been utilized with our newly developed functionality to create a virtual environment that aims to simulate reality.
- These developed features also help the user achieve presence within the scene, as they can visualize how they are moving and what they have done.

Future Work

We plan to extend the scope of the project not only for donning and doffing but also for other medical procedures to let medical students train while remaining safe and utilizing fewer precious healthcare resources.

References

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